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## Effect of high-impact targeted trap-neuter-return and adoption of community cats on cat intake to a shelter

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## ABSTRACT

Approximately 2–3 million cats enter animal shelters annually in the United States. A large proportion of these are unowned community cats that have no one to reclaim them and may be too unsocialized for adoption. More than half of impounded cats are euthanased due to shelter crowding, shelter-acquired disease or feral behavior. Trap-neuter-return (TNR), an alternative to shelter impoundment, improves cat welfare and reduces the size of cat colonies, but has been regarded as too impractical to reduce cat populations on a larger scale or to limit shelter cat intake. The aim of this study was to assess the effect of TNR concentrated in a region of historically high cat impoundments in a Florida community. A 2-year program was implemented to capture and neuter at least 50% of the estimated community cats in a single 11.9 km<sup>2</sup> zip code area, followed by return to the neighborhood or adoption. Trends in shelter cat intake from the target zip code were compared to the rest of the county.

A total of 2366 cats, representing approximately 54% of the projected community cat population in the targeted area, were captured for the TNR program over the 2-year study period. After 2 years, per capita shelter intake was 3.5-fold higher and per capita shelter euthanasia was 17.5-fold higher in the non-target area than in the target area. Shelter cat impoundment from the target area where 60 cats/1000 residents were neutered annually decreased by 66% during the 2-year study period, compared to a decrease of 12% in the non-target area, where only 12 cats/1000 residents were neutered annually. High-impact TNR combined with the adoption of socialized cats and nuisance resolution counseling for residents is an effective tool for reducing shelter cat intake.

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## Introduction

Approximately 2–3 million cats are impounded in animal shelters annually in the USA and over half of these are euthanased due to shelter crowding, shelter-acquired disease or feral behavior. Free-roaming, unowned stray and feral 'community cats' are estimated to number in the tens of millions throughout the USA (Levy and Crawford, 2004). Whereas >80% of owned pet cats are neutered, it is estimated that only 2% of community cats are neutered (Wallace and Levy, 2006; Chu et al., 2009). The sheer numbers and high reproductive capacity of community cats combine to make them the leading source of new kitten births and the greatest source of cats impounded in animal shelters.

In the past three decades, an alternative population control strategy known as trap-neuter-return (TNR) has been adopted by in-

creasing numbers of non-profit humane organizations and municipal animal control shelters. In this process, cats that are thriving in the community are captured, neutered, vaccinated and returned to their original locations. Many programs combine TNR with adoption of socialized cats and kittens, which creates an immediate reduction in cat colony size, while the permanent, resident cats are gradually reduced by attrition.

Numerous studies have shown that fertility control via TNR is effective in reducing cat colony size over time. A population of 155 cats in 11 colonies on a Florida university campus was reduced to 23 over 11 years, and three colonies became extinct (Levy et al., 2003a). Cats in six colonies in rural North Carolina were reduced by 36% in 2 years and continued to decline or the colonies were extinguished over the next 5 years (Nutter, 2005). In Rome, 103 colonies experienced an average decrease of 22%, while a colony at a Rio de Janeiro zoo fell by 58% over 7 years (Mendes-de-Almeida et al., 2011). In Florida, 132 colonies containing 920 cats were reduced by 26% in the first year of a TNR program (Centonze and Levy, 2002).

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E-mail address: [levyjk@ufl.edu](mailto:levyjk@ufl.edu) (J.K. Levy).<http://dx.doi.org/10.1016/j.tvjl.2014.05.001>1090-0233/© 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

While TNR has been well documented to reduce or eliminate cat populations at the colony level, it has yet to be shown whether the strategy can be adequately scaled up to remain effective over larger areas or can reduce the number of cats impounded in shelters. Population models demonstrate that controlling community-wide cat populations via TNR is theoretically possible, but could require sterilization rates of 51–94% (Andersen et al., 2004; Foley et al., 2005; Budke and Slater, 2009; Schmidt et al., 2009; McCarthy et al., 2013). Cat feeding surveys indicate that there are likely to be at least 100 community cats for every 1000 human residents (Levy et al., 2003b; Lord, 2008; Kass et al., 2013), suggesting that even relatively small communities can have tens of thousands of cats that might overwhelm the existing local TNR capacity.

