HFC Committee

From: Bryan Kortis <bryan@neighborhoodcats.org>
Sent: Tuesday, May 19, 2020 12:11 PM
To: HFC Committee
Cc: Alice L. Lee; Shane M. Sinenci
Subject: How many cats are on Maui? - Written testimony for Healthy Families and Communities Committee hearing on May 21, 2020, re: feral cat management
Attachments: JBoone Kanaha-Kahului-Iao Cat Survey Dec 2013 HSUS - Report (Final).pdf; How many cats on Maui_Kortis.docx

Dear Councilmembers,

During the Committee's deliberations on how best to manage Maui's feral cat population, an important issue that has emerged is, just how many cats are there on the island? According to conservationists who have testified, the feral cat population is so large, a spay/neuter program could not possibly be effective.

Dr. Fern Duvall testified at your March 10, 2020, hearing that there are 300 to 400,000 outdoor cats. He arrived at this figure, according to his testimony, by taking a count of cats that had been performed in part of downtown Kahului and multiplying it times the entire acreage of the island. (Healthy Families and Communities Committee Minutes, March 10, 2020, p. 43.)

The method Dr. Duvall used is of no merit. Cat density (the number of cats present in a given area) varies greatly across different types of landscapes. Feral cats are most numerous in urban areas and far less dense in natural settings. If years of research on feral cat density, performed by wildlife biologists, is relied upon, a more realistic count for Maui is in the range of 30,000 to 60,000 total cats (feral and pet).

Attached please find a detailed analysis of how research by conservationists, as well as the American Veterinary Medical Association, supports an estimate of 30,000 to 60,000. I am also attaching the official report on the cat-counting study performed in downtown Kahului in case Councilmembers are interested in seeing directly how badly Dr. Duvall has misinterpreted the results. The most relevant section can be found on pp. 30 to 31 where the author of the report, Dr. John Boone, PhD, discusses population size. Note that he specifically states, "Valid population size estimates can be made only for the area from which samples are drawn...." (Boone, p. 30.)

Thank you for your time and consideration,

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Baseline Surveys for Outdoor Cats in Kanaha Beach Park, Kahului, and Iao Valley State Park, Maui December 2013

Project Report

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for

Maui Humane Society and
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25 June, 2014

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SUMMARY

The project described in this document was undertaken to serve two main purposes: 1) to support and inform the current Trap-Neuter-Return (TNR) management program for outdoor cats that is being administered by Maui Humane Society (MHS) in Kanaha Beach Park, Kahului, and Iao Valley State Park on the island of Maui, and 2) to facilitate planning for a larger-scale cat management program on Maui. Specific goals were to compare and evaluate different methods for counting and monitoring cats, develop a standardized monitoring protocol, examine current rates of sterilization, assess patterns of cat distribution, estimate cat population size, develop recommendations to improve current management efforts, and develop recommendations for an expanded management program. Ultimately, this work was motivated by the belief that an integrated, data-driven approach to humane cat management can significantly benefit both cats and wildlife, and offer a constructive alternative to the current polarized debate about outdoor cats.

Field work was conducted in two focal areas; Kanaha Beach Park plus the adjoining portions of Kahului, and Iao Valley State Park. These are the program areas for the MHS TNR project, and are of further interest because they both contain or abut areas of significant conservation concern. In December, 2013, we implemented multiple cat surveys along 11 survey transects and at 14 survey points that were located adjacent to known cat colony feeding stations. We determined that nighttime transect surveys using supplement illumination (spotlights) were an effective and efficient primary survey method, and formalized a protocol for conducting these surveys. Other survey methods also provided useful supplementary information. We found that sterilization rates are generally high (~ 50 - 90%) in the areas where TNR effort has been most focused, but is considerably lower in adjoining areas, raising concerns about the possible impacts of cat immigration on population management efforts. Cats showed a pronounced tendency to cluster in close proximity to established feeding stations, and were not frequently seen more than 500m from stations. In some areas, we also observed a high density of informal feeding stations (i.e. stations not formally managed through a TNR program), which could present a challenge for centralized management efforts.

Based on this work, we present several recommendations for the current MHS program, including the conduct of regular monitoring surveys, the improvement of a data repository framework and compliance with data recording standards, and greater attention to mobilizing sufficient trapping effort to meet surgery goals. We also concluded that it would be feasible to conduct an effective larger-scale management program on Maui if sufficient resources can be made available. This report presents a series of steps that should be taken to further develop such a program.

ACKNOWLEDGMENTS

Funding for this project was provided by the Maui Humane Society through a grant from the Baker Trust. Laurie Pottish provided direct logistical and volunteer support for this project, facilitated the acquisition of additional volunteer support, and we thank and acknowledge her for her generous contributions and her dedication. We also thank Lynn Solu from Kihei Rent A Car and Feral Foundation of Maui for donating the use of a vehicle to the project during the period of field work, and Wayne Westplate for donating lodging. Marvin Moniz, Maui Airport District Manager, was very helpful in arranging permission to conduct field work on and around airport property. Jody Sparks, one of the primary cat caretakers in the project area, was very generous with his time and experience, and played a critical role in familiarizing us with cat colonies in the study area, as well as providing introductions to the broader cat caretaking community. A number of volunteers helped to conduct surveys and record data, for which we offer our thanks. These include (alphabetically): Erin Avallone, Deb Clark, Melissa Colegrove, Jen Drout, Jaime and Jennifer Fitzpatrick, Donya Izbicki, Laurie Pottish, Veni Villarimo, Terri and Rodney Shishido, and Carolyn Ytredal. Members of the Maui County Animal Coalition and the Hawaii Coalition for the Protection of Cats and Wildlife provided valuable advice, support, and knowledge during the course of our initial discussions and planning efforts, and Fern Duvall of the Hawaii Department of Lands and Natural Resources facilitated the development of a coalition agreement for cat management work to be conducted in the vicinity of the Kanaha Pond State Wildlife Sanctuary. At Maui Humane Society, Jocelyn Bouchard and Kelly Maguire played fundamental roles in operating the cat management program the study area, and were integrally involved in planning and supporting the work described in this report. Finally, at The Humane Society of the United States (HSUS), Inga Gibson, John Hadidian, and Andrew Rowan originally envisioned the need for this survey project along with the larger possibilities for integrated outdoor cat management on Maui, and were the driving forces behind the work accomplished thus far. John Boone, Inga Gibson, John Hadidian, and Jocelyn Bouchard functioned as a working committee in the planning and administration of this project. Finally, we would like to thank the many individuals and organizations that are contributing their time, their effort, and their resources to try to improve the circumstances for cats and wildlife on Maui.

INTRODUCTION AND PURPOSE

Outdoor cats have a significant presence on the landscape in many parts of the world. In the United States, controversy regarding outdoor cat management has grown dramatically in recent years, with advocates for wildlife protection and advocates for outdoor cats having become increasingly forceful in their expressing their positions (ACA 2012, Longcore et al. 2009). Many advocates for wildlife and for public health support attempts to remove outdoor cats from all or some of the landscape (Jessup 2004), and many are willing to accept the use of lethal removal methods if they are necessary to achieve this goal. Advocates for outdoor cats, in contrast, strongly prefer trap-neuter-return (TNR) approaches to cat management, and some have begun to promote the acceptance of a permanent or semi-permanent presence of outdoor cats as an alternative to traditional models of animal sheltering and control (Maddie's Fund, 2013). Given the degree of polarization that has been manifested in the evolving "cat debate", exploration and promotion of pragmatic approaches that seek to balance competing priorities and interests based upon the careful analysis of data have sometimes been neglected or overshadowed.

The Hawaiian Islands are a hospitable location for outdoor cats because of their moderate year-round climate and the presence of substantial resources that are critical for cat survival and persistence. These resources include food and shelter that are directly provided by human caretakers, food and shelter that are provided indirectly (without specific intent) as a by-product of human activities, and food in the form of prey items that are available in the environment. With regard to wildlife, the Hawaiian Islands are characterized by a very high level of species endemism, and by a disproportionate rate of extinctions, near-extinctions, and population declines of endemic species (most notably birds) in recent centuries. This has occurred as a result of human activities, introduced predators (including cats), introduced diseases, and wholesale habitat alteration (Warner 1968, Gurevitch and Padilla 2004, Boyer 2008, Duffy and Capece 2012). It is generally agreed that outdoor cats should not be present in close proximity to threatened or endangered species, but there is notable lack of agreement about whether their presence should be accepted or tolerated in other areas where conservation concerns are less pronounced.

TNR was conceived as a management approach that could improve quality of life for outdoor cats and potentially control cat numbers without resorting to lethal methods. A major topic in the current cat debate involves the effectiveness of TNR as a population control measure, and whether it represents an effective alternative to more traditional means of cat population control (Longcore et al. 2009). The resulting dialogue has been complicated by lack of clarity about the goals of TNR programs, by a widespread and fundamental set of misconceptions about animal population biology, and by the relative absence of good monitoring data from ongoing TNR projects. Many TNR efforts are probably initiated with the primary intention of reducing suffering and improving quality of life for outdoor cats, and without any specific population reduction goals. In other cases, reducing the size of a focal cat population may be an explicit or implicit goal, but no provision is made for collecting suitable baseline data and monitoring data, making it difficult or impossible to convincingly demonstrate whether the effort is effective. Regardless of the intent of a given TNR program, the generalized failure to clearly state programmatic goals has created a situation in which wildlife advocates, public health officials, concerned citizens, and municipal officials have tended to assume that TNR programs are in effect "promising" population-level results. When these fail to materialize, it creates the perception that TNR has been "proven" to be ineffective.

To further complicate these discussions, some TNR practitioners have also overgeneralized about the limitations of lethal control programs based on the fact that they also commonly fail to achieve stated or perceived goals. More specifically, they often cite concerns about the so-called “vacuum effect” that develops in the wake of cat removal, promoting recolonization of the vacated space by other cats. In biological terms, the vacuum effect is a type of density-dependent process that can occur whenever: 1) local population size is reduced below its maximum carrying capacity, and 2) dispersing or recently abandoned animals are present in the vicinity. Under these circumstances, wandering animals have an increased likelihood of becoming successfully established, and over time, this process will tend to drive population density back up to its carrying capacity unless control efforts are sufficiently intensive. What the critiques of lethal control fail to note is that if a TNR program succeeds in reducing the number of outdoor cats, a vacuum effect will materialize just as surely as if lethal control had been employed to achieve the same reduction. The only certain ways to avoid creating a vacuum effect are to reduce resource availability (carrying capacity) along with population size, to manage only isolated cat populations where no immigration can occur, or to simply abandon the attempts to reduce the density of outdoor cats and accept their presence on the landscape at their carrying capacity. Therefore, the need to overcome density-dependent population regulation mechanisms should be regarded as a reality of population control programs, not as something to be avoided at all costs.

In the absence of rigorous comparative management studies, modeling results provide our best information about the likely efficacy of different management methods and different implementation scenarios. A thorough review of the modeling literature is beyond the scope of this report, but they tend to suggest that if a clear majority of animals can be sterilized, and if this sterilization rate can be maintained consistently over time, cat density will decline over time (Anderson et al. 2004, Budke and Slater 2009, Miller et al. *in press*). The speed of the decline and the eventual new population equilibrium level will depend on the sterilization rate that is achieved and the degree to which it is consistently maintained. Although modeling results are relatively consistent in this regard, field validation of these predictions is generally absent or seriously limited.

The work described in this document was based on the premise that the potential utility of TNR for population-level management can only be fairly evaluated by conducting rigorous and well-documented pilot programs that are optimized for population managment. With knowledge derived from such pilot programs, we can being to develop a logical and defensible framework for determining the most appropriate management options for an array of different local situations, leading to improvements in the status quo for both cats and wildlife.

The island of Maui was chosen as a location in which to explore the potential for such a management program largely because of the presence of an active and functional coalition of stakeholder groups and a history of active involvement by The Humane Society of the United States (HSUS). The preliminary work that is described in this report occurred in two more narrowly defined focal areas: 1) Kanaha Beach Park and adjacent northeastern Kahului, on the north shore of Maui, and 2) Iao Valley State Park in western Maui, located just to the west of Wailuku (Figures 1 – 3). Both Kanaha Beach Park and Iao Valley State Park are known to have substantial outdoor cat populations that are currently targeted by a TNR program.

Figure 1. Location of project focal areas at two different spatial scales. Basemaps from Google Maps (www.googlemaps.com).

