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A Generalized Population Monitoring Program to Inform the Management of Free-Roaming Cats

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I. INTRODUCTION

Management of free-roaming cats was once a matter of interest primarily to animal control departments, public health officials, wildlife biologists, and a small but dedicated corps of cat colony caretakers. Over the last two decades, however, advocates for feral cats have become increasingly well organized, their ranks have grown substantially, and they have developed "TNR" (trap-neuter-return) programs as a humane alternative to lethal methods of population control. More recently, some conservationists and public health officials have questioned the efficacy of TNR and called for a return to traditional approaches to managing cat populations, including lethal control. Consequently, management approaches to free-roaming cats are now being debated in the public arena, and often receive substantial media attention. Because systematically-collected data on free-roaming cat populations is relatively limited, these exchanges take place in a substantial 'information vacuum', rendering it difficult to build a strategic consensus among different factions or to demonstrate convincingly the comparative effectiveness of different management options.

This problem could be mitigated by systematic and coordinated data collection, preferably in the form of programs that could be implemented at low cost by with the assistance of cat colony caretakers and other volunteers. This document introduces the design principles and basic implementation steps for such programs. It is our belief that if the data collection process described herein were widely and consistently implemented, it would help to improve the efficiency and effectiveness of non-lethal management alternatives, and would additionally provide a basis for constructive engagement about cat management issues.

II. SCOPE AND APPLICATION OF THIS DOCUMENT

The design principles and practices described in this document are most relevant for monitoring entire neighborhoods, cities, counties, or regions. For these larger-scale monitoring applications, only a subset of the entire target area is actually surveyed, and it is critical that this subset be representative of the whole area of interest. Achieving representative sampling requires that survey site selection be at least partly randomized, and that the survey efforts be adequately replicated. However, we recognize that many organizations will be interested in a distinctly different kind of application; namely monitoring cats over time at one or more specific colony sites. In such cases, the survey areas of interest are relatively small and pre-determined. Therefore, randomized survey site selection is no longer a concern, and monitoring design is greatly simplified. For these colony-focused scenarios, we present a simplified description of appropriate monitoring design Section VII.

III. GOALS OF POPULATION MONITORING

The fundamental goal of population monitoring is to estimate the absolute or relative size of a target population and to determine how that population changes over time. A well-designed monitoring program can also help to determine whether observed changes are attributable to intentional human interventions, unintentional human influences, environmental factors, or other causes. Animal population monitoring programs are most frequently used by biologists to assess the health and viability of wildlife populations, but a much more widely-known monitoring effort is the United States Census, which has been in continuous operation since 1790.

Population monitoring programs can be tailored to provide several different kinds of information, including the following:

1. Estimates of population size in a defined area. If this area is small enough, it may be possible to count all or nearly all of the population members within the area, a special case of monitoring known as a population inventory. A one-time monitoring effort performed before the initiation of management interventions is known as a baseline survey.
2. Population trends over time.
3. Changes in populations resulting from specific management actions, such as TNR programs.
4. Likely causes of observed differences among populations in different areas, or at different times.

In order to accomplish some or all these goals, a monitoring program must meet several basic requirements. It must carefully define a population of interest, and must sample within this population in a representative manner that does not introduce excessive biases. For most purposes, it must operate at regular intervals, ideally over a relatively long time span, and must use consistent field methods at all times. Sampling replication within the area of interest must be sufficient to compensate for random sampling error and allow for legitimate statistical analysis to occur.

Taken to an idealized extreme, meeting these requirements can be difficult and expensive. Fortunately, however, effective monitoring can usually be accomplished while making concessions to economic and logistical realities. In fact, given the size and complexity of the "real world", most monitoring programs compromise idealized design to some extent for the sake of feasibility and affordability. Monitoring costs can be controlled by making use of volunteers or cat caretakers to help collect data, by focusing on population attributes that can be measured, counted, or estimated quickly (even if they cannot be determined precisely), and by rigorously prioritizing the goals of the program.

