TORONTO HUMANE SOCIETY

like no other.

A GLANCE INTO THE COMMUNITY CAT POPULATION OF THE GTA

Using a Geographic Information System to more accurately estimate the community cat population

TORONTO HUMANE SOCIETY like no other.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

In 2017 there were approximately 36.5 million people that call Canada their home (Statistics Canada, 2017), and there was an abundance of statistical population information on these people. However, statistics and population information that relate to animals associated with this population is relatively non-existent, especially when referring to community cats.

Introduction

For the purpose of this study, community cats can be defined as free ranged and independent cats that have little to no resilience on human interaction (Dickman, 1996). when compared to domestic and stray cats, the biggest differences are the characteristics of socialization, define ownership, confinement, and fear/interaction/dependence on humans. Internationally, Denver population sizes are disputed but range is in the billions, across Canada they are estimated to be in the hundreds of thousands (Canadian Federation of Humane Societies, 2012). Be incredibly high estimations are due to community cats having undocumented, isolated, and "self-perpetuating populations" (Dickman, 1996, p.12).

This study targets southern Ontario's largest population centre to get a more accurate assessment on the number of community cats and where they are located. For the City of Toronto and the numerous communities that surround it, the community cat's population has been a cause for concern for many years. so much so that a number of groups within the City of Toronto created the trap neuter return (TNR) program in 2010. This created the Toronto Community Cat Coalition (TFCC), a group of seven organizations with the mandate to reduce the population of community cats (TFCC, 2014).

The aim of this study is to enhance the work of the TNR services provided by Toronto Humane Society, and the organizations in the TFCC. The main objective is to determine the most accurate population estimation for community cats within the GTA as of 2017. Spatial analysis, Geographic Information System (GIS) operation, in population statistics will be used to determine the exact locations of the community cat colonies. It was determined that in order to calculate the most accurate estimation of the community cat population that spatial variables would need to be considered. In order to account for spatial variables such as land use, population density, or different types of demographic data, a GIS should be used.

This study will have the powerful ability to model whether a specific location has, or could have, a community cat colony.

According to Esri (a company who creates one of the leading GIS software platforms; ArcGIS), a GIS does three major things:

1. It captures, manages, analyzes, and displays all forms of geographically referenced information
2. It allows us to view, understand, question, interpret, and visualize our world in ways that reveal relationships, patterns, and trends int eh form of maps, globes, reports, and charts.
3. It helps you answer questions and solve problems by looking at data in a way that is quickly understood and easily shared – on a map.

With the use of demographic data and data on the colonies, a map will be produced to illustrate cold, neutral, and hotspots for potential colonies not known to Toronto Humane Society in the proposed study area. This study has three main goals:

1. to establish the most accurate equation to estimate their probability of the location of unknown community cat colonies,
2. to determine the most accurate representation of the community cat population in the City of Toronto and surrounding area and map locations of known colonies,
3. to determine the effectiveness of the Toronto TNR program and provide population estimates for the future.

TORONTO HUMANE SOCIETY like no other.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

Study Area

The City of Toronto and the Region of Peel are the regions that make up the study area for the study. A map of the final study is shown in Figure 1. These two regions were selected based on available spatial data. Other areas within the GTA did not have all necessary spatial data available for use in this model, limiting our ability to use other regions that surround the city of Toronto. The chosen geographic level used for this study was census tracts (CTs). CTs are a stable geographic level consisting of 2500 to 8000 people, and are found within Census Metropolitan Areas (CMAs). Since the CT geographic level is within the Toronto CMA boundaries, it was easily accessible and standardized across the region of peel and the city of Toronto. Most importantly, CTs follow geographic features and natural boundaries that divide the landscape. These natural barriers also contribute to our determination of the community cat population.