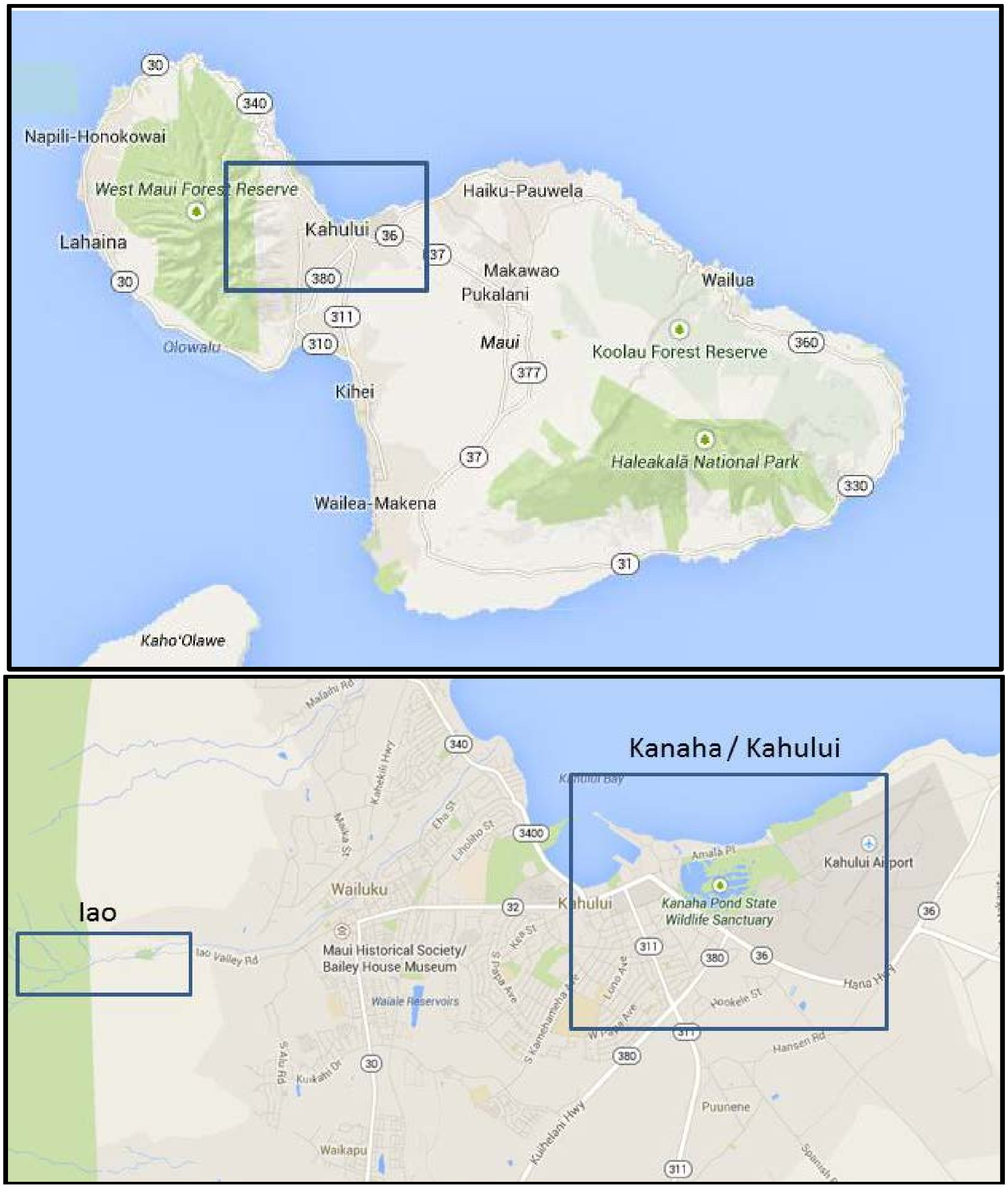


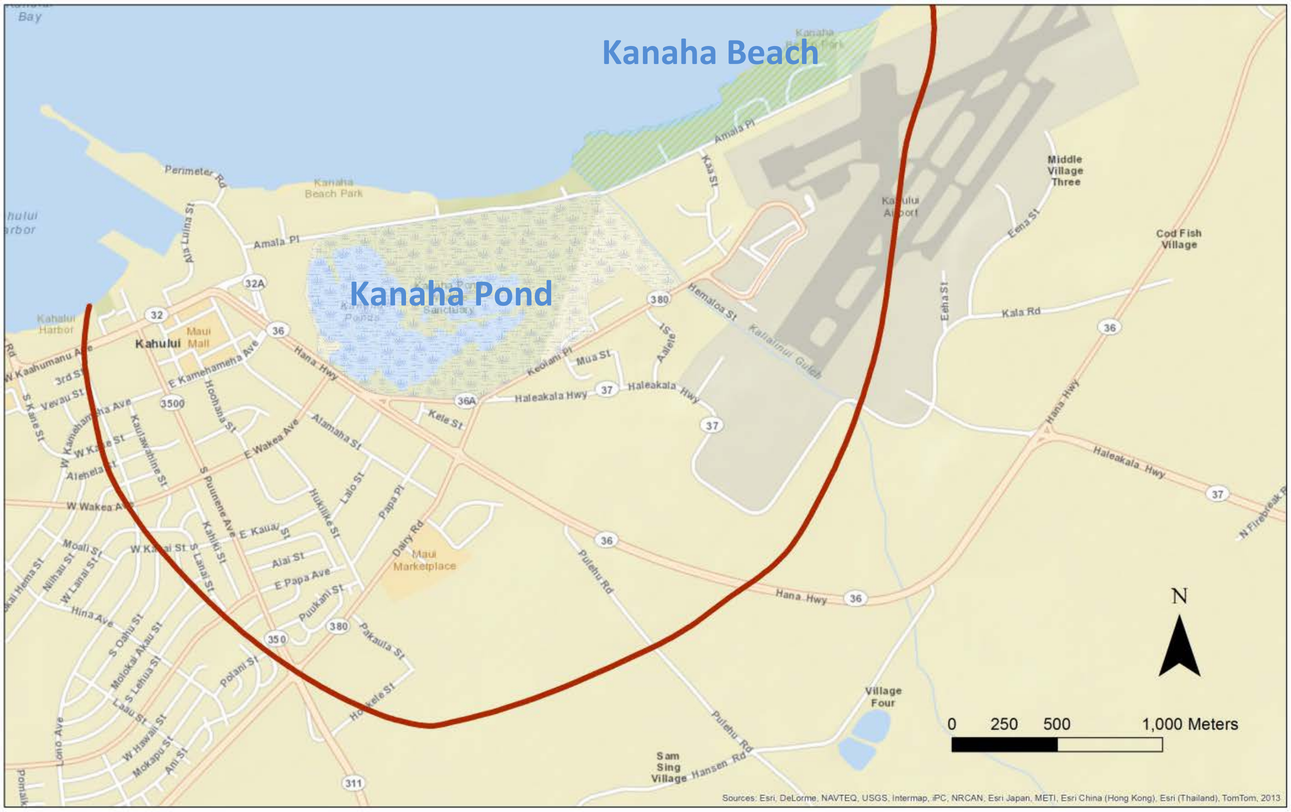
Figure 2. Aerial view (looking west) and ground level view of Kanaha Beach Park.

There are concerns about potential wildlife impacts in both areas. Kanaha Beach Park abuts the Kanaha Pond State Wildlife Sanctuary (Figure 3), home to three endangered and endemic bird species, the Hawaiian coot (‘alae, ‘alae ke‘oke‘o) (*Fulica alai*), the Hawaiian duck (koloa) (*Anas wyvilliana*), and the Hawaiian (or black-winged) stilt (ae‘o) (*Himantopus mexicanus knudseni*). Iao Valley State Park is a natural area with a diversity of bird species, including several cliff nesters that could potentially be vulnerable to cat predation. In addition, there is safety concern about outdoor cats being present on Kahului Airport property, which abuts Kanaha Beach State Park. For these reasons, a grant has been awarded to Maui Humane Society (MHS) by the Baker Trust to support TNR efforts in Kanaha and Iao. MHS determined that the program area for this grant should include the portions of northeastern Kahului and the Kahului Airport that form an urban “buffer zone” of approximately one-mile around Kanaha Beach Park (Figure 5). There are several known cat colonies in this buffer zone, and concern exists about the potential for cat immigration from the buffer zone into Kanaha Beach Park or the Wildlife Sanctuary.

Figure 3. Iao Valley State Park.

Figure 4. Kanaha Pond State Wildlife Sanctuary.

Figure 5. Location of Kanaha Beach Park (green shaded area), Kanaha Pond State Wildlife Sanctuary (stippled area), and the extent of the Kanaha / Kahului focal area (red boundary line).



PREMISES

We considered it important to conduct this project in a balanced and transparent manner. Towards this end, and to avoid potential confusion about our goals and agenda, we present our fundamental operating premises and assumptions, as follows:

1) Data must be collected and interpreted as objectively as possible. Selective presentation of data to advance a particular conclusion is not acceptable.
2) It is desirable to maximize the proportion of cats that are owned, cared for properly, and prevented from roaming freely, particularly in areas where there are conservation concerns.
3) It is desirable to humanely achieve a reduction in the number of outdoor cats, both for cat welfare and for wildlife conservation.
4) Assuming sufficient efficacy and practicality, management methods that are both humane and non-lethal are preferred over other methods. Where lethal means are deemed

necessary or are mandated to achieve specific management goals, minimizing the suffering associated with these methods is desirable.

5) The degree to which outdoor cats pose a conservation threat varies from place to place. Therefore, setting management goals that are locally appropriate - rather than applying generic management goals to large, diverse areas - can help balance competing interests and priorities.
6) Every management method requires appropriate design, implementation, and consistency of effort in order to be effective. It is an oversimplification to suggest that some methods always “work” and others never work.

PROJECT GOALS

This project is intended to serve two general purposes; to support and inform the current TNR program in the Kanaha and Iao areas, and to facilitate planning for a larger-scale management program on Maui. It encompasses the following specific goals:

1) Compare and evaluate several different methods for counting cats.
2) Develop recommendations for a standardized survey protocol.
3) Empirically determine current rates of sterilization within the focal areas, and compare these to sterilization rates reported by cat colony caretakers.
4) Examine patterns of cat distribution in relation to established colony feeding stations.
5) Look for evidence that cats from Kanaha Beach Park are foraging within the confines of the Kanaha Pond State Wildlife Sanctuary.
6) Derive preliminary population size estimates for outdoor cats within the two focal areas.
7) Develop recommendations for the current funded TNR management programs underway in the Kanaha / Kahului area.
8) Generate recommendations and propose a framework for developing an integrated management program for outdoor cats over a larger area or island-wide.

SURVEY DESIGN AND METHODS

Cats often conceal themselves for lengthy periods of time, and in many areas they are primarily active at night. With this in mind, one of our goals was to identify a survey protocol that satisfactorily balanced logistical feasibility, reliability, and ability to detect cats. Adopting a standardized survey method with known properties is a critical element of any effective cat management program. Monitoring data collected using a standardized protocol can be used to:

1) Establish pre-management counts against which future progress is gauged,

2) Determine how cat populations change over time in response to management efforts or other factors,
3) Quantify specific attributes of the cat population, such as age structure, sterilization rates, body condition, etc.,
4) Estimate population size, and
5) Analyze patterns of cat distribution.

Different survey methods have been used for counting cats. These include (but are not limited to) daylight counts along a survey route (i.e. transect), daylight counts at one or more fixed points, nighttime transect counts with supplemental illumination, nighttime point counts with supplemental illumination, and “camera trapping” techniques where cats are recorded by an array of motion-triggered cameras (Edwards et al. 2000, Sutherland 2006, Bengsen et al. 2011). More analytically sophisticated variants of these approaches, such as mark-recapture surveys and distance sampling, may be useful and appropriate in some situations as well. Each method is expected to have certain advantages and disadvantages, and each method will be characterized by a particular “detectability”, which is the likelihood that a given cat present within the survey zone is actually observed and counted. Obtaining good estimates of method-specific detectabilities is a time-consuming and iterative process, but an important prerequisite if our goal is to estimate population size. In general, it is more important for a detectability to be known than for it to be high. However, very low detection rates can be problematic and reduce the accuracy of inferred results. It should be further noted that detectability varies not only among survey methods, but may also vary with factors such as location, weather, time of day, and time of year. For this reason, it is important to develop a survey protocol that minimizes these extraneous sources of variability.

Because the project addressed an array of goals, several different study design requirements had be considered. We provided for these requirements as well as possible within the time frame available for conducting fieldwork, but some compromises were necessary. These are discussed later when relevant to interpreting results. Four survey methods were used during this project; daytime point counts, nighttime point counts, daytime transect counts, and nighttime transect counts. Point count locations were established at each of 14 known colony feeding stations (Figures 6a-c and 7). Five of these were located within Kanaha Beach Park, one on airport property, six in the northeastern portion of Kahului included within the focal area, and two within Iao Valley State Park.

Eleven survey transects were established (Figures 6a-c and 7). Five transects (Upper Kanaha, Lower Kanaha, Airport, Dairy Road, and Iao) were sited provide survey overlap with point locations. Of these, two transects (Airport and Iao) were also located in areas of particular management concern. Three transects (N. Fence, S. Fence, and S. Airport) were located in areas

Figure 6a. Survey points ("bulls-eye" points) and transects established in the Kanaha / Kahului focal area. Map is rotated to allow larger viewing scale. Points and transects are labeled in Figures 6b – c.

Figure 6b. Kanaha / Kahului focal area survey transects, with labels showing transect names. Map is rotated to allow larger viewing scale.

