HUMAN DIMENSIONS OF INTRODUCED TERRESTRIAL VERTEBRATES IN THE HAWAIIAN ISLANDS

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Abstract

The Hawaiian Archipelago is a remote, unique and fragile island system. There are at least 100 introduced terrestrial vertebrates with established wild populations in the Hawaiian Islands. The presence and impacts of introduced wildlife has caused several cases of human-wildlife conflict in the islands. The overarching goal of this dissertation is to understand the human dimensions of introduced terrestrial vertebrates in the Hawaiian Islands and to identify methods of managing these animals that optimize the priorities and values of the public, and the costs and benefits associated with managing wildlife. The three objectives of this research were to: identify stakeholders' future desired abundance for several species of introduced wildlife; identify the attitudes and beliefs that are influencing stakeholders' desired abundance for wildlife; and design models that may be used to identify optimal techniques for managing introduced wildlife. In 2011, I disseminated a state-wide survey to 5,407 residents of Hawaiʻi. Approximately, 20% of the general public, identified through a randomized mailing list, and 46% of pre-identified stakeholders responded to the survey. Results of a non-response telephone survey indicated that survey respondents did not differ significantly from non-respondents in terms of interest in wildlife, age, or education. Survey results for feral cats were unanticipated in that they revealed that the vast majority (~85%) of respondent's would like the abundance of feral cats to be reduced. These results are supplemented with research into two decision theory models (consensus convergence models and the analytical hierarchy process) that may be used to identify optimal management technique/s for reducing the abundance of feral cats. I also found that the desired abundance for game species (wild pigs, goats, mouflon, axis deer, wild turkeys, and zebra doves) varied among the six main Hawaiian Islands (Kauaʻi, Oʻahu, Molokaʻi, Maui, Lanaʻi, and Hawaiʻi) as did the explanatory variables for that desire. The results of this dissertation have considerable implications for the future management of introduced terrestrial vertebrates in the Hawaiian Islands and will aid the development of comprehensive management plans that are more acceptable to the people of Hawaiʻi.

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Chapter 1 Introduction

When, how and why were terrestrial vertebrates introduced to the Hawaiian Islands?

The Hawaiian Archipelago is the remotest set of islands on earth, supporting numerous endemic species and unique ecosystems. Notably, except for the Hawaiian hoary bat (*Lasiurus cinereus*) and Monk seals (*Monachus schauinslandi*), the islands supported no native mammals and no non-marine herpetofauna prior to human arrival (Ziegler 2002). Since human colonization people have introduced at least 18 mammal, 54 bird and 30 reptile and amphibian species that have successfully established wild populations in the Hawaiian Islands (Table 1.1; 1.2; 1.3; and 1.4). For the purposes of this research, introduced or non-native faunal species are defined as species that arrived in the Hawaiian Islands with the aid of humans, either intentionally or unintentionally.

The introduction of foreign fauna to Hawaiʻi began with the arrival of the Polynesians, who deliberately introduced Polynesian pigs (*Sus scrofa*), dogs (*Canis familiaris*) and red junglefowl (*Gallus gallus*), primarily as sources of food. Various species of geckos, such as the Stump-toed gecko (*Gehyra mutilata*), invertebrates, and the Polynesian rat (*Rattus exulans*) may have been stowaways on Polynesian canoes and hence inadvertently introduced to the Hawaiian Islands (Kirch 1985). Early European sailors, primarily Captain James Cook and Captain George Vancouver followed suit, introducing cattle (*Bos taurus*), sheep (*Ovis aries*), and goats (*Capra hircus*), as sources of fresh meat for future seafarers (Cook 1785; Kramer 1971). People have also introduced many other faunal species, such as: donkeys (*Equus asinus*) and rabbits (*Oryctolagus cuniculus*) as livestock; mouflon sheep (*Ovis musimon*), axis deer (*Axis axis*), quail (*Callipepla* spp.), doves (e.g. *Streptopelia chinensis*) and pheasants (e.g. *Lophura leucomelana*) as game species; cats (*Felis catus*), brush-tailed rock wallabies (*Petrogale pencillata*), chameleons (e.g., *Chamaeleo jacksonii xantholophus*), turtles (e.g. *Trachemys scripta elegans*), and parrots (e.g., *Psittacula krameri*) as pets; the small Indian mongoose (*Herpestes* *javanicus*) and cane toads (*Bufo marinus*) as biological control agents; and coqui frogs (*Eleutherodactylus coqui*) accidentally; among many others (Chung 1931; Schwartz & Schwartz 1950; Kramer 1971; Lewin & G. Lewin 1984; Tomich 1986; Pratt et al. 1987; McKeown 1996; Staples & Cowie 2001). While many of these species and their impacts on the natural ecosystems in Hawai‘i remain cryptic, other species cause damage to agricultural and economic interests, and the natural environment (Kepler 1967; Blackmore & Vitousek 2000; Natividad-Hodges & Nagata 2001; Hurley 2002; Gordon 2006; Koopman & Pitt 2007; Hess 2008; Hamilton 2009; Hess et al. 2009; Zaun & Weathers 2009; Choi 2011) which causes conflict among groups of people or wildlife stakeholders.

Table 1.1 Distribution of wild populations of amphibians that have been introduced to the main Hawaiian Islands.

Species	**Time of Initial Introduction/ Escape**	**Hawai‘i**	**Kaua‘i**	**Lana‘i**	**Maui**	**Moloka‘i**	**O‘ahu**
Common coqui (*Eleutherodactylus coqui*)	1990s	A			E		Ex?
Greenhouse frog (*Eleutherodactylus planirostris*)	1990s	E			E		E
Martinique robber frog (*Eleutherodactylus martinicensis*)	1990s				E		
Cane toad (*Bufo marinus*)	1932	E	E	E	E	E	A
Green and black poison-dart frog (*Dendrobates auratus*)	1932				E		E
Bullfrog (*Rana catesbiana*)	1880s	E	E	E	E	E	E
Wrinkled frog (*Rana rugosa*)	1896	E	E		E		E

Legend: A=abundant; E=Established localized populations; I=Invasive with currently spreading distribution; Ex=Extirpated.

Citations: (Evenhuis & Eldridge 2002; Sue & R. Pyle 2002; Ziegler 2002; President and Fellows of Harvard College 2012).

Table 1.2 Distribution of wild populations of terrestrial mammals that have been introduced to the main Hawaiian Islands.

Species	Time of Initial Introduction/ Escape	Hawaiʻi	Kauaʻi	Lanaʻi	Maui	Molokaʻi	Oʻahu
Brushtailed Rock Wallaby (*Petrogale penicillata*)	1916						E
European rabbit (*Oryctolagus cuniculus*)	Pre-1825				E		E?
Polynesian rat (*Rattus exulans*)	Polynesian	E	E	E	E	E	E
Norway rat (*Rattus norvegicus*)	Pre-1860	E	E	E	E	E	E
Black rat (*Rattus rattus*)	1870s	A	A	A	A	A	A
House mouse (*Mus musculus*)	Pre-1825	A	A	A	A	A	A
Feral dog (*Canis familiaris*)	Polynesian	E					
Small Indian mongoose (*Herpestes javanicus*)	1883	A	E?	E	A	E	A
House cat (*Felis catus*)	~1800	A	A	A	A	A	A
Horse (*Equus caballus*), Donkey (*Equus asinus*)	1803, 1825	Ex	Ex		Ex	E?	
Pig (*Sus scrofa*)	Polynesian	A	A		A	A	A
Axis deer (*Axis axis*)	1867	E		A	A	A	
Black-tailed deer (*Odocoileus hemionus*)	1961		I				
Feral cattle (*Bos taurus*)	1793	E					
Feral goat (*Capra hircus*)	1778	A	A		E	A	E
Feral sheep (*Ovis aries*)	1791	E					
Mouflon (*Ovis musimon*)	1954	E		A			
Guinea pig (Cavia porcellus)	<2008						Ex

Legend: A=abundant; E=Established localized populations; I=Invasive with currently spreading distribution; Ex=Extirpated.

Citations: (Kramer 1971; Tomich 1986; Ziegler 2002; Arakawa 2008).

Table 1.3 Distribution of wild populations of birds that have been introduced to the main Hawaiian Islands.

Species	Time of Initial Introduction/ Escape	Hawai'i	Kaua'i	Lana'i	Maui	Moloka'i	O'ahu
California quail (*Callipepla californica*)	1818	A	E		A	A	Ex
Gambel quail (*Callipepla gambelii*)	1928	E		E			
Chukar (*Alectoris chukar*)	1955	A	E	E	E	E	Ex
Gray francolin (*Francolinus pondicerianus*)	1958	A	E	A	A	A	A
Black francolin (*Francolinus francolinus*)	1959	A	E	E	A	A	E
Erkel francolin (*Francolinus erckelii*)	1957	E	E	E	E	E	E
Japanese quail (*Coturnix japonica*)	1866	A	E	E	E	A	E
Red jungle fowl (*Gallus gallus*); x feral chicken	Polynesian	A	E	E	E	E	E
Kalij pheasant (*Lophura leucomelanos*)	1962	A					E
Ring-necked pheasant (*Phasianus colchicus*)	1866	A	A	A	A	A	A
Common peafowl (*Pavo cristatus*)	1860s	A	E	Ex	E	Ex	A
Wild turkey (*Meleagris gallopavo*)	1788	A	E	A	E	A	E
Cattle egret (*Bubulcus ibis*)	1959	E	A	E	A	E	A
Chestnut-bellied sandgrouse (*Pterocles exustus*)	1961	A	Ex			Ex	
Rock pigeon (*Columba livia*)	1788	A	A	A	A	A	A
Spotted dove (*Streptopelia chinensis*)	1855	A	A	A	A	A	A
Zebra dove (*Geopelia striata*)	1922	A	A	A	A	A	A
Mourning dove (*Zenaida macroura*)	1929	A	E		E	E	E
Rose-ringed parakeet (*Psuttacula krameri*)	1930s	E	I		E		I
Mitred parakeet (*Aratinga mittrata*)	1986	E			E		E
Red-masked parakeet (*Aratinga erythrogenys*)	1987	E					E
Red-crowned parrot (*Amazona viridigenalis*)	1960s						E
Barn owl (*Tyto alba*)	1958	A	A	A	A	A	A
Mariana swiftlet (*Aerodramus bartschi*)	1962						E
Sky lark (*Alauda arvensis*)	1865	A	E	A	A	A	E
Red-vented bulbul (*Pycnonotus cafer*)	1965						A
Red-whiskered bulbul (*Pycnonotus jocosus*)	1960s						A
Japanese bush-warbler (*Cettia diphone*)	1929	I	I	E	E	A	I
White-rumped sharma (*Copsychus malabaricus*)	1931		E	E		E	A
Greater necklaced laughingthrush (*Garrulax pectoralis*)	1919		E				