The aim of this study was to assess the effect of high-impact TNR concentrated in a region of historically high cat impoundments in a Florida community. A 2-year program was implemented to capture and neuter at least 50% of the estimated community cats in a single zip code, followed by return to the neighborhood or adoption. Trends in shelter cat intake from the target zip code were compared to the rest of the county for the 5 years prior to the intervention and the 2-year study period of intensive TNR.

## Materials and methods

### Study community

Alachua County is located in north-central Florida. It has a geographic land mass of 2266 km<sup>2</sup> and a population of 247,366 in 2010.<sup>1</sup> Approximately half of the human population resides in the city of Gainesville and approximately one-quarter of the county population is comprised of students at the University of Florida and Santa Fe College.

The county is served by a single open-admission municipal animal shelter (Alachua County Animal Services) that receives stray and owner-relinquished pets. The shelter adopts out some animals and transfers others to a humane society and several pet rescue groups for adoption. Animals are also euthanased for behavioral reasons, poor health and to relieve crowding. In the baseline year of this study, the shelter impounded 3996 cats (71% as strays) and 4389 dogs (62% as strays). The shelter euthanased 2520 cats (63%) and 1936 dogs (44%). Intake and euthanasia of cats and dogs at the municipal shelter have been decreasing steadily for more than a decade.

### Target area

The target area was selected to represent a discrete geographical urban area in which shelter cat intake was higher than in other areas of the county. The non-target area was the remainder of the county. The target area selected was zip code 32601, which included 0.5% of the county's land mass (11.9 km<sup>2</sup>), 8% of the human residents and 6% of the baseline year cat intake by the county shelter (Table 1). Shelter cat intake in the baseline year was 247 (21 cats/km<sup>2</sup>) compared to 3749 cats in the non-targeted remainder of the county (1.5 cats/km<sup>2</sup>; Table 2). Cat intake per capita was similar in the target area (13/1000 residents) and the non-target area (15/1000 residents). In the previous 5 years, the countywide TNR program performed an average of 124 cat surgeries annually in the target area.

The target area was adjacent to the University of Florida campus and included the downtown Gainesville dining and business district, several residential neighborhoods, a mobile home park, two homeless shelters, industrial parks and one veterinary clinic. The target area was classified as lower middle class compared to other Florida zip codes. Compared to the county as a whole, the target area had higher unemployment, higher poverty, lower household income and lower homeownership (Table 1). The racial and educational trends were similar in both areas. The center of the target area was 8.9 km from the shelter.

### Household survey

At the beginning of study year 1, a randomized telephone survey of households in the target area was conducted by a commercial polling service (Bureau of Economic and Business Research, University of Florida) regarding pet ownership and activities involving community cats. This information was used to estimate the number of community cats fed by residents of the target area. For each telephone number, up to 10 calls were attempted at various times, including week days, evenings, and weekends, to contact potential respondents. Interviewers read from a prepared script and surveyed any adult at least 18 years old in the household who agreed to par-

**Table 1**

Geographic and human demographic characteristics of Alachua County, Florida, USA, and target area zip code (32601).