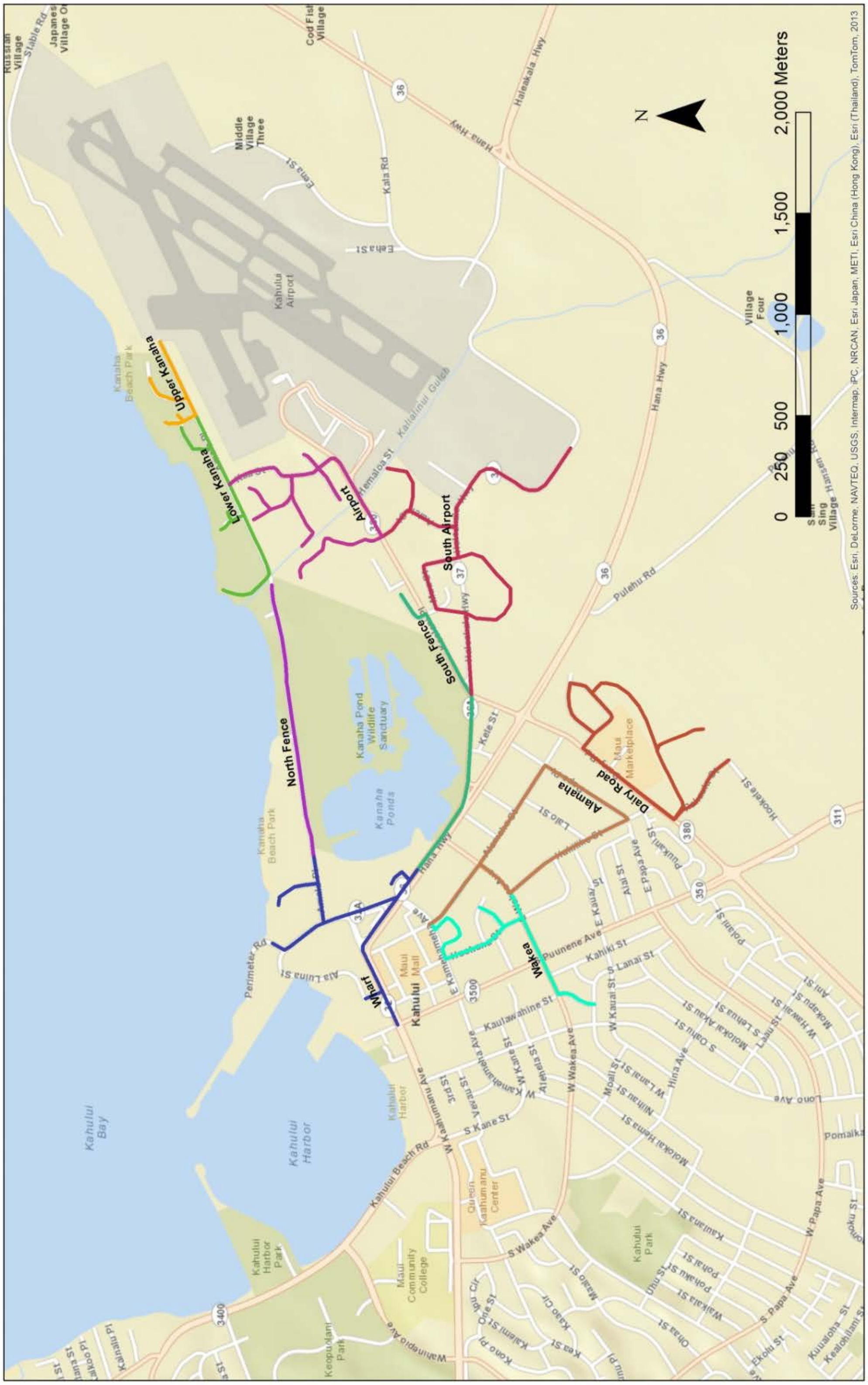
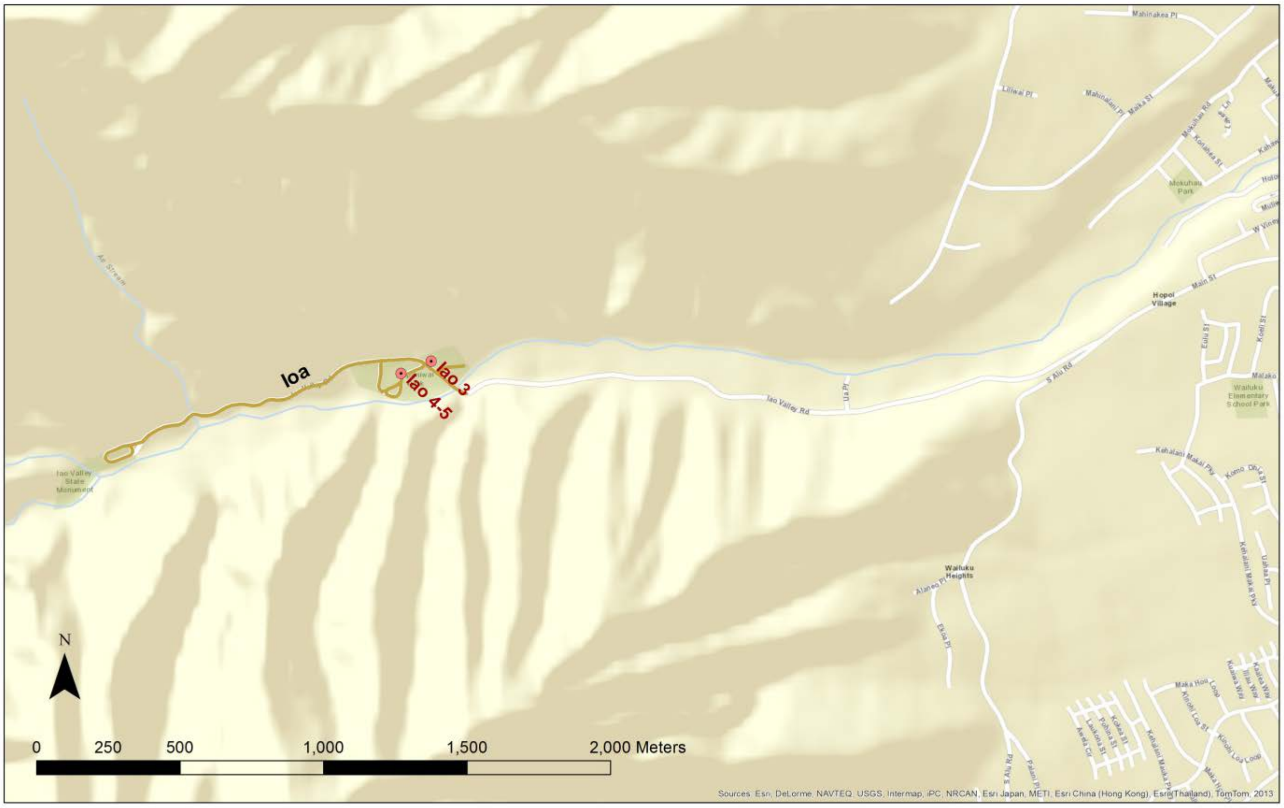


Figure 6c. Kanaha / Kahului focal area survey points, with labels showing point names. Map is rotated to allow larger viewing scale.

Figure 7. Survey transects and points in the Iao Valley focal area. The western edge of Wailuku is shown in this view for reference.



of management concern (Kanaha Pond State Wildlife Sanctuary and the Kahului Airport), but where there were no known cat colonies. Three transects (Alahama, Wakea, and Wharf) were established to randomly sample the portions of Kahului within the project focal area, without regard to colony locations or areas of conservation interest. Each transect was constrained to a length that could be surveyed by a team of two within the time frame described below.

Surveyors worked in pairs for safety reasons, and to permit one surveyor to concentrate on data recording while the other concentrated on observation. Daylight point counts began approximately 45 minutes before dusk and continued until darkening conditions made it difficult to see cats without supplemental illumination. Surveyors remained stationary during this period at a location that was close enough to the feeding station to observe cats effectively with the aid of binoculars, but not so close as to discourage most cats from approaching the feeding station. The exact distance between the feeding station and observation point varied among sites due to local topography, vegetation density, and viewing conditions, but was typically ~ 15 meters. During the survey period, notes were taken on characteristics of individual cats to reduce the chance of double-counting particular individuals, with the goal of tallying as many individual animals as possible. In addition, whenever possible age was recorded in one of three categories (adults = 6 mo. or more; juveniles = 2 – 6 mo.; kittens = less than 2 mo.) along with ear-marking status (tipped, notched, or unmarked) as an indicator of sterilization status. However, if ear status could not be clearly determined, no value was recorded. Nighttime point counts were conducted on the same date as daytime point counts for a given site. Nighttime counts involved the use binoculars and LCD spotlights to help illuminate cats directly or by means of eye shine. The nighttime counts commenced about 15 minutes after full darkness, and lasted only long enough to scan the entire area and count all cats observed, typically about 5 minutes. Because this was a short time frame in comparison to the daytime point counts, the chance for double-counting individuals was low and we did not attempt to record unique identifying information for each cat. We did, however, record ear-marking status when possible, although this was typically more difficult to determine at night.

Daytime transect counts occurred during the late afternoon, from approximately 3 hrs. – 1 hr. before dusk. Nighttime transect counts occurred during a period from approximately 30 min. – 2.5 hr. after full darkness. Daytime and nighttime transect counts differed only in that LCD spotlights and headlights were used for supplemental illumination during the nighttime counts. Otherwise, the protocols were the same, and involved the survey pair walking slowly along the assigned route searching for cats, using binoculars for assistance as needed. The estimated position of every cat seen was recorded by using a handheld GPS unit to note the geographical coordinates of the surveyor (UTM NAD 83 coordinate system), estimating the distance from the observer to the cat, and estimating the bearing from the observer to the cat. Whenever possible, we also recorded the ear-marking status of cats, as described above. As with the point counts, it was generally easier to obtain a clear indication of ear marking status in the daytime than in the nighttime, especially for cats that were relatively distant from the observer.

All points and transects were surveyed at least once in the daytime and once in the nighttime. In order to obtain a preliminary indication of the repeatability of survey results, we also performed a second pair of counts for the Upper Kanaha, Dairy Road, and Iao transects, and for one of the feeding station points (K0) at the eastern end of Kanaha Beach Park. Data sheets used for the point counts and transect counts are given in Appendix 1.

DATA PROCESSING AND ANALYSIS

Raw data were transcribed and collated into a set of MS-Excel tables. All feeding station points and transects were georeferenced in a GIS system for mapping and analysis. Locations of individual cats recorded during the transect counts were generated in GIS by projecting the recorded distance and bearing from the surveyor coordinates. The recorded characteristics of each cat (age, ear-marking status, survey type and date) were attached to these projected locations as GIS attributes. The full data set (in Excel format and GIS shape file format) have been submitted to HSUS and MHS, but they are not reproduced in their entirety in this report.

Sterilization rates were calculated for each count by dividing the number of cats that were notched or tipped by the total number of cats for which ear marking status could be determined. Cats for which ear marking status was unknown were not factored into this calculation. A final estimate of sterilization rate for a given point or transect was made by averaging rates obtained from daytime, nighttime, and duplicate counts. If a particular count resulted in a very small number of ear mark determinations (< 8), it was regarded as unreliable and not used in this averaging process.

Our study design offered some opportunities to estimate survey detectability by comparing transect count results and point count results to colony size estimates provided by colony caretakers. We emphasize that obtaining good detectability estimates is an iterative process that we have only begun, but nonetheless these provisional detectability estimates were used generate preliminary population size estimates for two focal areas. This process is described more fully in the following section.

TIMELINE AND KEY PERSONNEL

Preliminary meetings and discussions began in July 2013, culminating in an initial site visit to Maui by John Boone, Inga Gibson, John Hadidian, and Jocelyn Bouchard in September 2013. Coalition meetings were held at this time, and volunteers to help with upcoming field work. The field work described in this report was conducted 13 – 21 December 2013. John Boone and Kelly Colegrove (both from Great Basin Bird Observatory) supervised the field effort, and at least one of these individuals was part of the survey crew for each transect count and point count, which ensured adherence to survey protocols and a reasonable level of observer consistency. Boone and Colegrove were assisted by many volunteer surveyors, as described in the Acknowledgment section.