Hwamei (*Garrulax canorus*)	<1900	E	E		E		E
Red-billed leiothrix (*Leiothrix lutea*)	1917	A	Ex		A	A	A
Japanese white-eye (*Zosterops japonicus*)	1929	A	A	A	A	A	A
Northern mockingbird (*Mimus polyglottos*)	1928	I	A	E	A	A	E
Common myna (*Acridotheres tristis*)	1866	A	A	A	A	A	A
Yellow-faced grassquit (*Tiaris olivaceus*)	<1974						E
Saffron finch (*Sicalis flaveola*)	1960s	A	I		Ex?		I
Red-crested cardinal (*Paroaria coronata*)	1928	E	I	A	E	A	I
Yellow-billed cardinal (*Paroaria capitata*)	1960s?	I					
Northern cardinal (*Cardinalis cardinalis*)	1929	A	A	A	A	A	A
Western meadowlark (*Sturnella neglecta*)	1928		E				
House finch (*Carpodacus mexicanus*)	1859	A	A	A	A	A	A
Yellow-fronted canary (*Serinus mozambicus*)	1960s	A					A
House sparrow (*Passer domesticus*)	1871	A	A	A	A	A	A
Red-cheeked cordonbleu (*Uraeginthus bengalus*)	1966	E					
Lavender waxbill (*Estrilda caerulescens*)	1965	E					E
Orange-cheeked waxbill (*Estrilda melpoda*)	1965				E		E
Black-rumped waxbill (*Estrilda troglodytes*)	1960s	E					Ex
Common waxbill (*Estrilda astrild*)	1973	E	E		E		I
Red avadavat (*Amandava amandava*)	<1910	E	I		Ex		E
African silverbill (*Lonchura cantans*)	1960s	A	E	E	A	A	E
Nutmeg manikin (*Lonchura punctulata*)	1866	A	A	A	A	A	A
Chestnut munia (*Lonchura atricapilla*)	<1959		E	E	E		E
Java sparrow (*Padda oryzivora*)	<1900	A	E	E	E	E	A

Legend: A=abundant; E=Established localized populations; I=Invasive with currently spreading distribution; Ex=Extirpated.

Citations: (Pyle & Pyle 2009a).

Table 1.4 Distribution of terrestrial or fresh-water reptiles that have been introduced to the main Hawaiian Islands.

	Species	Time of Initial Introduction/ Escape	Hawai'i	Kaua'i	Lana'i	Maui	Moloka'i	O'ahu
	Chinese softshell turtle (*Pelodiscus sinensis*)	1800s		E		E		E
	Wattle-necked softshell turtle (*Palea steindachneri*)	1800s		E				E
	Red-eared slider (*Trachemys scripta*)	1980s				E		E
	Green anole (*Anolis carolinensis*)	1950s	E	E	E	E	E	E
	Knight anole (*Anolis equestris*)	1980s						E
	Brown anole (*Anolis sagrei*)	1980s						E
	Jackson's chameleon (*Chamaeleo jacksonii*)	1972	E	E		E		E
	Veiled chameleon (*Chamaeleo calyptratus*)					Ex?		
	Mourning gecko (*Lepidodactylus lugubris*)	Polynesian?	E	E	E	E	E	E
	Stump-toed gecko (*Gehyra mutilata*)	Polynesian?	E	E	E	E	E	E
	Small tree gecko (*Hemiphyllodactylus typus*)	Polynesian?	E	E	E	E	E	E
Reptiles	Fox gecko (*Hemidactylus garnotii*)	Polynesian?	E	E		E	E	E
	Common house gecko (*Hemidactylus frenatus*)	1951	E	E	E	E	E	E
	Orange spotted day gecko (*Phelsuma guimbeaui*)	1940s						E
	Gold-dust day gecko (*Phelsuma laticauda*)	1974	E			E		E
	Giant day-gecko (*Phelsuma madagascariensis*)	<2001						E
	Tokay gecko (*Gecko gecko*)	1980s?						Ex
	Snake-eyed skink (*Cryptoblepharus poecilopleurus*)	Polynesian?	E	E	E	E	E	E
	Moth skink (*Lipinia noctua*)	Polynesian?	E	E		E	E	E
	Copper-tailed skink (*Emoia cyanura*)	Polynesian?		E				
	Azure-tailed skink (*Emoia impar*)	Polynesian?	Ex?	Ex?		Ex?	Ex?	Ex?
	Metallic/Garden skink (*Lampropholis delicata*)	1917	E	E	E	E	E	E
	Brahminy blind snake (*Rhamphotyphlops braminus*)	1930	E	E	E	E	E	E

Legend: A=abundant; E=Established localized populations; I=Invasive with currently spreading distribution; Ex=Extirpated.

Citations: (Conant 1996; McKeown 1996; Ziegler 2002; Sue & Pyle 2002; Evenhuis & Eldridge 2002; Evenhuis & Eldredge 2003; President and Fellows of Harvard College 2012).

Human-wildlife conflict in the Hawaiian Islands

Typically, in the eyes of the forester, the biologist, and the conservationist, introduced animals in Hawaiʻi are a destructive, nonnative, inharmonious element of an ecosystem (Baker & Reeser 1972). Hence, conservation organizations, such as the US Fish and Wildlife Service (USFWS) and The Nature Conservancy (TNC) actively try to mitigate, if not eliminate, the impact of some introduced species on their land (Mitchell et al. 2005; US Fish and Wildlife Service 2009). Other organizations such as the Hawaiʻi Department of Land and Natural Resources (DLNR) are subject to dual mandates that require they both mitigate the impacts of introduced species and promote recreational uses of the State's natural resources (e.g. hunting). This dual mandate has resulted in conflict within DLNR, decreasing their efficiency at fulfilling either task.

Not all stakeholders in Hawaiʻi agree with the actions of the environmental professionals. Some hunters for example do not support the control or eradication of game species. Hunting is a popular recreational activity in Hawaiʻi that has been passed down through multiple generations over the past two centuries (Bryan 1937; Diong 1982; Hills 1988). Pig hunting in particular is popular and the disparity in ideologies, and opinions between environmental professionals and hunters caused a case of human-wildlife conflict that required two years of facilitated public meetings to resolve (See Case study 1).

Native Hawaiians are not documented as hunters of any faunal species except possibly Polynesian rats (Malo 1951). Despite the lack of archaeological evidence, some native Hawaiians claim that pig hunting in particular is a cultural right (Hubrecht 2006). Others disagree, stating that Polynesian pigs were a livestock animal and rarely found in the mountainous regions of the islands (Tomich 1986), and hence, pig hunting is a contemporary recreational activity and not a cultural right.

Case study 1: Resolution of the Pig Wars

Summarized from (Josayma n.d.)

In the spring of 1992 conflict between pig hunters and managers of Hawai‘i’s Natural Area Reserve system (NARS) erupted over contradictory opinions on the impact feral pigs (*Sus scrofa*) have on the natural environment and the use of fencing and/or hunting to protect areas of relatively pristine forest. The NARS was established in 1970 with the stated purpose that:

> "the unique natural assets should be protected and preserved both for the enjoyment of future generations and to provide base lines against which changes which are being made in the environments of Hawai'i can be measured [and]… to preserve in perpetuity, specific land and water areas which support communities, … natural flora and fauna, as well as geological sites of Hawai'i.”

The site nomination process for NARS is open to both public and private interests. If a proposed site passes initial review by the Honolulu-based commission then a request for public comment on the proposal is announced. The governor of Hawai'i grants final approval for the site. The responsibility for managing the NARS was assigned to the Division of Forestry and Wildlife (DOFAW), within the DLNR.

The Pu‘u O‘ Umi NAR on Hawaii Island was established in 1987 (State of Hawai‘i 2012). In 1989 the Hawai'i Natural Heritage Program recommended to the DLNR that an aggressive control program for long-term reduction of pigs be started. In 1992, a group of pig hunters from Hamakua and Waimea were surprised and angered by the appearance of a new fence within the reserve. The fence had been authorized by the Hawai'i Branch NARS manager for the Big Island who had finally received state funds to build the fence to meet the reserve's management objectives. While the public was aware the area was a NAR, they were not notified that DOFAW planned to begin fencing in the area. The hunters felt that the establishment of this new fence line was a deliberate attempt to restrict access to their traditional hunting grounds and that the fence symbolized the communication divide between their interests and that of the DOFAW, as well as increased encroachment on the freedom of pig and people to move unrestricted upon the mountain. The hunters contacted the district state legislator and organized protests, some of which became violent (Adler 2001).

In May 1993, the Hawai'i State Legislature passed two resolutions: House Concurrent Resolution No. 183, ordered DOFAW to hold public information meetings regarding the land-use management objectives and activities in the Kohala Mountain and Waimanu Valley. House Concurrent Resolution No. 185, stated that DOFAW should accommodate the hunters' interests to better manage the pig populations in the Laupahoehoe NAR. To comply with the resolutions, DLNR contacted the Center for Alternative Dispute Resolution, requesting the services of a qualified facilitator. The facilitated public meetings created the Natural Areas Working Group which drafted a series of recommendations that may be summarized as: establish joint monitoring of the biotic and abiotic environment; expand public and private stewardship programs; establish a mechanism for information exchange between NARS managers and public; establish Regional Forest Management Advisory Councils; expand game management areas and hunters' involvement in resource management; create a position for an information-education coordinator.

This case of human-wildlife conflict was concluded in April 1995, when the State of Hawai'i House of Representatives passed Resolution No. 248, "Requesting the DLNR to continue and expand the Natural Areas Working Group Process on the Island of Hawai'i to facilitate greater communication with the hunting community and involve them more directly in resource monitoring programs and planning and management of game management areas." In addition, the resolution called for the establishment of a joint monitoring program for game counts, migration studies, and habitat and native species inventories.

Feral pigs are currently found on all of the main Hawaiian Islands except Lana`i and Kaho`olawe (Stone 1984; Tomich 1986). It is unlikely that Polynesian pigs (pua`a) dispersed widely into the forested ecosystems of Hawai`i prior to the arrival of westerners due to the scarcity of available protein in the forest (Diong 1982; Stone & Loope 1987; Anderson et al. 2007). The introduction of earth worms, a source of protein, plus fruiting plants such as strawberry guava (*Psidium cattleianum*), banana poka (*Passiflora mollissima*) and firebush (*Myrica faya*) may have enhanced pig dispersal into the forests of Hawai`i (Diong 1982;

Katahira et al. 1993). Pigs are highly adaptable and today occupy nearly every available habitat type from the tropical zone at sea level, to the sub-arctic on the high mountain slopes. Feral pigs reportedly reach their greatest densities in dense rainforests (124 pigs/km^2) and parkland-forest ranchlands (38 pig/km^2), which is well above the estimated carrying capacity (25-65 pigs/km^2) for these areas (Giffin & Kosaka 1973). Recent estimates of pig density on Mauna Kea were approximately 30 pigs/km^2 (Hess, et al. 2006).

