Using Population Models and Field Studies to Develop More Effective and Efficient Sterilization Strategies: Relevant Literature

A review and analysis of articles was completed in 2013 as a foundation for our Flagship Initiative on population dynamics modeling and field studies to improve humane management of free-roaming cats. Below you will find a comprehensive annotated bibliography and synopses of these articles, as prepared by Dennis F. Lawler, with additions by Margaret Slater, on behalf of the ACC&D Population Dynamics Modeling Committee. The data derived from these studies are also compiled in a matrix that catalogues the source of data for each of several parameters defined in our computer simulation modeling.

The studies are largely organized by decade, with the most recent first. Since 2013 we have continued to review published research and have likewise included relevant synopses below. Within each grouping, they are organized chronologically, and by lead author's surname if published within the same year. Nothing published thus far has moved us to update parameters for the computer model. This list is not exhaustive and likely not complete. If you have a study you recommend we add to this list, please contact us.

Our sincere thanks to the ASPCA®, whose generous funding made this Flagship Initiative possible. The Initiative, in turn, developed from ACC&D's Think Tank on this topic.

Literature 2014–Present

Gunther I, Raz T, Berke O, E, Klement E. Nuisances and welfare of free-roaming cats in urban settings and their association with cat reproduction. Preventive Veterinary Medicine 119:203–210, 2015.
Urban, Israel, Database study

This is a retrospective study that sourced a citizen complaint database consisting of calls about free-roaming cat (FRC) nuisance and welfare issues. The authors looked at time-based distribution of complaint calls and their association with FRC population dynamics. Five Israeli cities participated, with total area 335.2 km2. Approximately 90,000 complaint calls were categorized as cat carcass, kittens, kitten births, aggressive cat, invading cat, injured cat, cat feeder nuisance, request to sterilize. Events were categorized also by month of occurrence, over a five-year period. Summarizing the data analyses, cat carcasses were 55% of calls, births-5%, kittens-11%, aggression–3%, invasions–10%, injuries–16%. Evaluation by month of occurrence revealed expected seasonality of reproduction-related complaints, but carcass, aggressiveness, invasion, and injury also were seasonal complaints. In general, cat nuisance–welfare complaints related to reproductive activity. The authors called for studies to assess FRC population control efforts on these complaints.

Fagundes AKF, Oliveira ECS, Tenorio BM, Melo CCS, Nery LTB, Santos FAB, Alves LC, Douglas RH, Silva VAJr. Injection of a chemical castration agent, zinc gluconate, into the testes of cats results in the impairment of spermatogenesis: A potentially irreversible contraceptive approach for this species? Theriogenology 81:230-236, 2014.
Brazil, experimental

This study used 6 control cats and 6 test cats to evaluate serum testosterone before and following intratesticular injection with isotonic saline or zinc gluconate, and to evaluate histological and ultrastructural testicular features at 120 days post-injection. Injection volumes were standardized, calculated based on testicular width.
Control cats remained normal by all measures. Plasma testosterone in treated cats declined to very low levels, averaging 6 pg/ml. Histological and ultrastructural studies confirmed atrophy of seminiferous tubules, germ cell degeneration, fibrosis, impaired spermatogenesis, and degenerative changes in Sertoli and Leydig cells.

Johnson KL, Cicirelli J. Study of the effect on shelter cat intakes and euthanasia from a shelter neuter return project of 10,080 cats from March 2010 to June 2014.
TNR, San Jose and Santa Clara County, CA, USA

This study was conducted to evaluate the effect of a TNR program on shelter intakes of cats over a 4-year time period. During this time, 10,080 feral cats were sterilized surgically and returned to capture sites. After 4 years, cat and kitten shelter intakes declined 29%. Euthanasia constituted 70% of shelter intakes before the study, declining to 23% of intakes in 2014. Cat upper respiratory disease and calls for cat carcass removals also declined. This report is further interesting in that the authors defined euthanasia rate and save rate, and excluded owner-requested euthanasia and dead-on arrivals from the data, as well as cats that died of natural causes after shelter entry. Thus, an effort was made to include, insofar as they could, just the free-roamers in the study. Also noteworthy is that the shelters made a strong effort to home as many intakes as they could. The data support that TNR, done properly, does reduce roaming cat numbers. It is important to recognize the large number of cats that were involved, supporting ACCD study models that point to a need for sufficiently intensive program efforts.

Levy JK, Isaza NM, Scott KC. Effect of high-impact targeted trap-neuter-return and adoption of community cats on cat intake to a shelter. Vet J 201:269-274, 2014.
Alachua County, Florida USA

The study purpose was to assess the effect of concentrating cat TNR in a high shelter impoundment area. A 2-year program was implemented to capture and neuter at least 50% of the estimated community cats in a defined zip code area of 11.9 km2 followed by adoption or return (TNReturn or TNAdopt), and to compare cat demographics with a county-wide non-target region.

The effort included 2366 cats, 54% of the target area estimated population. Two years later, shelter intake in the target was reduced 66%, compared to 12% non-target decline. Per capita, non-target shelter cat intake was 3.5 times that of the target area, and cat euthanasia was 17.5 times greater. TNR with adoption of acceptably socialized cats clearly resulted in favorable reduction of the roaming cat population.

Roebling AD, Johnson D, Blanton JD, Levin M, Slate D, Fenwick G, Rupprecht CE. Rabies Prevention and Management of Cats in the Context of Trap–Neuter–Vaccinate–Release Programmes. Zoonoses and Public Health, 2014, 61, 290–296, 2014.

This essay is essentially an argument against TNR based on incorrect interpretation of infectious disease biology, misinterpretation of some existing TNR literature, and exclusion of data contrary to the authors' evident goals. The first author is a recent graduate of a DVM-MPH curriculum, and is thus inexperienced. The acknowledgements include a statement that the stated views are not necessarily those of the contributing authors located at CDC. Because of the poor quality of this work, the reviewer (DFL) does not view it as credible.

Seimenis A, Tabbaa D. Stray animal populations and public health in the South Mediterranean and the Middle East regions. Vet Italiana 50(2): 131-136, 2014.
Public health and animal practices and policies

This report describes the most significant health hazards associated with stray dogs and cats in unmanaged urban growth in the South Mediterranean and Middle East. Several social factors that promote disease dissemination during rapid urban growth include: increased human population density; close human-animal proximity; high numbers of stray animals; intense animal production that often is illegal and unsanitary; cultural norms; lack of awareness; weak official collaborations; financial and resource limitations, poor decisions. Specific diseases of greatest primary zoonotic concern are rabies (virus), Echinococcus (tapeworm) hydatidosis, leishmaniasis (protozoon), and toxoplasmosis (protozoon). Primary possible actions include: establishing roaming animal policies, including adequate and enforced legislation; improving environmental sanitation and dead animal removals; exclude animal access to slaughter houses and dumps; improve public education about human-animal interactions and disease, including preventive medicine for both.

