Human–Wildlife Interactions 8(1):56–66, Spring 2014

Identifying people's most preferred management technique for feral cats in Hawaii

Cheryl A. Lohr,[1] Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI 96822 USA *cheryl.lohr@gmail.com*
Christopher A. Lepczyk, Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI 96822, USA
Linda J. Cox, Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI 96822, USA

Abstract: Feral cats (*Felis catus*) are abundant in many parts of the world and pose a threat to native wildlife. Human–wildlife conflicts regarding how feral cats should be managed have increased recently. In Hawaii, previous research has revealed that most residents would like to see the feral cat abundance reduced, but opinions differ regarding which techniques are acceptable for achieving this. This paper describes an analytical hierarchy process that combines rankings of decision criteria by Hawaii's residents with expert knowledge of the costs and benefits associated with 7 techniques (live-capture and adoption, live-capture and lethal injection, live-capture and lethal gunshot, trap-neuter-release [TNR]), lethal traps, predator-proof fence, and sharpshooter) for reducing feral cat abundance. We used a state-wide survey with 1,369 respondents and in-person surveys with 11 wildlife professionals to gather data for the model. Inconsistency values were below 0.1 for data from both the state-wide survey and the survey of wildlife professionals. Sensitivity analysis revealed that the model was not sensitive to changes in the public's ranking of the decision criteria, because when data were averaged all decision criteria became equally important. The final ranking of the management techniques was dominated by the costs and benefits of each technique. Lethal traps were ranked as the best technique, and TNR was ranked as the worst technique.

Key words: analytical hierarchy process, expert knowledge, human–wildlife conflicts, multi-criteria decision making, structured decision making, trap-neuter-release, wildlife management

Feral cats are abundant in many parts of the world and pose a threat to native wildlife (Sims et al. 2008, Medina et al. 2011; Figure 1). As such, many wildlife managers seek to reduce the abundance of feral cats. However, cats also are one of the most popular pets in many countries, including the United States (American Pet Products Manufacturers Association 2009). Human–wildlife conflicts regarding feral cat management has increased in recent years (Longcore et al. 2009, Bird et al. 2010).

Successfully managing wildlife requires an ability to combine information on the biotic and abiotic environments, balance the desires of multiple stakeholder groups, and manage financial and human resources. In the past, wildlife managers have relied on their knowledge and experience to integrate all these aspects of complex decision making (Paterson et al. 2008). People are increasingly finding it hard to put their trust in the unspoken, unjustified, and intuitive thinking of their leaders on complex matters (Saaty 2008). People are demanding transparency and accountability in government decision making (Morrison-Saunders and Bailey 2000, Brown et al. 2001, Huettmann 2005).

Policy makers may strive to use public opinion as a guide for policy decisions (Green et al. 1997). In the United States, wildlife are a public resource (Freyfogle and Goble 2009), and, hence the public has influence over how wildlife are managed by voting for public representatives, petitioning legislators, and commenting on management proposals (Manfredo et al. 1999). However, few people actively express their opinion to policy makers, and policies may come to reflect the opinions of a minority group (McComas 2003). An estimate of broader public opinion may be obtained via surveys or polls (Manfredo et al. 1999). Unfortunately, public opinion polls rarely direct a respondent's attention to trade-offs among costs and benefits to second best possibilities and to any unexpected risks (Weissberg 2001)

[1]Present address: 80 Gulf Links Drive, Carramar, Western Australia 6031, Australia

Figure 1. Feral cats pose a threat to wildlife the world over. *(Photo courtesy E. VanderWerf)*

associated with a management alternative. Therefore, the results of opinion polls have limited value because the public is generally uninformed of the costs and benefits associated with a wildlife management technique.

The analytical hierarchy process is a decision-making framework that allows decision makers to break down complex decisions into a series of interacting and interdependent components, arrange those components into a hierarchical order, assign numerical values to subjective judgments on the relative importance of each component, and, finally, synthesize all of the information to rank alternatives (Saaty 2008). The analytic hierarchy process is a flexible system that may be used by a single decision maker to facilitate transparency in decision making. It can also be employed by a team of experts to balance biotic, abiotic, sociological, and fiscal inputs, or by a group of nonexperts to prioritize decision components using personal judgments or qualitative data. The analytic hierarchy process has been successfully applied to decision making in a diverse array of situations, including environmental impact statements, fire research, riparian vegetation policy, and wildlife management (Schmoldt and Peterson 2000, Ramanathan 2001, Herath and Prato 2006, Hurley et al. 2009).