	Alachua county	Target area
<b>Geography</b>		
Land mass (km <sup>2</sup> )	2,266	11.9
<b>Population of human beings</b>		
Total population	247,366	18,585
Average household size	2.3	2.3
Average family size	2.9	3.1
<b>Housing</b>		
Total housing units	112,766	9,277
Owner occupied	54,768 (49%)	1,920 (21%)
Renter occupied	45,748 (41%)	5,813 (63%)
Vacant	12,250 (11%)	1,544 (17%)
Median home value (US\$) <sup>a</sup>	\$176,300	\$147,000
Median monthly rent (US\$) <sup>a</sup>	\$895	\$791
<b>Racial background</b>		
Caucasian	172,156 (70%)	12,808 (69%)
African-American	50,282 (20%)	3,728 (20%)
Other	24,928 (10%)	2,049 (11%)
<b>Employment and income</b>		
Per capita income (US\$) <sup>a</sup>	\$25,287	\$15,238
Median household income (US\$) <sup>a</sup>	\$42,818	\$22,103
Unemployment rate	7.9%	9.4%
Individuals below poverty level	24%	43%
<b>Highest educational achievement (&gt;25 years old)</b>		
No high school diploma (or equivalent)	13,479 (9%)	790 (9%)
High school	56,406 (39%)	3,253 (38%)
Associate's degree	15,724 (11%)	673 (8%)
Bachelor's degree or higher	60,012 (41%)	3,781 (44%)

<sup>a</sup> US\$1.00 = GB£0.59 = €0.72 as at 30 April 2014.

icipate. The survey was approved by the University of Florida Institutional Review Board.

### Community outreach and assistance

Informational postcards explaining the free TNR program were mailed to every residential and business address in the target area five times during the 2-year program. Flyers and brochures were distributed to business locations and churches. Study staff members and volunteers went door to door to speak with residents about the neutering program. Residents were encouraged to contact program staff if they were aware of unowned community cats that had not been sterilized. Humane traps

**Table 2**

Baseline animal control shelter cat and dog intake and disposition in non-target and target areas.

	Non-target area	Target area
<b>Cats</b>		
<b>Cat intake</b>		
Total cats	3749	247
Cats/square mile	4	54
Cats/1000 human residents	15	13
<b>Location of intake</b>		
Cat intake from field	1181 (32%)	116 (47%)
Cat intake at shelter	2568 (68%)	131 (53%)
<b>Type of intake</b>		
Stray cats	2660 (71%)	190 (77%)
Owned cats	1089 (29%)	57 (23%)
Euthanasia	2363 (63%)	157 (64%)
<b>Dogs</b>		
<b>Dog intake</b>		
Total dogs	4123	266
Dogs/square mile	5	58
Dogs/1000 residents	17	14
<b>Intake location</b>		
Dog intake from field	1882 (46%)	148 (56%)
Dog intake at shelter	2241 (54%)	118 (44%)
<b>Type of intake</b>		
Stray dogs	2541 (62%)	161 (61%)
Owned dogs	1582 (38%)	105 (39%)
Euthanasia	1816 (44%)	120 (45%)

<sup>1</sup> See: <http://www.census.gov> (accessed 26 April 2014).

and carriers were loaned to residents who agreed to deliver cats for neutering. Staff and volunteers also performed trapping and transportation of free-roaming cats without identified caregivers and for residents who were unable or unwilling to perform the trapping themselves.

While continuing to respond to cat nuisance complaints and to impound cats upon request in the non-target area, the shelter's animal control staff referred concerns about free-roaming cats in the target area to program staff for further discussion. Study staff members provided nuisance mitigation assistance and encouraged residents to accept the option of neutering instead of having the cats impounded at the shelter. If assistance was refused, cats were impounded or relocated. All of the program services were available at no cost to residents.

#### Trap-neuter-return program

A TNR program (Operation Catnip) had performed approximately 2100 TNR surgeries annually throughout the county since 1998, which translated to a per capita rate of approximately eight community cat sterilizations/1000 residents. This TNR program was available to all unowned free-roaming community cats in the county, regardless of whether the cats were feral or socialized to people. The TNR program continued to perform baseline surgeries throughout the county during the 2-year study period. For the targeted zip code, each cat admitted to the program received a veterinary examination. Animals deemed healthy enough for surgery were spayed or castrated, had the tip of the left ear removed for visual identification and were vaccinated against rabies, feline panleukopenia virus, feline herpesvirus and feline calicivirus. Cats also received selamectin (Revolution, Pfizer) for internal and external parasites and were implanted with a microchip for permanent identification. Cats deemed unsuitable for immediate surgery due to age or condition were either euthanased or assigned to a treatment plan in a veterinary clinic or foster home. Post-mortem examinations were performed on all cats that died or were euthanased. Cats made available for adoption, transfer to rescue or relocation, and those that were ill were tested for feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV; IDEXX SNAP Combo). Animal care was approved by the University of Florida Institutional Animal Care and Use Committee.