Feral pigs have been shown to damage the natural environment in many different ways. Their rooting and feeding behavior destroys vegetation, leaving bare soil which is susceptible to increased rates of erosion and invasion by exotic plant species (Giffin & Kosaka 1973; Jacobi 1976; Diong 1982; Cuddihy 1984; Stone 1984; Aplet et al. 1991). Feral pigs spread and hasten the germination of propagules of invasive plants on their skin and through their faeces (Diong 1982; Stone 1986). Pigs may alter the structure and function of the natural ecosystem. For example, pig activity was linked to altered soil condition and decreased biomass and diversity of endemic micro-arthropods (Vtorov 1993). Feral pigs may serve as disease reservoirs. Brucellosis, which decreases reproductive success in swine, has a prevalence rate of 24% in Hawaiian feral pigs, is transmissible to both humans and domestic stock (Giffin 1978) and raises conflict as it decreases profits for swine producers (APHIS 2005). Similarly, feral pigs have transmitted bovine tuberculosis to domestic cattle on Moloka`i, resulting in the slaughter of approximately 6000 cows (Hills 1988). Feral pigs also aid the spread of avian malaria by creating pools of standing water through their feeding behavior, which provides a breeding ground for the mosquito vector *Culex quinquefasciatus* (Stone 1986). Feral pigs are also potential predators of ground nesting birds. However, no studies have conclusively confirmed pigs as predators that significantly impact any native bird species in Hawai`i.

Given the impacts that feral pigs are known to have on the natural environment many environmental professionals support the control or eradication of feral pigs from the Hawaiian Islands. Hunters are frequently in conflict with environmental professionals as they demand the continued presence of the large game animals in Hawai‘i for hunting recreation, subsistence and cultural reasons.

Axis deer cause similar types of human-wildlife conflict. Axis deer were first brought to the Hawaiian islands in 1867 by a Hawaiian consul from Hong Kong as a gift for King Kamehameha V (Kramer 1971; Tomich 1986). They were initially introduced to Moloka`i which was followed by Lanai in 1920, and Maui in 1959 to improve opportunities for hunting recreation (Tomich 1986). Axis deer negatively impact the Hawaiian Islands by consuming native vegetation (Kramer 1971) and dispersing invasive plants such as miconia (*Miconia calvescens*), guava (*Psidium sp.*) and koa haole (*Leucaena leucocephala*), as well as fire adapted grasses (Anderson 2003). Axis deer may increase the rate of soil erosion in some areas (Stone & Scott 1984) and pose a disease risk to people through their heavy use of watersheds whilst carrying common diseases such as leptospirosis and *E. coli* (Mungall & Sheffield 1994). Axis deer also cause a series of other problems when they interact with people such as deer-vehicle collisions; damage to crops; property damage to fences and golf courses; and competition with livestock for forage (Anderson 2003). Human-wildlife conflict surrounding axis deer in Hawaii involves at least three stakeholder groups (See Case Study 2).

Case study 2: Human-wildlife conflict and Maui axis deer

Summarized from (Subcommittee on Public Information and Deer Management Planning of Maui Axis Deer Group 2002)

Axis deer were first introduced to Maui on Kaomoulu Ranch, Puʻu O Kali in 1959. The largely unmanaged population of axis deer on Maui has grown exponentially since its introduction (Anderson 2003; Hamilton 2009) creating a number of human-wildlife conflicts including vehicle accidents, property damage, poaching, ecosystem damage, disease dissemination, and crop damage (Anderson 2003). A survey of ranchers, farmers, and island resorts in Maui Nui (Maui, Molokaʻi, and Lanaʻi) suggested that axis deer cause in excess of $2.2 million in damages in 2 years. Unreported agricultural losses are not included in this figure. Deer removal control measures (including exclusive fencing) during the same two years cost $1.07 million dollars, resulting in the removal of 3,431 deer (K. Yamamura, Maui County Agricultural Specialist, pers. comm.).

In April 1996, the Maui Axis Deer Group (MADG) formed with two goals: 1) develop axis deer control methods; 2) provide information and public education regarding axis deer and their impact. MADG secured funding for research acquiring baseline data on axis deer on Maui including a historical perspective on axis deer, population expansion, resource and community impacts, and methods of control (Anderson 2003). Following completion of the research MADG coordinated a series of public workshops to develop recommendations for the management of axis deer on Maui. Three of the workshops drafted a series of recommendations. A MADG-subcommittee was tasked with finding common ground among the workshops. In 2002 the MADG-subcommittee concluded that a comprehensive, island-wide plan would be the most effective and efficient way to address the negative impacts of axis deer on Maui, but that no MADG member had the time or capabilities to draft such a plan. It was recommended that DLNR hire a consultant to draft such a plan. A DLNR management plan specifically for axis deer is currently unavailable. The axis deer population has continued to expand on Maui since 2002. In 2011 the MADG reformed with the purpose of drafting a management plan to control (not eradicate) Maui's axis deer population. The draft plan, which includes using trained teams of hunters to cull deer herds (Parsons 2012), is scheduled to be ready by mid-2012 (Tanji 2012).

The human-wildlife conflict surrounding axis deer in Hawaii continues. In 2011 it was officially announced that private individuals had introduced axis deer from Maui Nui to Hawai‘i Island (Ward 2011). DLNR had attempted to introduce axis deer to Hawai‘i Island to improve hunting opportunities in the 1960s, but were successfully opposed by ranchers and farmers who feared severe agricultural damage (Anonymous 1964; Anonymous 1968; Anonymous 1969; Anonymous 1970; Benson 1972). In response to the unplanned introduction of axis deer on Hawai‘i Island, the Hawai‘i State Legislator has made it illegal to possess, release or transport inter-island wild or feral deer (SB3001). DLNR is coordinating an eradication program for axis deer on Hawai‘i Island (Ward 2012). Not all Hawaii Island residents support the eradication efforts (Smith 2012). Some hunters believe axis deer could supplement hunting opportunities. Axis deer are a source of human-wildlife conflict among environmental professionals, hunters, and agriculturalists.

Feral sheep and mouflon have been the source of one of the most heavily cited cases of human-wildlife conflict in Hawai‘i, the lawsuit palila v DLNR (See Case study 3). Feral sheep were first introduced to Hawai`i by Captain George Vancouver in 1793 (Kramer 1971). Mouflon (*Ovis musimon*) were introduced in the late 1950s to improve hunting recreation (Giffin 1979; Tomich 1986). Sheep, mouflon, and their hybrids became firmly established on the Island of Hawai`i, principally on Mauna Kea and Mauna Loa with a total population of approximately 30-40,000 sheep (Kosaka 1975; Tomich 1986; Hess et al. 2006). As with the other herbivores, sheep have damaged the native ecosystems of Hawai`i through grazing. Feral sheep show a preference for native plant species (Scowcroft & Giffin 1983), probably because native plants have fewer defenses against herbivory and hence are more palatable. Mouflon are both grazers and browsers (Giffin 1979). Feral sheep and mouflon gained the spotlight when their grazing was linked to the reduction in critical habitat, and hence, abundance of the endangered and endemic bird, the palila (*Loxioides bailleui*) (Scowcroft & Giffin 1983; US Fish and Wildlife Service 1986).

Case study 3: Palila v DLNR

Palila v DLNR is a case of environmental management agency in conflict with its own mandates, other environmental preservation groups, and hunters. In 1979, three non-profit organizations, the Sierra Club, the National Audubon Society, and Dr. Alan Ziegler joined forces to sue the Hawaiʻi DLNR on behalf of the palila (*Psittirostra bailleui*) (Durrett & Yuen 1982). The palila is an endangered and endemic bird of Hawaiʻi and sheep, mouflon, and goat populations were damaging critical habitat of the palila through browsing and grazing behavior. Feral sheep suppress the regeneration of māmane (*Sophora chrysophylla*) forest on Mauna Kea, and were pushing the upper boundary of the māmane habitat, and hence the range of the palila, to lower altitudes on the mountain (Scowcroft & Giffin 1983; Stone & Scott 1984). Since the palila requires the māmane habitat (US Fish and Wildlife Service 1986) and may be susceptible to avian malaria and avian pox (van Riper III et al. 1982), which is more prevalent at lower altitudes, the sheep severely increased the extinction risk for this species (Hess et al. 2006). The plaintiffs argued that under Section 9 of the Endangered Species Act (1973) the DLNR are 'taking' palila by maintaining population of ungulates in the palila's critical habitat on the slopes of Mauna Kea. In 1979 the courts ruled in favor of the plaintiffs and DLNR was ordered to remove feral sheep and goats from the area (United States District Court District of Hawaiʻi 1979). In 1985 the courts added that mouflon should also be removed from the area (United States District Court District of Hawaiʻi 1985). In 1988 these decision were affirmed by the US Court of Appeals, Ninth Circuit (Ninth Circuit United States Court of Appeals 1988).

The vast majority of the sheep were removed by 1982. Efforts to control ungulates on Mauna Kea resulted in some improvement in the critical māmane habitat (US Fish and Wildlife Service 1986). Unfortunately, mouflon, sheep and goats are still present in the area and palila numbers have not recovered. In 2011 DLNR initiated the funding and construction of an 18 mile fence on Mauna Kea to prevent ungulate from entering or damaging palila critical habitat (Hawaiʻi Department of Land and Natural Resources 2011).

DLNR has a dual mandate to both provide hunting opportunities and to protect native species and other natural resources. Game species that directly threaten natural resources, as is the case with palila and feral ungulates, are a difficult source of conflict for DLNR to manage. This conflict is well illustrated by the fact that DLNR was both the plaintiff and the defendant in the 1988 hearing in the US Court of Appeals, Ninth Circuit (Ninth Circuit United States Court of Appeals 1988). Fencing to exclude introduced animals, especially game animals, is not popular with hunters in Hawaiʻi. Many hunters view fencing for conservation as an attempt to exclude local people from public land, and natural resources.

Both hunters and environmental professionals frequently disagree with animal rights and/or welfare activists, who can be defined as people actively working toward increasing the rights and/or welfare of animals. Animal rights activists frequently oppose any form of wildlife management, especially lethal control of animals (Decker & Brown 1987), as they place equal value on individuals of both common, invasive, and endangered species (Hutchins 2007). Unfortunately, in many cases, lethal management techniques are still the most logistically feasible methods of managing vertebrates (Ramsey 2005; Merrill et al. 2006). Thus, even if animal welfare activists agree that introduced animals pose a threat to an ecosystem, the management options that they support are limited.

These examples are some of the more common conflicts aroused by wildlife management. Conflict also occurs between other groups of stakeholders including: agricultural producers and advocates of an agricultural pest; and hikers and hunters (i.e. when pet dogs come into conflict with hunting dogs on hiking trails). Conflict will arise whenever a species or its management is of benefit to one group of stakeholders, while another group pays an associated cost (Stokes et al. 2006) (See Case Study 4). Human-wildlife conflict escalates when people feel that the needs or values of wildlife or other people are given priority over their own needs. If wildlife professionals fail to address human-wildlife conflict then people may turn to legal and legislative processes to over-turn their decisions (Manfredo & Zinn 1996; Teel et al. 2002). Eventually, conservation initiatives suffer, the economic and social well-being of people is impaired, and support for conservation declines (Madden 2004).What is needed in such instances is a sociological approach to conflict resolution coupled with management options. The research outlined in this proposal aims to use society's values and preferences to identify goals and methods of wildlife management that may reduce stakeholder-wildlife conflict and stakeholder-stakeholder conflict over introduced wildlife. Less conflict may increase the efficiency of programs designed to protect the unique ecosystems of Hawai'i.