Literature 2011–2013

Alberthsen C, Rand JS, Bennett PC, Paterson M, Lawrie M, Morton JM. Cat admissions to RSPCA shelters in Queensland, Australia: description of cats and risk factors for euthanasia after entry. Aust Vet J 91:35-42, 2013.
Australia: Database study of shelter admissions and outcomes

The authors focused on describing population characteristics of feline shelter admissions. This was done by shelter database analysis from years 2006-2008. The evaluation included nearly

34,000 cats, of which 54% were kittens under age 3 months. Members of the general public presented 88% of the kittens, with 54% being strays and 44% owner-surrendered. Overall, 54% of all admissions were presented as strays. Euthanasia was the most frequent outcome at 65%, followed by homing of 30%. Kittens had lower odds of euthanasia, as did cats that were sterilized. The authors indicate the need for programs to reduce admissions and euthanasia, especially for kittens. Reducing delayed sterilization is one important avenue for the latter. Additional stray population studies are needed. Tables 1 and 2 of this report provide a considerable level of demographic information, but no financial data are included.

Gerhold RW, Jessup DA. Zoonotic diseases associated with free-roaming cats. Zoonoses and Public Health 60:189-195, 2013.
USA, Literature synthesis

This paper is a literature synthesis, describing cats as zoonotic risks for rabies, toxoplasmosis, larval migrans, tularemia, and plague. The primary point the authors make seems to be that TNR programs may lead to increased local numbers of disease-naïve cats through immigration, thus increasing zoonosis risk.

Some of their main supportive concerns are: a) free-roaming cats lack necessary preventive health care; b) a societal philosophy exists toward non-euthanasia of free-roaming "animals"; c) rabies numbers suggest increasing identification of the disease in cats, as compared to dogs; d) a majority of post-potential exposure prophylaxis given to humans is cat-associated.
They make incomprehensible statements such as "17% of all confirmed human rabies exposures in Georgia were attributable to cat bites from 2004 – 2006, whereas dogs comprised 5% of all confirmed human rabies in Georgia during the same time period". Such statements suggest that the authors are not distinguishing in every case the difference between potential and actual rabies exposure, or between true feral cats, unowned free-roaming cats that are not truly feral, and wandering owned pets.

The authors do correctly suggest that a colony of TNR-sterilized cats may attract new unsterilized immigrants, but do not address abandonment. They state that greater kitten survival occurs in these integrated TNR-immigrant colonies, based on one study.
Most of their parasite-associated observations are referenced but not accompanied by descriptions of comprehensive research data.
The report seems to equate potential risk with actual disease transmissions, presumably as an argument for collection and euthanasia of free-roaming cats, without addressing re-population of the then-opened ecological space.

Kass PH, Johnson KL, Weng H-Y. Evaluation of animal control measures on pet demographics in Santa Clara County, California, 1993–2006. PeerJ 1:e18; DOI 10.7717/peerj.18

The authors examined dog and cat populations, owned and unowned, in Santa Clara Co, CA. This population area has been studied several times. For this study, a random telephone survey (1000 responders) provided estimates for numbers of owned pets, strays fed or

sterilized, among other parameters. Animal entry and sterilization data were gathered from shelter records. Costs and other statistics were obtained from local government records. Data from 1982-1993 were used to project shelter entry expectations from 1994-2005. US Census data were used to estimate county households and were combined with survey results to estimate owned pet numbers. Survey results also were used to estimate numbers of fed, unowned dogs and cats, and numbers of strays in the study area. Described statistical methods were used to examine shelter intakes associated with a county spay/neuter program, and to compare those numbers to projected numbers. A benefit-cost analysis also was done.

Veterinarians initially were reimbursed $25 per female and $15 per male. Pregnancy or complications increased reimbursements over $50 - $150. Adding $5 citizen co-pay and $5 fee for rabies vaccine and license appeared had negative effects on use of the program.
Cats in the spay-neuter program, if not sterilized, would have produced 312,000 kittens (1994-2005), resulting in 8,600 surrenders at $250 per cat, or $2.15 million. At an average $23 per spay-neuter, the program would have cost $0.6 million; thus the program reduced shelter intakes and saved taxpayers $1.5 million. Further, projections indicated that, under plausible scenarios (20-80% of sterilized cats being feral), shelter costs would have exceeded $2 million, but could have exceeded $6 million at the high end.

Sparkes AH, Bessant C, Cope K, Ellis SLH, Finka L, Halls V, Hiestand K, Horsford K, Laurence C, MacFarlaine I, Neville PF, Stavisky J, Yeates J. ISFM Guidelines on Population Management and Welfare of Unowned Domestic Cats (Felis catus). J Fel Med Surg 15
Essay, cat welfare and interventions

This report presents guidelines from the International Society of Feline Medicine's Welfare Advisory Panel. The guidelines are published to provide reference for unowned or rehoming cats with respect to welfare and population control. The stated intent is to define guiding principles, provide direction for interactions between humans and cat populations, and establish welfare assumptions. No financial data are included.
The sections provided include cat-human interactions, aspects of welfare for cats, cats in populations, TNR programs, housing, homing, rehoming of cats, categorizations of unowned cats, discussion of euthanasia, and a glossary of terms. Overall is a theme of defining appropriate human activities and behaviors for population interventions.

Thomas RL, Fellowes MDE, Baker PJ. Spatio-Temporal Variation in Predation by Urban Domestic Cats (Felis catus) and the Acceptability of Possible Management Actions in the UK. PLOS One 7(11):1-13, 2012.
Reading, United Kingdom (city); study conducted 2008–2010

Cat density, predation rates, and citizen attitudes were collected in 12 random 1-km squares that included varying types of human housing and socioeconomic status. Questionnaire information requested from cat owners included number owned, sterilization status, use of anti-predation devices, roaming habits, and prey brought home.

Proportion of non-responding cat-owning households was estimated in a 50-100 random contact second phase. Cat density was estimated from (un-surveyed households); (phase II proportion with owned cats); (mean number of owned cats in responding phases I-II homes). Other calculations included human housing density associated with proportion of cat-own households; mean cat number per household; and total cat density.
Prey return rates were estimated in some squares by owner records for 6 weeks each season, calculated as dead and live prey divided by number of cats under observation. Data also were segregated as single- and multiple-cat households that saw no prey, and minimum number of cats (multiple) delivering no prey.

Predation rates were calculated as return rates x 2.17 (adjustment for 6-week seasonal observations and a conversion factor estimating number of kills that were brought home - 30%). Breeding density of 6 bird species in 6 squares was estimated by point counts to evaluate potential predation effects.