IV. WHY SHOULD WE MONITOR?

In terms of costs and benefits, there are two compelling reasons why monitoring should accompany any substantive management effort. First, management strategies and tactics cannot be legitimately evaluated or optimized without collecting monitoring data. We all, as animal advocates, want to find the prescriptions and approaches that do the most good within our funding constraints, and there is no better approach to achieving this goal than to implement a well-designed monitoring program. Over time, the relatively small amount of funding required to operate such a program will repay itself many times over in the form of more effective and efficient management plans. Second, those who provide funding for humane management programs increasingly require the generation of metrics, and it can be reasonably surmised that they will also become increasingly skilled in evaluating the quality of the metrics with which they are provided. A well-designed monitoring program provides metrics that are scientifically defensible, suitable for statistical analysis, and capable of generating insights that are often not obtainable when less structured approaches are used.

Despite all of its tangible benefits, monitoring is often omitted or inadequately addressed in many management efforts. For this reason, it may be instructive to briefly describe a highly-effective monitoring effort that parallels, in many ways, what we propose in this document. The North American Breeding Bird Survey (BBS) (https://www.pwrc.usgs.gov/bbs/) was established in 1966 to meet an urgent conservation need to document population trends of multiple bird species. From its modest beginnings, the BBS grew to the point where today, over 4,000 survey routes are monitored regularly, almost entirely by volunteers. The BBS survey design has been criticized as inadequate and outdated by many commentators (http://www.pwrc.usgs.gov/bbs/bbsreview/bbsfinal.pdf), but nonetheless it has produced a continuous 46-year data set of unparalleled utility in conservation biology, and BBS data often provide our "first warning" when a bird species begins to decline. The power of this monitoring program lies not in its perfection, but in its consistency over a long period of time, its broad geographical coverage, and its exceptional cost-effectiveness.

It is sobering to contemplate the amount of effort that has been expended over years and decades in thousands of local humane management efforts without an adequate effort to document whether these efforts have achieved their desired goals. Had systematic monitoring occurred in even a small fraction of these instances, our understanding of cat population dynamics and our ability to productively focus future efforts would now be much farther advanced. We suggest that there is a viable prospect for creating effective monitoring programs for free-roaming cats. Several important pre-requisites exist, including;

1. Public and municipal interest in the management of free-roaming cats.
2. A corps of potential volunteers that could be drawn from the ranks of cat caretakers, humane organization members, or other sources.
3. A potential administrative structure provided by existing humane organization(s).
4. Ongoing (if generally uncoordinated) programs of cat management that lack sufficient monitoring support.

5. Sufficient basic understanding of cat population biology and ecology to design effective monitoring programs.
6. A clear need for the information a monitoring program could provide.

Building a large monitoring program, or a coordinated network of smaller programs, is a long-term process that can most effectively be initiated by implementing pilot programs. These pilot programs can demonstrate the feasibility and value of systematic monitoring, while simultaneously serving as a laboratory in which to fine-tune and optimize field methods and administrative oversight.

V. PRINCIPLES OF MONITORING PROGRAM DESIGN

The concepts described below provide the basis for all biological monitoring program design. Some of the concepts describe HOW to count cats; others describe WHERE and WHEN to count cats. Collectively, they provide a framework for assessing population trends and measuring management impacts in a scientifically valid way. Additional information on all of these topics can be explored in Sutherland (2006) and Thompson et al. (1998).