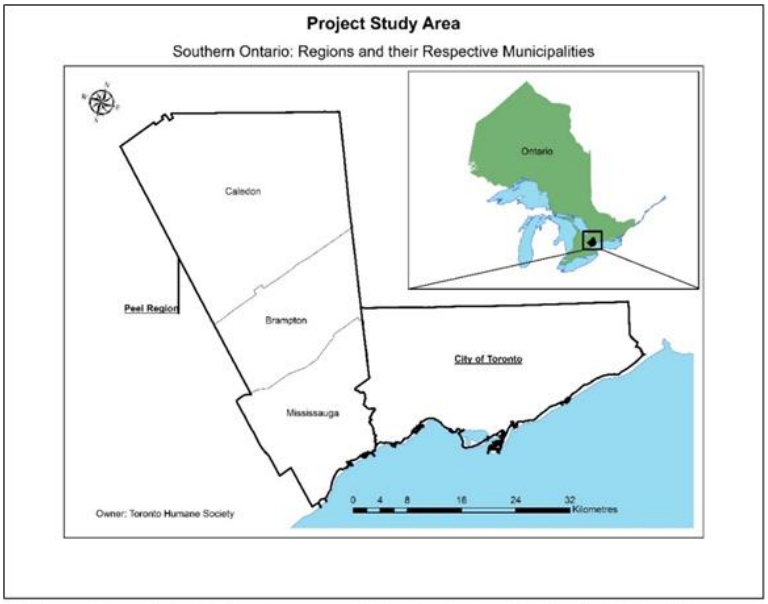

Figure 1: Map of the final study area containing the Region of Peel and the City of Toronto

Surveys and Data Collection

The first step of this study was to contact as many colony caretakers as possible to collect information regarding the community cat colonies they manage. 155 Colony Caretakers were contacted, and 68 of them responded with information about their colonies. Additionally, 13 people came forth about colonies they manage. The 81 people who responded were able to provide information, including the approximate location, of 144 community cat colonies.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

Model Development

Using this collected data, a Multicriteria Decision Analysis (MCDA) was used to aid us in the community cat population model. Simply put, the MCDA takes into account multiple variables and standardizes them across one another by creating a weight.

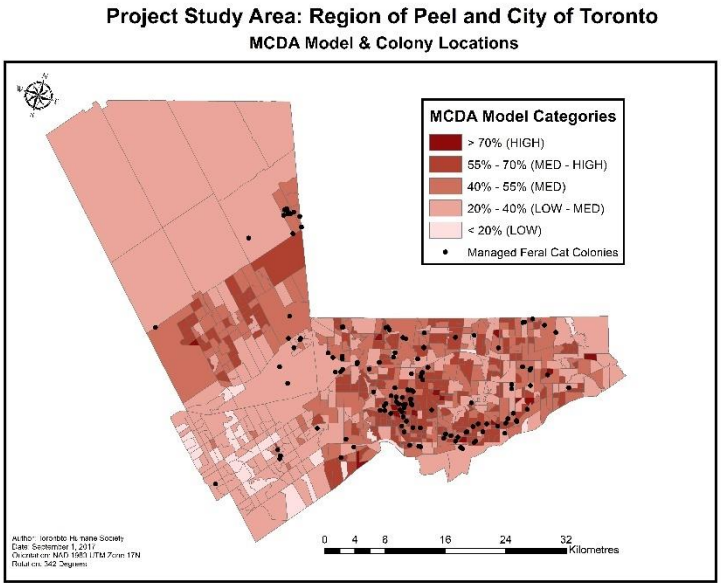

Figure 2: Map of the Region of Peel and the City of Toronto illustrating the result of the MCDA Model in relation to known community cat colony locations.

The MCDA required three integral components: the decision makers (analysts), the physical criteria (variable weighting), and the alternatives (Malczeewski & Rinner, 2015). The decision makers being the analyst, group or organization that has a problem or goal in mind (Toronto Humane Society), for which the tool is used to solve it. The physical criteria are the indicators that evaluate the normalized variables that were formerly raw counts. The indicators are, for example, income, age, and land use. The variables are, for example, residential, population, density, and annual income of 20 to 39 thousand.

The idea behind the use of MCDA is to more easily depict where in the study area there is a high likelihood of community cats.