Attitudes to management options were measured for: ecologically sensitive exclusion; urban center exclusion; anti-predation devices; confining cats outdoors in owner gardens; forbidding all outdoors roaming; registering cats; compulsory cat sterilization; and de-clawing to decrease harm to prey species.

Completing all the surveys, estimates, data analyses indicated that prey kills were only moderately dependent on adult cat density, but could decrease local bird populations in urban areas for some species in some situations. Most urban residents did not regard cat predation as a significant concern. Anti-predation devices were the only acceptable management approach. Reviewer (DFL) comment: While intuitively sensible conclusions were reached, there should be some concern surrounding the fact that a good deal of serial data calculation was employed, from generally small actual numerical data sets. Possibilities for judgmental errors could be significant and serially magnifying.

Devillard S, et al. Linking genetic diversity and temporal fluctuations in population abundance of the introduced feral cat (Felis silvestris catus) on the Kerguelen archipelago. Mol Ecol 20:5141-5153, 2011.
Kerguelen archipelago

The Kerguelen archipelago is in the sub-Antarctic Southern Indian Ocean, covering about 7200 km2. The cat population was founded during the 1950s by an estimated 5 cats introduced for rodent and rabbit control. The present population size approximates 7000 cats, the estimated carrying capacity. Cats hold large territories at a low density of about 1.5 cats/km2. The study was conducted from 1996-2007, with structured observations and sampling on 3 transects. Total transect counts were 1332 by the end of the study. DNA samples were acquired by hair sampling following trapping and sedation. Eighteen microsatellites were selected for PCR amplification and evaluation. Genotyped cats were n=281. Cat populations were estimated at the island and site-specific levels, thus allowing, with genetic data, annual estimation of genetic diversity at each population or level. Summer populations increased over the study time, but

fluctuated widely, paralleled by genetic indices for diversity. Local population abundance was a significantly influential factor on outcomes. Genetic diversity was high when local populations were larger, and study sites were synchronous in size fluctuations. The number of adults reproducing moderately impacted the genetic diversity of offspring. Kerguelen archipelago, introduced free-roaming cat population, growing from 5 to 7000 individuals in about 50 years.

Key findings: The authors suggest that the rate of change model for summer population size best explains yearly fluctuations in genetic diversity. The changes were insufficient to effect permanent alterations in genetic diversity. Natal dispersal and recruitment were facilitated by higher juvenile survival rates when adult numbers were lower, and were important factors in the study outcome.

Ferreira JP, et al. Human-related factors regulate the spatial ecology of domestic cats in sensitive areas for conservation. PLoS One 6(10):1-10, 2011. e25970.
Mixed agricultural, sylvatic, and pastoral land in rural Portugal

This study was conducted during 2006 and 2007 in the Moura-Barrancos Nature 2000 site and in a Bird Special Protection Area partly encompassing agroforestry areas near a village (Barrancos) in the area of the Southeast Portugal-Spain border. Limited regional human activity includes cattle rearing, agriculture, and hunting. The region is largely a combination of agricultural, sylvatic, and pastoral land. Live-trapping and evaluation of free-roaming cats was conducted in scrubland areas absent of humans, and at farms near the Natura 2000 site. No cats were found in two natural areas not near any humans, although numerous other mammalia were trapped and released. No cats were found in abandoned farmsteads. Forty-two farms with humans present yielded cats from 39, with a cat density of 0.26/km2. Among 88 trapped cats, females outnumbered males 2:1 (41 additional cats with sex not recorded). Humans did not feed the cats, but food refuse often was accessible. Data analyses demonstrated that human presence was the most important factor in cat locations. Number of cats per farm was mostly influenced by access to human refuse, as food provision. Cats avoided areas with high fox density, presumably to avoid being victims of predation.

Key findings: Successful feline populations likely benefit in important ways from associations with humans.

Finkler H, et al. The Impact of Anthropogenic Factors on the Behavior, Reproduction, Management and Welfare of Urban, Free-Roaming Cat Populations. Anthrozoos 24(1):31-49, 2011.

In neighborhoods with differing socioeconomic status (SES), the authors examined caretaker relationships to eight free-roaming cat populations. High SES neighborhoods covered 12 km2, compared to 15km2 in low SES neighborhoods. Of 622 feeding groups, 392 were in high SES areas and 230 were in low SES areas.

Four hypotheses were considered: (a) caretaker behaviors and housing type (density of

humans) influences cat behaviors; (b) reproduction control is influenced by city management and caretaker behaviors; (c) pregnancy rates are influenced by city management and caretaker behaviors; (d) cortisol levels are affected by caretaker attitudes and socioeconomics. City veterinary data were acquired for the years 2000-2005 for (a) number of cat groups; (b) number of cats sterilized; (c) number of veterinary visits to cat group; (d) pregnancy rate; (e) rabies vaccination rate. SES variables for selection of 8 of 63 neighborhoods included (a) educational matriculation; (b) employment rate; (c) immigration rate; (d) computer ownership; (e) income. Final neighborhood selection (n=8) also included predominant type of housing. Cat group inclusion criteria included (a) nutritional adequacy; (b) cooperating caretaker; (c) at least 10 cats; (d) cooperation of neighbors; (e) access for observation.

Density was 33 groups/km2 in high SES areas versus 15/km2 in low SES areas. In high SES areas, more cats were sterilized, more were vaccinated, and there were more veterinary visits with more captures/veterinary visit. Caretaking resulted in improved behaviors, as did sterilizing, while housing and SES did not influence behaviors. High SES areas had lower frequency of pregnancies, while housing and caretaking had no influence. Sterilized cats had lower serum cortisol, but caretaking had no influence.

Key findings: Anthropogenic factors need to be considered in municipalities that are considering cat population control measures.

Finkler H, et al. Behavioral differences between urban feeding groups of neutered and sexually intact free-roaming cats following a trap-neuter-return procedure. J Am Vet Med Assoc 238(9):1141-1149, 2011. (Same study as following paper.)
Israel, Tel-Aviv, urban

Four feeding groups of free-roaming cats (n=184), widely separated to prevent interactions, were evaluated from October 1999 to October 2000. Regular feedings and observations were conducted, although there were some differences among the four groups in observation length, cat handling, and caretaker preferences for particular cats. Cats within group varied in affinity to humans. Caretakers provided food daily, usually in excess of need, at times familiar to the cats in each group. For the study, cat group A was TNRed at 73%; group B was TNRed at 75%; groups C and D were not TNRed. TNRed cats were mixed male and female. Efforts were made to identify and track cats as individuals, with behaviors and presence/absence recorded as such. Observation periods were group-specific in length, done before and during feeding. For the first 5-7 weeks, observations were 2-3 days/week. For the following 8 months, observations were weekly. For the last 5-7 weeks, observations were 2-3 days/week.