Field survey protocol: The success of a monitoring program depends on developing a workable and efficient counting protocol, and maintaining consistent adherence to this protocol. Data sets that are collected using inconsistent protocols cannot be legitimately combined or compared, and thereby lose a great deal of their potential utility. Until recently, very little work had been done to determine the most efficient and effective way to count cats in the field. Identification of a suitable counting protocol is critical because the propensity of cats for nocturnal activity and concealment could make them more difficult to detect than some other species. By way of comparison, in the authors' experience, about 40% of all free-roaming dogs living in a given area can be detected by simply walking through that area during the morning hours, a detection rate that is fully adequate for effective monitoring. It is not yet well documented whether simple walking surveys for free-roaming cats would achieve a detectability that approached this level, an important consideration given that very low detection rates create significant problems in data analysis. Some researchers have effectively overcome these issues by using motion-activated "camera trapping" to count cats in specific locations (Bengsen et al. 2011, Finkler et al. 2011, Jones and Downs 2011), but it seems unlikely that this method would be suitable for use by non-professionals across a geographically extensive network of monitoring locations, and in any case, it would be hard to ensure that standardized methods were used across different locations. It would be preferable to develop and validate a lower-tech, lower-cost method that could be more broadly implemented.

Recently, Slater and colleagues have been conducting cat surveys in New York City, and their work may soon provide a basis, along with information about the activity pattern of cats (Haspel and Calhoon 1993), for proposing a standardized field counting protocol that offers sufficient detectability. For now, we provisionally propose a basic cat counting protocol that is described in Section VI. We stress that this or any proposed protocol would need to be field tested and evaluated before it could be considered suitable for broad use.

Target population, or "sampling frame": In all monitoring efforts, it is critical to carefully delineate the population or populations that we are attempting to characterize. A target population could be a particular colony of cats that are centered on a city block, the cats residing in a particular county, or the entire cat population of North America. Characterizing the target population is critical because it defines the area within which field surveys are conducted (the sampling frame), and defines the area within which we can potentially draw inferences from the data we collect.

Sampling: For small target populations (such as a single colony), it may be possible to count all, or nearly all, of the cats present. This is known as a population inventory or census, and where it is feasible, this approach minimizes the uncertainty associated with statistically inferring population size from a less complete data set. However, the cost and effort required to conduct a true inventory becomes problematic with larger target populations, and we must then resort to a sampling approach. Sampling refers to the process of surveying multiple subsets (or replicates) of the target population that are collectively representative of the target population as a whole, and then using those results to extrapolate (or infer) to the larger target population. At the most basic level, sampling plans require that survey sites be selected randomly in an attempt to eliminate potential biases, and the number of samples required can be determined from a mathematical formula. As we will see below, however, simple randomization is not always an adequate or efficient way to obtain representative samples for the target population and determining the degree of replication required is rarely a straightforward exercise.

Replication: Replication of sampling effort is both spatial (the number of different survey sites within the sampling frame) and temporal (the number of times that survey sites are re-visited over time). In principle, the amount of replication that is required for a particular monitoring effort can be determined with mathematical calculations. In reality, however, these calculations rely on a number of simplifying assumptions that rarely apply in complex, real-world settings. Therefore, degree of replication is more often determined within a cost-benefit framework, tempered by the judgment of an experienced study designer.

Stratification: Stratification is a modification of basic randomized sample site selection that becomes increasingly important as our target populations and sampling frames become larger and more diverse. It can best be explained by means of an example. Imagine that our goal is to characterize the free-roaming cat population of San Bernardino County, CA. This county has one large metropolitan area (greater San Bernardino) and a handful of smaller towns (Victorville, Barstow, Needles), but by far the greatest surface area of the county is covered by natural to semi-natural mountain forests and Mojave Desert scrublands. If we were to randomly select 25 sites for counting cats within this county, most of them would occur, purely by chance, in the undeveloped portions of the county that are relatively inhospitable to free- roaming cats. Few, if any, random samples would occur in the populated areas where we would expect most county's free-roaming cats to live. Estimates that were derived from such an unrepresentative set of samples would therefore be unlikely to accurately portray the county's free-roaming cat population. The most basic solution to this problem is to divide, or stratify, the sampling frame into two parts; urbanized areas and relatively uninhabited areas. Within each of these two areas, we can then select random sampling sites, and use the data they produce to generate different population density estimates for cats in the two types of areas. These estimates can then be recombined to generate an overall estimate of cat numbers within the entire county. Depending on the diversity of the target population and environment that characterizes its sampling frame, stratification can either be very basic, or relatively complex, and for smaller and relatively uniform target populations, it can be eliminated altogether. It is important to note that even for large, diverse target populations a stratification plan does not need to account for all significant sources of variability; only those that could conceivably result in significant biases or inefficiencies if a purely randomized sampling approach were pursued. In general, it is advisable to consult with an experienced monitoring program designer when a proposed survey area is geographically diverse, or when the density of cat populations within the survey area is highly varied.