In this study, we attempt to identify the best technique for managing feral cats in the Hawaiian Islands using both expert knowledge and the public's values and opinions. Feral cats have been common in the islands since at least the early 1800s (Twain 1866). Free-roaming cats are widely fed by people. The Hawaiian Humane Society (2012) promotes the use of trap-neuter-release (TNR) for managing free-roaming cats, despite evidence that cats prey upon endangered and endemic fauna (Smith et al. 2002, Bonnaud et al. 2011, Medina et al. 2011). Previous research revealed that most residents (85%) in Hawaii would like to see the abundance of free-roaming cats reduced (Lohr and Lebczyk, in press). When residents were asked to rank 7 management techniques (live capture and adoption, live capture and lethal injection, live capture and lethal gunshot, TNR, lethal traps, predator-proof fence, and sharpshooter), the results revealed that, on average, they approve of most of these techniques (Lohr and Lepczyk, in press). However, the results differed considerably among the various stakeholder groups. Animal welfare advocates for example, disapproved of live capture and lethal injection (the top ranked technique when all responses were pooled), live capture and lethal gunshot, lethal traps, and sharp shooters, and approved of trap-neuter-release. In contrast, conservation professionals disapproved of the use of TNRand approved of the other options (Lohr and Lepczyk, in press). We used the analytic hierarchy process to combine public opinion of several decision-making criteria with expert knowledge of the costs and benefits of various techniques to identify the best technique for managing feral cats in the Hawaiian Islands.

Methods

We met first with 4 wildlife managers and decision makers to build a decision hierarchy (Figure 2). During the meeting, we identified the 7 techniques (listed above) that may be employed in Hawaii to reduce feral cat abundance. We did not include techniques that are still being developed, such as immunocontraception (Courchamp and Cornell 2000; Gorman et al. 2002; Levy et al. 2004, 2005). The group also identified 7 decision criteria that illustrate many of the costs and benefits associated with each of the 7 management techniques (Figure 2). For example, if the goal of a management plan is to reduce feral