Groups A and B, sterilized at approximately 75%, displayed fewer agonistic encounters. Male-male encounters were more agonistic between intact cats than between sterilized cats. Group A neuters appeared for feeding earlier in feeding periods than intact cats, and stayed longer.

Key findings: The authors conclude that neutered cats timed their arrival for feeding earlier than intact cats, possibly as an available response to decreased sexual and agonistic

interactions, and possibly as learned behaviors related to better choices among offered foods. Further, TNR reduced fighting and vocalizations, which would be expected to result in fewer injuries and opportunities to transmit diseases.

Gunther I, et al. Demographic differences between urban feeding groups and sexually intact free-roaming cats following a trap-neuter-return procedure. J Am Vet Med Assoc 238(9):1134-1140, 2011. (Same study as preceding paper.)
Israel, Tel-Aviv, urban

Four feeding groups of free-roaming cats (n=184), widely separated to prevent interactions, were evaluated from October 1999 to October 2000. Regular feedings and observations were conducted, although there were some differences among the four groups in observation length, cat handling, and caretaker preferences for particular cats. Cats within group varied in affinity to humans. Caretakers provided food daily, usually in excess of need, at times familiar to the cats in each group. For the study, cat group A was TNRed at 73%; group B was TNRed at 75%; groups C and D were not TNRed. TNR cats were mixed male and female. Efforts were made to identify and track cats as individuals, with behaviors and presence/absence recorded as such. Observation periods were group-specific in length, done before and during feeding. For the first 5-7 weeks, observations were 2-3 days/week. For the following 8 months, observations were weekly. For the last 5-7 weeks, observations were 2-3 days/week.

Groups A and B experienced post-TNR population increases through unsterilized immigrations and few emigrations. Groups C and D experienced population decreases over one year. Groups A and B demonstrated greater kitten survival.

Key findings: The authors interpreted their observations to be reflections of lesser reproductive and competitive pressures. The authors concluded that continuous TNR would be required to maintain a high proportion of sterilized individuals in a free-roaming population.

Horn JA et al. Home range, habitat use, and activity patterns of free-roaming domestic cats. J Wildlife Management 75(5):1177-1185; 2011.
*USA, Champaign-Urbana Il, urban to rura*l

Radiotelemetry and activity sensors were used to study home ranges, habitat use, and activity of owned and unowned free-roaming cats. Groups of 11 owned and 16 unowned cats were monitored over 2544-hectares during 2007-2008. Owned cats (all sterilized) had smaller home ranges ($p=0.02$) than unowned cats (2 sterilized). Annual ranges of unowned cats were larger than their seasonal ranges because of season-related habitat use that did not occur in owned cats. No gender-related interactions or seasonal differences were found. Time given to denning and sleeping was less ($p<0.01$) among unowned cats, while time given to high activity levels was greater ($p<0.01$) among unowned cats. Among a group of 27 unowned and 12 owned cats, following censoring of data from 5 unowned (disappeared) cats, cumulative survival was 50% among unowned cats (392 days) and 92% among owned cats (596 days). (Note that sample sizes were quite small.)

Key findings: The authors concluded that ranging and activity suggest that unowned cats may influence local wildlife more than owned cats, although greater effect of owned cats in smaller ranges also is possible. Feeding and owner care modify space use and activity.

Trevejo R, et al. Epidemiology of surgical castration of dogs and cats in the United States. J Am Vet Med Assoc 238:898-904, 2011.

The authors evaluated medical records of 320,172 cats and 1,339,860 dogs examined at 651 Banfield-owned USA veterinary hospitals during 2007. Conditions for inclusion were age, breed, sex, spay-neuter (castration) status, and knowledge of wellness plan enrollment status. Data were divided into six geographic regions.

In this database, intact cats' average age was 1.5 years, compared to 5.2 years for castrated cats ($p<0.001$). Male cats were slightly more numerous, at 83% castration versus 81% of females ($P<0.001$). Cats enrolled in prepaid wellness plans were more likely to be castrated ($p<0.001$). The lowest prevalence of cat castration was in the northeastern US, at 80% ($p<0.001$). Castrated dogs' average age was 4.7 years, compared to intact at 2.2 years, with slightly greater female numbers than males ($p<0.001$). Dogs enrolled in prepaid wellness plans were more likely to be castrated, and the lowest prevalence of dog castration was in the southeastern US, at 61% ($p<0.001$).

Key findings: The authors concluded that wellness communications need to be tailored to age, sex, and breed observations by geographic region, with respect to trends for intact or castrated status.

Comment: Regional societal attitudes likely are reflected in these data, but the demographics of location for Banfield-owned practices, and characteristics of employed clinicians, should be considered also.

Literature 2001–2010

Lacheretz A, Moreau D, Cathelain H. Causes of death and life expectancy in carnivorous pets (I). Revue Med Vet 153(12):819-822, 2002.

The authors present the review of corpses of 1044 dogs and cats sent to the incineration center of Beauvoir in Cambresie, France in 1999. They came from 15 veterinary clinics that sent all animals here and provided data on the pet. Dogs and cats are lumped; causes of death by euthanasia, accident natural or disease and types of chronic diseases are summarized. Life expectancy by type of death is given also by urban or rural status. Data on age of death and type of death is given.

Scott KC, Levy JK, Crawford PC. Characteristics of free-roaming cats evaluated in a trap-neuter-release program. JAVMA 221(8):1136-1138, 2002.
Various county-wide habitats, Alachua County FL, USA

The authors evaluated characteristics of free-roaming cats in a TNR program in Alachua County, Florida. Data were collected between July 1998 and December 2001; 5323 cats were evaluated in the program during this time. Cats included in the study were over age 3 months. Preventive care given at the time of capture included spay/neuter and vaccinations. Recorded data included sex, maturity, pregnancy and fetus count, cryptorchidism, serious illnesses, and loss of life. Number of females (57%) exceeded males, but it was unclear whether ease of capture or caretaker preference influenced this outcome. Fifteen percent were kittens. Capture involved only 1.9% previously sterilized cats. Pregnancy occurred seasonally, as would be expected, at a 19% overall rate with mean litter size of 3.6 kittens. Pyometra was found in 0.4% of adult females; cryptorchidism was found in 1.9% of males; 0.4% of cats were euthanatized because of various illnesses.

Key findings*:* This study supports safe TNR programs for free-roaming cats, and the data indicate demographics and disease prevalence that should be within the management capacity of properly-structured TNR programs.