RESULTS

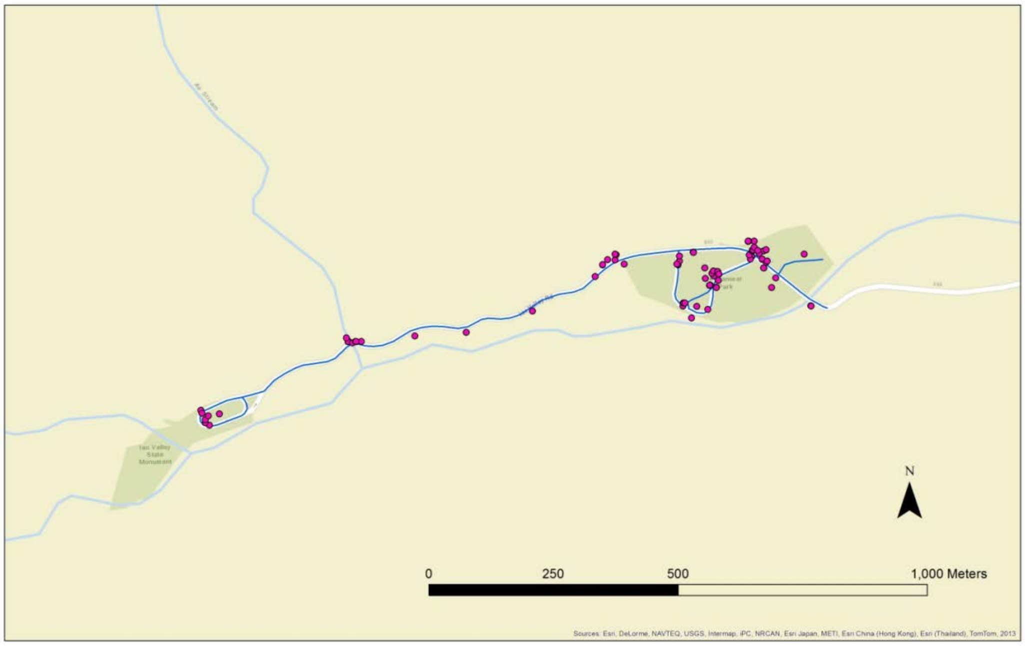
Point Counts and Transect Counts

Fifteen sets of daytime – nighttime point counts were conducted (30 counts in all) on 14 established points. Thirteen of the points received on set of counts, and point K0 in Kanaha Beach Park received two sets of counts. Fourteen sets of daytime – nighttime transect counts were performed (28 counts in all) on 11 different transects. Eight transects received one set of counts, and three transects (Iao, Upper Kanaha, and Dairy Road) received two sets of counts. For all points and transects that received a duplicate set of counts, the first count was regarded as the primary data source that was used for most of the analyses shown below. The second count was used to investigate survey repeatability, and to bolster data on sterilization rates. The dates and surveyors associated with each count are presented in Appendix 2.

A total of 620 cats were recorded during transect counts (Figures 8 and 9). The number of unique individuals counted is unknown, although it is less than this number since many individuals were invariably detected during both daytime and nighttime counts. However, the likelihood of double counting within a single transect count was thought to be very low given that surveyors were actively traveling along the transect route.

Figure 8. Points showing all cats detected on transect counts in the Kanaha/Kahului area.

Figure 9. Points showing all cats detected on transect counts in the Iao Valley area.



Nighttime transect counts detected about five times as many cats as daytime transect counts, as shown in Table 1. This result was fairly consistent across transects.

Table 1. Comparison of daytime vs. nighttime transect counts. Duplicate transects are not shown.

Transect	Day Count	Night Count	Ratio Day/Night
Airport	14	28	0.5
Alamaha	5	19	0.26
Dairy Road	14	48	0.29
Lower Kanaha	16	67	0.24
N. Fence	0	1	0
S. Fence	0	0	-
S. Airport	2	4	0.5
Upper Kanaha	16	86	0.19
Wakea	1	14	0.07
Wharf	0	3	0
Iao	2	46	0.04
Mean	**7.00**	**31.6**	**0.21**

Visual comparisons of daytime and nighttime results for the Upper Kanaha, Lower Kanaha, Dairy Road, and Iao transects are shown in Figures 10 – 12.

Figure 10. Comparison of day vs. night transect counts on the Upper and Lower Kanaha transects. Map rotated to allow larger viewing scale.

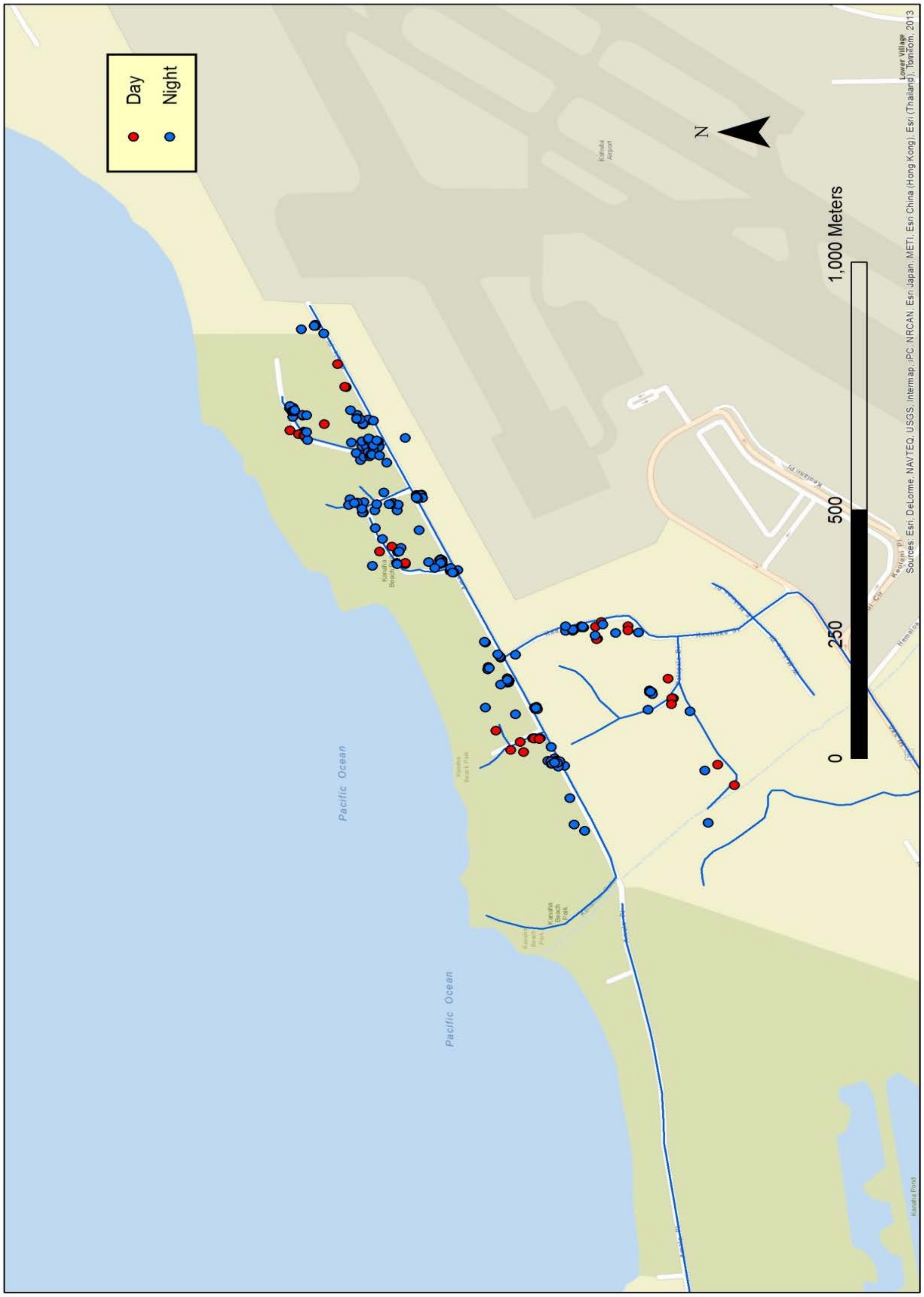


Figure 11. Comparison of day vs. night transect counts on the Dairy Road transect.

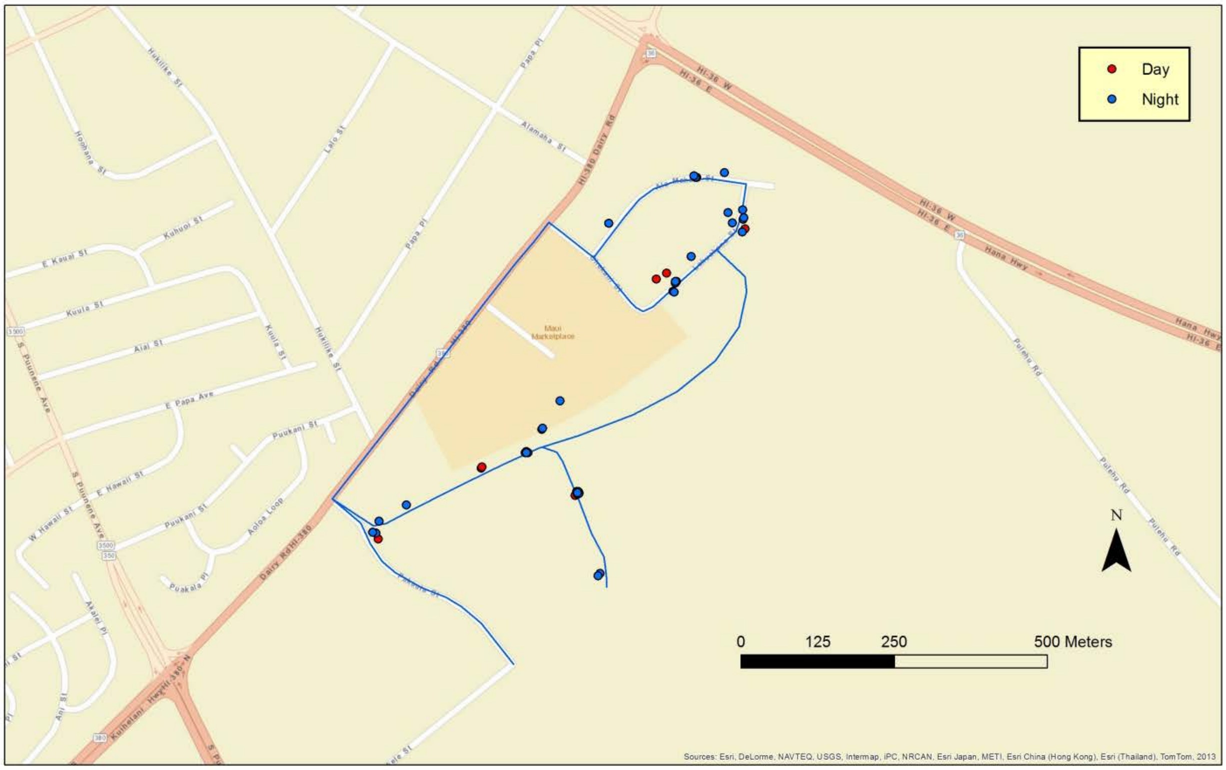
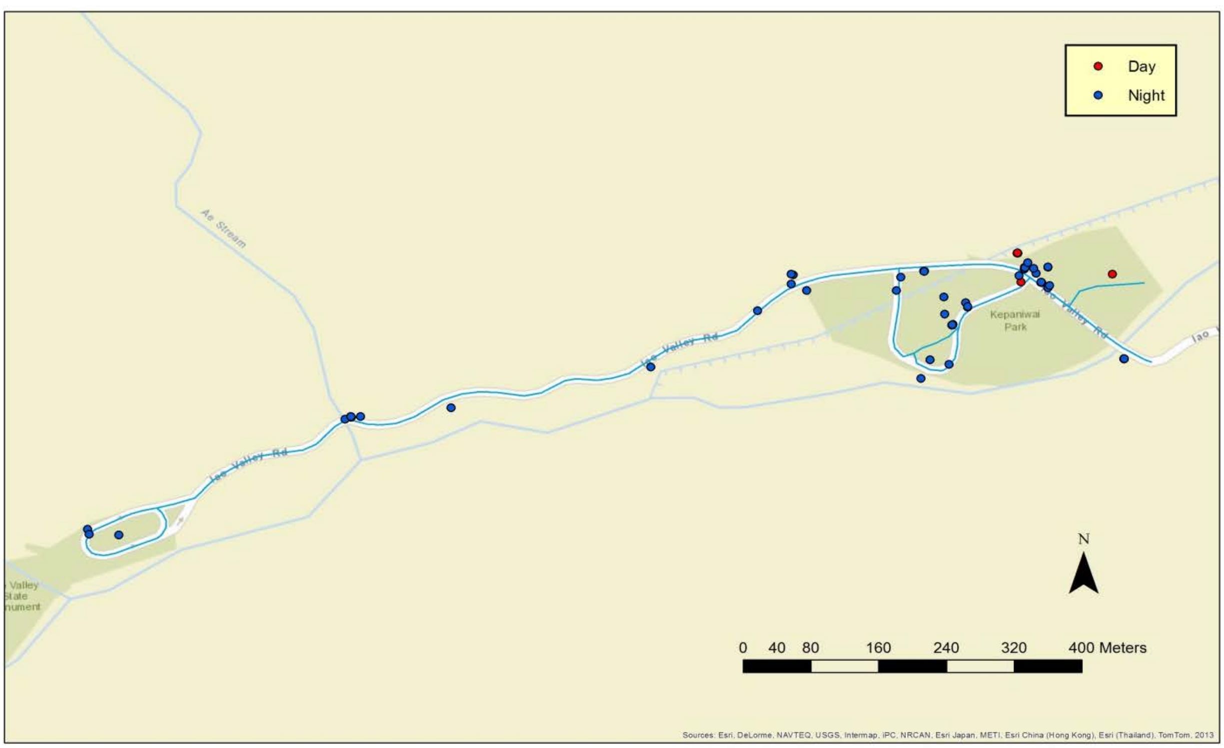


Figure 12. Comparison of day vs. night transect counts on the Iao transect.



