

Evaluation of the effect of a long-term trap-neuter-return and adoption program on a free-roaming cat population

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Objective—To evaluate the effect of a long-term trap-neuter-return program, with adoption whenever possible, on the dynamics of a free-roaming cat population.

Design—Observational epidemiologic study.

Animals—155 unowned free-roaming cats.

Procedures—Free-roaming cats residing on a university campus were trapped, neutered, and returned to the environment or adopted over an 11-year period.

Results—During the observation period (January 1991 to April 2002), 75% of the cats were feral, and 25% were socialized. Kittens comprised 56% of the original population. Male cats were slightly more numerous (55%) than females. At the conclusion of the observation period, 47% of the cats had been removed for adoption, 15% remained on site, 15% had disappeared, 11% were euthanatized, 6% had died, and 6% had moved to the surrounding wooded environment. Trapping began in 1991; however, a complete census of cats was not completed until 1996, at which time 68 cats resided on site. At completion of the study in 2002, the population had decreased by 66%, from 68 to 23 cats (of which 22 were feral). No kittens were observed on site after 1995, but additional stray or abandoned cats continued to become resident. New arrivals were neutered or adopted before they could reproduce.

Conclusions and Clinical Relevance—A comprehensive long-term program of neutering followed by adoption or return to the resident colony can result in reduction of free-roaming cat populations in urban areas. (*J Am Vet Med Assoc* 2003;222:42–46)

Populations of unowned free-roaming cats exist throughout the world. Concern about the impact of free-roaming cats on the environment and public health, as well as consideration of the welfare of the cats themselves, has led to various efforts to reduce their numbers. After decades of effort, free-roaming cats have been extirpated from several small, uninhabited islands as a result of intensive control measures, including poisoning, hunting, trapping, and introduction of infectious feline diseases.¹⁻⁴ Despite the success of eradication campaigns on geographically isolated islands, logistic barriers and opposition from resident citizens often make application of such strategies to populated mainland territories unfeasible.⁴⁻¹⁰ Cat con-

trol programs in populated areas must incorporate safety considerations for nontarget animals and humans, be affordable for participating municipal agencies or charitable organizations, include plans to curtail continuous cat immigration and reproduction, and be aesthetically acceptable to the public.⁴

The number of unowned free-roaming cats in the United States is unknown, but is suspected to rival that of pet cats (73 million in 2000) and to contribute substantially to cat overpopulation.¹¹⁻¹⁴ The free-roaming cat population consists of both socialized stray cats and unsocialized feral cats. Individual cats may have a variety of lifestyles during their lives, including owned pet, stray, and feral status. Because of the vast overlap of lifestyle and socialization status continuums, it is difficult to define discrete populations of free-roaming cats.¹⁵

Considerable controversy surrounds methods for controlling free-roaming cats, particularly identification of the option that is most practical, effective, and humane. Trap-neuter-return (TNR) programs are intended to halt reproduction without causing harm to the cats.^{7,10,16-18} In this approach, cats are trapped, neutered, returned to the site of capture, and released. Veterinarians are central to the process, because they perform the surgeries and are frequently asked to consult on issues of health and welfare of free-roaming cats. The concept of TNR as a humane method for cat population control is endorsed by the AVMA¹⁹ and many humane organizations.¹⁰ More than 1,000 veterinary members of the California Veterinary Medical Association neutered more than 170,000 cats between July 1999 and May 2002 in a \$12 million project funded by Maddie's Fund. However, virtually no information exists to support the contention that neutering is an effective long-term method for controlling free-roaming cat populations.

The purpose of the study reported here was to evaluate the effect of a TNR program on a free-roaming cat population. The site of the study was a university campus on which several cat colonies had become established soon after inception in the late 1960s; typically, the colonies formed around food services and student dormitories. Periodically, cats were trapped for euthanasia when cat populations increased to nuisance levels. Beginning in 1991, university employees and students developed a program to capture cats for neutering, followed by return to the colony or adoption. For the purposes of this study, the term free-roaming refers to unowned cats of feral or socialized status.

Materials and Methods

Location—The University of Central Florida occupies 1,415 acres; approximately one-third of the campus site, especially the outer perimeter, is heavily wooded. The cam-

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pus population comprises over 38,000 students and employees; resident students are not allowed to keep pets. On-site construction frequently affects the availability of cat habitats.