Levy JK, et al. Evaluation of the effect of a long-term trap-neuter-return and adoption program on a free-roaming cat population. JAVMA 222:42-46, 2003.
College Campus, Florida, USA

Long-term (11-plus-year) evaluation of the effect of TNR on population dynamics of un-owned, free-roaming cats (n=155). Seventy-five percent of the cats were truly feral, and 25% showed some human-orientation; 56% of the originals were kittens. After year 4, no kittens were on site. Immigrants were provided TNR prior to reproduction opportunity. By study conclusion, human-orientation allowed 47% adoption, while 15% were on site; 11% were euthanized, and 15% had disappeared.

Key findings*:* Consistently-applied TNR, along with population monitoring, effectively reduced and maintained this population of cats over a long period of time.

Levy JK, et al. Number of unowned free-roaming cats in a college community in the Southern United States and characteristics of community residents who feed them. JAVMA 223:292-205, 2003.
Florida, Alchera County, USA, mixed geography

In a telephone survey, 587 households (0.7% of county households) answered questions regarding feeding unowned, free-roaming cats. Twelve percent of households fed an average of 3.6 cats; 43% of households feeding unowned cats did not own cats. Ninety percent of owned household cats were sterilized, compared with only 11% of feeding households that attempted

to have roaming cats sterilized. Frequencies of observations were analyzed using chi-square.

Key findings*:* Feeding unowned cats is a human behavior that crossed socio-economic status and pet-ownership, as previous studies have shown.

Moreau D, Cathelain P Lacheretz A. Comparative study of causes of death and life expectancy in carnivorous pets (II). Revue Med Vet 154(2):127-132, 2003.

The authors present the review of corpses of 1044 dogs and cats sent to the incineration center of Beauvoir in Cambresie France in 1999. They came from 15 veterinary clinics that sent all animals here and provided data on the pet. The data included 259 cats and 784 dogs, separated by species. Listed causes of death included euthanasia, accident, natural, or disease. Types of chronic diseases and a category of infectious disease are summarized. Accidents are broken down by HBC, poisoning and other. Data on age of death and life expectancy and type of death is given.

Andersen MC, et al. Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats. JAVMA 225:1871-1876, 2004.
A matrix population model was constructed using parameter estimates of: Mean litter size, 3.6; litters/year, 1.1–2.1; first conception mean age 212 days; offspring 50:50 sex ratio; female offspring/year, 1.98–3.78 female offspring/year; juvenile survival estimates, 50–75%; adult survival 2–3 years. Annual population growth rate in this model: 1.34–2.49, geometric mean 1.84. TNR intervention at 75% of females = population growth rate 1.08 annual. Population females euthanasia ≥ 50% = population growth rate < 1.00 annual.

Key findings*:* Population growth was more sensitive to survival than fecundity, for equivalent percent interventions TNR or euthanasia.

New JC Jr. Birth and death rate estimates of cats and dogs in US households and related factors. J Appl Anim Welfare Sci 7(4):229-241, 2004.
A commercial survey company sent questionnaires to 7400 American households in 1996, based on an unequal probability sampling plan, from which data national (USA) estimates were acquired. 1996 estimates suggested 9 million cat and dog deaths (8.3% of estimated household cats, 7.9% of estimated household dogs). Cat litters were estimated at 2x dog litters, averaging 5.73 kittens and 7.57 puppies. Kitten births were estimated at 11.2/100 household cats. Puppy births were estimated at 11.4/100 household dogs.

Key findings*:* This was, evidently, the first nationalized estimate study of its kind. The data, while from 1996, illustrate the magnitude of household turnover of US pet dogs and cats.

Note: These numbers align well with data in various research publications as well as team members' community practice experience.

Nutter FB, et al. Reproductive capacity of free-roaming domestic cats and kitten survival rate. JAVMA 225:1399-1402, 2004.
North Carolina, USA, semi-feral cats

Data were collected from managed (human intervention) feral colonies, as part of a trap-neuter-release (TNR) study of 625 individuals. Litters/year/queen ranged from 1.4 low–3.0 high, with fetus mean count (at surgery) exceeding mean full-term count for kittens. Seventy-five percent of full-term kittens died or disappeared by age 6 months.
Key findings*:* Given mortality rates, colony regenerative capacity is surprisingly high without intervention.

Say L, Pontier D. Spacing pattern in a social group of stray cats: effects on male reproductive success. An Behav 68:175-180, 2004.
Lyon, France, urban free-roaming

Spatial distribution of male and female cats was evaluated over 3 years (1996-1998) in a park that encircles a hospital in Lyon, France. The habitat was "typical urban for stray cats" and isolated by highways and buildings. The site covered 7.2 hectares (ha) and held five permanent feeding stations that were supplied by humans. The population consisted of 25–28 males and 25–38 females, with a density of 7–9 adult cats/ha. Estrus synchronized seasonally among females. Social dominance indexing was done for males, with three social classes described. Home ranges were defined by direct observation, while reproductive success and kittens sired were based on microsatellite-facilitated paternity analysis. Eighty percent of total litters were sired by multiple males. Visual sightings per cat ranged from 53 to 395.

Home range sizes did not differ by year of study or breeding status. Male home range averaged 0.8 ha, compared to 0.19 ha for females. Sexually mature males occupied an average 1.51 ha, compared to 0.15 ha for immature males. Females tended to use only 1 food station, whereas males used up to 3. Female number per male home range was related to size of male home range, with home range of some females included in the home range of more than one male. Genetic sire was determined for 192 kittens from 42 litters. Eighteen range-located males had sired 107 kittens among them, with 0–6 per male, with home range size the primary driver, independent of dominance. Thirty kittens were sired by males outside their own home range. Social status of males was less important to reproductive success. The authors concluded that ability to maintain a large home range was an important driver of reproductive success.

Key findings*:* Some of these data differ from data in other reports, both of sheltered and non-sheltered cats. It is possible that human interventions influence cat group characteristics in ways that usually are not considered.

Foley P, et al. Analysis of the impact of trap-neuter-return programs on populations of feral cats. JAVMA 227:1775-1781, 2005.
Semi-feral cats fed by householders in California and Florida USA

Excel and "R" software were used for data analysis and modeling. A Ricker model was used to describe population dynamics. Subjects were 26,274 (semi-feral) cats in California and Florida over 11 and 6 years, respectively. Nine percent of over 1mm households fed mean 2.6 semi-feral cats. A total 14,129 surgeries were done during the study. Overall and annual neutering rates to achieve 1.0 population growth rate were calculated for various mean life spans, growth rates, and survivorship.

Key findings*:* The authors interpreted their data as mixed results with respect to TNR effectiveness.