A total of 510 cats were recorded during the point counts. As with the transect counts, the number of unique individuals is unknown, but the likelihood of double-counting during any single count was thought to be low. In contrast to the transect counts, point counts showed no systematic difference between daytime and nighttime results, as shown in Table 2. This may be largely attributable to the fact that more time was spent making the daytime point count than the nighttime point count, as described in the "Study Design and Methods" section. We can therefore note that the number of cats counted in approximately 45 minutes of daytime survey effort was about the same as the number counted in approximately five minutes of nighttime survey effort. However, there was substantial variability in the ratio of daytime/nighttime counts among the surveyed points. We suspected that two factors contributed to this variability: 1) Cat attendance in the vicinity of a feeding station seemed to be strongly influenced by feeding schedules, which typically occur around dusk, but which vary from station to station. Our study design did not control for this factor. 2) Viewing conditions varied greatly among points, with largely unobstructed sight lines in some areas, and highly obstructed conditions prevailing in others due to thick vegetation.

After conducting the point counts, we obtained colony size estimates for some points from caretakers. Given the likelihood of displacement behaviors within the confines of a feeding station, we did not expect all cats within a colony to be simultaneously present at a feeding station, and we therefore we assumed that our point counts captured only a subset of the colony. Caretaker estimates, in contrast, are developed over time and can in principle provide a relatively complete colony count. For the points where caretaker estimates were available, they were about twice as large as the number of cats recorded during point counts, although there was considerable variability in this ratio (Table 2). This result suggests that the detectability associated with daylight and nighttime point counts in the vicinity of a feeding station is approximately 50%, although we stress that this is a preliminary estimate and that more investigation is needed.

Table 2. Comparison of day vs. night point counts. Duplicate point counts are not shown. Where available, caretaker estimates for the total colony size associated with feeding stations (i.e. points) are given. The final column is a detectability estimate for the point counts, with the numerator being an average of the day counts and night counts, and the denominator being the caretaker estimate. We did not generate a separate detectability for day point counts and night point counts since they did not produce a systematically different result.

Point	Day Count	Night Count	Ratio Day/Night	Caretaker Estimate	Ratio Survey/Caretaker
Airport	10	9	1.11	-	-
Alahama	4	0	-	-	-
Costco	16	9	1.78	-	-
Dairy Road 1	10	6	1.67	24	0.33
Dairy Road 2	8	11	0.72	27	0.35

Point	Day Count	Night Count	Ratio Day/Night	Caretaker Estimate	Ratio Survey/Caretaker
Home Depot	14	12	1.17	10	1.30
Iao 3	19	16	1.19	-	-
Iao 4-5	14	8	1.75	-	-
K0	38	38	1.00	75	0.51
K1	6	13	0.46	40	0.24
K2	12	11	1.09	33	0.35
K3	24	13	1.84	25	0.7
K4	9	13	0.69	30	0.37
Kiffman/Bounty	34	32	1.06	-	-
Mean	**15.57**	**13.64**	**1.19**		**0.51**

Sterilization Rates

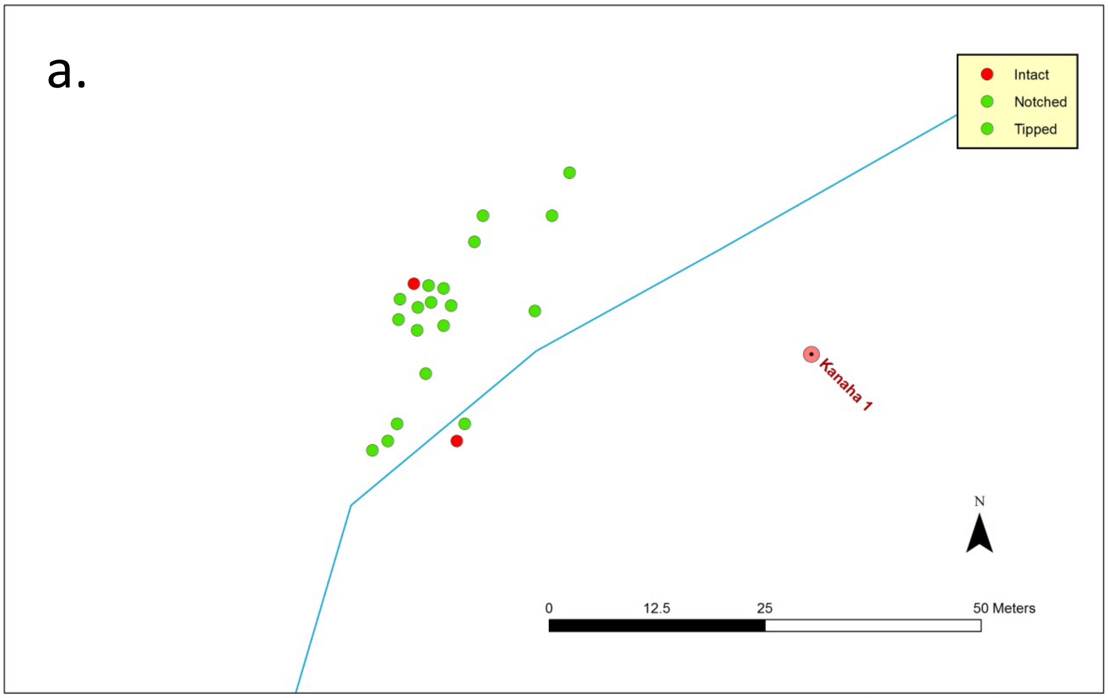
Data were sufficient to generate sterilization rate estimates on five transects, which are shown in Table 3. These estimates varied considerably among transects, as would be expected given that TNR efforts have been concentrated in the Iao and Kanaha areas.

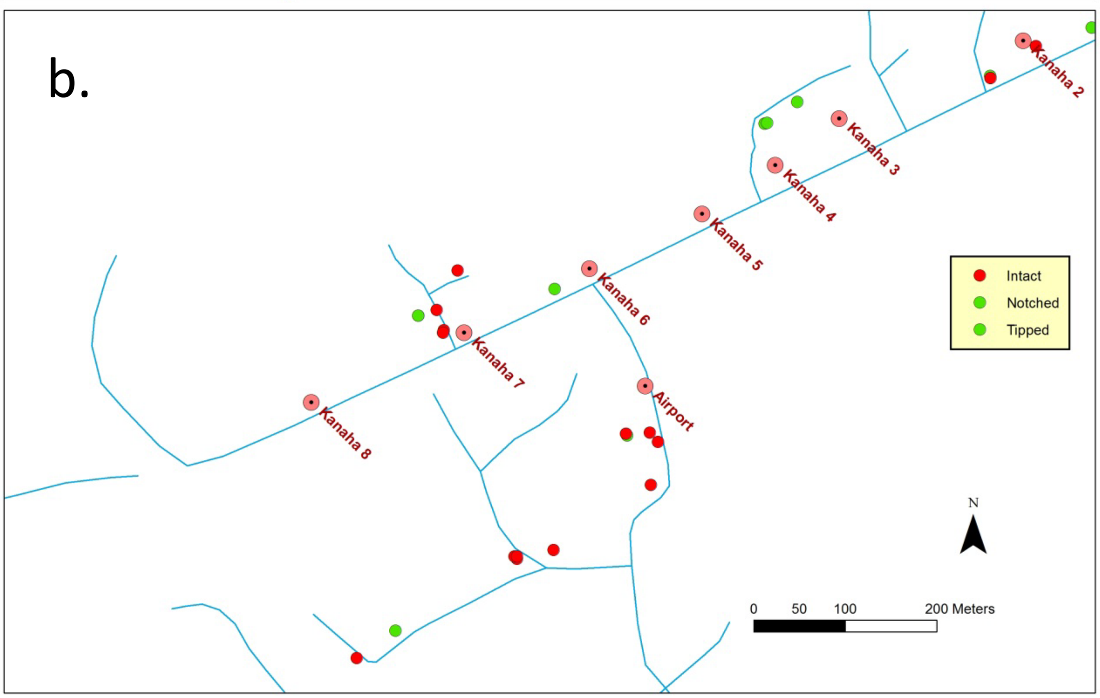
Table 3. Estimated sterilization rate (number of tipped or notched cats / number of cats for which ear marking status could be determined) for transects with sufficient data.

Transect	Est. Sterilization Rate
Airport	0.18
Dairy Road	0.43
Lower Kanaha	0.64
Upper Kanaha	0.8
Iao	0.67

Sterilization status of individual cats in the Kanaha Beach Park area (covered by the Upper Kanaha and Lower Kanaha transects) is illustrated in Figure 13a-b. There is a discernible contrast between the upper (eastern) part of the park – where the TNR effort has been pursued vigorously – with the lower (western) end of the park where caretaker conflicts have interfered to some extent with cat trapping efforts. Our own survey effort in the lower Kanaha area was conducted with circumspection to avoid potential conflicts, and the time spent attempting to determine ear marking status in this area was comparatively abbreviated. Had this not been the case, we suspect that the contrast between Figures 13a and 13b would appear more pronounced.

Figures 13a-b. Patterns of sterilization based on ear marking status in two portions of Kanaha Beach Park; the vicinity of the Kanaha 1 feeding station (a) in the upper portion, and the area of conflict (b) in the lower portion. Figure 13b shows several known feeding stations (Kanaha 5 – 8) that were not sampled during this project to avoid conflicts.





Good estimates of sterilization rates were obtained at most of the points, where the 45 minute daytime observation period allowed ample opportunity to determine ear mark status. Three points had insufficient data to generate a reliable estimate (K1, Alahama, Dairy Road 2), but results for the other 11 points are given in Table 4. Estimated sterilization rates within these managed colonies tended to be high (> 60%), with the exception of the Airport and K3 points. Estimates of sterilization rates provided by caretakers were provided by four of the colonies, and these estimates tended to agree fairly closely with the estimates derived from the point counts (Table 4).

Table 4. Estimated sterilization rate (number of tipped or notched cats / number of cats for which ear marking status could be determined) for managed colonies associated with 11 survey points.

Point	Est. Sterilization Rate – Determined by Point Count	Est. Sterilization Rate – Provided by Caretaker
Airport	0.30	-
K0	0.76	0.87
K2	0.67	0.91
K3	0.44	-
K4	0.67	0.93
Kiffman/Bounty	0.78	-
Home Depot	0.91	-
Costco	0.85	-
Dairy Road 1	0.83	0.75
Iao 3	0.94	-
Iao 4-5	1.00	-

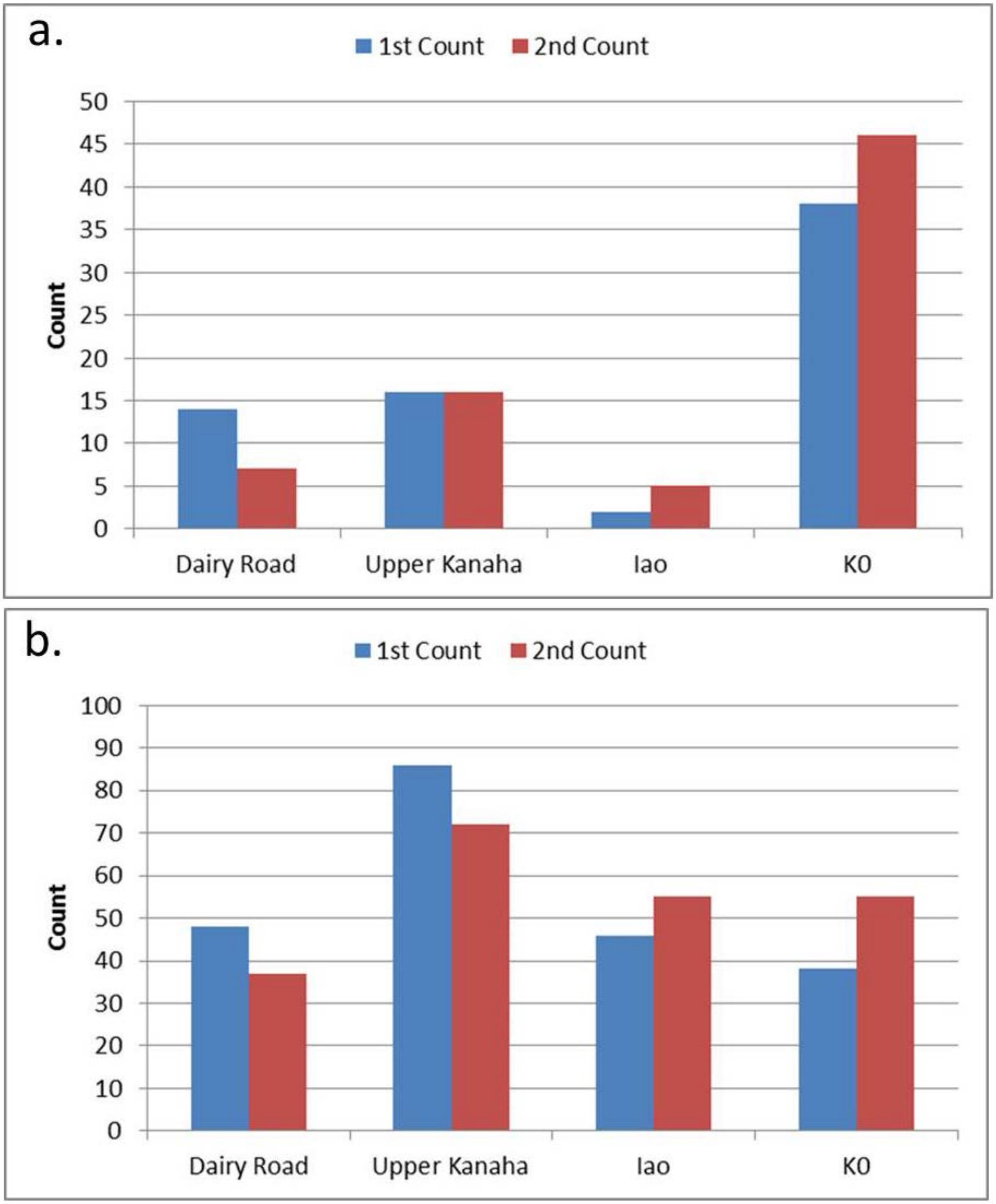
Repeatability

Information collected on repeatability of survey results was limited, but relatively encouraging. As depicted in Figure 14, deviations between 1^{st} and 2^{nd} counts were typically moderate relative to the average number of cats counted.