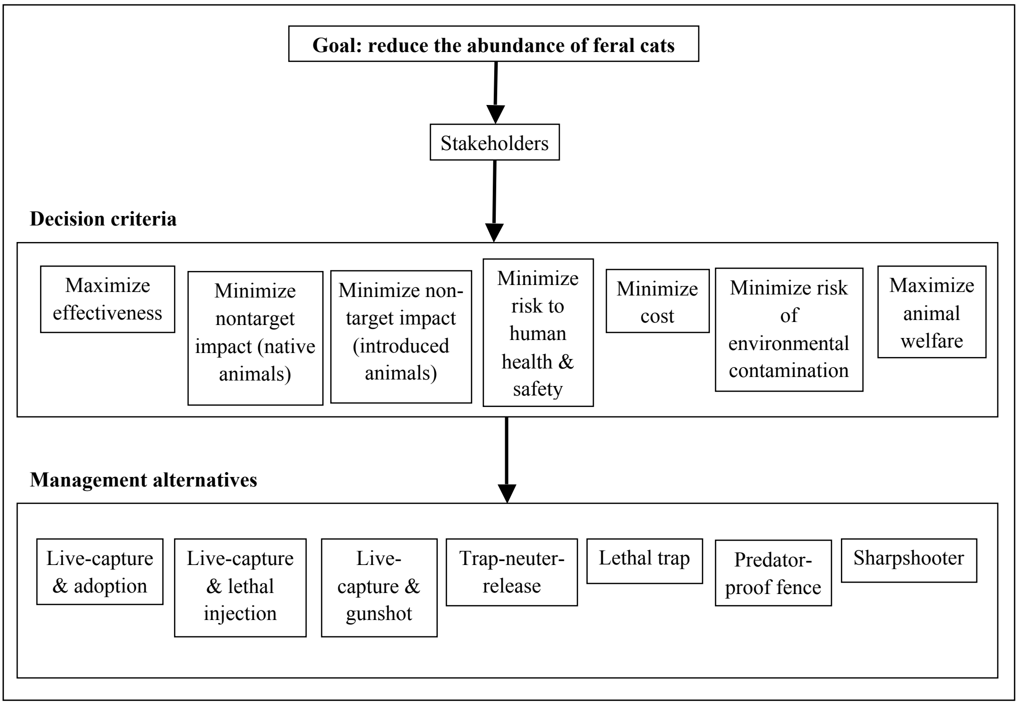

Figure 2. Decision hierarchy for ranking 7 feral cat management techniques and identifying the most preferred management techniques.

cat abundance, then an important decision criterion is how effective each technique is at achieving that goal. Similarly, decision makers need to determine how much it is likely to cost to implement each technique adequately to achieve the goal of the management plan. Because the decision criteria were to be compared using survey data, we minimized the number of criteria in the analytic hierarchy process. Respondent fatigue is a common problem during the implementation of long or complicated surveys and may undermine the quality of data collected (Dillman et al. 2009). The goal of the decision hierarchy was informed by previous research into the desires of the residents of Hawaii, in which 85% of survey respondents stated that they would like to see feral cat abundance decline (Lohr and Lepczyk, in press).

We administered a mail and Internet

Table 1. Question presented to recipients of the state-wide survey: "You have been given the task of changing the number of free-roaming cats in an area. How important to you are each of the following items when choosing a method to complete this task? Please use numbers 1 through 9 to express your opinion. You may use the same number more than once, (1 = extremely important; 5 = somewhat important; 9 = extremely unimportant)."

Decision critiera	Number
Native nontarget animals: possible harm to other native animals.	
Cost: amount of money required to implement the method.	
Introduced nontarget animals: possible harm to other introduced animals.	
Animal welfare: humane treatment of animals.	
Effectiveness: is the method likely to work?	
Environmental contamination: possibility of soil or water contamination.	
Human health and safety: could people be hurt by the method?	
Public opinion of the method: is it a positive or negative opinion?	

survey between July and September 2011 using the tailored design method with 3 mailings (Dillman et al. 2009). The survey was disseminated to 5,407 people from 6 pre-identified stakeholder groups that, in previous years, have been involved in cases of human–wildlife conflict in Hawaii (Hess et al. 2004, Koopman and Pitt 2007) as follows: hunters (1,650), conservation professionals (698), agriculturalists (373), animal welfare activists (277), native Hawaiians (i.e., members of a Hawaiian Civic Club; 49), and the general public (2,360). We identified survey recipients via direct solicitation, internet searches, and assessment of organization membership lists. We used a list of random Hawaii mailing addresses purchased from AccuData Integrated Marketing (Fort Myers, Fla.), stratified by zip code, to contact the general public. The survey was mailed to the general public and hunters because sufficient e-mail addresses were unobtainable, while other stakeholders received an electronic version of the survey via SurveyMonkey™. The sample size for hunters, and the general public was determined via a probability sampling formula (Dillman et al. 2009) and the total number of individuals within each group (i.e., human population per island or number of people who purchased a hunting license). Survey recipients were asked to state how important a series of decision criteria were when they were (hypothetically) given the task of changing the abundance of cats in an area (Table 1).

The survey response rate was calculated as the number of completed surveys divided by the initial number of surveys disseminated minus the number of undeliverable surveys. On average, 20% of the general public and 46% of the pre-identified stakeholders responded to the state-wide survey. Upon completion of the survey, we attempted to contact 5% of the nonrespondents via telephone to request participation in a short nonresponse survey. Partial responses to survey questions were eliminated from the final data set.

Finally, in August 2012, we conducted in-person surveys with 11 wildlife professionals having experience managing feral cats. The analytic hierarchy process typically requires the use of interactive software in conjunction with a meeting of professionals to make pair-wise comparisons between decision components. Analytic hierarchy process pair-wise comparisons may also be collected via survey questions (Saaty 2008). Unfortunately, the standard questionnaire created during analytic hierarchy process resulted in approximately

Table 2. Matrix-style questions used to collect expert knowledge from wildlife professionals with experience managing feral cats. Wildlife professionals were asked: "Please rank the following management techniques for feral cats in terms of which techniques may minimize the cost of managing feral cats." The other 6 questions asked wildlife professionals to state which techniques were likely to minimize environmental contamination, were most humane, would minimize risk to human health and safety, would be most effective at reducing feral cat abundance, would minimize harm to introduced fauna, and would minimize harm to native fauna. Variable that best met the criteria was given a 9.