Data collection—Beginning in 1991, volunteers began an organized effort to capture free-roaming cats on campus for neutering and to keep records of cat sightings and human interventions. Additional colonies were added to the control program as they were discovered. Cats were recorded as kittens if they were believed to be ≤ 6 months of age. Cats were classified as feral if they avoided human contact. The distinction between feral and socialized cats was imprecise because some cats became more tame with time, and some cats were friendly only toward their feeders and not toward other humans. The socialization status of cats was recorded only at the time of first appearance and was not revised to reflect changes over time. By 1996, all cats on campus were identified and cataloged, including photographs and written descriptions of each cat, socialization status (feral vs socialized), colony affiliations, and final outcomes. Data from the daily observation logs were condensed into quarterly reports. These reports were reviewed retrospectively for the period from January 1991 to April 2002.

Cat care program—Free-roaming cats were trapped by members of the Friends of Campus Cats volunteer organization and transported to veterinarians in private practice or Orange County Animal Services for neutering. Cats were vaccinated against panleukopenia, calicivirus infection, rhinotracheitis, and rabies. The tip of an ear was removed or notched to identify neutered cats. Selected cats, primarily those that appeared ill or those that were mature males, were tested for FeLV and FIV. Cats with positive test results were euthanized. Following neutering, most cats were returned to their trapping site and released. Many cats, especially kittens and socialized adults, were eventually removed for adoption, but this often occurred long after neutering and return to the colony. Most socialized cats were transferred to other local rescue organizations for adoption, but some cats were adopted by campus employees and students. Cats found their own shelter, often under buildings. Cat food was provided every day by volunteers. Feeding stations were placed to avoid drawing human attention to the cat colonies; food dishes were placed in small moats to prevent insect infestation. Amounts of food provided were adjusted to prevent accumulation of excessive leftovers that might attract wildlife. Injured or ill cats were recaptured for veterinary attention or euthanasia.

Statistical analyses—Descriptive statistics were calculated for data regarding population variables.

Results

Cats—One hundred fifty-five cats were recorded on the campus during the reporting period; these included 116 unsocialized feral cats and 39 cats that were socialized at the time of first appearance (Table

1). Of the feral cats, 58% were kittens; most (69%) of the socialized cats were adults. Fifty-five percent of the 155 cats were males. Only 7 (5%) cats were neutered at the time of initial capture, including 5 socialized adults, 1 socialized kitten, and 1 feral adult.

Cat colonies—Colonies were defined as a feeding area and shelter frequented by an apparently stable population of cats. Eleven discrete cat colonies were identified. In most instances, cats were initially attracted by a readily available food source and then deliberate feeding ensued. Two of the colonies were located near university food service areas, 3 near dormitories, 5 near academic or administrative buildings, and 1 in a parking garage. The cats typically found their own shelter, usually beneath buildings or trailers. The maximum number of cats in each of the 11 colonies ranged from 3 to 25. During the reporting period, all colonies had reductions in numbers of cats so that the size of colonies at the end of the study ranged from 1 to 5 cats; cats were removed for adoption, disappeared, euthanized, died, or moved to the surrounding wooded environment (Table 2).

All cats did not remain in the same colony throughout the reporting period. Of the 155 cats, 24 moved locations at least once, 17 spent time in other colonies, 11 roamed without a fixed colony, and 10 moved to the perimeter woods where they were not regularly observed. Of the 24 cats that moved between locations, 14 (58%) were males; this finding was similar to the proportion of males overall. Some cats moved locations on 2 or 3 occasions, often after long periods of residence at a single location; median time spent in the original location was 3.0 years (range, 0.1 to 6.0 years). Subsequently, cats spent a median of 3.3 years (range, 0.2 to 5.8 years) in a second site ($n = 24$ cats), 1.3 years (range, 0.3 to 2.6 years) in a third location (6), and 1.5 years in a fourth location (1). For example, 1 male cat was first observed as a feral kitten in August 1993. The cat was castrated in January 1994 and then returned to its colony, where it remained for

Table 1—Characteristics of 155 free-roaming cats at inclusion in a trap-neuter-return and adoption population control program