Case study 4: Nuisance peafowl euthanized

Peacocks illustrate how human-wildlife conflict can occur between any two groups of people and how almost any person can be considered a wildlife stakeholder. The removal of peacocks from various areas of Hawaiʻi has drawn protest from animal welfare/rights groups and members of the general public for years (Hoover 2005). In 2009 a 70 year old woman was charged with misdemeanor cruelty for bludgeoning a peacock to death outside her condominium (Daranciang 2011). The woman had grown frustrated by the incessant noise made by the peacocks and the association board's refusal to take action to reduce the number of birds. DLNR considers peafowl feral animals and does not require hunting permits to kill peafowl. To be guilty of misdemeanor cruelty prosecutors had to prove that there was no need for the woman to kill the bird. The woman was acquitted (Daranciang 2011).

In 2010 peacocks were a source of conflict between residents of Hawaiʻi Kai, the DLNR Department of Parks and Recreation, and the USDA Wildlife Services. The Department of Parks and Recreation has a Cooperative Service Agreement with the USDA to remove nuisance wildlife from public areas (Hamada 2010). The peacocks were reportedly killing rare plants in the Koko Crater Botanical garden, so they were euthanized. Hawaiʻi Kai residents questioned the need to kill the birds and submitted complaints against the removal program to the various authorities. As feral animals it is against the policies of DLNR to relocate peacocks (Watanabe 2012), which may cause peacocks to simply become someone else's problem.

Human dimensions of wildlife

Scientists and wildlife managers have known for some time now that wildlife management does not exist in a human-dimension vacuum [e.g. (Leopold 1933)]. In fact, managing natural resources is really about understanding and managing people as much as, if not more than, managing the resource. Wildlife in particular are owned by the public in the US (Freyfogle & Goble 2009), therefore the public has some influence over how wildlife are managed. As time has progressed, stakeholders across the U.S. have become increasingly frustrated at wildlife managers' failure to consider the values of stakeholders (Manfredo & Zinn 1996; Riley et al. 2002). The field of human dimensions of wildlife is an organized field of research that attempts to understand and clarify peoples' perspectives on wildlife management programs and issues in order to systematically incorporate them into decision making, replacing assumptions with knowledge (Decker & Enck 1996). A person cannot be expected to make a good decision without all of the relevant and available information. Similarly, elected officials and publically employed natural resource managers cannot make decisions that represent the interests of the public they serve without information on the desires, values and priorities of the public and various stakeholder groups.

Human dimensions studies use a wide variety of tools to gather and analyze data. For example, wildlife scientists frequently use survey questionnaires to assess peoples' perceptions of wildlife and associated management practices [e.g., (Bath & Buchanan 1989; Teel et al. 2002; Kaczensky 2004)]. Previous surveys of hunters' attitudes in Hawai‘i (Lum & Ohashi 1989; Hubrecht 2006), have not been published in the scientific literature, nor did they simultaneously examine the attitudes of multiple groups of wildlife stakeholders in Hawai‘i. In this dissertation I used a survey questionnaire sent to residents of the six main islands (Kaua‘i, O‘ahu, Moloka‘i, Maui, Lana‘i, and Hawai‘i) to gather data. The quality of this data was confirmed via a non-response telephone survey of 5% of people that did not respond to the state-wide survey. I used four tools to analyze the data: 1) wildlife stakeholder acceptance capacity models; 2) potential for conflict index; 3) consensus convergence models; 4) the analytical hierarchy process.

Wildlife stakeholder acceptance capacity models

Social theory pertaining to wildlife issues led to the development of the wildlife stakeholder acceptance capacity (WSAC) concept (Decker & Purdy 1988; Carpenter et al. 2000). WSAC is an estimate of the minimum and maximum abundance of a wildlife species that people will tolerate in a particular area. WSAC is based on stakeholders' perceptions of a species' impacts on natural environments, human land-use, other wildlife, or people's well-being, rather than an estimate of populations in relation to their habitat (Riley &Decker 2000; Schusler et al. 2000; Lischka et al. 2008). WSAC has both a minimum and a maximum value because it represents a community as a whole. The minimum is synonymous with the desires of stakeholders who suffer from the presence of a species (i.e. agriculturalists who suffer crop damage), whereas the maximum is synonymous with the desires of stakeholders that benefit from the presence of a species (i.e. hunters) (Riley & Decker 2000).

In this dissertation I do not attempt to quantify a tolerable maximum or minimum abundance of wildlife in terms of a desired density of animals. Defining a desired density of animals requires information on the current density of each species in each area of interest. Reliable indices of wildlife density do not exist for most introduced species in Hawai‘i. Rather I asked survey recipients if they would like to see populations of introduced species increase or decrease in abundance. The weakness with this approach is that peoples' responses to this question will be influenced by their perception of the current abundance of wildlife and hence their desired increase in abundance may be confused with a desire to interact more frequently with wildlife, a desire that could be satisfied by allowing access to nature reserves rather than an actual increase in the abundance of wildlife. Therefore, I have combined information on peoples' desired abundance of wildlife with additional information on the perceived abundance and impacts of each species. The WSAC models in this dissertation have been used to gain insight into why people want the abundance of introduced species to increase or decrease, but they may not be used to define quantifiable goals for animal abundance.

Potential for conflict index

The best wildlife management plans use measurable goals and objectives to determine whether management activities have been successful. Since a person's desired future abundance for wildlife may be influence by so many factors I have also used the potential for conflict index (PCI) to gain further insight into peoples' desired abundance of wildlife. The PCI ranges from 0 (minimal potential for conflict) to 1 (maximum potential for conflict). The minimal PCI is equivalent to a unanimous response to the question. A normal distribution of responses generates a low to moderate PCI value (e.g., 0.25). A uniform distribution in responses will generate a moderate PCI value (e.g., 0.5). The maximum potential for conflict occurs when responses are equally divided between the two extreme values on a Likert scale (e.g., 50% highly unacceptable and 50% highly acceptable) (Vaske et al. 2010). Graphically, the scale mean in PCI analysis in represented by the center point of bubbles on a bubble graph and PCI values are represented by bubble size. PCI analysis allows greater understanding of people's tolerance for wildlife than contingency tables as it provides an index of the amount of consensus among people. A high PCI value will indicate high levels of public support for a given action and can be used to justify management goals, objectives or actions, whereas a low PCI value will identify actions that are likely to draw public protest.

Consensus convergence models

When people's values are diverse, for example, bimodal with stakeholders falling into two distinct camps of thinking, identifying a management goal or objective that is effectively a compromise between these two camps can be very difficult or impossible to achieve. The more stakeholders involved in a conflict the harder it can be to resolve. Informal methods of consensus building (e.g., mediation) are common methods of resolving conflict, and have been used in at least two wildlife related conflicts in Hawai‘i (See Case studies 1 and 2). Unfortunately, informal methods of decision making do not guarantee consensus, rarely yield repeatable results, and cannot be transferred to alternative scenarios (Mitchell et al. 1997; Regan et al. 2006). The mediation over pigs and axis deer did not change wildlife management practices in Hawai‘i (Adler pers. Comm.). Informal methods are also prone to domination by special interest groups, political agendas, and sub-optimal decisions (for the sake of consensus), which may harm the protected resource (Regan et al. 2006).

Alternatively, formal methods of decision making do guarantee a consensus (Regan et al. 2006). Formal methods use information gathered from surveys and workshops to assign a numerical rank or weight to various management alternatives or priorities. Several analytical techniques may then be used to balance out the priorities of people who supplied the initial information. Consensus convergence modeling uses disparities in priorities among the people involved to calculate levels of respect/cooperation between participants. The initial weight or rank of the priorities and the disparity in priorities are then combined to mathematically converge on a single ‘best’ or ‘most important’ alternative or priority (Regan et al. 2006). Consensus convergence models replicate the behavior seen during negotiation with like-minded people coming to a consensus, followed by a consensus being formed with the person with the next most-similar priorities, and so on. The advantage of consensus convergence modeling over informal methods is that it is blind to dominant personalities, allows for quantitative treatments of uncertainty and is repeatable (Regan et al. 2006). The weakness with formal methods of decision making is that a consensus is forced by a third-party. Models do not allow participants to learn and readily incorporate new data or changing perspectives at a future time. Models also do not facilitate building relationships between public representatives, or government employed resource managers and the public they serve. A lack of communication among these entities frequently initiates human-wildlife conflict and may serve to inflame an issue (Warner & Kinslow 2011). Whereas, building relationships between managers and stakeholders can help prevent future human-wildlife conflict (Madden 2004).

Analytical hierarchy process

Consensus convergence models are useful for ranking a single group of priorities or management alternatives. Many decisions involving natural resources however are complex with multiple groups of priorities or alternatives to rank and compare. While consensus convergence models are useful for digesting large quantities of data that contribute to components of a decision making process a larger modeling framework that allows for multiple interacting components is needed for many decision involving natural resources. The analytical hierarchy process (AHP), is a modeling framework that allows decision makers to break down complex decisions into a series of interacting and interdependent components, arrange those components into a hierarchic 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). AHP optimizes the costs and benefits included in the models to identify the optimal management alternative (Kiker et al. 2005). The AHP is a flexible modeling system that may be used to by: a single decision maker to facilitate transparency in decision making; a team of experts to balance biotic, abiotic, sociological, and fiscal data; or a group of non-experts to prioritize decision components using personal judgments or qualitative data. AHP has been successfully applied to a diverse array of decision-making problems including environmental impact statements, fire research, comparing riparian vegetation policy, and wildlife management to name a few (Schmoldt & Peterson 2000; Ramanathan 2001; Herath & Prato 2006; Hurley et al. 2009). Very few people seem to have used the AHP to inform policies and actions in regards to introduced animal species.

Goals and Objectives

The overarching goal of this dissertation is to understand the human dimensions of introduced terrestrial vertebrates in the Hawaiian Islands and to identify methods of managing these animals that optimize the priorities and values of the public, and the costs and benefits associated with managing wildlife. The three objectives of this research are to:

1) Identify stakeholders’ future desired abundance for a selection of introduced terrestrial vertebrates.
2) Identify the attitudes and beliefs that are influencing stakeholders’ desired abundance for introduced terrestrial vertebrates.
3) Design models that may be used to identify acceptable techniques for managing introduced terrestrial vertebrates.

Four of the chapters within this dissertation were written with the intention of submitting them to various scientific journals. Aside from formatting differences the text is identical to the submitted manuscripts. As such some information is repeated throughout this dissertation, predominantly methods. One state-wide survey of residents of Hawai‘i was used to generate data for chapters three, four, five, and six. The next section of this dissertation contains a complete description of this state-wide survey. Chapters five and six are manuscripts slated for journal submission that discuss the use of decision theory models for identifying acceptable management techniques for feral cats. Both of these chapters use data collected via the state-wide survey plus additional data.

Chapter 2 Methods

Survey Design and Implementation

To address my research objectives I designed and administered a state-wide survey using the tailored design method (Dillman et al. 2009). The survey was designed to generate all of the data necessary to achieve objectives one and two, and part of the data necessary to achieve objective three.

The survey was disseminated to 5,407 people from six pre-identified stakeholder groups: hunters, conservation professionals, agriculturalists, animal welfare activists, native Hawaiians (members of a Hawaiian Civic Club), and the general public (Table 2.2). An in-depth search of scientific and grey literature revealed that these 6 stakeholder groups have been involved in previous cases of human-wildlife conflict in Hawaiʻi (See Case studies 1 through 4).