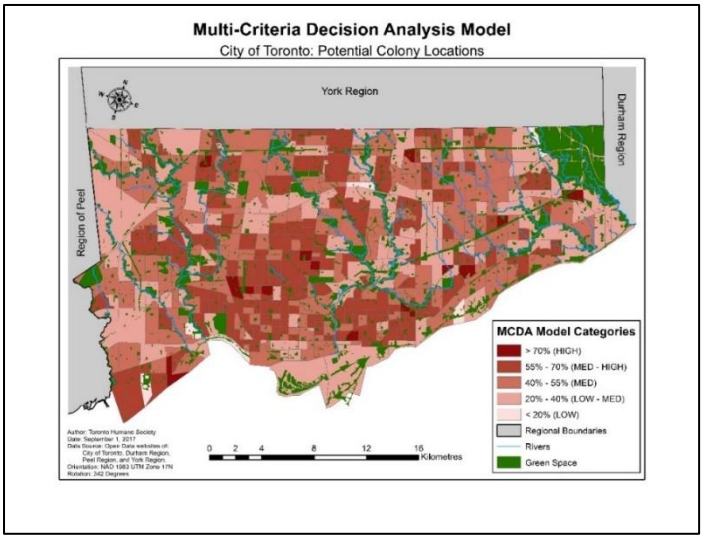

Figure 3: Map illustrating the MCDA Model results for the City of Toronto in relation to other land use features

Using the MCDA model, the output will show areas of high and low likelihood of community cat colonies and help to give us a more accurate population estimate. For example, in this study the land use variable was weighted higher than population density and other demographic data because the known colony locations were more statistically correlated to land use. The results of this model provided one of five classifications to each CT in this study area. these classifications included: LOW, LOW-MED, MED, MED-HIGH, and HIGH. this classification considered all the weighted variables in each CT and determined an overall possibility for each CT I've how likely it would be that a community cat colony existed here.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

Results

This study determined three outcomes

1. the MCDA Model results,
2. population calculation results,
3. TNR and stray intake trends.

There were a number of detailed calculations that went into the MCDA model in this study. These calculations determine standardized rates for each variable being considered. Using these standardized rates, we were also able to standardize each CT against each other. The map in figure two illustrates the results of these values, depicting areas likelihood of housing F community cat colony.

The final appearance out of the map is dependent on the classification values of each category (Heywood, Cornelius & Carver, 2006). For the purpose of this study, it was determined that CT with the percentage over 70% would be classified as HIGH. CT's with the percentage that fell between 55% and 70% would be classified as MED-HIGH.

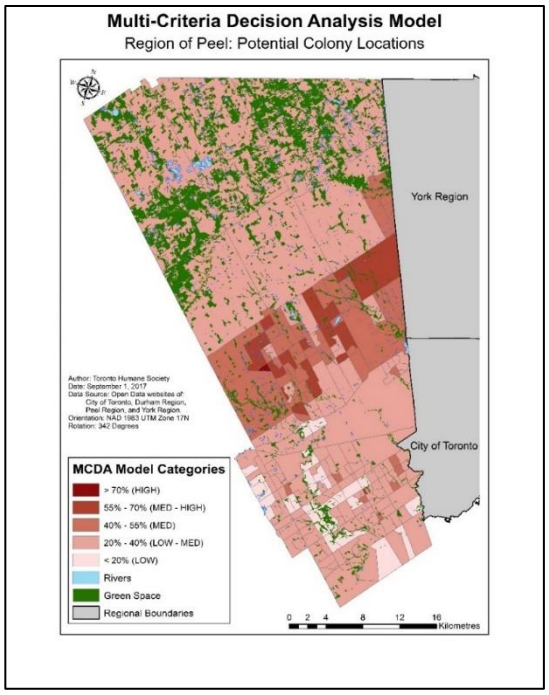

Figure 4: Map illustrating the MCDA Model results for the Region of Peel in relation to other land use features

CT's with the percentage that fell between 40% and 55% would be classified as MED. CT's that had a final percentage value that fell between 20% and 40% were classified as LOW- MED, and finally CT's who's percentage fell lower than 20% were classified as LOW. if the classification values were broken down differently, the map were displayed differently, and a different number of CT's would fall into these categories.

To look closer at the results of the MCDA model, figure 3 focuses on the City of Toronto and illustrates greenspace and rivers. Here it can be seen that the HIGH and MED-HIGH categories are mostly located near residential areas of the city. The CT's Surrounding greenspace tend to fall into the LOW-MED or LOW categories. When analyzing the Region of Peel results a similar trend is noted.

Figure 4 illustrates the MCDA model results for that region of peel. As mentioned above, the trend of CT categorisation is notice again for the pigeon of real. In the northern part of the region, you can see have the green space coral aids to the lower categorisation of the CT. another impact here is likely to be population density. The northern part of the region of peel is Caledon which is more rule than the centre part of the region, which is Brampton. What is interesting though is the difference seemed between Brampton and Mississauga (on the South side of the region). Mississauga is also more population dense, however, what is likely playing a part here, is the income of the residents in both cities.