Variable	Feral cats	Socialized cats	Total
No.	116	39	155
Age			
Kittens	75	12	87
Adults	41	27	68
Sex			
Male	67	18	85
Female	49	21	70

Table 2—Disposition of 155 free-roaming cats included in a trap-neuter-return and adoption population control program

Disposition	No. of cats (%)	Sex		Original socialization status		Age group at disposition		Duration on campus (y)		
		Male	Female	Feral	Socialized	Kitten	Adult	Mean \pm SD	Median	Range
Remaining	23 (15%)	11	12	22	1	0	23	6.7 \pm 2.2	6.8	1.3–11.5
Adopted	73 (47%)	35	38	42	31	22	51	1.6 \pm 2.3	0.4	0–10.5
To woods	9 (6%)	6	3	9	0	0	9	0.6 \pm 0.9	0.1	0–2.2
Disappeared	23 (15%)	15	8	22	1	0	23	3.3 \pm 2.1	2.9	0.4–7.5
Died	10 (6%)	4	6	10	0	0	10	4.6 \pm 2.4	4.7	0.3–8.3
Euthanized	17 (11%)	14	3	11	6	0	17	3.0 \pm 2.7	2.9	0–8.5
Total	155	85	70	116	39	22	133	2.9 \pm 2.9	2.0	0–11.5

3.4 years until its shelter was demolished during construction in June 1997. The cat then roamed without a fixed colony for 2.3 years until September 1999 when it joined a second colony for 1.3 years. None of the cats in the second colony had shared the original colony with this cat. Finally, in January 2001, the cat again roamed without a fixed colony throughout the remainder of the reporting period (1.2 years). Overall, this cat spent 8.3 years in 2 different colonies with 2 extended periods of roaming without a fixed colony.

Three of the 11 colonies were eventually depleted of cats. In 1 colony, the cats' shelter was demolished to make way for construction of new dormitories. Of the 6 cats residing in the colony at the time of demolition, 1 was adopted immediately, 1 was not observed again, 2 immediately joined other colonies, 1 joined another colony after roaming for 2 years, and 1 was adopted after roaming without a fixed colony for 2 years. All 3 cats that relocated selected different colonies to join. Two colonies gradually decreased in size because of attrition and relocation of members to other colonies; eventually, these were depleted as the last members were adopted. Despite the presence of cats for 7 to 9 years before the colonies were disbanded and the ongoing availability of food, these colonies have not been reestablished by new arrivals.

Ten cats relocated to the perimeter woods where they were not regularly observed. Nine of these remained in the woods. One cat had been in its colony for 1.1 years but moved into the woods for 3.9 years; on return to the main campus area, this cat joined a different colony for an additional 1.1 years before it disappeared.

Adoptions—Nearly half (47%) of the 155 cats were adopted, including 70% (19/27) of the socialized adults and all 12 of the socialized kittens. In addition, 9 of 41 (22%) feral adults and 33 of 75 (44%) feral kittens were adopted. Socialized kittens and cats were more likely to be adopted soon after their capture and neutering than were feral cats. All but 1 of the 12 socialized kittens were adopted within 4 months of arrival, and 12 of the 19 socialized adults were adopted within 4 months. The other 8 socialized cats remained on site for a median of 3.2 years (range, 0.5 to 5.8 years) before being adopted. Within 4 months of arrival on site, 11 of 33 feral kittens and 2 of 9 feral adults were adopted. The other 29 feral cats remained on site a median of 2.4 years (range, 0.4 to 10.5 years) before adoption. One female feral cat was observed on site for several years prior to the recording period and was adopted after 10.5 years in the study, at the estimated age of at least 14 years.

Deaths and disappearances—Ten cats (6% of the population) were found dead during the reporting period. In 6 cats, death was attributed to automobile trauma. Cause of death was unknown in the other 4 cats.

Severe illnesses, including neoplasia ($n = 2$), injury (1), and unspecified diseases (3) resulted in the euthanasia of 6 cats (4%). Eleven (7%) cats without outward evidence of illness were euthanatized because of positive test results for FeLV or FIV. Euthanasia performed solely on the basis of positive FeLV or FIV test

results occurred equally among feral and socialized cats and frequently after several years of residence on site. It was not possible to evaluate the actual prevalence of these viral diseases, because only cats for which there was a strong index of suspicion were tested.