Short J, Tanner B. Control of feral cats for nature conservation. IV. Population dynamics and morphological attributes of feral cats at Shark Bay, Western Australia. Wildlife Res 32:489-501, 2005.
Feral populations, Australia

Investigators studied population dynamics of feral cats over a 14-year period. Two adjoining semi-arid sites had differing levels of site management. Project goal for non-cat species conservation: Identify levels of harvest to eliminate or control feral cats at low density, via euthanasia. Cat diet was 88% rabbits, 4% other small mammals, 3% carrion, 2% birds, and invertebrates. Two (trap-shoot-poison) terminal studies were done: Total capture and index-manipulation-index. Density, size, age, and sex of cats, and their distributions, were evaluated. Summer peak density (carrying capacity) was the index = 0.244 (slope/intercept of population regression plot). Season and energy availability influenced cat condition, ease of trapping. Cat densities averaged 0.6–1.0 km^2, with considerable variation.

Key findings*:* Constant harvest at 0.37 cats km2was estimated to maintain the population near local extinction, but approximately 6-fold increase of capture effort occurred with declining density, indicating ongoing problems in larger ranges.

Mendes-de-Almeida F, et al. The Impact of Hysterectomy in an Urban Colony of Domestic Cats (Felis catus Linnaeus, 1758). Int J Appl Res Vet Med 4(2):134-141, 2006.
Rio de Janeiro Zoological Garden grounds, Brazil

A mark-recapture method (n=96 cats) was used to estimate the population for a 36-month study. Upon capture, gender was determined and age estimated via dental appearance; vaccination, microchip implanting, and parasite control was practiced at this time. Females (n=37) underwent hysterectomy, while ovaries remained intact. Kittens declined from initial 17% percent to 2.5%, and male:female ratio of adults was 1:3. Immigrations decreased from 54% to 15% of the population. Twenty-two attritions occurred, influencing the population size. Key findings*:* Biennial intervention by hysterectomy stabilized the population structure at no

growth.

Natoli E, et al. Management of feral domestic cats in the urban environment of Rome (Italy). Prev Vet Med-2214, online, 2006.
Rome, Urban, Italy

Data are presented on colony cats in Rome from 1991-2000. Italian law protects free-roaming cats, requires TNR, and institutionalizes human care of the colonies; the cat colonies are registered. Over 10 years, neutering reduced median cats/colony from 12 to 10; large colonies were fewer. Given sterilization and mortality/disappearance, overall decline in cat numbers was about 22%. Non-sterilized cats have greater mortality risk, and immigration/emigration impact total numbers.

Key findings*:* TNR programs can reduce numbers of free-roaming colony cats, but unsterilized roaming (abandoned) cats and immigration must be controlled as well. Public education is critical to these efforts.

Wallace JL, Levy JK. Population characteristics of feral cats admitted to seven trap-neuter-return programs in the United States. J Fel Med Surg 8:279-284, 2006.
Multi-source, free-roaming, USA

Data were evaluated from seven TNR programs in various geographical areas. Between 1993 and 2004, a total 103,643 cats underwent TNR. Intact females were 53.4%, intact males were 44.3%, with 2.3% previously sterilized. Sixteen percent pregnancy was noted seasonally, with an average litter size 4.1 (larger than a well-known average litter size at parturition). Among these cats, 5.2% were retrovirus-positive; most were euthanized. A 0.4% TNR-related mortality was recorded.

Key findings*:* Large numbers of cats can be sterilized with good safety records, and infectious disease control can be practiced effectively at the same time, although additional investment is required.

Campos CB, et al. Diet of free-ranging cats and dogs in a suburban and rural environment, southeastern Brazil. J Zool 273:14-20, 2007.
Brazil, suburban-rural

Investigators estimated density of cats in winter 181 km^2; cats in summer 112 km^2; dogs in winter and summer 77 km^2. Suburban cat density in winter was 4.6/km^2/day; summer 0.10/ km^2/day. Invertebrates were most-consumed by cats, followed by mammals that included opossum, 19.3%; guinea pig, 15.4%; small rodents, 21.4% winter; armadillo, 14.3% winter; opossum, 14.3% winter; rabbit and hare, 16.7% winter. Murinae were consumed also.

Key findings*:* These data could be useful for developing programs to minimize impacts of feral cat (and dog) predatory behavior against wildlife.

Schmidt PM, et al. Survival, fecundity, and movements of free-roaming cats. J Wildlife Management 71(3):915-919, 2007.
Texas, USA, suburban

Investigators tracked 54 radio-collared cats that were owned, semi-feral (being fed), or feral. Feral cats had 1.0 litters/year; semi-feral, 1.6 (owned cats sterilized). Seven feral litters had mean of 3.5 kittens; survival, 1.75. Eight semi-feral litters had mean of 3.6 kittens, survival 2.75 (survival ≥12 wk). Feral cat survival was only slightly lower than semi-feral survival. Annual ranges decreased with increasing "ownership." Feral cats 50% kernel estimate 1.4 hectares (ha), 95% kernel estimate 10.4 ha; semi-feral cats 50% kernel estimate 0.4 ha, 95% kernel estimate 3.3 ha; owned cats 50% 0.06 ha, 95% 0.4 ha. No determination whether predation, nuisance behaviors, or disease transmission are altered by TNR or other sterilizations.

Key findings: Human interventions, such as feeding, can concentrate free-roaming cats to increase local environmental effect, or limit their impact by keeping them in a smaller area. These factors need to be considered in population management strategies.

LeCorre M. Cats, rats, and sea birds. Nature 451:134-135, 2008.
New Zealand Coast, island, rural

A 35-year island data set from Little Barrier Island, off New Zealand's North Island, was evaluated for the effects that cat removal had on reproduction in sea birds, such as Cook's petrel (Pterodroma cookie). The results supported theoretical models, showing that mesopredator release effects, rats in this study, can actually enhance unregulated predator effects and diminish prey populations, when a competing predator is targeted for elimination. Cat removal facilitated expansion of the rat population; rats target eggs and small young birds, thus effectively reducing population size. Predator management needs to be planned very carefully, considering the presence of, and effect on, space-sharing predators and prey.

Key findings*:* Human interventions, done without full considerations to consequences, can have disastrous outcomes. In this instance, zoonotic and other infectious disease spread by rats also would become serious problems under the given space limitations (island).

Budke CM, Slater MR. Utilization of Matrix Population Models to Assess a 3-Year Single Treatment Nonsurgical Contraception Program Versus Surgical Sterilization in Feral Cat Populations. J Appl AnimWelfare Sci 12:277-292, 2009.