Using the results illustrated in the MCDA map in figure 2, the CT's containing known community cat colonies were used to determine the average population of the colonies within them. This average wasn't applied across all CT's but the same classification. Table one illustrates the results for the five classifications.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

Table 1: Number of CTs and the Average Community Cat Population within each CT classifcation.

CT Classification	Number of CT's	Average Community Cat Population Within CT
HIGH	16	9.00
MED-HIGH	261	7.63
MED	227	7.47
MED-LOW	236	11.20
LOW	36	0.00

Extending the averages across all of the CT's allows for the consideration of all of the spatial variables that went into the original MCDA model. The results in Table 1 may seem a bit misleading, as one would expect that CT's that were classified as "HIGH" would have a larger population of cats within them. We must remember that the model determined the likelihood of community cats' presence within those CT's. This does not mean that because it has been determined that an area has a high likelihood of community cats it would also have a higher population than other locations. The MED-LOW classification actually has the highest population average at 11.20. If we look at how the variables were weighted in the MCDA model, we know that land use and population density were rated high.

And many of the areas that were classified as MED-LOW we see low population densities an A number of them located within green space. But this could mean is that although those areas are less likely to have community cat colonies, if there are colonies found in them, they tend to be larger in population size.

This could be for a number of reasons. Some reasons that may be considered is the presence of humans. When colonies are managed, they are not only provided with food and water, but also have higher probabilities of being part of a TNR program. If colonies are located outside of residential areas, it is more difficult for people to discover them, but also to manage them. Proximity to human population could also play a role in this.

The Average Population (Extrapolated Collected Data) takes the data we knew and collected first from colony caretakers and spreads it across the appeal of region and the city of Toronto. However, we know that we had a 44% response rate from the colony caretakers that we contacted, and an additional response from 13 colony caretakers that were not included in Toronto Humane Society's database. According to the centre of innovation in research and teaching (CIRT), surveys put out to the general public can receive response rates between 1 to 20%. For the purpose of this study, the 13 people will be assessed at 1%, 10% and 20% to provide a possible population range. 10% is assumed because it lies in the middle of the range defined by CIRT. knowing this, we can assume the numbers are in fact higher than what was collected. Table three outlines the range of population.

Table 3: Final Population Estimates Extrapolating Data to Represent an Estimated 100%.

Region	Estimated Population 13 Additional Responses 1% Data	Estimated Population 13 Additional Responses 10% Data	Estimated Population 13 Additional Responses 20% Data
City of Toronto	93,314.08	16,912.08	12,589.58
Region of Peel	40,729.81	7,381.80	5,495.11
TOTAL	134,043.89	24,293.88	18,084.69

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

It is unlikely that those 13 people only represented 1% of the unknown period it is also unlikely that they represented 20% of the unknown. A safer assumption would be that they represented 10% of the unknown population. If this were to be the case, the population of community cats within the City of Toronto would sit near 17,000 cats. For the Region of pPeel, the population of community cats would sit closer to 7400 cats. This would put the total estimated community cat population for the entire study area around 24, 400 cats. Prior to the study, it was estimated that over 100,000 community cats resided within the city of Toronto; this is vastly different from the estimated 17,000 cats determined by this study.