Plots: Typically, the sampling frame is divided into multiple, contiguous plots using hardcopy maps, Google Earth maps, or a Geographic Information System (GIS). Plots can be assigned to different sampling strata (see above) depending on their properties. These plots, or more often a subset of them, become the functional "survey sites" described throughout this document. Plot size does not need to be entirely consistent, but as a general rule, it is helpful for plot size to be reasonably uniform, and to be tied to a reasonable unit of survey effort. More specifically, it is advantageous if rapid surveys (see below for description) within a typical plot can be completed within 2 - 4 hours.

Relative versus absolute estimates:
When designing monitoring plans for cats, particularly for larger target populations, we should always explicitly consider whether or not it is important to estimate absolute population size. If it is, combining rapid and intensive survey methods (see next section), or using another method to adjust for detectability, is required. Oftentimes, however, it may be sufficient to simply determine whether a population is stable, increasing or declining, without knowing the actual size of the population. In these cases, a relative index of population size is sufficient, which can typically be obtained using only rapid survey methods, with less effort and at less cost than is required for generating a population size estimate.

Intensive versus rapid surveys: The most effective monitoring programs, especially for larger target populations, have a two pronged strategy that involves a combination of "rapid" and "intensive" survey techniques. This approach is particularly critical if estimating absolute population size is a goal. Rapid surveys, which are in essence just simple cat counts, are conducted at more sampling sites than intensive surveys, and each of these sites is surveyed using a less time-intensive protocol. Rapid surveys may produce data that is less precise and less detailed than data from intensive survey sites, but their relatively modest time requirements allow them to be conducted at a large number of sites, providing a broadly-based (if sometimes imprecise) cross-section of natural variability within a large, diverse population. Rapid surveys therefore provide contextual baseline data against which to compare any changes that might occur as a result of management actions. They can also help to identify the areas that are most suitable for upcoming management efforts. Finally, rapid surveys capture any broad population trends that might occur as a result of environmental factors (such as climate, seasonality, food supplementation, or disease), and they are often quite valuable in exploratory data analysis (described below).

Intensive surveys are more focused and more time-consuming than rapid surveys, and they are conducted at a smaller number of sites, typically a subset of the sites that receive rapid surveys. In their simplest form, intensive surveys differ from rapid surveys only in the amount of time devoted to the survey effort. Often, they involve using detailed notes or photo-capture methods to try and determine how many different individual cats exist within the survey plot, and they may also incorporate so-called “mark-recapture” techniques to estimate true population size (Bengsen et al. 2011, Finkler et al. 2011, Jones and Downs 2011). Additionally, intensive survey methods can potentially accommodate the collection of behavioral data and individual-based data that cannot be incorporated into the rapid survey framework. Regardless of method, intensive surveys serve two main purposes. First, because they result in a more complete count of cats than rapid surveys conducted in the same area, they allow us to estimate the proportion of cats that are typically detected during rapid surveys. This “detectability factor”, once adequately determined, can them be applied to all rapid survey results within the study area, allowing for better estimates of total population size. Second, even if a population size estimate is not needed, intensive surveys can provide information about population processes such as immigration, survivorship, reproduction, and behavior than cannot be obtained within a rapid survey framework. An understanding of these processes may prove critical in assessing how and why cat populations respond to management efforts.