	Very low cost		Low cost		Moderate cost		Expensive		Very expensive
Management technique	9	8	7	6	5	4	3	2	1
Live capture and adoption	○	○	○	○	○	○	○	○	○
Live capture and lethal injection	○	○	○	○	○	○	○	○	○
Live capture and gunshot	○	○	○	○	○	○	○	○	○
Trap-neuter-release	○	○	○	○	○	○	○	○	○
Lethal trap	○	○	○	○	○	○	○	○	○
Predator-proof fence	○	○	○	○	○	○	○	○	○
Sharpshooter	○	○	○	○	○	○	○	○	○

140 questions which, based on feedback during the decision hierarchy workshop, proved to be prohibitively long for wildlife professionals. Therefore, we created a survey with 7 matrix style questions that allowed the wildlife professionals to simultaneously compare all 7 management techniques in terms of each decision criteria (Table 2). The survey data were coded with numbers 1 through 9 with the technique that best meets the criteria given a 9 (Saaty 2008). We calculated the ratio that represented each pair-wise comparison as follows: let A_i, Aj, …An, be the set of management techniques. Comparisons between pairs of management techniques are represented by: $A = [a_{ij}]$, $i, j = 1\ 2 \ldots_n$. The entries a_{ij} are governed by the following rules: $a_{ij} > 0$, $a_{ji} = {}^1/_{aij}$, $a_{ii} = 1$ for all *i*. We then calculated the geometric mean of each ratio and entered the resulting value into a decision hierarchy built using SuperDecisions Software for Decision-Making (Creative Decisions Foundation 2012). We calculated the inconsistency index for each set of data (state-wide survey and in-person expert survey). The inconsistency index is a measure of how a given matrix of data compares to a random matrix, which would be created if survey respondents were selecting responses without comparing options. Inconsistency index values below 0.1 are considered acceptable (Saaty 2008). Larger values indicate a need to ask survey respondents to revise their judgments. We used the sensitivity analysis available in the SuperDecisions Software to test the stability of the final ranked order of management techniques (Chang et al. 2007). We also used Kruskal-Wallis, tests to assess variation among stakeholder groups regarding ranks assigned to each decision criterion.

Results

There were 1,369 responses to the state-wide survey, excluding partial responses. The nonresponse survey revealed that survey respondents and nonrespondents had similar interest in wildlife ($K = 0.98$, $P = 0.32$), education level ($K = 0.25$, $P = 0.62$), and average age ($K = 0.13$, $P = 0.72$). The average rank for five of the 7 decision criteria varied significantly among stakeholder groups (Table 3). The risk to human health and safety was considered neither important nor unimportant or slightly unimportant by all stakeholder groups ($K = 7.7$, $P = 0.17$), whereas the probability of environmental contamination was considered moderately important by all groups ($K = 4.1$, $P = 0.54$). Monetary cost ranged between 4.3 and 6 (5 = neither unimportant nor important); humaneness ranged between slightly and moderately important; impact on nontarget introduced species was slightly unimportant; whereas, impact on native nontarget species was moderately important, and effectiveness of the technique at reducing the abundance of feral cats was considered to be moderately to very important (Table 3).

The average rank applied by wildlife managers to each decision criterion for each management techniques illustrates the characteristics or costs and benefits associated with each technique (Table 4). Trap-neuter-release was considered the least and lethal traps the most effective techniques. Trap-neuter-release was also considered the most likely to cause environmental contamination, most likely to present a risk to human health and safety, most likely to negatively impact both native and introduced nontarget species, and the least humane. A predator-proof fence preventing immigration of cats into an area was considered the most humane, but the most expensive. Lethal traps were considered the least expensive. A sharp shooter was least likely to negatively impact either native or introduced nontarget species. The 3 techniques that involved live-capture and euthanasia received moderate scores of all 7 decision criteria (Table 4).