Spatial Distribution of Cats

Cats within the surveyed areas showed a strong tendency to cluster in proximity to feeding stations, as previously seen in Figures 8 and 9. This is illustrated more clearly in Figure 15, which indicates a majority of cats were observed within 150 m of a known feeding station. This pattern of cat distribution was not an artifact of transect layout; Figure 16 shows the expected distribution of cats in relation to feeding stations had they been randomly distributed along the

Figure 14a-b. Repeatability of transect counts and point counts for three transects (Dairy Road, Upper Kanaha, and Iao) and one point (Kanaha 0 = K0) that received duplicate counts, in daytime (a) and nighttime (b).



transects. Actual (observed) cat distribution clearly differed from this random distribution. We further note that the actual affinity for feeding stations may be underestimated in Figures 15 and 16, which do not account for informal or unknown feeding stations that were not factored into the analysis.

Figure 15. Histogram of the spatial distribution of all cats detected on transect counts as a function of distance to nearest feeding station.

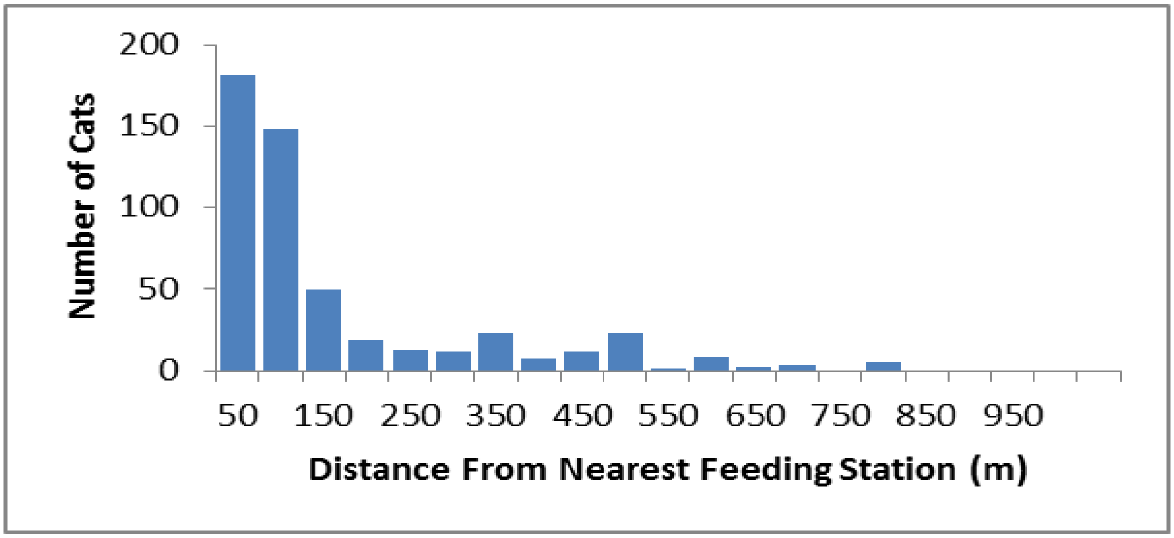
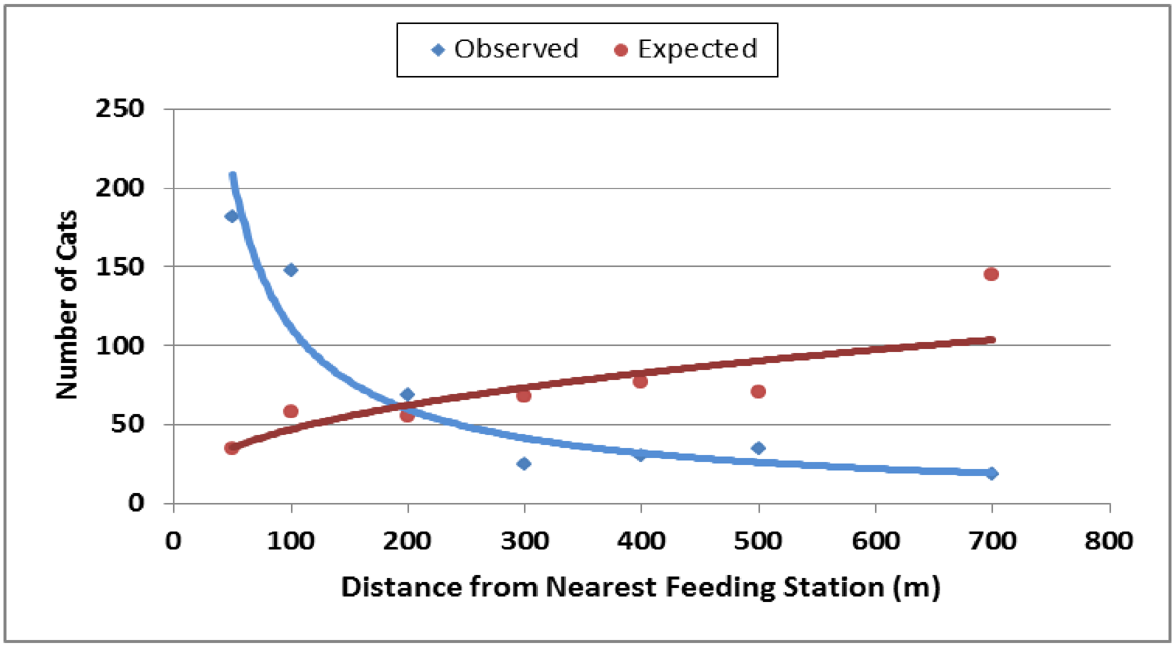


Figure 16. Actual (observed) distribution of cats along transects compared to random (expected) distribution.



Transects that did not lie in close proximity feeding stations (S. Fence, N. Fence, South Airport, Wharf) generally had few cat detections. The Alahama transect was an apparent exception to this pattern, with a moderately high number of cat detections despite the absence of known feeding stations. However, in the course of conducting the transect count, we discovered that smaller-scale and more informal feeding activity was quite common in this area. A similar phenomenon was also observed along the more northerly portion of the Dairy Road transect. Figure 17 documents some of the informal feeding stations in these areas.

Figure 17. Two informal feedings stations along the Diary Road (top) and Alamaha (bottom) transects.

Detectability and Population Size Estimates

The survey points used in this project were located at known feeding stations where atypically large concentrations of cats were present. For that reason, results from these points cannot be legitimately extrapolated to surrounding areas for the purpose of estimating total population size. Therefore, we focus in this section on data from transects, which sampled a more extensive and representative portion of the landscape within the focal areas. As discussed previously, determining detectability and generating population size estimates was not a primary goal for this project, but we can still make some preliminary calculations. Detectability estimates are possible for the Upper Kanaha transect and a portion of the Dairy Road transect that lies in close proximity to two know feeding stations (Figure 6). For both of these transect segments, it seemed reasonable to assume that all or nearly all of the cats present in the surveyed areas were members of the K0 – K4 colonies or the Dairy Road 1-2 colonies, respectively. Good caretaker estimates of colony size were available for all of these colonies, allowing a comparison between transect counts and presumed total population size in the surveyed areas, as shown in Table 5. Based on these two transects, detectability for the nighttime transect count method is estimated at 0.39, which (if accurate) is amply sufficient to generate reliable population size estimates. Daytime detectability, as expected, was much lower. The Discussion section (below) elaborates upon some caveats associated with these provisional estimates.

Table 5. Calculation of provisional detectabilities for the daytime and nighttime transect count method, based on two transects with sufficient data as described above.

Transect	Daytime Count *	Nighttime Count*	Cumulative Caretaker Est.	Daytime Detectability	Nighttime Detectability
Upper Kanaha	16	79	203	0.08	0.39
Dairy Road**	6	20	51	0.12	0.39
Mean				**0.10**	**0.39**

** Values shown are the mean of the original and duplicate survey for each transect.*
*** Only the more southerly segment of this transect that followed dirt roads and tracks near the two known feeding stations was used for this calculation. Results from the remainder of the transect that followed hard-surfaced roads are omitted because of the absence of feeding stations in this area.*

Valid population size estimates can be made only for the area from which samples are drawn - in this case, the two project focal areas. However, as discussed previously, non-random sampling in the Kanaha / Kahului focal area suggests that we adopt a cautionary attitude towards population size estimation at this point. Compensating for non-random sampling to some extent is the large proportion of the focal areas that were physically encompassed by the survey transects. With these issues in mind, and using the approach described in the “Data Processing and Analysis” section, we estimate a total outdoor cat population of 1,000 – 1,100 in the Kanaha / Kahului focal area. This estimate is the sum of separate estimates for the Kanaha Beach Park area and the adjoining sections of northeastern Kahului and the Kahului Airport. In Iao Valley State Park, we estimate a population of 110 – 125 cats within the surveyed area. This does not include any cats that may live primary away from the road system in the valley, as this area was not sampled.

Because the Kanaha / Kahului focal area did not include all of Kahului, we cannot formally extrapolate to generate a city-wide population size estimate. However, for illustrative and exploratory purposes we could assume that the portion of Kahului lying outside of the focal area is comparable to the sampled portion of Kahului with respect to cats, which would result in a population size estimate for all of the Kahului / Kanaha area of 1,900 – 2,050 outdoor cats. Given Kahului's human population of 26,337 according to the most recent census data, this translates to an approximate ratio of 7.50 outdoor cats per 100 people. Extrapolating these results from Kahului throughout all of Maui cannot be justified in even an exploratory fashion, since the degree to which Kahului is representative of other populated parts of the island is completely conjectural at this point.

In terms of cat density, these estimates equate to:

1) 740 cats/km^2 in Kanaha Beach County Park
2) 180 cats/km^2 in the sampled portion of Kahului (excluding Kanaha Beach County Park).
3) 260 cats/km^2 in the combined Kanaha / Kahului focal area.

This falls within previously observed ranges for urbanized areas, though the density in Kanaha Beach County Park is at the high end of this range (Liberg et al. 2000, Baker et al. 2008). Density was not calculated for Iao Valley, since it is difficult to define the surface area that was effectively sampled.

The estimates given in this section do not include pet cats that are kept exclusively or primarily indoors, so the ratio of all cats to people will invariably be higher. It should be understood and reiterated that all preliminary estimates given above are subject to revision as additional data accrue and detectability estimates are refined.

DISCUSSION

<u>Survey Methodology</u>

One of the primary goals of this project was to field test and compare survey methods, and to develop a standardized protocol for future work. In most respects, nighttime transect counts using spotlights performed well. They can be implemented reliably by volunteers or technicians with proper training and supervision, and produce versatile and repeatable data. Detectability appears to be good, and eye shine from cats can be seen at substantial distances under good viewing conditions (Figure 18). However, determining ear marking status at night can present challenges, although these can be reduced by using binoculars in conjunction with spotlights and allowing sufficient time for making observations. The effective range of detection does tend to vary within and among transects, depending on the types of buildings, structures, and vegetation that are present, introducing a potential source of uncontrolled variability. The most practical approach to this issue is to determine detectabilities for each of several common survey settings, as discussed below, and to ensure that survey designs are sufficiently replicated.

Our survey points were intentionally located at known feeding station locations, and they therefore did not comprise a representative sample of the broader landscape. For this reason, they were not used as a direct basis for extrapolation. The number of cats present at a point during the count also seemed to be strongly influenced by feeding schedule, which was not controlled for in our study design. However, point counts were useful in several respects. Daytime point counts offered an opportunity to observe cats for an extended period and determine ear marking status for many individuals. In addition, point counts that are positioned at feeding stations provide an opportunity to cross-check the colony size estimates and sterilization estimates that are provided by caretakers. As an alternative to placing survey points at feeding stations, it would be possible to select survey points that randomly sample a broader landscape, but we suspect that in most situations, this approach would generate less data per unit effort than transect-based surveys.