#### Disposition of cats

Neutered cats were returned to their caregivers or to their location of origin when fully recovered from anesthesia. When return was not appropriate due to an unresolvable nuisance complaint, loss of original habitat or an unsafe environment, cats were relocated to more suitable locations. Some well-socialized cats were offered for adoption directly from the program or transferred to other pet adoption groups as space allowed.

#### Statistical analysis

For the household survey, the  $\chi^2$  test was used to compare the use of neutering by cat owners with the use of neutering by residents who fed community cats.  $P < 0.05$  was considered to be significant. Shelter intake and disposition data were collected for both cats and dogs from the shelter's electronic database (Chameleon/CMS). The zip code entered for each animal's original location was verified against the United States Postal Service website.<sup>2</sup> During the study period, 155–283 cats/year were left at the shelter without address of origin being provided (2–4% of total cat intake). These cats were assigned to the shelter's zip code for statistical purposes. Results were divided into two time periods: (1) 5 years of historical data culminating in the baseline year; and (2) the 2-year study period during which intensive community outreach and TNR were performed in the target area. If a program of more intensive TNR was successful in preventing cats from entering the shelter, it would be expected that the negative slope of shelter admissions would be steeper for cats in the target area than for cats in the non-target area, and steeper for cats in the target area than for dogs in either area.

The effect of the TNR program on the key metrics of shelter intake and shelter euthanasia was assessed by comparing values in the two study years to the mean values from the 5 historical pre-treatment years. If a study year's value fell outside the pre-treatment mean  $\pm 2$  standard deviations, the effect was considered to be significant.

## Results

### Household survey

A person was successfully contacted at 830/1171 (71%) of the randomly selected working residential telephone numbers. The most frequent reasons why an individual was not successfully con-

**Table 3**

Surgical treatment and disposition of 2366 cats admitted to the high-impact TNR program in the target zip code.

	Age	Number of cats
<b>Neuter status</b>		
Neutered in program (95%)	>6 months	1049 (44%)
	≤6 months	1200 (51%)
Already neutered (5%)	>6 months	107 (5%)
	≤6 months	4 (0.2%)
Died before surgery (0.3%)	>6 months	0 (0%)
	≤6 months	6 (0.3%)
<b>Cat disposition</b>		
Returned to colony (49%)	>6 months	871 (37%)
	≤6 months	298 (13%)
Relocated outside of target area (2%)	>6 months	32 (1%)
	≤6 months	14 (0.6%)
Relocated within target area (1%)	>6 months	11 (0.5%)
	≤6 months	4 (0.2%)
Transferred to rescue (34%)	>6 months	151 (6%)
	≤6 months	654 (28%)
Adopted (13%)	>6 months	84 (4%)
	≤6 months	224 (9%)
Died (0.5%)	>6 months	4 (0.2%)
	≤6 months	8 (0.3%)
Euthanased (0.5%)	>6 months	6 (0.3%)
	≤6 months	5 (0.2%)

tacted at the remaining 341 numbers included no answer (130; 38%), answering machine (187; 55%) and busy signal (24; 7%); 29/830 (3%) individuals who were contacted were ineligible to participate because they were not a resident of the household or were <18 years old.