Inconsistency values were <0.1 for all of the stakeholder groups (Table 3). Therefore, the survey data were deemed acceptable for use in the analytic hierarchy process (Figure 2). Similarly, inconsistency values were <0.1 for responses to the in-person survey of wildlife professionals (Table 4).

Our analytic hierarchy process model ranked lethal traps as the best and TNR as the worst management techniques for achieving the goal of the analytic hierarchy process which was to reduce the abundance of feral cats. In contrast, lethal traps were ranked as the fourth best technique when survey respondents were asked to rank management techniques directly. Live capture and lethal injection was ranked as

Table 3: Means (SD) for each decision criterion for the 6 stakeholder groups. Data are from 1,369 respondents of the state-wide survey. 1 = extremely unimportant; 5 = neither unimportant nor important; 9 = extremely important. Kruskal-Wallis tests (K) was used to assess variation among stakeholder groups.

			Stakeholder group						
Decision criteria	K-statistic (5 df)	P-value	All respondents	Agriculture	Animal welfare	Conservation	Hawaiian	Hunter	Public
Inconsistency	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Risk to human health and safety	7.7	0.17	4.6 (2.9)	3.9 (2.9)	3.5 (2.9)	4.1 (2.7)	5.1 (3.1)	4.9 (2.9)	5.1 (2.8)
Impact on nontarget introduced fauna	128.9	<0.01	4.9 (2.8)	4.6 (2.7)	5.5 (2.7)	3.0 (2.9)	5.2 (3.0)	5.6 (2.6)	5.5 (2.5)
Humaneness	86.9	<0.01	5.3 (2.7)	5.2 (2.7)	7.4 (2.1)	5.1 (2.5)	6.5 (2.3)	4.9 (2.8)	5.7 (2.7)
Cost	28.5	<0.01	5.6 (2.4)	5.8 (2.3)	4.3 (2.6)	5.9 (2.3)	6.0 (2.7)	5.9 (2.4)	5.3 (2.5)
Impact on nontarget native fauna	25.7	<0.01	6.8 (2.3)	6.9 (2.0)	6.3 (2.5)	7.7 (1.7)	7.1 (2.4)	6.6 (2.4)	6.5 (2.4)
Probability of environmental contamination	4.1	0.54	6.8 (2.3)	6.9 (2.1)	6.6 (2.4)	7.3 (1.8)	7.3 (2.1)	6.7 (2.4)	6.6 (2.4)
Effectiveness	38.9	<0.01	7.3 (2.0)	7.7 (1.8)	7.9 (1.5)	8.0 (1.6)	8.6 (1.2)	7.1 (2.1)	6.9 (2.2)

the best technique by the public, whereas the analytic hierarchy process ranked it the fifth best technique. The rankings of the alternatives were identical for each of the 6 stakeholder groups (Table 5).

Sensitivity analysis revealed that the ultimate ranking of the management techniques was not sensitive to changes in rankings assigned to the decision criteria. The ratios that represent the pair-wise comparisons of management techniques in terms of each decision criteria ($0.1 \leq a_{ij} \leq 6.3$) were considerably more diverse than the ratios generated by comparing each of the decision criteria in terms of the goal of the model ($0.4 \leq a_{ij} \leq 2.7$). Limited variation in a_{ij} was an artifact of the diverse rankings applied by survey respondents to each of the decision criteria (Table 3), which forced the geometric mean to the center of the scale. Hence, changes in the public's priorities would have little influence on the selection of a management technique. When we experimentally doubled the range of the ratios (i.e., $0.4 \leq a_{ij} \leq 2.7$ increased to $0.2 \leq a_{ij} \leq 5.2$), the inconsistency index increased from 0 to 0.04, and the ranking of the alternatives varied among the stakeholder groups in accordance to the priorities of respondents within each group. This data manipulation confirms that when we averaged individual's rankings of the decision criteria, the decision criteria effectively became equally important, forcing the analytic hierarchy process to select the optimal management technique based on the costs and benefits of each technique.