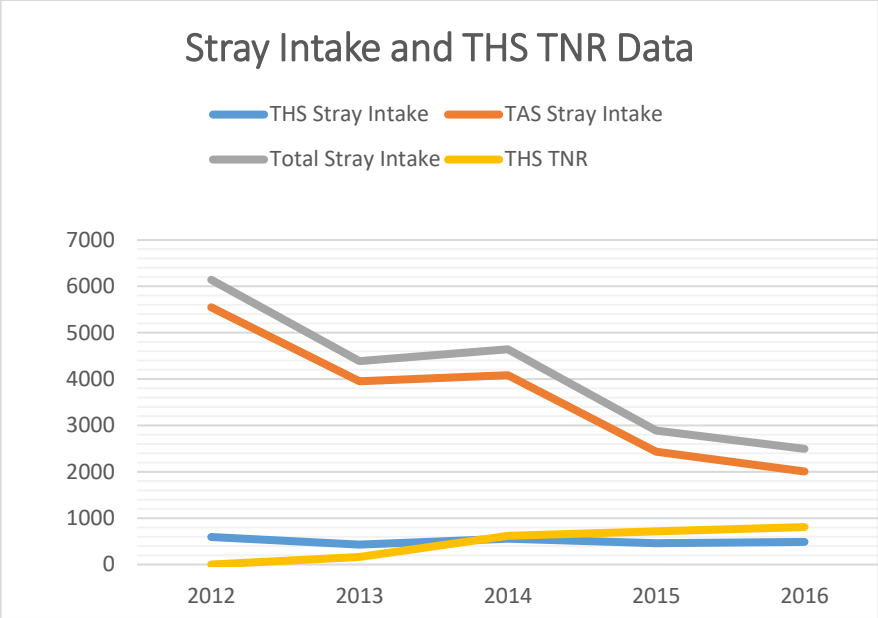

Figure 5: Stray Intake and Toronto Humane Society TNR Data from 2012 - 2016

Now that we have an estimate of the current state of the community cat population within the city of Toronto, it is important to look at other factors that impact this value as well. TNR programs have been "well documented to reduce or eliminate cat populations at the colony level" (J.K. Levy, 2014, p.270). With this noted, it is important to glance at TNR within the city of Toronto. Seeing as we don't have historic population data to compare it to instead, we will be looking at the stray intake data and how it correlates with TNR. Straight and take data is representative of cats who are brought into a shelter from the street.

Table 4: Stray and TNR Data from 2012 to 2016

Year	Toronto Humane Society Stray Intake	Toronto Animal Services Stray Intake	Total Stray Intake	Toronto Humane society TNR
2012	594	5,547	6,141	0
2013	430	3,954	4,384	165
2014	560	4,081	4,641	616
2015	457	2,432	2,889	616
2016	488	2,007	4,495	808

Table four outlines the data collected year over year at TNR at the Toronto Humane Society and straighten tick data for Toronto Humane Society and Toronto Animal Services (TAS). Looking at the numbers from table 4, and by looking at the graph in figure 5 at a glance, you can see TNR numbers are increasing and stray intake numbers are decreasing. this upper trend in TNR numbers would be more prevalent with the addition of TAS's TNR data. Unfortunately, we did not have access to this data and can only illustrate TNR data from Toronto Humane Society. While there could be other external factors playing into the trend seen in figure 5, it was important to test how strong the relationship was between the known variables. To test this, the values were statistically assessed using Pearson's Correlation Coefficient.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

"Pearson's Correlation Coefficient is the ration of the joint variation of two variables to the total variation of the entire dataset" (Mitchell, 2009, p.204). Effectively, it measures the "strength of association between two variables" (University of the West of England, 2017). When this test is run, it produces a r value between -1 and +1. The closer the value is to (+/-) the stronger the relationship is.

The positive and negative sign indicate the relationship trend. For example, if you were to test age with relation to wrinkles, you would expect a position relationship (as age increases, so do wrinkles). Negative relationships would be inverse; as one variable increases, the other decreases. An example of negative relationship may be as temperatures increase, the amount of snow on the ground will decrease.

When considering the variables of the TNR and Stray Intake, Figure 6 illustrates the result of the relationship. X Values represent TNR data, while the Y Values represent the Stray Intake Data. It can be seen from the chart that there is a negative relationship formed between the two variables. The R-Value calculated from the Pearson Correlation coefficient was 0.8642. This value indicates a strong, negative correlation between high TNR and low Stray Intake values (Stangroom, 2017).