Of the 801 individuals who were contacted and eligible, 446 (56%) agreed to participate in the survey. Of these, 49 (11%) acknowledged feeding an average of 4.3 community cats each. Feeders cared for cats primarily in their own neighborhoods ( $n = 23$ , 47%) or on their own properties ( $n = 13$ , 27%). Extrapolation of this information to the 9277 households in the target area suggested that approximately 1019 households fed approximately 4383 community cats in the target area (367 cats/km<sup>2</sup>; 236 cats/1000 human residents). However, this is not a precise estimate of the community cat population. Underestimation was possible, since some cats were not fed by residents and some cat feeders might have been reluctant to report the care of cats they did not own. Overestimation was also possible, since some cats could have been fed by more than one household and some fed cats might have actually been free-roaming pets that belonged to other residents.

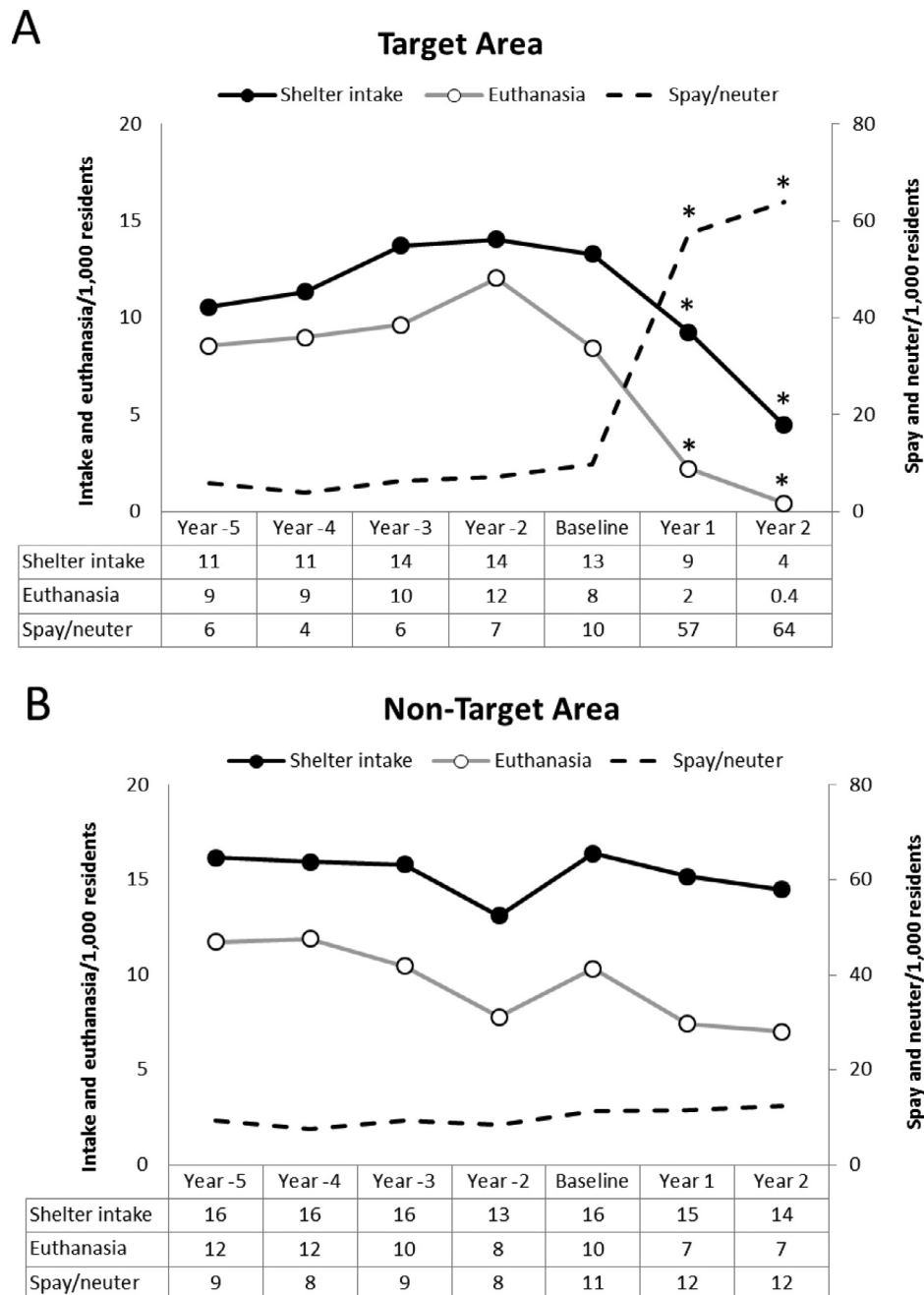
A total of 129 (29%) households owned an average of 1.9 cats each for an extrapolated total of 5098 owned cats in the target area. This suggests that approximately 54% of the cats in the target area were owned pets and 46% were unowned but fed community cats. Neutering was more commonly implemented by pet cat owners (126/129 owners, 98%) than by those who fed community cats (7/49 feeders, 14%;  $P < 0.001$ ).