Discussion

The analytic hierarchy process presented here ranked lethal traps as the best and TNR as the worst management techniques for achieving the goal of the model, reducing the abundance of feral cats (Table 5). Wildlife managers considered lethal traps the most effective, humane, and least expensive technique that was least likely to cause environmental contamination (Table 4). Lethal traps were the optimal alternative for most of the decision criteria.

Priorities vary among people, even within

Table 4. Mean (SD) for each feral cat management technique in terms of each decision criterion as assessed by 11 wildlife managers with experience reducing feral cat abundance in Hawaii. Ranked from 1 (least) to 9 (most).

		Management techniques						
Decision criteria	Inconsistency index	Live capture and adoption	Live capture and lethal injection	Live capture and lethal gunshot	Trap-neuter-release	Lethal trap	Predator-proof fence	Sharpshooter
Effectiveness	<0.01	3.1 (1.6)	5.7 (1.5)	6.3 (1.9)	1.0 (0.0)	8.2 (0.9)	4.7 (3.6)	5.4 (2.4)
Impact on nontarget native fauna	<0.01	6.9 (2.0)	3.0 (2.0)	3.0 (2.0)	8.7 (0.9)	4.7 (2.7)	1.8 (1.3)	1.6 (0.8)
Impact on nontarget introduced fauna	<0.01	6.4 (1.4)	3.1 (1.7)	3.1 (1.7)	7.9 (1.6)	6.9 (3.7)	3.7 (2.6)	1.5 (0.8)
Risk to human health and safety	<0.01	6.0 (2.4)	4.7 (2.4)	4.0 (2.2)	8.2 (1.9)	3.3 (2.5)	1.5 (1.2)	4.8 (2.6)
Cost	0.08	7.8 (1.2)	5.6 (1.1)	4.4 (1.7)	7.7 (1.6)	2.2 (1.2)	8.2 (1.6)	5.3 (2.4)
Probability of environmental contamination	<0.01	4.6 (2.4)	2.9 (1.2)	2.8 (1.3)	8.4 (1.7)	1.5 (0.8)	2.8 (1.4)	2.7 (1.6)
Humaneness	<0.01	6.1 (2.4)	5.9 (1.6)	6.6 (1.7)	2.1 (2.0)	6.8 (1.8)	7.9 (1.6)	6.1 (2.2)

a stakeholder group. None of the stakeholder groups included in this research and other studies using the analytic hierarchy process in Hawaii (Leung et al. 1998) appear to have a consistent set of priorities. In the event that the average ranking of priorities by the public effectively lists all decision criteria as equally important, then natural resource managers have little choice other than to rely on their own expert knowledge and accepted best practice regarding the costs and benefits of the available management techniques. Elected officials and natural resource managers are tasked with representing the interests of society during a decision-making process, which is difficult when people's values and opinions are diverse and rapidly changing. Management plans for natural resources are designed to guide management activities for several years and cannot easily reflect rapidly changing opinions. Other authors have noted that changes in policy rarely correlate with frequent item-specific opinion polls, but tend to track stable opinion changes on salient issues (Page and Shapiro 1983).

The analytic hierarchy process model described here illuminates 2 courses of action for natural resource management. Models exist that will aid managers in their attempts to incorporate stakeholder values into the decision-making process. Public surveys are a common and relatively cheap tool for collecting information on public opinion. However, surveys must be carefully designed with the analytical or modeling tool in mind. Inferences drawn from public surveys can be misleading if untrained personnel manage the design and analysis of survey data (Heberlein 2012). With an adequate and appropriately analyzed data set, resource managers can combine public values with expert knowledge to identify the most acceptable management technique.

Second, outreach materials generated by natural resource agencies rarely contain information on the costs and benefits of various management techniques (Department of Forestry and Wildlife 2012). The public cannot be expected to understand the decisions made by natural resource managers unless it is provided with information on the costs and benefits of the various management techniques. Marketing science and interactive media have developed tools, such as the comparison matrix, that improve the quality and efficiency of people's purchase decisions (Haubl and Trifts 2000). A comparison matrix allows consumers to quickly view the attributes of multiple products and, in some cases, sort alternatives by an attribute. Online shopping sites use simplified comparison matrices that allow consumers to compare products. Similar tools could be used to educate the public about various management techniques and allow stakeholders to identify the tool that best meets their priorities.