Given our results and observations, we suggest using nighttime transect counts as the primary method to sample large landscapes and monitor population trends, supplemented by other survey methods to provide specific kinds of information. If supplemental survey methods are employed thoughtfully and efficiently, the resulting data sets and analyses will ultimately be more robust and informative than if the primary method is used exclusively. Potential uses of supplemental methods (including camera trapping and other techniques that were not utilized in this project) are summarized in Table 6.

Table 6. Supplemental survey and study methods and their potential applications.

Supplemental Survey Method	Uses
Feeding station point counts (day or night)	Estimating sterilization rates.
	Mark-recapture estimates if used in conjunction with TNR clinic records.
	QC / QA assessment of caretaker estimates.
Caretaker colony size estimates	If obtained from a reliable source, these provide a mechanism for making detectability estimate for transect surveys. With a proper data collection framework and protocol, caretakers can also provide useful data on immigration and abandonment rates, and demographic attributes such as lifespan and age structure.

Camera trapping	Over time, a camera trapping survey can provide a thorough count (inventory) of cats in a given area, particularly if camera stations are "baited" with objects of interest. This provides a direct basis for estimating detectability for transect surveys. Camera trapping can also potentially provide data on immigration and abandonment rates and home range.
Telemetry and observational studies	Provide data on movement patterns, home range,

There is good potential for developing a standardized data-gathering approach for outdoor cats that works in synergy with existing TNR and colony caretaking efforts, as summarized in Table 6. With proper training and vetting, colony caretakers are a potential source of detailed information that would be very difficult and expensive to gather in any other fashion. Incorporating caretakers as citizen scientists into larger-scale and longer-term monitoring efforts also provides a pathway for broader stakeholder participation in the management enterprise.

Figure 18. Eye shine from a cat a during a nighttime point count.

Sterilization Patterns

In the areas that have been the focus of intensive TNR efforts to date – Kanaha Beach Park and Iao Valley State Park - sterilization rates as of December 2013 were relatively high. Sterilization rates in neighboring areas tended to be lower, as expected. Even within the Kanaha Beach Park area, however, there appeared to be some spatial variation in sterilization rates, as previously described (Figure 13). More specifically, the “territory” informally claimed by a homeless couple along the Lower Kanaha transect appears to have higher proportion of unsterilized cats than neighboring areas, and an unusually high number of kittens were also observed. Efforts to trap and sterilize cats in this immediate area have been met with resistance, and unconfirmed reports suggest that importation of cats may also be occurring here. It therefore seems possible that this portion of Kanaha Beach Park is acting as a source of reproductively capable cats that can dilute or reverse the progress made in neighboring areas and undermine the potential for achieving population reduction in Kanaha.

Outside Recruitment

Immigration, abandonment, and importation of cats into the focal areas (i.e. “outside recruitment”) are matters of significant management concern. Simulation modeling studies (Anderson et al. 2004, Budke and Slater 2009, Miller et al. *in press*) suggest that if sterilization rates of 60% - 70% can be maintained consistently within a focal population, there should be some reduction in the size of that population over a course of several years. However, the same models also indicate that even modest levels of population recruitment from outside the focal population can counteract this effect. The potential impact of outside recruitment can be reduced by carefully choosing how we delineate our focal populations. As an example, a focal population that is embedded within a larger, functionally connected population is likely to experience much higher levels of outside recruitment than a focal population that is partly or completely isolated from neighboring populations. For these reasons, gathering information about outside recruitment rates may be of critical importance for interpreting the patterns of population change that occur (or fail to occur) in managed focal areas.

Spatial Structure of Cat Distribution and Use of Sensitive Areas

Within our two focal areas, cats were strongly clustered in the vicinity of well-established feeding stations and more diffuse networks of informal feeding stations. Several transects traversed areas that were far from any known feeding stations, and sightings of cats in these areas were relatively unusual (Figures 8 and 9). This spatial affinity for food sources is in some respects fortuitous with regard to minimizing cat-wildlife conflicts, and indeed, we observed only one cat around the margin of the Kanaha Pond State Wildlife Sanctuary despite its close proximity to the large outdoor cat population in Kanaha Beach Park. However, feeding stations are not automatically a positive force in cat management. Provision of food *ad libitum* increases the carrying capacity of an area, and can result in population growth if there are dispersing cats in the vicinity. People might also be encouraged to abandon cats in the vicinity of visually apparent feeding stations, rationalizing that they will be adequately provisioned and “cared for”. Ideally, feeding stations should not be established or maintained close to areas of potential conservation concern, and where they do exist, they should be moved away from the area of concern in an incremental fashion, if possible. In principle, unlimited food should not be provided, but the amount of food should be tailored to basic needs of the resident cats, and should decline if and when the population of resident cats declines. However, it is difficult or impossible to achieve adherence to this standard when cat management is a diffuse and relatively unstructured enterprise. It may be possible, however, to approach these standards within the framework of larger, integrated management programs.

Detectability and Population Size Estimates

Population size estimates are of great interest to many stakeholders in the “cat debates”, but they need to be approached cautiously and with a realistic understanding of the potential sources of estimation error. It should also be clearly understood that population trends can be effectively monitored without attempting to estimate population size, and that this approach is entirely appropriate and reasonable in many situations. The uncorrected transect counts obtained during this project can (and should) be used for as a baseline “index count” that will be the first in a series of ongoing index counts. That said, we recognize that there are important reasons why population size estimates are of value in management planning, and have therefore begun to address this goal.

When animals cannot be completely enumerated (as is normally the case), it is necessary to use a sampling approach. Counts that are obtained from these sample sites can then be corrected for detectability and project to unsurveyed areas to produce a population size estimate. In this project, detectability was estimated for two transects in a relatively natural setting. We could not make a reasonable estimate of detectability for any transects that were located in the more urban portions of the focal areas, and it is possible that detectability could have been substantially different in these areas. Therefore, detectabilities and population size estimates presented in this report are limited and provisional, and may be revised as more information is gathered to characterize detectability in different settings.

Improving our estimates of detectability can be pursued using a combination of approaches, including:

1) Gathering more estimates of colony size in surveyed areas from vetted and reliable caretakers.

2) Conducting camera trap inventories of selected colonies or study areas. A very limited amount of exploratory camera trapping work was conducted as part of this project, and results suggested that this technique could be useful on Maui if properly implemented.
3) Obtaining mark-recapture population size estimates by combining TNR clinic data with survey data. This technique is subject to the usual assumptions of underlying mark-recapture methods, and will further require that: a) some demographic assumptions about survival rates be invoked, and b) improvements be made in current TNR clinic data standards, specifically to provide greater locational specificity (see below).
4) Exploration of so-called "distance" methods to estimate local population size (Thomas et al. 2013). These are analytical methods developed by wildlife biologists that may be of use for cat surveys.

Once the detectabilities associated with transect counts reasonably-well determined, it will be feasible to sample larger areas (including the entirely island of Maui) with sufficient coverage and replication to generate a valid population size estimate, if desired.

RECOMMENDATIONS

Recommended Survey Protocols

As discussed above, we recommend nighttime transect counts as a basic survey method, using the protocol described herein, to be supplemented with other survey methods as opportunity and circumstance permit. Even in the absence of supplemental surveys, transect counts provide a valid and fully adequate index for monitoring population change. Consistent monitoring of this type is needed in the current Baker Trust program area to determine if high sterilization rates are being successfully maintained, and to assess whether or not a population-level response is being achieved. Minimally, a four transect routes (Upper and Lower Kanaha, Airport, and Dairy Road) should be resurveyed at least once (preferably twice) per year within fixed date ranges. We suggested establishing December as the primary annual survey period to maintain consistency with the baseline effort, and June as a second annual survey period if resources permit. Data collected during these surveys should be analyzed in a timely way so that they can constructively inform the current program.

If it is determined to pursue a cat management program for a geographically larger focal area (see below), the same standardized survey and monitoring protocols can be used. A baseline survey should be planned and executed prior to initiation of the management plan, and with a larger focal area, greater attention must be given to choosing transects that sample the target population in an unbiased and representative manner. The management plan should specify a detailed monitoring schedule and protocol, and identify all mechanisms and resources needed to actually implement the monitoring plan. Supplemental surveys will serve in important function in any larger and higher-profile management effort, and provision should be made for devoting some resources to their implementation.

Recommendations for the Current Program

Based on the data and observations obtained during this project, we can offer several recommendations of relevance to the ongoing Kanaha – Iao management programs funded by the Baker Trust. These include:

1) *Monitoring*: Formalize a monitoring plan, as described in the previous section.
2) *Data Management*: Adaptive management requires integrated and accessible data. This has been previously recognized, and funding was made available to broaden and enhance the data management framework for feral cats and colonies that was previously developed by the Feline Foundation of Maui. Recommendations for specific enhancements to this data framework were made during our initial Maui site visit in September, 2013, and these recommendations need to be implemented. Additionally, steps should be taken to encourage the widest possible use of this data repository by all cat trappers and clinics operating in the two focal areas, to retroactively enter accumulated data into the new data system, and to encourage the systematic recording of locational information for cats that are trapped, sterilized, and returned.
3) *Accessibility*: Steps should be taken to make all of Kanaha Beach Park fully accessible for cat trapping, and to discourage active importation of cats into the park. As of December 2013, these problems had not been adequately addressed.
4) *Mobilizing trapping effort*: As of December 2013, MHS had performed fewer grant-subsidized surgeries for the two focal areas than originally projected due largely to difficulties in mobilizing sufficient trapping effort. Steps have been taken to attempt to address these concerns, including an expansion of the original focal area into part of Kahului, but obtaining a sufficient number of unsterilized cats to meet surgery goals is still a functional bottleneck that needs to be better addressed. More generally, we note that obtaining unsterilized cats will typically become more difficult as sterilization rates in the target population increase, and management plans need to account for this reality, as discussed in the next section.

Recommendations for a Broader Management Program

It is our hope and intention that the lessons learned in this project will lead to a larger-scale program of data-driven cat management on Maui. Below, we present prerequisites and recommendations for developing such a program. These include:

1) Identify and delineate focal management population(s). Unless the entire island is targeted, these should be chosen to minimize the likely rate of outside recruitment into the population. Identify quantitative population goals and demographic goals, and identify reasonable timelines for achieving these goals. Make a detailed assessment of the resources that will be required to achieve these goals.
2) Prepare a plan to promote and build support for the management initiative.
3) Conduct a baseline survey for the focal population(s). Minimally, this survey must be adequate for trend monitoring, which will require the random selection of transects within a stratified framework. Determine whether population size estimation will also be a survey goal, and make planning allowances as needed if this goal is adopted.
4) Identify critical information needs, which may include better estimation of survey detectabilities and better understanding of immigration rates.
5) Prior to initiating management efforts, develop a management plan that includes provisions for data gathering, monitoring, and periodic data analysis.
6) Strongly consider conducting a “human dimension” survey program that addresses human attitudes and practices as they relate to cats.
7) Develop a plan for periodically disseminating findings to maintain stakeholder interest and cooperation, and to foster public and municipal support.
8) Begin to generate an inventory of cat caretakers and cat colonies in the focal area(s) (the Feral Foundation of Maui database may be a helpful starting point). A longer term goal is to make this inventory as complete as possible, but it is understood that initially, some caretakers will be reluctant to share information.
9) Develop a simple protocol to promote the collection of standardize and informative data by caretakers. Recruit caretakers for participation in this data collection effort.
10) Promote the widest possible adherence to data sharing (through the Feral Foundation of Maui database) and adherence to uniform data standards.
11) Formalize and disseminate a set of principles for effective and responsible colony caretaking and management, and promote the adoption of these principles by all collaborators and stakeholders.
12) Actively build corps of to assist with surveying and develop mechanisms to train these volunteers.
13) As soon as possible, experiment with camera trapping as in inventory method that can generate a reliable detectability estimates. Camera trapping may also be useful for conducting index counts in certain rural or natural areas.
14) Investigate options to address the reduced return on trapping efforts as sterilization rates rise. Ensure that adequate provision is made for the required amount of trapping effort to meet program goals.
15) Prepare and implement a concurrent public education program to discourage abandonment and encourage sterilization and responsible cat stewardship.

16) Ensure that the administrative structures and individuals responsible for each critical step are identified.

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APPENDIX 1: Data sheets used for feeding station point counts (first page) and transect counts (second page).

FEEDING STATION DATA SHEET – MAUI CAT STUDY – GREATER KANAHA AREA

Feeding Station Name: ________ Date:______________ Observers:_____________________

Start Time Indvd Tally: _______ Stop Time For Indvd Tally: __________ Page ____ of _____

Cat #	Mark	Age	Description (color, fur length, distinguishing marks)

Mark: T=tipped, N=notched, I=Intact, U (or blank)=unknown
Age: A=Adult, J=Juvenile (~ 2 – 6 mo), K=Kitten

TOTAL SPOTLIGHT (NIGHTTIME) COUNT (6:00 – 6:15 pm) (enter on last page only): __________

TRANSECT DATA SHEET – MAUI CAT STUDY – GREATER KANAHA AREA

Transect Name: ____________ Date:________________ Observers:_____________________

Day __ Night __ Start Time: ____________ Stop Time: ____________ Page ____ of ___

Cat #	Waypoint #	Mark	Distance	Direction	Location	Comment

Mark: T=tipped, N=notched, I=Intact, U (or blank)=unknown

Distance: Estimate of distance from waypoint to cat to the nearest 10 feet

Direction: Use the 12 o'clock system, with direction of transect route as 12.