### Cat disposition

A total of 2366 cats (approximately 54% of the projected community cat population) were admitted to the TNR project over the 2-year study period (1114 in Year 1; 1252 in Year 2). This included 1186 (50%) intact females, 1069 (45%) intact males and 111 (5%) previously sterilized cats.

A total of 1230 cats (52%) were returned to their original locations ( $n = 1169$ ) or relocated to other colonies ( $n = 61$ ) following neutering (Table 3). Of these, 914 (74%) were adults >6 months of age. A total of 1113 cats (47%) were either adopted ( $n = 308$ ) or transferred to rescue groups ( $n = 805$ ). Of these, 878 (79%) were kittens ≤6 months of age.

<sup>2</sup> See: <http://www.usps.com/nationalpremieraccounts/findzipcodes.htm> (accessed 26 April 2014).



**Fig. 1.** Annual per capita community cat trap-neuter-return (TNR) surgeries in the target area (A) increased significantly during the 2 study years (Years 1 and 2;  $P < 0.05$ ). This was accompanied by a significant decrease in shelter cat intake and euthanasia. In the non-target area (B), annual TNR surgeries remained at a baseline rate, and shelter cat intake and euthanasia did not change significantly ( $P > 0.05$ ). Per capita results are reported as cats/1000 residents. \*Significantly different than mean  $\pm 2$  standard deviations of 5 pre-treatment years.

Euthanasia was performed for 11 (0.5%) debilitated cats. Of these, four adults had neoplasia, two adults had debilitation of unknown cause and five kittens had failure to thrive, four of which were FeLV-positive. Six (0.3%) cats died perioperatively. Of these, postmortem examinations revealed that one adult had a diaphragmatic hernia, one adult had pneumonia, one adult had heartworms and one kitten had liver disease, while the causes of death were undetermined in one adult and one kitten.

Of 1128 cats that were tested for FeLV and FIV for adoption, relocation or illness, 28 (2%) were positive for FeLV and 12 (1%) were positive for FIV. Of the cats that tested positive for FeLV, five kittens tested negative 2–4 weeks later and four kittens were euthanased