Exploratory data analysis: Monitoring programs are designed primarily to estimate absolute or relative population size, and to determine population trends. However, they can also facilitate exploratory data analysis, more specifically the attempt to find relationships between cat distribution patterns and the underlying factors that might help to explain those patterns. Within the United States and many other parts of the world, it is straightforward to obtain a wide array of information about the specific areas in which cats are surveyed in the form of GIS data sets, This information could include human population density, socioeconomic status, ethnic profile, demographic profile, average household size, average time of residency, educational levels, traffic data, proximity to certain kinds of locations (dump sites, water sources, parks), and much more. By combining this externally derived data with the data generated by a monitoring effort, exploratory data analyses can be conducted to identify correlations between human or environmental factors and the number of cats that are present.

VI. EXAMPLE: DESIGNING AND IMPLEMENTING AN OUTDOOR CAT MONITORING PROGRAM

In order to more tangibly illustrate the concepts described above, this section outlines the process of designing and implementing a monitoring program, using an area well-known to the authors. This exercise is entirely theoretical, and judgments about the design of this program were made without the level of analytical diligence that would characterize the design of an actual program. Additionally, the hypothetical details discussed herein may not be directly applicable to other potential target populations of interest to the reader. Nonetheless, this section captures the basic steps of developing a monitoring program.

Target population: Free-roaming cats in Churchill County, NV. Churchill County contains one moderately-sized town (Fallon), substantial agricultural / rural areas, a large wetland preserve complex, and extensive public lands dominated by sagebrush shrublands and pinyon-juniper woodlands.

Goals:

1. Estimate the relative population size of free-roaming cats in Churchill County.
2. Quantify how TNR programs in Fallon affect relative population size over time.
3. Determine the density of cats in the wetland preserve, in comparison to the other parts of the county.
4. Develop a better understanding of whether or not agricultural / rural areas surrounding Fallon influence population dynamics within the town.

Time frame: Because TNR programs in Fallon are projected to continue indefinitely, the monitoring program should operate for at least five years, in order to potentially document changes in relative population size.

Stratification: There is reason to suspect that the density of free- roaming cats will vary among the town of Fallon, agricultural areas, the wetland reserve complex, and undeveloped shrubland and forest landscapes. Furthermore, the physical extent of these four land cover types varies substantially within Churchill County, rendering a fully randomized survey site selection process inefficient. Therefore, the sampling frame will be stratified by four land cover types. Within the sampling frame, contiguous plots are delineated, and assigned to strata based on their predominant land cover type. We considered stratifying further within the town of Fallon to distinguish between relatively affluent neighborhoods dominated by owned, single-family housing versus relatively depressed neighborhoods dominated by rental housing. However, given that these two potential strata are roughly equal in geographical size, we concluded that randomized survey site selection within Fallon would adequately capture both, and that no formal stratification for this factor was required.

Replication: Given that there are limited resources available, we constrained the monitoring plan to adhere to a fixed annual budget, and chose to distribute effort in the following ways:

1. In the Fallon stratum, ten plots will be randomly selected for rapid surveys. Two of these ten plots will also receive intensive surveys. One of the intensive survey plots will be randomly selected. The second will be placed in a location where TNR efforts are focused. Intensive survey plots are used in this design only because we are interested in knowing more about cat movements, reproduction, and survival in our different geographical areas; they are not required for generating detectability estimates because we are not attempting to generate a valid population size estimate.
2. In agricultural / rural stratum, six rapid survey plots will be randomly selected.
3. Two of these six plots will be randomly chosen to receive intensive surveys as well.
4. In the wetland preserve stratum, six rapid survey plots will be randomly selected, and two of these plots will be randomly selected to also receive intensive surveys.
5. In the natural shrubland and woodland areas, which are relatively arid and resource-poor, we expect to find very few, if any cats, and will therefore assume an effective population size of zero. No survey effort will be devoted to this stratum.