Location: Use only within UK and LK transects. K=Kanaha Park land, A=Airport land

APPENDIX 2: Dates and surveyors for each point count (first table) and transect count (second table). Also shown is whether a given point count or transect count was considered to be the "main" count or a "duplicate" count, as described in the "Study Design and Methods" section. For all point counts and transect counts except for those noted with an asterisk, the daytime count and the nighttime count occurred on the same date. Therefore, each line in the following tables is indicative of the completion of two counts; daytime and nighttime. Surveyor codes are as follows: JB = John Boone, KC = Kelly Colegrove, CY = Carolyn Ytredal, DC = Deb Clarke, DI = Donya Izbicki, ESA = Erin Avallone , Jaime = Jaime Fitzpatrick, JD = Jennifer Drout, LP = Laurie Pottish, MC = Melissa Colegrove, Ronald = Ronald Shishido, T = Terri Shishido, and Veni = Veni Villarimo.

Feeding Station Point	Date	Surveyors	Main or Duplicate
K3	12/13/2013	KC / CY	Main
K4	12/13/2013	JB / TI	Main
K0	12/14/2013	KC / Veni	Main
K1	12/14/2013	JB / DC	Main
Airport	12/15/2013	KC / JD	Main
K2	12/15/2013	JB / DC	Main
Kiffman / Bounty	12/16/2013	KC / Ronald	Main
Dairy Road 1	12/16/2013	JB / T	Main
K0	12/17/2013	KC / ESA	Duplicate
Alahama	12/17/2013	JB / DC	Main
Costco	12/18/2013	KC / LP	Main
Dairy Road 2	12/18/2013	JB	Main
Home Depot	12/19/2013	KC / Jaime	Main
I3	12/20/2013	KC / DC	Main
I4/I5	12/21/2013	KC / MC	Main

Transect	Date	Surveyors	Main or Duplicate
Lower Kanaha	12/13/2013 and 12/14/2013*	JB / DI / DC	Main
Upper Kanaha	12/13/2013 and 12/14/2013*	KC / CY / Veni	Main
N. Fence	12/14/2013	JB / DC	Main
Airport	12/15/2013	KC / JD	Main
Dairy Road	12/15/2013	JB / DC	Main
Wharf	12/16/2013	KC / Ronald	Main
S. Fence	12/16/2013	JB / T	Main
Upper Kanaha	12/17/2013	KC / ESA	Duplicate
Alamaha	12/17/2013	JB / DC	Main
South Airport	12/18/2013	KC / LP	Main
Dairy Road	12/18/2013	JB	Duplicate
Wakea	12/19/2013	KC	Main
Iao	12/20/2013	KC / DC	Main
Iao	12/21/2013	KC / MC	Duplicate

* *Nighttime count initiated on first date and completed on second date, due to expiration of spotlight batteries on the first night. Daytime count conducted on the first date.*

Bryan Kortis, Esq.
National Programs Director
Neighborhood Cats
May 19, 2020

How many cats on the Island of Maui?

Introduction

The most accurate estimate of Maui's cat population would require extensive and costly research. Random representative locations throughout the island would have to be surveyed, using a variety of proven counting techniques, such as transect walks, camera traps, daytime and nighttime counts from fixed points, etc. Sophisticated statistical analysis would then be required to support legitimate extrapolations from surveyed sites to other similar areas of the island. Given the variety of Maui's landscape, it's likely the number of locations needing to be surveyed would be relatively high.

Absent such research, it is still possible to get a general sense of the size of the cat population by making use of existing research and tools. While this amounts to an educated guess, not a conclusive finding, it does provide valuable insight into what the numbers may be.

Discussion

For purposes of estimating cat numbers, it's useful to divide cats into three categories: (1) owned or pet cats, (2) free-roaming, unowned cats in populated areas and (3) free-roaming, unowned cats in unpopulated areas.

(1) Pet cats

Pet cats can be estimated by using the calculator tool developed by the American Veterinary Medical Association which is based on national data on pet ownership. According to the AVMA, the number of pet cats in a community is calculated by multiplying the number of households by 0.457.[1] For the island of Maui, that comes to 23,371 pet cats.[2]

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[1] https://www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics

[2] Calculated as follows: In 2018, there were 54,274 households in Maui County, including the islands of Maui, Lanai and Molokai. (https://www.census.gov/quickfacts/mauicountyhawaii). Subtracting households on Lanai (1,140) and Molokai (1,995) leaves 51,139 households on the island of Maui. See https://www.census.gov/quickfacts/mauicountyhawaii and https://www.point2homes.com/US/Neighborhood/HI/Molokai-Demographics.html) Multiplying 51,139 by 0.457 results in 23,371 pet cats on the island of Maui.

(2) Free-roaming, unowned cats in populated areas

Free-roaming cat density in populated areas is generally much higher than in unpopulated, natural locations.[3] This is likely due to more readily available food sources in locations where people reside and work. As a result, cat numbers in inhabited areas must be estimated differently than in wilderness or uninhabited regions.

Cat-counting studies have been conducted, among others, in the Kanaha Pond area of downtown Kahului, a Florida county and a city in Ontario.

(a) Kanaha Pond

In December of 2013, Dr. John Boone, PhD, worked with The Humane Society of the United States and Maui Humane Society to conduct a count of free-roaming cats around Kanaha Pond. The study area included part of downtown Kahului, Kanaha Pond, Kanaha Beach Park and part of the Kahului Airport. Dr. Boone concluded there were 1,000 to 1,100 cats in the study area. By assuming the same cat density was present throughout Kahului (pop. 26,000), Dr. Boone estimated 1,900 to 2,050 cats total in the city, equaling approximately 76 cats per 1,000 residents.[4]

(b) Alachua County, Florida

Alachua County, Florida, includes the city of Gainesville. The research conducted there in 2003 The Florida study found 12% of households were feeding a mean of 3.6 unowned, free-roaming cats. The authors noted their findings were similar to earlier research that had found 10% of households fed a mean of 3.4 cats (San Diego County, CA), 9% of households fed a mean of 2.6 cats (Santa Clara County, CA) and 8% of households fed 3.7 cats (Massachusetts).[5]

(c) Guelph, Ontario

A population survey of the city of Guelph, Ontario (pop. 120,000) estimated a population of 7,662 cats, or 64 free-roaming cats per 1,000 residents.[6]

As noted, the island of Maui has approximately 51,139 households. Estimated population is

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[3] See http://www.nespthreatenedspecies.edu.au/news/how-many-cats

[4] Boone, J., *Baseline Surveys for Outdoor Cats in Kanaha Beach Park, Kahului, and Iao Valley State Park, Maui December 2013*, 2014, Project Report for The Humane Society of the United States and Maui Humane Society, pp. 30-31.

[5] Levy, J., et al, *Number of free-roaming cats in a college community in the southern United States and characteristics of community residents who feed them,* 2003, Journal of the American Veterinary Medical Association, Vol. 223, No. 2, pp. 202-205.

[6] Flockhart, D.T.T. et al, *Predicting free-roaming cat population densities in urban areas*, 2016, Animal Conservation, doi:10.1111/acv.12264

157,000 residents.[7] If the findings of the three aforementioned cat-counting studies are extrapolated,[8] the number of free-roaming, unowned cats in populated areas on the island of Maui is 10,048 based on the Guelph study,[9] 11,932 based on the Kanaha Pond survey,[10] and 22,092 based on the Alachua County research.[11] Taken together, the research suggests free-roaming, unowned cats in populated areas of Maui number somewhere from 10,048 to 22,092.

(3) Free-roaming, unowned cats in unpopulated areas

The island of Maui is 727 square miles (1,883 square kilometers). The vast majority of the land mass is uninhabited and contains few if any human-based food sources, including the West Maui Mountains, the slopes and summit of Haleakala, the former sugar cane fields and more.

Globally, wildlife biologists have conducted numerous surveys of feral cat populations in wilderness and other natural locations. A recent review of over 100 studies on cat density concluded there are an average of .27 feral cats per square kilometer throughout the wild areas of the Australian continent.[12] If Maui's unpopulated areas have a similar cat density, that would equal approximately 508 total cats in those regions.[13]

Marion Island is an uninhabited island in the southern Indian Ocean. Before undertaking a campaign to eradicate all cats on the island, an effort that lasted 18 years, conservationists calculated there were between 1,849 to 2,429 feral cats present throughout the island's 290 square kilometers.[14] This equaled a cat density of 6.4 to 8.4 cats per square kilometer. Extrapolating that density to Maui leads to an estimate of 12,051 to 15,817 feral cats in unpopulated areas.[15]

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[7] Based on total population of about 167,000 in Maui County minus populations of Molokai (5,779) and Lanai (3,102). See fn 2 and https://mauinow.com/2018/04/09/report-maui-population-continues-to-increase-as-honolulus-declines/

[8] The extrapolations are conjectural because inhabited areas on Maui differ from each other in important respects and from the study areas in the research. The numbers are helpful, however, in estimating a possible population range.

[9] 64 cats per 1,000 residents when there are 157,000 residents equals 10,048 unowned, free-roaming cats.

[10] 76 cats per 1,000 residents when there are 157,000 residents equals 11,932 unowned, free-roaming cats.

[11] 12 percent of 51,139 households = 6,136.68 households. 6,136.68 x 3.6 cats fed by each household = 22,092 unowned, free-roaming cats.

[12] Legge, S. et al, *Enumerating a continental-scale threat: How many feral cats are in Australia?* 2017, Biological Conservation, Vol. 206, pp. 293-303; https://doi.org/10.1016/j.biocon.2016.11.032

[13] 1,883 square kilometers multiplied by .27 feral cats equals 508 cats. This is a slight overestimation as it includes inhabited areas of Maui where cats are being counted separately.

[14] Bester, M.N. et al, *A review of the successful eradication of feral cats from sub-Antarctic Marion Island, Southern Indian Ocean,* 2002, South African Journal of Wildlife Research, Vol. 32, No. 1, pp. 65-73.

[15] 1,883 square kilometers multiplied by 6.4 feral cats equals 12,051; multiplied by 8.4 feral cats equals 15,817. This is a slight overestimation as it includes inhabited areas of Maui where cats are being counted separately.

In a semi-rural park in New Zealand, researchers found between 1.06 to 1.19 feral cats per square kilometer.[16] Applied to Maui's total land mass, that equals between 1,995 to 2,241 cats in uninhabited areas.[17]

Taken together, this research on free-roaming, unowned cats in unpopulated regions suggests a total on Maui in this category of somewhere from 508 to 15,817.

Summary

Estimates for the three different groups of cats for Maui are: (1) 23,371 pet cats, (2) 10,048 to 22,092 unowned, free-roaming cats in populated areas, and (3) 508 to 15,817 unowned, free-roaming cats in uninhabited areas. Added all together, this equals an estimated range of 33,927 to 61,920 cats on the island of Maui.

The true numbers may vary. However, this estimated range is based on the best available research and data and indicates the population of cats on Maui is in the tens of thousands. There is no credible basis for concluding the actual number is significantly higher and in the magnitude of hundreds of thousands.

Dr. Duvall's estimate of 300,000 to 400,000 has no scientific basis

During his testimony on March 10, 2020, to the Healthy Families and Communities Committee of the Maui County Council, Dr. Fern Duvall estimated there are between 300,000 to 400,000 cats on the island. He articulated two bases for this range. First, he claimed these were the figures arrived at by the Humane Society of the United States as part of the cat-counting research conducted around Kanaha Pond, referred to earlier in this paper. Second, he multiplied the cat density found around Kanaha Pond by the entire acreage of the island. Both bases are clearly invalid.

The findings produced by the Kanaha Pond research did not include any island-wide estimates. Dr. Boone, the author of the project report, only went as far as making an educated guess on the total free-roaming, unowned cat population in the city of Kahului.[18] Nowhere in the project report is there any mention of a possible 300,000 to 400,000 cats on Maui.

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[16] Hansen, C. et al, *Estimating feral cat (Felis catus) density in a rural to urban gradient using camera trapping*, 2018, New Zealand Journal of Zoology, Vol. 45, No. 3; https://doi.org/10.1080/03014223.2018.1494609

[17] 1.06 cats x 1,883 sq km = 1,995 cats; 1.19 cats x 1,883 sq km = 2,241 cats. Again, this is a slight overestimation as it includes inhabited areas of Maui where cats are being counted separately.

[18] Boone, J., *Baseline Surveys for Outdoor Cats in Kanaha Beach Park, Kahului, and Iao Valley State Park, Maui December 2013*, 2014, Project Report for The Humane Society of the United States and Maui Humane Society, pp. 30-31.

Dr. Duvall's extrapolation of cat density around Kanaha Pond to the entire island is arbitrary and misleading. As noted previously, it's well-established that cat density is considerably higher in populated areas compared to unpopulated regions. The study area around Kanaha Pond is dense and urban. Dr. Duvall's assumption the same relatively high cat density around the pond also exists in Maui's natural areas, which make up most of the island, is mistaken and results in an extreme overestimate of total cat numbers.