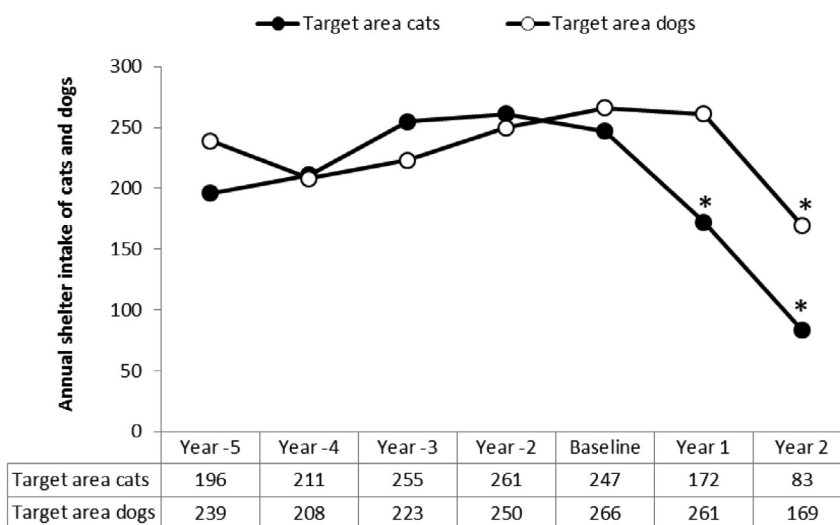
for failure to thrive. A total of 19 FeLV-positive cats were transferred to rescue groups. Of the cats that tested positive for FIV, two were adopted, two were euthanased after neoplasia was diagnosed and eight were transferred to rescue groups.

#### Impact on shelter intake and euthanasia

Annual community cat TNR surgeries in the target area historically were 4–10/1000 residents, then increased to 57–64/1000 residents during the two study years. The increase in neutering was accompanied by a decrease in shelter cat intake and euthanasia (Fig. 1A).

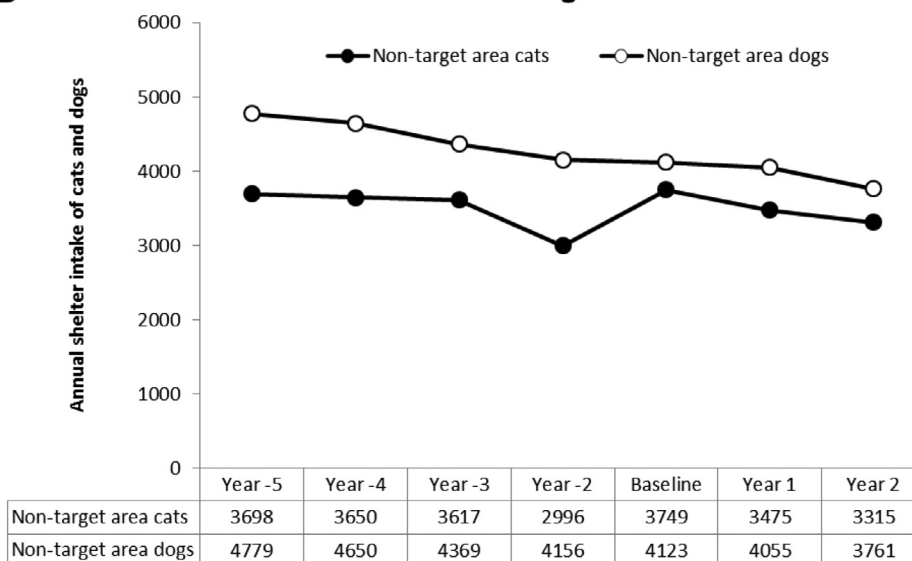
A

Target area



B

Non-target area



**Fig. 2.** Shelter cat impoundment from the trap-neuter-return (TNR) target area (A) decreased 66% from the baseline year during the 2-year study period compared to a decrease of 12% in the non-target area (B). Shelter dog intake from the target area (A) decreased 36% from the baseline year during the 2-year study period compared to a decrease of 9% in the non-target area (B). \*Significantly different than mean  $\pm$  2 standard deviations of 5 pre-treatment years.

In the non-target area, annual TNR surgeries were 8–12/1000 residents throughout the 7-year observation period. In contrast to the target area, intake remained at 14–15/1000 residents (Fig. 1B). At the end of the study, non-target area per capita shelter intake was 3.5-fold higher and per capita shelter euthanasia was 17.5-fold higher than in the target area.

Shelter cat intake from the target area decreased by 66% during the 2-year study period (Fig. 2A) compared to a decrease of 12% in the non-target area (Fig. 2B). Shelter dog intake from the target area decreased 36% during the 2-year study period (Fig. 2A) compared to a decrease of 9% in the non-target area (Fig. 2B).