Field survey protocol: In the absence of an existing standardized survey protocol, we developed a proposed protocol for this monitoring program. If actually employed, this protocol should be tested during the first survey round, and modified if necessary to insure that it is workable and effective. The proposed survey protocols are as follows:

Rapid surveys: Each stratum is divided on a map into plots of ~ 20 acres (4 ha). The correct number of rapid survey plots is randomly selected from those available in each stratum. If any of the selected plots present pragmatic concerns related to safety or accessibility, they can be discarded and replaced with a new randomly-selected plot. Selected plots are surveyed twice every year; once in May – June, and once in October – November. If the plot has a well-developed road system (as will be the case within the town stratum), the rapid survey consists of a single surveyor walking all roads within the plot over a 2-3 hour period beginning just after dawn (when cats appear to be more active than many other times of day, see Haspel and Calhoon (1993)), counting every cat observed, marking their positions on maps, and recording other attributes indicated on a standardized rapid survey data sheet.

Attributes could include:

a. estimated age of cat
b. sex, if determinable
c. spay – neuter status, if determinable
d. ear-tipping or other markings
e. presence of a collar
f. general condition
g. evidence of pregnancy or lactation
h. behavior engaged in when observed
i. size of the group in which the cat is observed
j. evidence of any resource supplementation

In areas where the road system does not provide adequate access to the entire plot, cross county travel may be required, which should follow a grid search pattern provided to the surveyor. Surveys will not be conducted during periods of inclement weather.

Intensive surveys: Intensive surveys occur in selected plots once per year, during the May – June rapid survey time frame. The primary goal of the intensive survey effort is to determine the number of different individual cats that are observed within the survey plot. Each intensive survey consists of a two-day period in which two observers attempt to observe as many cats as possible, and record their attributes and behaviors as indicated on a standardized intensive survey data sheet. Additionally, the intensive surveyors should photograph as many cats as possible, creating a catalogue of individuals present within the plot. To the extent that individual cats can be identified by unique appearance, this will allow some information to accrue over time regarding cat movements between plots or between strata. This avenue of investigation could be significantly accelerated if cats captured in a TNR program are marked in a manner that allows their point of origin to be determined visually. Any cats so marked would be noted when sighted during subsequent rapid or intensive surveys. As with rapid surveys, attributes of individuals will also be recorded, and the expanded time frame of intensive surveys may allow for more detailed observations of cat behaviors than is possible during rapid surveys.

Administration and volunteer recruitment: We determined that it is necessary to recruit and train at least four, and up to eight reliable volunteers to conduct surveys. Ideally, some or all of these volunteers would already be involved in local cat management efforts. The monitoring budget provides for a small stipend to reward these volunteers for their effort, and covers the costs of any driving required. Surveyors will be provided with relatively simple guidance materials that can be printed on a "ready-reference" card. This will be accompanied by data sheets for recording data in a standardized format, and a map of the assigned survey routes or areas. Volunteers will be assigned to conduct rapid counts only, at least initially. SPCA employees will conduct intensive surveys, which require a greater level of commitment and attention, until if and when volunteers can be sufficiently trained to perform this function. Administration is provided by a designated employee of the SPCA of Northern Nevada, who coordinates with local TNR groups and the volunteers they provide to ensure that the survey schedule is maintained and that data sheets are submitted in a timely manner.

Data analysis: The SPCA administrator collates data, and collaborates with qualified consultants to analyze data to address project goals. Over time, the relative population size counts obtained at the surveyed plots can be examined to determine if the change in a statistically significant way. Depending on where TNR efforts are concentrated, some survey plots might serve as "control" sites, while others serve as "treatment" sites.