A hypothetical matrix model was constructed to explore feral cat population growth under conditions of (a) no interventions; (b) TNR intervention; (c) single 3-year nonsurgical contraception. Juvenile and adult cats were considered. Fecundity was defined as female kittens/year/queen. Data were processed with Excel and Poptools software. Assumptions for the model included: a single, closed breeding population with males and females available; half-year survival rates for breeding individuals; no breeding seasonality; no carrying capacity; modeling of sterilized females only; nonsurgical contraception 100% effective. Vital rates

(lifecycle metrics) included juvenile and adult female fecundity and survival. Other assumptions: no re-trapping of contracepted cats; contracepted cats fertile at +3 years; each model began with 100 adult females; carrying capacity was not represented; environmental effects such as climate were not represented; males and male-dominance-related breeding patterns were not represented; immigration was not assumed. Study modeled 10%, 20%, and 30% annual TNR and contraception. Zero population growth required ≥ 51% annual juvenile/adult TNR, with continuing maintenance of 71% & 81% all-female and adult-female sterilized rate after stabilization. Without juvenile sterilization, 91% annual sterilization was necessary. One hundred percent-effective contraception required 60% application, with re-trapping and re-sterilization as well.

Key findings*:* These practices might be logistically infeasible in very large populations. Long-term effect of contraception would depend on survival and re-treatment. Colony-specific metrics can be quite variable, and at times, ecosystem sensitivity must be considered in option-selection.

Short J, Tanner B. Control of feral cats for nature conservation. IV. Population dynamics and morphological attributes of feral cats at Shark Bay, Western Australia. Wildlife Res 32:489-501, 2005.
Owned cats, USA

Investigators conducted a professionally-executed telephone survey of several characteristics of owned cats, with particular emphasis on associations with neuter (spay-neuter) status. The structuring of data gathering and data analyses was done with careful attention to account for a number of potentially interfering variables, and weighting of data to align with varying social aspects within the database. The random-call final list was distilled from 64 million households. The study was done in 2007. From the database, the 82.4 million cats live in 36.8 million US households. Results of the study included: 32% of surveyed households had 1 or more cats, with an average of 2.24 per household; 80% of cats were neutered, and 82% of neutered cats had not reproduced prior to surgery; over 90% of cats in mid- and upper-level income homes were neutered, compared with 51% of cats in lower-income homes; older cat owners were more likely to have neutered cats; cat gender was not a factor in neuter status; the most common reasons for neutering included avoiding unwanted litters, cat health, and avoiding inappropriate urination.

Key findings*:* Income status was the primary association with spay-neuter status of owned cats, and 80% of owned cats were sterilized, the vast majority before reproducing. Increasing the proportion of sterilized cats in the USA must involve attention to stray and feral populations. Increased attention to lower income households with respect to owned cat sterilization appears to be warranted.

Schmidt PM, et al. Evaluation of euthanasia and trap–neuter–return (TNR) programs in managing free-roaming cat populations. Wildlife Res 36:117-125, 2009.
Texas, USA, suburban

Investigators evaluated a 25-yr model of euthanasia and TNR methods of controlling free-roaming cat populations. Parameters were estimated from 43 radio-tracked cats, from an unmanaged free-roaming cat population and within the same population described in reference above. TNR and euthanasia were modeled at 25%, 50%, and 75% of the population, as was a 50:50 TNR: euthanasia model at these rates plus 100% implementation. Maximum immigration rates were included in the model, at 0%, 25%, 50%, and 100%. STELLA7 was used for programming. Primary readouts were final population size, cats handled, method effort. TNR and euthanasia resulted in population decreases that were similar across options and implementation rates at 0% immigration, but decreases were greater for the 25% euthanasia with 50% immigration.

Key findings*:* Carrying capacity was a more sensitive outcome indicator than was immigration, but both influenced final population size. The euthanasia effort was greater than was the TNR effort. Implementation rates must be high, and immigration prevented, to achieve population reduction.

Loyd KAT, DeVore JL. An Evaluation of Feral Cat Management Options Using a Decision Analysis Network. Ecol Soc 15(4):10, 2010.
A model-based approach was developed to predict population response to management options, and to extend calculations to impact on wildlife. A Bayesian Belief Network was developed to evaluate and rank population management decisions by efficacy, regional cultural factors, and cost. Choice of management variations depended on initial cat population size. The model predicted that TNR programs are initially optimal for local populations n<50 cats. Removal programs were predicted to best protect adjacent wildlife when cat populations are larger. Costs for removals are about ½ those of TNR-variant programs; public opinion plays an important role in regional solutions.

Key findings*:* The decision analysis network predicts that removal will reduce feral cat populations quickly, which may be important in some environments.

Loyd KA, Miller CA. Factors related to preferences for Trap-Neuter-release management of feral cats among Illinois homeowners. J Wildlife Manage 74(1):160-165, 2010.
Illinois, USA, mixed community of residence

The data for this report was acquired using an 8-page survey (Wildlife and Conservation Survey) done during 2004, with a goal of measuring experiences, attitudes, and management preferences regarding wildlife issues, including feral cat populations. Choices listed in the survey for cats included TNR, capture & euthanize, capture & shelter, and other. Final assessment of 1680/2600 (65%) surveys was distilled to community categories of rural, small

town (<10000), small city (10000-100000), or urban (>100000). Multiple analytical methods were applied, depending on the nature of the pertinent portions of the database. Among all community categories, TNR was least preferred, but preference for TNR did increase with community size (16% rural to 36% urban). Women preferred TNR more than men (47% to 20%). Education level did not significantly influence preference, but the highest preference for TNR (30%) was among respondents who did not finish high school. Positive or negative prior experiences with cats influenced preference, and support for wildlife rights predicted support for feral cat control. The human population produces a dichotomy between view of feral cats as wildlife and view of feral cats as pets.

Key findings*:* Identification of impacts of public knowledge and attitudes toward feral cats supports development of information and education programs, along with development of control programs.

Loyd KAT, Miller CA. Influence of demographics, experience and value orientations of preferences for lethal management of feral cats. Hum Dimen Wildlife 15:262-273, 2010.
Illinois, USA, mixed community of residence

Data for this report were acquired using a survey of 2600 randomly selected single-family homeowners during 2004, with a goal of measuring experiences, attitudes, and management preferences regarding wildlife issues, including feral cat populations. The return rate from 2600 homes was 65% (see Loyd et al., *J Wildlife Manage* 74(1):160-165, 2010), above. Choices listed on the survey, relative to lethal control of "feral free-ranging cats," included TNR, capture and euthanize, capture and shelter, or other. Final assessment of 1680/2600 (65%) surveys was distilled to community categories of rural, small town (<10000), small city (10000-100000), or urban (>100000). Multiple analytical methods were applied, depending on the nature of the pertinent portions of the database. Respondents most preferred capture and euthanasia (52%), followed by TNR (27%), capture and shelter (18%), and other (3%). However, 67% had not directly experienced problems with feral cats. Rural residents (71%) preferred lethal feral cat management, compared to 39% of urban residents. Men (61%) preferred lethal management, compared to women (22%). Persons with high school education or greater non-significantly preferred lethal management, compared to the less educated. Value orientation toward wildlife and negative experiences with feral cats also predicted preference for lethal management.
Key findings*:* Several predictors of preference for lethal management of feral cat populations offer insight relative to demographics of human attitudes that could impact public policy decision-making.