Table 5. Ultimate priorities and rank assigned to each of the 7 feral cat management techniques by each of the stakeholder groups when public priorities and expert knowledge are combined in the analytical hierarchy process. Results were the same for each stakeholder group.

Alternatives	Normalized priorities	Rank
Lethal trap	0.18	1
Predator-proof fence	0.17	2
Sharpshooter	0.17	3
Live capture and gunshot	0.17	4
Live capture and lethal injection	0.16	5
Live capture and adoption	0.10	6
Trap-neuter-release	0.05	7

Caveats need to be considered when interpreting the results of the analytic hierarchy process model. The question presented in Table 2 was a small part of a 46 question state-wide survey. Ranking items is an arduous task, and survey respondents are likely to become fatigued and put less thought into answering questions. Approximately 9% of survey respondents in this study assigned the same ranking to all of the items in Table 2 (i.e., all items equal 1). These respondents in particular may have been suffering survey fatigue. While removing these individuals from the dataset did not alter the results of the analytic hierarchy process model, we recommend using shorter surveys for future decision-making models that intend to combine public opinions with expert knowledge. Additionally, the analytic hierarchy process model outlined here does not reflect the pressure that special-interest groups can place on decision makers. Many animal welfare advocates, for example, would disagree with the results presented in Table 5, despite the fact that the average priority assigned to decision criteria by animal welfare advocates ranked lethal traps as the best management technique for reducing the abundance of feral cats. This suggests that values held by people in this group do not correlate with the advantages and disadvantages of their preferred technique. It would be beneficial if future research identified methods of defining stakeholder groups that reduce the variation among individuals within the group.

Management implications

Many people are unaware of the costs and benefits associated with various wildlife management techniques, and, therefore, people's values do not necessarily concur with their preferred technique. The opportunity to rank alternatives without consideration for the advantages and disadvantages of each option is the greatest weakness of polls that assess public policy (Weissberg 2001). The analytic hierarchy process model described here is a tool for combining public values and opinion with expert knowledge during the decision-making process. In this case, public opinion was so diverse that wildlife professionals ranked management techniques in accordance with the costs and benefits assigned to each technique. This analytic hierarchy process model ranked lethal traps as the best and TNR as the worst techniques for reducing the abundance of feral cats in Hawaii.

Acknowledgments

We thank all those individuals who contributed data for this research, especially the wildlife professionals who contributed their expert knowledge of the costs and benefits of each management technique. This project was partially supported by USDA National Institute of Food and Agriculture, Hatch project (HAW00110-H), and the Hawaii Department of Land and Natural Resources with funds going to C. Lepczyk. The funding sources were not involved in the collection, analysis, or interpretation of the data. The surveys were fully evaluated and approved by the University of Hawaii Committee on Human Subjects (CH #18144).

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Cheryl A. Lohr is a research scientist for the Hawaii Department of Parks and Wildlife, science division. She has a B.S. degee in animal science, an M.S. degree in natural and agricultural science from the University of Western Australia, and a Ph.D. degree in natural resources and environmental management from the University of Hawaii–Manoa. She has worked on several projects related to the management of introduced vertebrates, including baiting technologies, wildlife contraceptives, cost-benefit analyses of wildlife management practices, and human attitudes toward introduced animals. Currently, she is working on identifying efficient biosecurity actions for Western Australia's islands.

Christopher A. Lepczyk is an associateprofessor of ecosystem management in the Department of Natural Resources and Environmental Management and a cooperating faculty member in the Department of Biology and the Program in Ecology, Evolution, and Conservation Biology at the University of Hawaii–Manoa. He received a dual doctorate in fisheries and wildlife; and ecology, evolutionary biology, and behavior, from Michigan State University and conducted his post doctoral research at the University of Wisconsin–Madison. His research focuses on interdisciplinary questions related to people, landscapes, ecosystems, and animals, with a goal of improving conservation, management, and policy.

Linda J. Cox has served a community economic development specialist at the University of Hawaii for the past 30 years. In this position, she provides formal and informal instruction, while also engaging in applied research in sustainable development and natural resource management. She has published more than 230 journal articles, book chapters, fact sheets, newsletters, and other publications. She has also served as graduate program chairperson, department chair, and associate dean of extension.