**Discussion**

This study confirmed that caring for unowned community cats is a common activity and that community cats accounted for almost

half of the local cat population. A program of concentrated community outreach, high-volume TNR and adoption in an 11.9 square km (4.6 square mile) area of high shelter cat intake resulted in a 66% decrease in shelter impoundment over 2 years.

The reduction in intake was most likely to be due to several factors, including a decrease in kitten births via neutering, decreased nuisance behavior associated with breeding and territorial defense, and creation of alternatives to impoundment. Approximately half the cats (primarily kittens) were adopted directly from the project or were transferred to rescue agencies for adoption. The adoption of friendly cats is one of the most tangible ways that TNR programs can quickly reduce the number of homeless cats in a community.

Instead of encouraging impoundment by the shelter, the shelter’s animal control officers referred calls regarding stray cats in the target area to the study team for resolution. In nearly every case,

the team was able to find a solution in which residents agreed to allow the cats to stay on site following sterilization. Many residents indicated that they enjoyed the cats, but that they felt overrun with kittens, frustrated by noisy cat breeding behavior or concerned about aggression towards their own cats, problems that are usually resolved by sterilization.

Intangible effects could have also played a role in the outcomes of this study. An unexpected phenomenon was a concurrent decrease in shelter dog intake from the target area during the 2-year study period. Although not as rapid or marked as for cats, dog intake decreased by more than one third in the target area but by less than one tenth in the non-target area. It is possible that the community education component of the project alerted residents to the need for responsible pet management, creating a bystander effect that motivated them to take action on behalf of all animals in their care. A shift in the response of animal control officers from the usual policy of responding to calls with offers of immediate impoundment to one of connecting residents with community resources to keep animals in place was a result of the study design and the research team's daily engagement with the shelter staff.

The pre-existing TNR program historically performed approximately 2100 neuters of cats annually. Cat selection was not formally targeted in any way and was driven primarily by the interest and motivation of individual cat caregivers who were willing to borrow traps and bring cats to the monthly clinics. The benefits of this approach are reflected in the improved health of the enrolled cats (Scott et al., 2002), management of individual colonies (Centonze and Levy, 2002) and mitigation of specific nuisances. However, it is possible that spreading the effort over the entire county diluted any measurable impacts on population control and shelter intake.

The implementation of widespread neutering of pets and neuter-before-adoption policies in shelters is believed to have played an important role in the decrease of cats and dogs entering USA shelters from >20 million in 1970 to ≤8 million in 2014. However, it has proven problematic to correlate the implementation of specific levels of subsidized spay/neuter surgery with incrementally decreased shelter animal intake (Hughes et al., 2002; White et al., 2010; Scarlett and Johnston, 2012). One reason for this is the difficulty in ensuring that subsidized neutering is preferentially targeted to animals at risk for contributing to shelter intake and not just replacing other sources of neutering. Previous studies using retrospective analysis of shelter records have been hampered by missing data and the inability to identify confounding factors, such as changes in shelter funding and intake policies, the emergence of new animal welfare agencies, and infusions of funding and programs directed toward reducing shelter intake and euthanasia. In the prospective study reported here, the only apparent change that occurred during the 2-year study period was the implementation of the TNR program in the target area.

## Conclusions

This study concentrated intensive TNR and adoption in a single urban area with high shelter cat impoundment. The high-impact TNR and adoption rate of approximately 60 cats annually/1000 residents resulted in a reduction in shelter cat impoundment of 66% over 2 years. This compares to a long-standing low-impact countywide per capita TNR rate of approximately 8 cats/1000 residents annually; this rate did not appear to be adequate to cause a substantial reduction in shelter cat intake. Tracking shelter data on intake and nuisance complaints to target high-impact TNR interventions is likely to reduce shelter cat impoundment faster than spreading the limited resource of TNR over a wider area.

## Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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