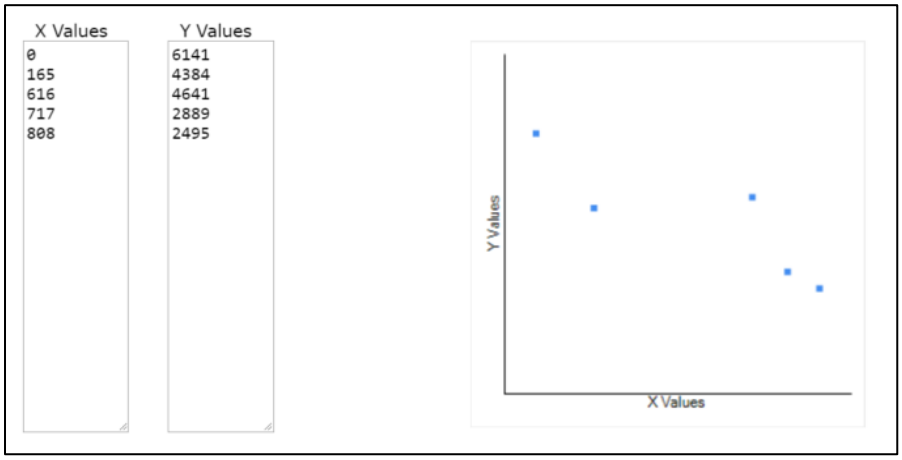

Figure 6: Pearson Correlation Coefficient input values and output trend chart (Stangroom, 2017)

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

What Does the Future Hold?

Using the results of this model, the average population of non community cats each classification was determined. It was then applied across all CT's (even those without known colony locations). calculations were completed to determine an estimate of how much data was actually collected in order to properly project what the community cat population number could be. It was determined that the city of Toronto is likely to have approximately 17,000 community cats, and the region of peel is likely to have 7400 community cats. One of the goals of this study was to determine what the future may hold for the community cat population, TNR programs in the city of Toronto and its surrounding areas, and straight and take numbers at shelters across the GTA.

Luckily in this study we have found a closed approximation to at the current population looks like and in future years, this number can be used. However, there are a select few pieces of literature out there that have analyzed populations of community cats in other locations.

One of these studies was done at the University of Florida and another in Rome, Italy. Both studies were assessing the effectiveness of TNR. In 11 year's time, the University of Florida notice to 66% decrease in the community cat population they were studying, and over a 10-year time frame for the study in Rome, they saw a 16% - 43% decrease in the community cat population. Toronto, although not identical by any means is more similar to the City of Rome than it is to the campus of the University of Florida. Considering this, we can apply an estimate of 10%, 20% and 30% decrease over 10 years to the current population number. Table 5 outlines what this would look like.
Estimating a population decrease of 10% - 40% would men in 10 year's time the community cat population could range between 10 and 15 thousand.

Table 5: Future Population of Community Cars within the City of Toronto.

2017 Estimated Population	Estimated 10% decrease over 10 years	Estimated 20% decrease over 10 years	Estimated 30% decrease over 10 years	Estimated 40% decrease over 10 years
16,914.08	15,220.87	13,529.67	11,838.46	10,1474.25

TNR and Stray Intake

Even though we cannot accurately project population numbers for the future, we can assess an look at trends that we have seen through TNR and stray intake numbers. As we noted, there is a strong correlation between the number of TNR's completed but the number of St cats being brought into shelters. If we continue this trend into the future, we can expect that street intake numbers or cross the GTA shelters will continue to decline.

If it is assumed that there will be a mere 10% increase in TNR and a small 10% decrease in string intake numbers over the next 10 years, in 2021 Toronto Humane Society will be completing around 1300 TNR services in a year, and less than 1500 stray cats will be entering into the shelters across the City of Toronto. In 10 year's time, in in 2026, Toronto Humane Society will be completing over 2000 TNR surgeries in a year and there will be less than 1000 St cats entering shelters. Using the value of 10% was less than most trends noted in the past period this is relatively safe estimate given some of the significant changes in stray intake numbers.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

Conclusion

The city of Toronto lends itself to be a fantastic place for community cats to populate; with its dense populations, residential areas, and other key factors all playing a role period prior to the study it was thought that there were over 100,000 community cats living in Toronto. The goal of this study was to determine their most accurate equation to calculate the community cat population. Having an understanding of community cats and how they live, aided in the decision to use GIS for this equation. Using a GIS allows for the consideration of the spatial aspects of the community cat population. For example, it was positively correlated that known colonies were located near residential areas with high population density. Without using a GIS, the locational aspect of this detail could not be accounted for, and is likely what led to the high population projections.

in this study, a number of key objectives were completed. There is no locational data attributed to known managed community cat colonies; we can see them on a map. Using a number of different variables, a MCDA Model was completed and depicted the CT's probability of community cats residing within them. This model also played a vital role in our population estimates. with an estimated 17,000 community cats living within Toronto, our TNR program is an important piece to this puzzle and other municipalities should consider a program for themselves. This study supports the strong relationship between TNR and stray intake numbers by running statistical tests.