I identified individuals affiliated with these six groups using direct solicitation at conferences and expos, internet searches, assessment of organization membership lists, and snowball techniques that use known individuals to gather contact information for other individuals. To identify hunters I obtained a list of 9,400 people that had bought a hunting license in 2009 from the DLNR. I randomly selected 1,650 individuals from this list to contact. I obtained lists of registered attendees at the 2009 and 2010 Hawaiʻi Conservation Conference in order to contact conservation professionals. Exhibitors and individuals with unlisted affiliations were removed from these lists because they were not known to be conservation professionals. I contacted the Hawaiʻi Farm Bureau Federation and the 10 branches of the Farm Bureau in Hawaiʻi to gather contact details for agriculturalists. The contact details for agriculturalists were also obtained via internet searches and solicitation at the 2010 Hawaiʻi Agriculture Conference. The contact details for animal welfare activists were obtained via snowball techniques, beginning with the highly active members of various animal shelters. I contacted the various Hawaiian Civic Clubs in an attempt to gather contact information for native Hawaiian. I also contacted the Office of Hawaiian

Affairs, but due to agency policy they were unable to give me access to contact information or disseminate a request for native Hawaiians to contact me. I used a list of random mailing addresses purchased from AccuData Integrated Marketing, stratified by zip-code, to contact the general public. 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. The maximum number of people possible was contacted from the other stakeholder groups.

The survey contained questions regarding multiple species of introduced terrestrial vertebrates. Hawaiʻi is home to at least 100 species of introduced terrestrial vertebrates (See Tables 1.1 to 1.4). To my knowledge very few studies of the human dimensions of terrestrial species have been completed in Hawaiʻi, and none of these studies have been published in scientific journals. Human-wildlife conflict surrounding introduced terrestrial vertebrates in Hawaiʻi is rife and there is anecdotal evidence that the people of Hawaiʻi have lost faith that DLNR can effectively manage wildlife resources (Edwin Johnson, pers. comm.). It was my aim with this research to gather baseline human dimensions data on multiple species of introduced terrestrial vertebrates. Interesting results could then be followed with well directed single species studies.

In this dissertation I present data relating to 7 species that I believe cover a broad range of human-wildlife conflict issues in Hawaiʻi (Table 2.1). Feral cats are common pets in Hawaiʻi and across the US. Conflict among stakeholders over how populations of feral cats should be managed has been increasing in recent years. Based on personal experience animal welfare advocates in Hawaiʻi are very active and they may be presenting a biased view of the public's perceptions of feral cats to legislators. I see an urgent need for human dimensions studies of feral cat issues in Hawaiʻi and across the US. Game species management is another frequent source of human-wildlife conflict in Hawaiʻi (See Case studies 1 through 4). Like cats, wildlife managers seem to have a poor understanding of human dimensions issues for game species in Hawai‘i. Many management decisions seem to be unpopular. A senior game manager in Hawai‘i believes that the public, and hunters in particular have lost faith in the States ability to manage wildlife resources. The results presented in Chapter 3 will hopefully aid agency staff in their attempts to manage wildlife resources in a publically acceptable manner.

Table 2.1 List of species included in this study

Common name	Latin name	Reason
Feral Cat	*Felis catus*	Common pet; frequent source of conflict (Williams 2009)
Axis deer	*Axis axis*	Game species; gift to King Kamehameha V (Tomich 1986); agricultural pest (Anderson 2003)
Goats	*Capra hircus*	Game species; less frequent source of conflict
Mouflon sheep	*Ovis musimon*	Game species; present on Lana‘i and in Hawai‘i Volcanoes National Park (Hess 2008)
Pigs	*Sus scrofa*	Game species; frequent source of conflict (Josayma n.d.)
Wild turkey	*Meleagris gallopavo*	Game species; agricultural pest (Koopman & Pitt 2007)
Zebra dove	*Geopelia striata*	Game species that is not frequently hunted; urban pest (Pyle & Pyle 2009c; Linnell et al. 2009)

The 46 question survey was emailed via SurveyMonkey™ to people listed as conservation professionals, agriculturalists, animal welfare activists, or native Hawaiians, while a hard copy of the survey was mailed to the general public and hunters because an insufficient number of email addresses were obtainable for these two stakeholder groups. Each survey recipient was sent a cover letter with the initial copy of the survey, a reminder postcard or email, and then a second copy of the survey (See Appendix A). The survey response rate (Table 2.2) was calculated as the number of completed surveys divided by the initial number of surveys disseminated minus the number of undeliverable surveys.

Table 2.2 Response rate to state-wide survey of pre-identified stakeholders and the general public in Hawai'i.

Stakeholder Group	n	# Responded	# Declined	# Undeliverable	# Non-respondents	Final Response rate (%)
Agriculture	373	162	15	38	158	48.4
Animal Welfare	277	137	8	27	105	54.8
Conservation	698	307	40	51	300	47.4
Hawaiian Civic Group Members	49	22	2	2	23	46.8
Hunter	1650	483	11	235	921	34.1
Public	2360	399	28	369	1564	20.0

Response rate = # responded/(n - # undeliverable).

Upon completion of the survey, I attempted to contact 5% of the non-respondents via telephone or email to request participation in a short non-response survey. Non-respondents from the stakeholder groups that were initially contacted by email received an emailed version of the non-response survey, the public and hunters were telephoned.

The United States Postal Service could not deliver surveys to 604 of the addresses listed for hunters and the general public (Table 2.2). Results of the non-response survey reveal that an additional 34.5% of the mailed surveys were not received by the intended recipient. An additional 9.5% of surveys mailed back to UHM were not received by the researcher (Table 2.4). These results suggest that an additional 779 surveys were neither received by the intended recipient nor returned to the researcher. The true response rate for the general public may be higher than 20% (Table 2.2). Considerably fewer (8.6%) emailed surveys were undeliverable (Table 2.2). The majority of people who did not respond to an emailed survey (45.7%) stated that they did not have time to answer surveys (Table 2.4). On average 7.8% of survey recipients opted-out of the email survey.

Table 2.3 Results of survey of individuals that did not respond to the state-wide survey of wildlife stakeholders and the general public in Hawai‘i. Non-respondents for state-wide survey (NR1); non-response survey (NRS). Average number of non-respondents that responded to the non-response survey = 10.77%.

Stakeholder Group	N (%) NR1 contacted	N (%) did not respond to NRS	N (%) responded NRS	N (%) Declined NRS	N (%) with incorrect contact details	% NR1 responded to NRS
Agriculture	158 (100)	131 (82.9)	27 (17.1)	2 (1.3)	1 (0.6)	17.1
Animal Welfare	105 (100)	94 (89.5)	11 (10.5)	0 (0)	0 (0)	10.5
Conservation	300 (100)	271 (90.3)	29 (9.7)	8 (2.7)	0 (0)	9.7
Hawaiian Civic Group Members	23 (100)	18 (78.3)	5 (21.7)	0 (0)	0 (0)	21.7
Hunter	200 (21.7)	90 (45.0)	25 (12.5)	15 (7.5)	26 (13.0)	2.7
Public	319 (20.4)	154 (48.3)	46 (14.4)	33 (10.3)	28 (8.8)	2.9

The people who responded to the state-wide survey did not differ significantly from those people that responded to the non-response survey (Table 2.5) in regards to their interest in wildlife (K = 0.98; 1df; P = 0.32), education level (K = 0.25; 1df; P = 0.62), or average age (K = 0.13; 1df; P = 0.72). Interesting, fewer people who responded to the telephone survey (1.9%) than respondents to the initial state-wide survey (18.6%) said that they had no interest in wildlife (Table 2.5).

Table 2.4 Reasons why people did not respond to the state-wide survey of wildlife stakeholders and the general public in Hawaiʻi. Non-respondents (NR)

Reasons for not responding to survey	n all NR	% all NR	% mailed surveys	% emailed surveys
Do not have time for surveys	48	29.1	13.1	45.7
Did not receive survey	36	21.8	34.5	8.6
I know very little about wildlife	13	7.9	6.0	9.9
Do not like answering surveys	12	7.3	4.8	9.9
Returned survey not received at UHM	9	5.5	9.5	1.2
Not resident of Hawaiʻi	6	3.6	2.4	4.9
Not interested in survey topic	6	3.6	7.1	0.0
Survey was too long/complicated	6	3.6	3.6	3.7
Against company/agency policy to answer surveys received at work	5	3.0	0.0	6.2
Don’t remember	5	3.0	3.6	1.2
Lost or forgot about survey	4	2.4	1.2	2.5
Did not believe survey was legitimate	3	1.8	6.0	0.0
Survey seemed biased	3	1.8	3.6	0.0
Survey did not allow me to express my opinion fully	3	1.8	0.0	3.7
No wildlife in my area	2	1.2	2.4	0.0
My opinions are conflicted/hypocritical/biased	2	1.2	0.0	2.5
Survey was damaged	1	0.6	1.2	0.0
Poor English skills	1	0.6	1.2	0.0

Table 2.5 Characteristics of people who responded to the state-wide survey versus those who responded to the non-response survey.

Characteristics	State-wide survey	Non-response survey
No interest in wildlife (%)	18.6	1.9
Mild interest in wildlife (%)	6.4	20.7
Moderate interest in wildlife (%)	23.1	27.8
Strong interest in wildlife (%)	19.9	26.5
Very strong interest in wildlife (%)	24.4	22.1
No high school certificate (%)	1.9	1.9
High school graduate or GED (%)	14.1	12.8
Some college (%)	17.9	18.9
Associates degree (%)	3.2	10.4
Undergraduate degree (%)	28.8	25.0
Graduate degree (%)	17.3	22.0
Average age (years)	45.9	46.4

Wildlife Stakeholder Groups in Hawai'i

Survey recipients were initially assigned to a stakeholder group based on their affiliation with an organization (e.g., people with hunting licenses are hunters). However, because people can fall into multiple stakeholder groups (e.g., conservation professional and a hunter), the number and characteristics of the stakeholder groups were modified following *post hoc* cluster analysis of socio-demographic and behavioral data (Brophy et al. 2006). Specifically, I used k-means cluster analysis with the Caliniski and Harabasz algorithim (Calinski & Harabasz 1974) and corrected Akaike's Information Criterion (AICc; Q-Analysis Software for Market Research©; Numbers International Pty Ltd 2007-2012) to identify the optimal number of clusters within a dataset that included information on survey respondent's interest in wildlife (4 response options); education level (8 response options), home location (4 response options); and tendency to feed wildlife; watch wildlife; hunt; hike; volunteer for conservation programs; or participate in Hawaiian cultural activities (4 response options) (See Appendix A).

I used Cronbach's alpha as a guideline for selecting the final set of socio-demographic and behavioral variables used in the cluster analysis. There were 24 socio-demographic and behavioral variables available (See Appendix A). The maximum Cronbach's alpha value was obtained by including five variables into the dataset (Table 2.6). Cluster analysis of these five variables identified 10 potential clusters of stakeholders (Table 2.7; Figure 2.1). Unfortunately, the profiles of the 10 clusters over-lapped considerably and would not have aided interpretation of the results. Similarly, maintaining these 10 clusters would have inhibited my ability to compare my results to the results of other human dimensions studies. Cluster analysis was repeated with a gradually increasing number of socio-demographic and behavioral variables until six fairly unique clusters of stakeholders were identified (Table 2.8; Figure 2.2). Nine out of the possible 24 socio-demographic and behavioral variables were used in the cluster analysis.