Twenty-three (15%) cats were lost to follow up, and all but 1 of these cats were feral. One feral cat escaped during transportation for neutering; it is not known whether the other cats died, relocated to other areas, or were adopted without the knowledge of the study volunteers.

Deaths, euthanasias, and disappearances often occurred after cats had resided on site for several years. Deaths occurred following a median of 4.7 years (range, 0 to 8.3 years), euthanasias of debilitated cats after a median of 5.1 years (range, 0.1 to 8.5 years), euthanasias of cats with positive test results for FeLV or FIV after a median of 2.1 years (range, 0 to 5.8 years), and losses to follow up after a median of 2.9 years (range, 0.4 to 7.5 years).

Impact on the cat population—Although the neutering and adoption program had been in effect since 1991, a complete census of cats was not completed until 1996. At that time, 68 cats were recorded in residence, and all but 1 male feral cat were neutered. The total number of cats present at the end of the reporting period 6 years later was 23, representing a 66% reduction in the cat population from the original census. Of those remaining cats, only 1 was a socialized adult, and the others were adult feral cats; 11 males and 12 females remained. No kittens were observed on site after 1995. Median duration on site for the cats present at the end of the reporting period was 6.8 years (range, 1.3 to 11.5 years).

Discussion

Before the initiation of a TNR program with adoption, free-roaming cats were considered by campus authorities to constitute a nuisance. Periodic trap and removal efforts were made when excessive cat numbers prompted complaints about on-site noise and odor. Campus employees and residents contributed to these problems by offering large amounts of cat food in public locations, attracting not only more cats but also wildlife such as raccoons and opossums and pests including cockroaches and ants. Although records were not kept prior to 1991, observers estimated that the campus cat population might have reached 120 cats. A group of students attempted to reduce the number of resident cats by removing approximately 50 kittens for adoption, and approximately 8 adult cats were neutered and returned to campus. However, the control effort was not sustained, and the cat population again increased.

The TNR program instituted in 1991 incorporated neutering, euthanasia of sick animals, and adoption of socialized cats and feral cats that eventually became tame enough to become pets. With the exception of 1 male cat, all original study cats were neutered between 1991 and 1995, and no kittens were known to be born on campus after 1995. As a result of deaths, disappearances, and adoptions, the known maximum cat popu-

lation (68 cats in 1996) gradually decreased to 23 cats, the lowest number for the entire recording period.

A majority (57%) of the cats entered the project as kittens, and most of those were feral cats born on site. Feral cats were most numerous, comprising 75% of the population. Male cats comprised 55% of the population. Several studies have revealed that males equal²⁰ or outnumber^{6,21,22} females in free-roaming cat populations, although majorities⁹ of females have also been reported. In contrast, female cats are reported to comprise a slight majority (55 to 58%) of cats neutered in 2 large TNR programs, which together have neutered more than 20,000 cats.¹⁸ It is possible that female cats are more easily trapped or that cat caretakers preferentially target females for neutering.

Adoptions accounted for a substantial portion of the decrease in the cat population, even among feral cats. It has been reported^{15,6,10,23,24} that feral cats become less aggressive toward each other and more friendly toward their feeders following neutering, and this may have encouraged adoption of previously feral cats. Cats were often transferred to private homes only after several years of free-roaming status. The permanent placement of cats in homes is consistent with conventional animal welfare values; the more traditional pet lifestyle is considered to meet the needs of domesticated pet species better than a homeless and free-roaming existence.⁷

Despite widespread concern about the welfare of free-roaming cats, many of the animals in our study survived for a number of years. Most cats (83%) still remaining on site at the end of the observation period had been present for > 6 years. This compares favorably with the mean lifespan of 7.1 years reported for pet cats,²⁵ particularly as almost half of the cats in our study were first observed as adults of unknown age. Most cats (61%) that disappeared, died, or were euthanized for debilitating conditions had been present for at least 3 years. In general, the cats were in adequate physical condition, and only 4% were euthanized for humane reasons. Previous studies^{26,27} found no significant differences in body weights of free-roaming cats, compared with pets; commonly, free-roaming cats were in adequate body condition.^{24,28,29} Neutering of free-roaming cats results in increased weight and body condition, similar to that observed following neutering of owned cats.²⁴