This section has described a purely theoretical exercise, but it accurately illustrates the process of creating and implementing an actual monitoring plan. Although the ongoing operation and administration of such programs can be successfully accomplished by informed administrators from the humane field and volunteer field surveyors, the initial design and the subsequent analysis phases of a monitoring program can benefit substantially from expert assistance. Sources for this assistance could be obtained by contacting a local University (typically Geography or Biology Departments), or City / County Departments of Public Health or Planning. Additionally, the authors of this paper may be able to provide suggestions for obtaining assistance in your area.

VII. A SIMPLIFIED MONITORING PROGRAM FOR ONE OR MORE COLONY SITES

Colony caretakers may often be more interested in determining the population trend for a specific colony or group of colonies than in exploring larger-scale patterns of cat population dynamics. This is a reasonable and valid goal for a monitoring effort, especially when some type of active management is occurring at the colony site. However, it should be understood that because these colony sites are not randomly selected, they cannot be assumed to represent the larger area within which they occur. Furthermore, interpreting trends within a colony in the absence of control data from other areas may be problematic. That said, colony-focused monitoring is simpler in many respects than the more generalized monitoring program described throughout this document. Stratification, subsampling, replication, and correction for detectability become less relevant or irrelevant, and the major requirements for valid monitoring are the identification of a standardized counting protocol and the consistent implementation of that protocol at predetermined time intervals (monthly, seasonally, annually, etc.). The counting protocol used could be sufficiently intensive to identify all or most of the cats present within the colony (i.e.

an inventory), or conversely it may be a less intensive method that generates a relative index of cat population size. If an index is used, it is critical that all surveyors adhere rigidly to the counting protocol, and avoid the temptation to count new cats that may be observed outside of the designated counting periods. If colony-based monitoring is envisioned as an accompaniment to a management action (such as a TNVR), monitoring should ideally begin well in advance of the management action in order to generate pre-treatment baseline data. If the opportunity to collect pre-treatment baseline data has passed, monitoring for treatment effect is still valuable, although the interpretation of post-treatment trends must be approached more cautiously. Monitoring should continue well beyond the initiation of management activity to allow for the response lags that are often observed in biological populations. Finally, monitoring nearby untreated colonies that can function as control sites for treated colonies is a good practice that allows for a more rigorous analysis of management impacts, and that to some extent can compensate for the absence of pre-treatment baseline data.

VIII. CONCLUSION

Efforts to assess the effectiveness of humane management programs for outdoor cats, while well-intentioned, have been hampered by the lack of sufficient monitoring data. This problem has become more and more apparent as debates and conflicts about different management options have escalated. By adapting the population monitoring framework developed over decades by wildlife biologists, cat advocates can better focus and optimize their efforts, and can more effectively engage with other constituencies. The development of monitoring programs does require some professional assistance, particularly in the early design stages and for data analysis, but given time, precedent, and the ongoing involvement of national animal welfare organizations, systematic monitoring can evolve into a relatively low-cost, high-value adjunct to ongoing management efforts.

IX. LITERATURE CITED

Bengsen A, J Butler, and P Masters. 2011. Estimating and indexing feral cat population abundances. Wildlife Research 38:732-739.

Finkler H, E Hatna, J Terkel. 2011. The influence of neighbourhood socio-demographic factors on densities of free-roaming cat populations in an urban ecosystem in Israel. Wildlife Research 38:235-243.

Haspel C and RE Calhoon. 1993. Activity patterns of free-ranging cats in Brooklyn, New York. Journal of Mammalogy 74(1):1-8.

Jones AL and CT Downs. 2011. Managing feral cats on a university's campuses: how many are there and is sterilization having an effect? Journal of Applied Animal Welfare Science 14(4):304-320.

Sutherland WJ (ed.). 2006. Ecological Census Techniques: A Handbook (2nd ed.). Cambridge University Press, Cambridge, UK. 432 pp.

Thompson WL, GC White, and G Gowan. 1998. Monitoring Vertebrate Populations. Academic Press, San Diego CA. 365 pp.