Table 2.6 Maximized Cronbach's alpha values for 5 variables used to define post-hoc stakeholder groups.

Variable	Mean	Std Dev	Item Total R	Item Reliability Index	Excl Item R	Excl Item Alpha
Freq. participate in Hawaiian cultural activities	1.18	1.09	0.67	0.73	0.46	0.75
Freq. Hike	1.99	1.03	0.70	0.73	0.53	0.73
Freq. watch wildlife	1.66	1.19	0.72	0.85	0.52	0.74
Freq. volunteer for conservation	1.21	1.05	0.80	0.84	0.67	0.68
Interest in wildlife	2.55	1.11	0.72	0.80	0.54	0.73
Cronbach's alpha	**0.77**					
Spearman-Brown coefficient	**0.80**					
Coefficient alpha	**0.77**					

Table 2.7 Fit statistics for clusters derived from a dataset with 5 socio-demographic and behavioral variables.

Model	# Parameters	AICc value	McFadden R^2	% Respondents/Cluster
Aggregate	16	12852.2	0.00	14.1
2 clusters	32	10947.6	0.16	9.5
3 clusters	48	10326.3	0.22	13.6
4 clusters	64	9773.1	0.27	13.2
5 clusters	80	9524.7	0.30	7.1
6 clusters	96	9404.9	0.31	9.3
7 clusters	112	9311.1	0.33	7.1
8 clusters	128	9228.9	0.35	10.8
9 clusters	144	8965.9	0.37	9.9
10 clusters	160	8921.0	0.39	5.4

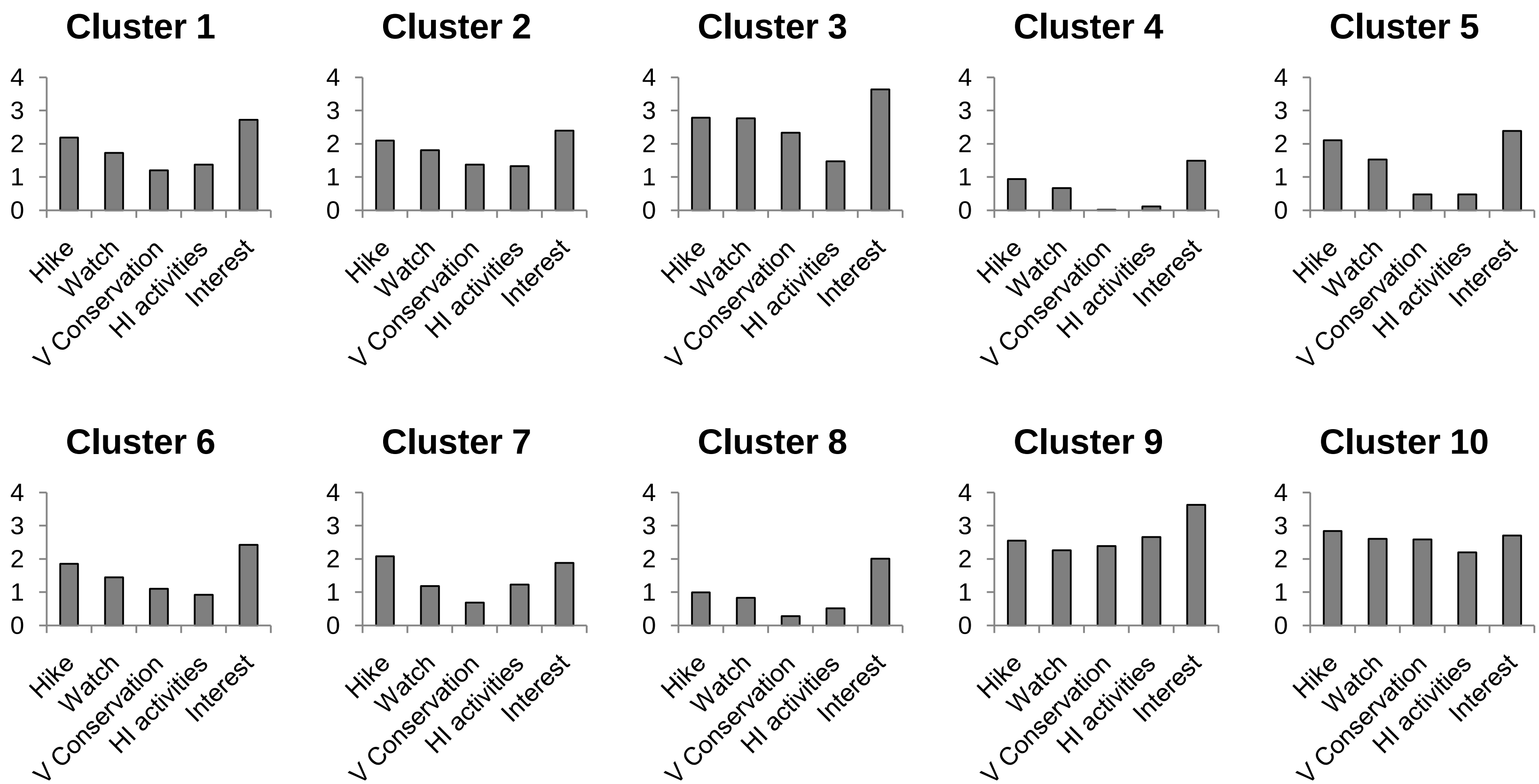


Figure 2.1 Profiles for 10 clusters of wildlife stakeholders generated by dataset with 5 socio-demographic and behavioral variables.

For the categories Hike, Watch, V Conservation, and HI activities responses range between 0-3; 0=never; 1=once/year; 2=biannually; 3=monthly or more. Interest values ranged between 0-4 with 0=not interested; 1=mildly interested; 2=moderately interested; 3=strongly interested; 4=very strongly interested.

When nine socio-demographic and behavioral variables were included in the dataset the cluster analysis identified six *post hoc* stakeholder groups with relatively unique characteristics (Table 2.8; 2.9; and Figure 2.2): Cluster 1 contained people that frequently feed animals; Cluster 2, 72% people with mild or no interest in wildlife; Cluster 3, 94% people had at least one college degree; Cluster 4, 78% people hunted frequently; Cluster 5, 98% of people lived in rural areas; Cluster 6, 96% people were strongly or very strongly interested in wildlife issues. Two socio-demographic variables were combined so that ‘Feeders’ were defined as people who fed both feral cats and wild birds frequently ($\sum$freq. feed cats + freq. feed birds $\leq$ 5; Frequency values range between 0-3; 0=never; 1=once/year; 2=biannually; 3=monthly or more). Cronbach’s alpha (0.5; Table 2.8) was lower for a dataset with nine variables than for a dataset with five variables (0.77; Table 2.6). Rather than maintain groups as identified by cluster analysis, which minimizes the ability to compare studies, I sorted and analyzed the whole data set according to the characteristics identified by the cluster analysis. I also selected native Hawaiians as an additional *post hoc* stakeholder group (individuals reported their ethnicity; Appendix A) because I was unable to pre-identify a sufficient number of native Hawaiians (Table 2.2). At the conclusion of the cluster analysis I defined 5 pre-identified stakeholder groups and seven post hoc stakeholder groups (Table 2.10).

Table 2.8 Maximized Cronbach's alpha values for 9 variables used to define post-hoc stakeholder groups.

Variable	Mean	Std Dev	Item Total R	Item Reliability Index	Excl Item R	Excl Item Alpha
Freq. participate in Hawaiian cultural activities	1.18	1.09	0.53	0.58	0.34	0.43
Freq. Hike	1.99	1.03	0.60	0.61	0.44	0.41
Freq. watch wildlife	1.66	1.19	0.63	0.75	0.45	0.39
Freq. volunteer for conservation	1.21	1.05	0.66	0.69	0.51	0.38
Freq. hunt	1.11	1.29	0.24	0.31	-0.02	0.55
Interest in wildlife	2.55	1.11	0.65	0.72	0.49	0.39
Current home rural/urban	2.05	1.02	0.25	0.26	0.05	0.52
Feed animals	1.19	1.71	0.29	0.50	-0.05	0.60
Education	4.31	1.47	0.38	0.56	0.09	0.52
Cronbach's alpha	**0.50**					
Spearman-Brown coefficient	**0.54**					
Coefficient alpha	**0.50**					

Table 2.9 Fit statistics for clusters derived from a dataset with 9 socio-demographic and behavioral variables.

Model	# Parameters	AICc value	% respondents/cluster
Aggregate	29	24267.5	16.3
2 clusters	57	22221.1	17.2
3 clusters	85	21504.3	19.7
4 clusters	113	20982.4	12.2
5 clusters	141	20860.0	15.3
6 clusters	169	20334.4	19.3
7 clusters	197	20488.6	-

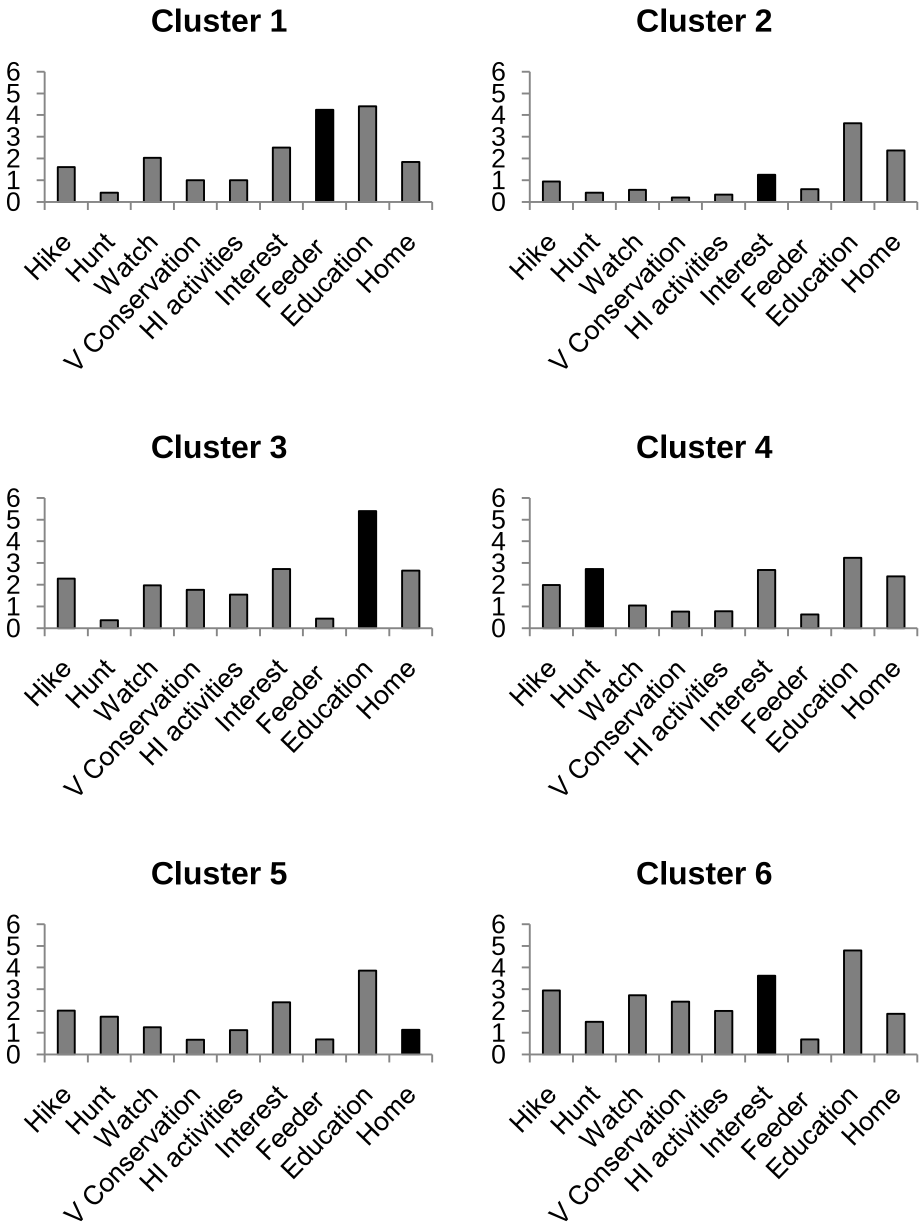


Figure 2.2 Profiles for 6 clusters of stakeholders generated by a 9 variable dataset.