The future was another important aspect of this study. It was determined using what few published studies there are, that in 10 years the City of Toronto could have a community cat population between 10,000 and 15,000. the future of TNR and stray intake numbers were also assessed as they are important part of the equation as well. In 10 years, Toronto Humane Society could be completing around 2000 TNR surgeries in a year. With this increase in surgeries, there would be a noted decrease in stray intake numbers. If trends continued we could expect to see as few as 1000 stray cats enter the shelters in Toronto in the year 2026.

Throughout this study it has been abundantly evident that there are not enough academic studies out there looking into community cats. In recent years, there have been a few studies conducted but nothing consistent enough that relevant comparisons can be made. For more accurate results to be determined, studies similar to this one need to occur year after year to monitor the population.

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

References

Alley Cat Allies. (2017). *Why Trap-Neuter-Return Community Cats? The Case for TNR*. Retrieved November 2017, from Alley Cat Allies: https://www.alleycat.org/resources/why-trap-neuter-return-community-cats-the-case-for-tnr/

Canadian Federation of Humane Societies. (2012). *Cats in Canada: A Comprehensive Report on the Cat Overpopulation Crisis.* N/A: Canadian Federation of Humane Societies.

CIRT. (No Date). *Survey Response Rates*. (Grand Canyon University) Retrieved November 2017, from Center for Innovaton in Research and Teaching: https://cirt.gcu.edu/research/developmentresources/research_ready/designing_surveys/response_rates

Dickman, C. R. (1996). *Overview of the Impacts of Community Cats on Austrailian Native Fauna*. Sydney: National Parks and Wildlife Australian Nature Conservation Agency.

Heywood, I., Cornelius, S., & Carver, S. (2006). *An Introduction to Geographical Information Systems* (Third ed.). Harlow, Essex, England: Pearson Education Limited.

J.K. Levy, N. I. (2014). Effect of high-impact targeted trap-neuter-return and adoption of community cats on cat intake to a shelter. *The Veterinary Journal*, 269-274.

Malczewski, J., & Rinner, C. (2015). Multicriteria Decision Analysis in Geographic Information Science. *Advances in Geographic Information Science*.

Mitchell, A. (2009). *The Esri Guide to GIS Analysis - Volume 2: Spatial Measurements and Statistics* (Vol. 2). Redlands, California, USA: Esri Press.

Stangroom, J. (2017). *Pearson Correlation Coefficient Calculator*. Retrieved from Social Science Statistics: http://learntech.uwe.ac.uk/da/Default.aspx?pageid=1442

Statistics Canada. (2017, September 27). *Population by year, by province and territory*. Retrieved November 2017, from Statsitcs Canada: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/demo02a-eng.htm

Toronto Community Cat Coalition. (2014). *Who are We?* Retrieved November 2017, from Toronto Community Cat TNR Coalition: https://torontocommunitycatcoalition.ca/about-us/

University of the West of England. (2017). *Data Analysis*. (Bristol) Retrieved November 2017, from University of the West of England: http://learntech.uwe.ac.uk/da/Default.aspx?pageid=1442

info@torontohumanesociety.com
416-392-2273
11 River Street, Toronto, M5A 4C2

The Organization

Toronto Humane Society is an animal shelter and non-profit organization fighting to make the world a better place for animals. Through constructive collaborative efforts in their community and beyond, they fight every day to free animals from distress and discomfort, hunger and thirst, pain, injury, and disease.

Following it no-kill principles, trial Humane Society aspires to be a best-in-class animal shelter and a leader in the animal welfare advocacy. for over 130 years they have been working with their community to find creative solutions to the challenges, old and new, animals face everyday. By leading, educating, and inspiring people towards humane action, they will continue their fight, one life at a time.

The Author

Tegan Buckingham has had a passion for animals all her life. After graduating from her Master in Spatial Analytics (SMA) program, Tegan continued her journey toward finding a path where she could help animals. She began her career at an environmental consulting firm where she assisted with many projects, including projects for the betterment of wildlife. Her passion for animals pushed her to a more animal focus organization, Toronto Humane Society. She began to see how her knowledge in data analytics, and geographic information systems, would benefit the organization. Not only could her experience and knowledge aid in research and report writing, but also in organizations marketing and fundraising efforts. This report is the first of many more that will help advance not only Toronto Humane Society, but the animal welfare industry.