Patronek GJ. Mapping and measuring disparities in welfare for cats across neighborhoods in a large US city. AJVR 71:161-168, 2010.
Massachusetts, urban, owned cats, USA

Addresses (cat-related, n=15,285) in a large American city were geocoded and evaluated with cat mortality data from two sheltering groups and from animal control data. Addresses were overlaid into 16 polygonal neighborhood maps, defined socioeconomically. Software used was

ESRI Arcmap 9.3. Greater cat mortality was significantly associated with human-related socioeconomic deprivation markers (public assistance, unemployment, crowded housing, children in poverty, female head of household, overall poverty, under-education, males in professional occupations). Premature human death (<75 yrs) explained 77% of cat mortality variation. Combined shelter cat mortality data indicated 2.6 cat deaths/1000 humans, consistent with good city-wide animal sheltering, but neighborhood-related cat death gradients differed between 14- and 40-fold.

Key findings*:* Shelter-associated cat deaths correlated with premature human death and socioeconomic indicators of deprivation, and thus may be an index for the latter. Given cat death gradients, the need for low-cost spay-neuter programs may be more localized than previously was recognized.

Literature 1991–2000

Pontier D, Rioux N, Heizmann A. Evidence of selection on the orange allele in the domestic cat Felis catus: the role of social structure. OIKOS 73:299-308, 1995.
Free-roaming populations, urban and rural, France

Authors evaluated, in multiple feline populations, genetic differentiation as related to spatial and social structures. Populations were evaluated between 1982 and 1992, in various parts of France. Number of cats evaluated among the populations varied between 56 and 391, among 17 rural and 2 urban populations. Interviews with humans established feeding by caretakers in all instances, and established "residences" of the cats. Data recorded included sex, age, weight, place of birth, coat phenotype (sex-linked orange, autosomal non-agouti, striped and blotched tabby, dominant piebald spotting, dominant white, siamese), and human preferences for coat characteristics and cat gender. A possible rural-urban ecological effect was additionally evaluated in 30 populations, 21 rural and 9 urban. Gene frequencies were calculated previously. In this study, using correspondence analysis (CA), 36% of the variation between cat populations was explained by the 1st factor of the CA, with the sex-linked orange allele contributing 74% of the 1st factor; also segregated were urban and rural populations. Orange allele was more frequent in rural populations. Rural populations also had low density (140-230 cats/km^2) compared to urban populations (1300 cats/km^2). The 1st and 2nd factors explained 77.5% of male age distribution. Populations with higher orange allele frequency had lower mortality values by age group. Males were heavier than females, as expected. Orange males were heavier than non-orange males, but among females, non-orange were heavier. Orange males, being heavier, may compete for mates better in low-density rural settings, but also may be at higher mortality risk because of greater mobility, thus limiting dissemination of the orange allele.

Key findings*:* Data from this study demonstrate complex associations among geography, size, population density, and coat color phenotype. Researchers investigating interacting effects in modeling studies should be aware of these outcomes. Note also that other demographic studies of cats have suggested the possibility that the human intervention of feeding may

influence the biology of free-roaming cat populations.

Patronek GJ, Beck AM, Glickman LT. Dynamics of dog and cat populations in a community. JAVMA 210(5):637-642, 1997.
Urban, Washington, Iowa, USA

A cross-section, random-digit telephone survey was used to collect pet ownership data from 1272 households in a single community. 63% of dogs and 80% of cats were sterilized. Among unsterilized females, 3.4% of dogs and 7.9% of cats had a pregnancy within 12 months of the study. Cat litters were unplanned, but 2/3 of dog litters were planned. Annual turnover of owned dogs was 14.1%, versus 18.4% for cats. Surveyed pet owners under-reported relinquishment.

Key findings*:* The dynamics of pet populations should not be assumed across communities, but need to be evaluated locally when control measures are being considered.

Literature 1981-1990

Warner RE. Demography and movements of free-ranging domestic cats in rural Illinois. J Wildlife Management 49(2):340-346, 1985.
Rural farmed land, Illinois, USA

Cats free-roaming a 5182-hectare (ha) farming area (90% farmed) of Central Illinois were evaluated from 1987–1981. There were 62 rural residences in the area, and all cats were provided food by humans. Cats/human residence averaged 5.6 (3.5–8.0). With livestock present, there were 13.5 cats/residence, compared to 4.3/residence without livestock. Total cats averaged 326 (207–448), varying by year, and averaged 6.3 cats/ha. Number of breeding females increased with time, resulting in a ratio change from about 70 males/100 females to about 150 males/100 females by the end of the study. Juveniles recruited per adult female increased from 1.0 to 2.1 over the course of the study. Breeding females averaged 1.6 litters per year (1.3–1.9), with litter average 4.4 kittens. Annual kitten production averaged 7.1 (6.0-8.4) per breeding female. Most births occurred between March and August (81%). By the end of the study, 6% of living cats were 3 years or older; mortality was high. Most frequent causes of death were estimated at 27% dispersal or unknown, 26% vehicle accidents, 17% disease. Taking of prey was common despite humans providing food. Prey brought to residences consisted mainly of rodents, small birds, and rabbits. Radio-tracked cats (11) indicated 40% of locations on farmsteads and 44% in linear or edge habitats. Off of farmsteads, 73% of locations were in linear or edge habitats. Truly feral cats were absent, a likely consequence of land use and minimal cover away from farmsteads.

Key findings: The data underscore the claim that predation by free-roaming cats be quite significant, even when humans provide food. Thus, behavioral traits are involved, in addition to food-seeking traits.

Haspel C, Calhoun RE. Home ranges of free-ranging cats (Felis catus) in Brooklyn, New York. Can J Zool 67:178-181, 1989.
Urban, New York, USA

Urban cats were studied in two neighborhoods, distinguished primarily by presence or absence of poverty factors, including multiple housing, vacant buildings, and exposed garbage in the latter. Home ranges in male (2.6 ha) and female cats (1.7 ha) were smaller than in more rural areas. Male home ranges varied more in size than those of females, and males were more active at home range peripheries. Seasonal estrus, neighborhood, garbage, abandoned buildings, and supplementary feeding did not influence home range size. Rather, cat size was the influential factor, as a gender effect, averaging 4.1 kg among males and 2.9 kg among females ($p<0.01$).

Key findings*:* Urban home ranges of male and female cats were accounted for primarily as a size-related gender effect.