Figures present scale mean for each category. For categories Hike, Hunt, Watch, V Conservation, Feeder, and HI activities frequency values are; 0=never; 1=once/year; 2=biannually; 3=monthly or more. Interest values are; 0=not interested; 1=mildly interested; 2=moderately interested; 3=strongly interested; 4=very strongly interested. Education values are; 1=no high school diploma; 2=high school diploma or GED; 3=some college; 4=associate degree; 5=undergraduate degree; 6=graduate degree. Home values are; 1=rural; 2=small town <25,000; 3=suburban 25-100,000; 4=metropolitan >100,000 people.

The purpose of surveying a random sample of the general public is to identify a representative sample of opinions. Unfortunately, only 20% of the general public responded to the survey. While the non-response telephone survey indicates that non-respondents did not differ significantly from respondents the ability of my data to represent broader public opinion is debatable. Therefore, it is important to identify the prevalence of each stakeholder group in society. Responses from the random sample of the general public were sorted according to each of the characteristics used to define stakeholder groups. The majority of survey respondents (82.5%) indicated that they lived in a rural area or small town (Table 2.10). According to the 2010 US Census, only 10% of Hawai‘i’s population live in rural areas with fewer than 50,000 residents (US Census Bureau Geography Division 2010). Approximately, 41% of the general public stated that they had a college degree and little interest in wildlife. 24% of the public stated that they hunted at least once per year, whereas only 8% hunted once per month or more. I did not ask survey respondents whether they bought a hunting license. However, in 2009 9,400 people bought a hunting license, which is approximately, 0.7% of the state population. Over half of the public either donated money to or volunteered for a conservation organization, whereas only 26% of the public volunteered for or donated money to an animal welfare organization. Approximately 15% of the public stated that they were at least part native Hawaiian (Table 2.10). According to the 2010 US census only 10.1% of Hawai‘i’s residents are native Hawaiian or Pacific Islander. The stakeholder group listed a ‘public’ henceforth may be biased towards people who live in a rural area, and hunters. Hunters and rural residents are more likely to interact with many of the introduced terrestrial vertebrates listed in this dissertation, especially the larger game species.

Table 2.10 Response rate from both pre-identified and post hoc stakeholder groups and the percentage of the respondents from the general public that meet the characteristics of the pre-identified and post hoc stakeholder groups.

	Stakeholder Group	n Responded	% Public within group
Pre-identified	Agriculture	162	8.6
	Animal Welfare	277	25.9
	Conservation Professionals	698	55.8
	Hunter all levels	482	24.0
	Public	396	100
Post hoc	Hawaiian	290	15.2
	Hunt frequently	368	8.4
	College education	726	41.9
	Feed wildlife frequently	131	7.0
	Low interest in wildlife	316	41.0
	High interest in wildlife	697	22.0
	Rural home	964	82.5

Chapter 3 The islands are different: Human perceptions of game species in Hawai‘i

Abstract

Hawai‘i’s game species are all non-native provoking human-wildlife conflict among stakeholders. Human-wildlife conflict issues in Hawai‘i are further complicated by the discrete nature of island communities and cultures. The goal of this research was to understand the beliefs, values, and desires held by residents of Hawai‘i regarding six game species [pigs *Sus scrofa*), goats (*Capra hircus*), mouflon (*Ovis musimon*), axis deer (*Axis axis*), turkeys (*Melagris gallopavo*), and zebra doves (*Geopelia striata*)]. My first objective was to assess the social carrying capacity for game on each of the six main Hawaiian Islands using the potential for conflict index. My second objective was to use multiple regression with AICc model selection to identify explanatory variables for stakeholders’ desired abundance for the six game species across the islands (total 36 models). In 2011 I administered a mail and internet survey to six pre-identified stakeholder groups: hunters (n = 1650), conservation professionals (n = 698), agriculturalists (n = 373), animal welfare activists (n = 277), native Hawaiians (n = 49), and the general public (n = 2360). I used cluster analysis to identify additional *post hoc* stakeholder groups. On average 46% of pre-identified stakeholders and 20% of the public responded to the survey with 1,510 surveys being returned in total. The desired abundance differed significantly among species ($F = 40.2_{5,\ 8416}$; $P < 0.001$), stakeholder group ($F = 396.1_{11,\ 28595}$; $P < 0.001$), and island ($F = 53.1_{5,\ 8004}$; $P < 0.001$). Survey respondents desired larger increases in the abundance of axis deer, mouflon and wild turkeys than wild pigs, goats, or zebra doves. Enjoyment at seeing or hearing game animals (33/36 models), and the cultural value (31/36 models) assigned to game species were the two most common explanatory variables for desired abundance. Models for Lana‘i emphasized the positive economic value of game species, whereas models for Maui identified the negative potential for game to contaminate soil and water as an explanatory variable. Results for O‘ahu and Kaua‘i revealed a concern for human health and safety. Models for island of Hawai‘i identified the

potential for game to impact native species as an explanatory variable. I recommend that wildlife managers design management plans for each island taking into consideration the values of local residents.

Introduction

Hunting game has been a part of the culture of the United States for hundreds of years. It is a source of subsistence, recreation, and an important component of indigenous ceremonies (McCorquodale 1997). Many conservation regulations and much conservation funding exist because of hunting (Williams 2010). Hunting is declining in popularity however (Brown et al. 2000; Enck et al. 2000), and hunters are frequently involved in conflict with other members of society (Josayma n.d.; Manfredo et al. 1999). Human dimensions studies can illuminate sources of conflict by identifying differences in opinion or perception among members of society allowing wildlife managers to incorporate the views of traditional and non-traditional stakeholders into their management plans.

Hawaiʻi recognizes 6 mammals (DLNR 2012b) and 15 bird (DLNR 2012a) game species, all of which are non-native (Lepczyk et al. 2011). These species were introduced at different times for various reasons. Pigs (*Sus scrofa*) were introduced as domestic livestock by Polynesians when they colonized the Hawaiian Islands in approximately 1200 AD (Kirch 1982; Wilmshurst et al. 2011). In the late 1700s goats (*Capra hircus*) and sheep (*Ovis aries*) introduced by European sailors were protected by kapu (taboo) to ensure rapid increases in their abundance (Tomich 1969). With the emergence of a market economy in the 1800s the skins and meat of game species became a source of revenue (Henke 1929; Cuddihy & Stone 1990; Tummons 2002). Abundant game populations were promoted. In the early 1900s high densities of ungulates became a source of human-wildlife conflict as over-grazing of forested mountains and watersheds degraded water supplies (Cuddihy & Stone 1990). The politically powerful sugar industry required a consistent and abundant water supply to grow sugar cane. This conflict initiated a statewide program to reduce ungulate populations and restore watersheds, with tens of thousands of animals being removed (Gagne 1988; Stone 1989; Duffy 2010).

In the 1930s, the Great Depression increased the demand for meat and animal eradication programs were opened to the public (Walker 1978). Public hunting programs became well funded in Hawaiʻi in 1945 when the amount of U.S. Pittman-Robertson dollars given to Hawaiʻi tripled (Board of Commissioners of Agriculture and Forestry 1948). Concurrently, interest in hunting increased across the US during the 1950s through to the mid-1970s (Manning 2000; Brown et al. 2000; Enck et al. 2000). Increasing interest in hunting instigated an informal agreement between the Hawaiʻi Division of Fish and Game and hunters, whereby hunters would manage populations of destructive ungulates through their hunting activities (Giffin 1975a; b). This system was effective until the abundance of feral sheep declined dramatically, which resulted in a temporary moratorium on ungulate control (Giffin 1975a; b). In the 1970s sentiment towards the environment changed again, and Hawaiʻi State Act 139 mandated the establishment of a Natural Area Reserves System (NARS), so that "…the unique natural assets should be protected and preserved…" This mandate does not allow for the persistence of destructive game mammal species. Today, the Hawaiʻi Department of Land and Natural Resources (DLNR) has two conflicting mandates: to protect the unique environmental assets of Hawaiʻi, and to provide hunting recreation. This dual mandate has led to conflict among wildlife stakeholders, as exemplified by the federal lawsuit Palila v. Hawaiʻi DLNR (Juvik & Juvik 1984).

Human-wildlife conflict issues in Hawaiʻi are further complicated by the discrete nature of island communities and cultures. Culture provides social groups with patterns of thinking, feeling, and behaving that are transmitted from person to person and from generation to generation (Kennedy 1985). Cultural variation is enhanced when human movement, communication and exchange between areas or social groups in limited (Eriksen 2001). To the extent that members of a community share common goals and values, the community can be viewed as fostering a distinct culture/subculture or worldview (Manfredo et al. 2003). Many studies use ethnicity to define cultural groups (Lim et al. 2009; Clarke & Agyeman 2011). Given the diverse ethnic backgrounds of today's residents of Hawai‘i, one must look at differences in cultural systems and lifestyles among locations and communities rather than at ethnic variation (McDermott 1980).

Historical game harvest trends support the hypothesis that attitudes towards the presence and impacts of game species may vary among the six largest islands (Hawai‘i, Kaua‘i, Lana‘i, Maui, Moloka‘i, and O‘ahu). Location (island) was a significant explanatory variable for changes in game species harvest levels in Hawai‘i between the 1940s and 2009, as was variation in game species present on each island (Duffy 2010). Understanding historical hunting trends and current human dimensions profiles associated with various game species is especially important when formulating appropriate management goals in Hawai‘i. Considering this importance, the goal of this research was to understand the beliefs, values, and desires of residents of Hawai‘i regarding game species. My first objective was to assess the social carrying capacity for four game mammals [wild pigs, goats, mouflon (*Ovis musimon*), axis deer (*Axis axis*)], and two game birds [wild turkeys (*Melagris gallopavo*), and zebra doves (*Geopelia striata*)] on each island using the potential for conflict index (PCI) analysis (Jerry Vaske et al. 2010). My second objective was to use Wildlife Stakeholder Acceptance Capacity (WSAC) models to identify explanatory variables for stakeholders' desired abundance for game animals across the Hawaiian Islands (Decker & Purdy 1988; Manfredo et al. 1999; Riley & Decker 2000; Organ & Ellingwood 2000; Lischka et al. 2008).