The program enhanced the welfare of cats by preventing the birth of kittens. Virtually no information exists concerning survival of free-roaming kittens, but death rate is expected to be high in this age group. It is proposed that a mortality rate of > 50% in free-roaming kittens prior to maturity contributes to the relatively stable population of cats.^{3,21,30-33} Free-roaming female cats produce 1.1 to 2.1 litters of 3.6 to 5.0 kittens/y^{3,18,21,34}, in the population of 70 female cats of this report, the birth rate would therefore be 277 to 735 kittens/y, and most would die before adulthood.

Multiple studies^{26,35-39,a} have confirmed that the provision of food for free-roaming cats is a widespread activity involving 9 to 22% of households. Several studies^{5-7,10,16,32,35,40,41} have also documented the intense human-animal bond that forms between cat feeders

and free-roaming cats, even if the cats are too wild to be approached. Attempts to control populations by removal of cats are often met with opposition and sabotage by cat feeders who have formed an attachment to the cats; in our study, employees and students openly violated policies against feeding the cats and interfered with trapping efforts by university officials during removal campaigns. In contrast, programs that control the population and improve the well-being of cats via neutering frequently have the support of cat feeders who may be recruited to assist with trapping and management.^{5,6,10,16,18} Several TNR programs to control individual colonies of cats have been reported.^{5-7,32,41} In a TNR program to control a population of 41 free-roaming cats at a research and hospital facility, researchers gained the cooperation of patients with assurances that cats would be returned after neutering.⁶ Forty of the cats were returned, and 1 was euthanized because of advanced illness. Three years later, 30 of the original cats remained and 6 new cats had joined the colony, resulting in a slight decrease in colony size. A series of 254 cats in multiple small colonies were neutered at various British locations in the 1970s and 1980s⁷; after 5 years, 21% of the cats were adopted, and 70% of the cats that were returned to the colonies remained. In another long-term study,³² TNR was used to control a colony of cats residing in abandoned garages in London. The original colony size of 20 cats remained relatively stable, primarily because the number of immigrants into the colony was nearly balanced by deaths during the 5-year study period. Only 1 litter of kittens was born during the study. At the end of the study, 17 cats were present, and complaints about the cats were virtually eliminated. These studies concluded that TNR results in stabilization or modest reduction of colony size, reduced cat turnover, and healthier cats.

Failures of TNR to control cat colonies also exist. A 1-year study^b of TNR programs in 2 southern Florida parks revealed that the presence of well-fed cat colonies encouraged illegal abandonment of additional cats. While the original population of 81 cats declined 20% during 1 year, the arrival of new cats prevented reduction of the colonies, and 88 cats were present at the end of the study. Results of the study also refuted an oft-cited claim that an established colony of cats will defend its territory and prevent the immigration of new arrivals. Minimal territorial activity by the cats was observed, and aggressive encounters between cats were usually limited to enforcement of feeding order. In our study, placement of feeding stations in discrete locations minimized public awareness of the cat colonies. Sexually intact socialized cats that were apparently abandoned joined the colonies; their presence could have undermined the control program had they not been promptly captured and neutered. Migration of cats between colonies was common, and resident cats did not always prevent the immigration of new members.

The results of our study indicated that long-term reduction of free-roaming cat numbers is feasible by TNR. However, natural attrition of cats would be expected to result in a slow rate of population decline. Implementation of an aggressive program of adoption for socialized cats accelerates that decline. Immigration

or abandonment of new cats may be a frequent event, and free-roaming cats do not appear to have sufficient territorial activity to prevent new arrivals from permanently joining colonies. These new arrivals could substantially limit the success of TNR if an ongoing surveillance and maintenance program is not effective.

^aWoods JE, Levy JK. Human interactions with free-roaming cats in Alachua County, Florida (abstr), in *Proceedings*. Coll Vet Med Res Presentation Day 2000.

^bCastillo D. *Population estimates and behavioral analyses of managed cat (Felis catus) colonies located in Miami-Dade County, Florida, parks*. MS thesis, Department of Environmental Studies, Florida International University, Miami, Fla, 2001.

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