Methods

I administered a mail and internet survey between July and September 2011 using the tailored design method (Dillman et al. 2009). The survey was disseminated to 5,407 people from six pre-identified stakeholder groups: hunters (n = 1650), conservation professionals (n = 698), agriculturalists (n = 373), animal welfare activists (n = 277), native Hawaiians (members of a Hawaiian Civic Club; n = 49), and the general public (n = 2360). I identified hunters, conservation professionals, agriculturalists, animal welfare activists, and native Hawaiians to survey direct solicitation, internet searches, and assessment of organization membership lists. A list of random mailing addresses purchased from AccuData Integrated Marketing, stratified by zip-code, was used to contact the public. The 46 question survey (see Appendix A) was emailed via SurveyMonkey™ to people listed as conservation professionals, agriculturalists, animal welfare activists, or native Hawaiians, while a hard copy of the survey was mailed to the general public and hunters as sufficient email addresses could not be obtained for these stakeholder groups. 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 surveyed as many conservation professionals, agriculturalists, animal welfare activists, and native Hawaiians as possible.

Survey recipients were initially assigned to a stakeholder group based on their affiliation with an organization (e.g., people with hunting licenses are hunters). However, because individuals can fall into multiple stakeholder groups (e.g., agriculturalist and animal welfare advocate), the number and characteristics of the stakeholder groups were modified following *post hoc* cluster analysis of socio-demographic and behavioral data (Brophy et al. 2006). Specifically, I used k-means cluster analysis with the Caliniski and Harabasz algorithim (Calinski & Harabasz 1974) and AICc (Q-Analysis Software for Market Research©; Numbers International Pty Ltd 2007-2012) to identify the optimal number of clusters within a dataset that included information on survey respondent’s interest in wildlife, education level, home location (rural/urban), and tendency to feed wildlife, watch wildlife, hunt, hike, volunteer for conservation programs, or participate in Hawaiian cultural activities. The cluster analysis identified six *post hoc* stakeholder groups with unique characteristics: people with little or no interest in wildlife, people with a high interest in wildlife, people that hunt frequently (once per month or more), people that feed wildlife frequently, people whose current home is in a rural area or small town (<25,000 people), and people with a college education (Cronbach's alpha 0.5; Spearman-Brown coefficient 0.54). Rather than maintain the *post hoc* groups I used the results of the cluster analysis to identify characteristics that may be influencing people's values or opinions. New over-lapping *post hoc* groups were created by sorting data for the six identified characteristics listed above. I also selected native Hawaiians as an additional *post hoc* stakeholder group (individuals who reported at least part Hawaiian ancestry) because I was unable to pre-identify a sufficient number of native Hawaiians. All further analyses were completed for the resulting five pre-identified and seven *post hoc* stakeholder groups.

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. Upon completion of the survey, I attempted to contact 5% of the non-respondents via telephone to request participation in a short non-response survey.

Survey recipients were presented with 11 questions about the perceived abundance, impacts, and desired abundance for game species. Each question was presented as a matrix with all six game species listed under each question (Table 3.1). One of the potential explanatory variables, 'has the abundance of game increased or decreased in the recent two years (TW)' was removed from the final data set as the majority of respondents did not supply a useful answer to the question. A second explanatory variable, 'do you benefit from just knowing that game species persist in Hawaii (IN)' was also removed from the data set because it was highly correlated ($r_{rank} > 0.8$) with another explanatory variable ('do you enjoy seeing or hearing game (EN); Table 3.1). Enjoyment derived from seeing or hearing wildlife (EN) requires interactions with wildlife and hence was thought to a more relevant explanatory variable than the question designed to derive information on the intrinsic value of wildlife (IN; Table 3.1).

The disparity in people's desired abundance (Y; Table 3.1) for each game species on each island and for each stakeholder group was analyzed via the potential for conflict index (PCI) (Vaske et al. 2010), ANOVA and pairwise comparisons with Bonferroni correction (ά = 0.05). The PCI ranges from 0 (minimal potential for conflict) to 1 (maximum potential for conflict). A minimal PCI value indicates a unanimous or near unanimous response to the question. A moderate PCI value indicates a uniform distribution in responses. The maximum potential for conflict occurs when responses are equally divided between the two extreme values on a Likert scale (e.g., 50% highly unacceptable and 50% highly acceptable) (Vaske et al. 2010). Data were pooled across stakeholders for tests of variation among islands and vice versa. Although data were not normally distributed, I used parametric tests as they are robust to non-normal data with large sample sizes (Norman 2010).

Table 3.1 Survey questions used to collect data for wildlife stakeholder acceptance capacity (WSAC) models of 6 game species in the Hawaiian Islands.

	Question	Variable	Measurement Scale
1)	In the future I would like the number of game animals in the wild to increase or decrease?	Y	5-point bi-polar with responses: Strongly disagree; disagree; neither agree nor disagree; agree; strongly agree
2)	Game animals are enjoyable to see/hear in the wild in HI?	EN	
3)	Game animals damage people's property or source of income?	PR	
4)	Game animals pose a health or safety risk for people?	HE	
5)	Game animals pose a risk for native animals or plants?	AP	
6)	Game animals may contaminate or degrade the soil or water?	CO	
7) *	Whether or not you see game animals, you benefit from just knowing they exist in the Hawaiian Islands?	IN	
8) *	Has the abundance of game animals increased or decreased during the last 2 years?	TW	
9)	Game animals are culturally important or valuable animals?	CU	4-point uni-polar with response: Not valuable; slightly valuable; somewhat valuable; very valuable
10)	Game animals are economically important or valuable animals? Do they generate income or revenue?	EC	
11)	How frequently do you see game animals in the area where you live?	SE	5-point uni-polar with responses: Never seen one; seen once per year; seen monthly; seen weekly; seen daily

*These variables were removed from the dataset prior to analysis, as explained in the text.

To identify the beliefs and values that were commonly held by stakeholders regarding to game species I used multiple regression (SYSTAT® 13 Statistics, SYSTAT Software, Inc 2009) to compare how people's desired change in the abundance of game (dependent variable (Y): Table 3.1) related to peoples' beliefs about the impacts of game species and attitudes towards the presence of game (questions 2-11; Table 3.1) (Christoffel 2007; Lischka et al. 2008). I tested all linear model combinations. I did not test for interactions or transform the data because data were collected via Likert scales with limited variation in possible responses (Norman 2010). As islands are discrete, the best WSAC model was identified via AICc (Anderson 2008) for each game species on each island (total 36 models). Data were pooled across stakeholder groups to get an overall evaluation of beliefs and values for each island.

Results

Potential for conflict index

On average 46% of pre-identified stakeholders and 20% of the public responded to the survey, while 7.8% of survey recipients opted-out of the email survey and 14.9% of mail surveys were undeliverable.

The desired abundance for game animals in Hawaiʻi differed significantly among species ($F = 40.2_{5, 8416}$; $P < 0.001$), stakeholder group ($F = 396.1_{11, 28595}$; $P < 0.001$), and island ($F = 53.1_{5, 8004}$; $P < 0.001$). Pair wise comparisons reveal that survey respondents desired significantly more axis deer and mouflon than wild pigs or goats (Figure 3.1: $P < 0.001$). Results for mouflon and axis deer did not differ significantly ($P = 1.0$). Respondents desired significantly more turkeys than zebra doves, pigs or goats ($P < 0.001$).

The 12 stakeholder groups differed significantly in their opinions about the future abundance of game species (Figure 3.2). Specifically, agriculturalists and conservation professionals consistently wanted a small decrease in the abundance of game animals, while animal welfare activists wanted a very small decrease in game abundance. These three groups exhibited a high level of consensus in their opinions (PCI < 0.21). Hunters were the only stakeholder group that desired an increase in the abundance of all game animals, except zebra doves (Figure 3.2). People with a high interest in wildlife held similar opinions to those with a low interest in wildlife but there was less consensus within the group (Figure 3.2). People who feed wildlife frequently want the abundance of game species to remain constant and people with a college education generally want the abundance of game species to decrease. The public consistently (PCI < 0.21) wanted a small decrease in the abundance of all six game species.

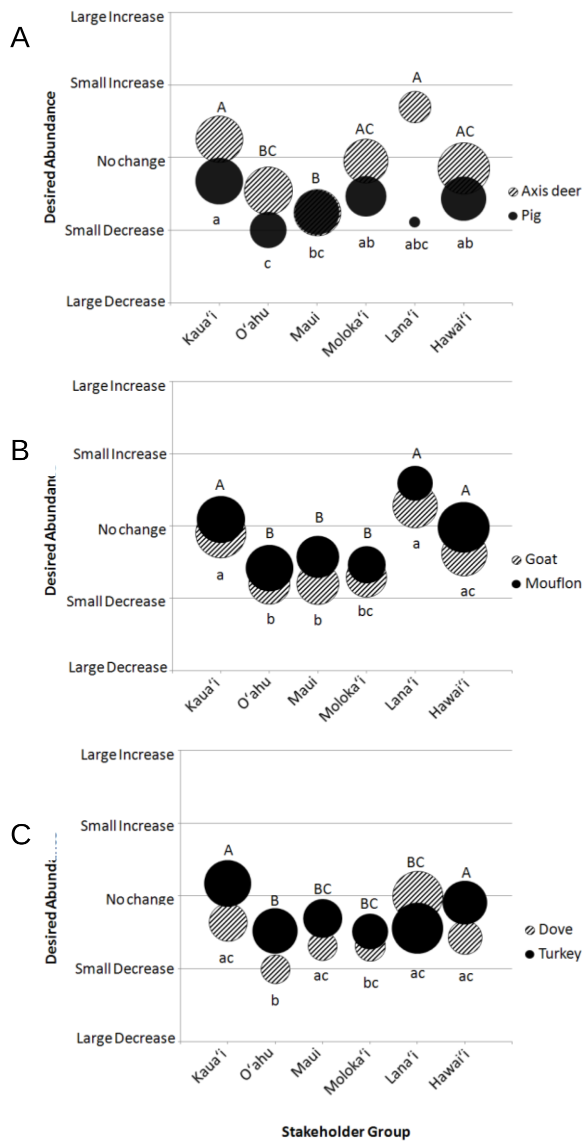


Figure 3.1 PCI results for the desired abundance of 6 game species across 6 Hawaiian Islands.

The desired abundance differed significantly among islands for each species. Results of pair wise comparisons with Bonferroni correction among islands are denoted by lettering: Upper case lettering denotes significance relationships for axis deer, mouflon and turkey. Lower case lettering denotes significance relationships for pig, goat, and dove. Bubble center equals scale mean for desired abundance. Bubble size reflects PCI value (Min PCI = 0.02 pig, Lanai; Max PCI = 0.45 axis deer, Hawaii).

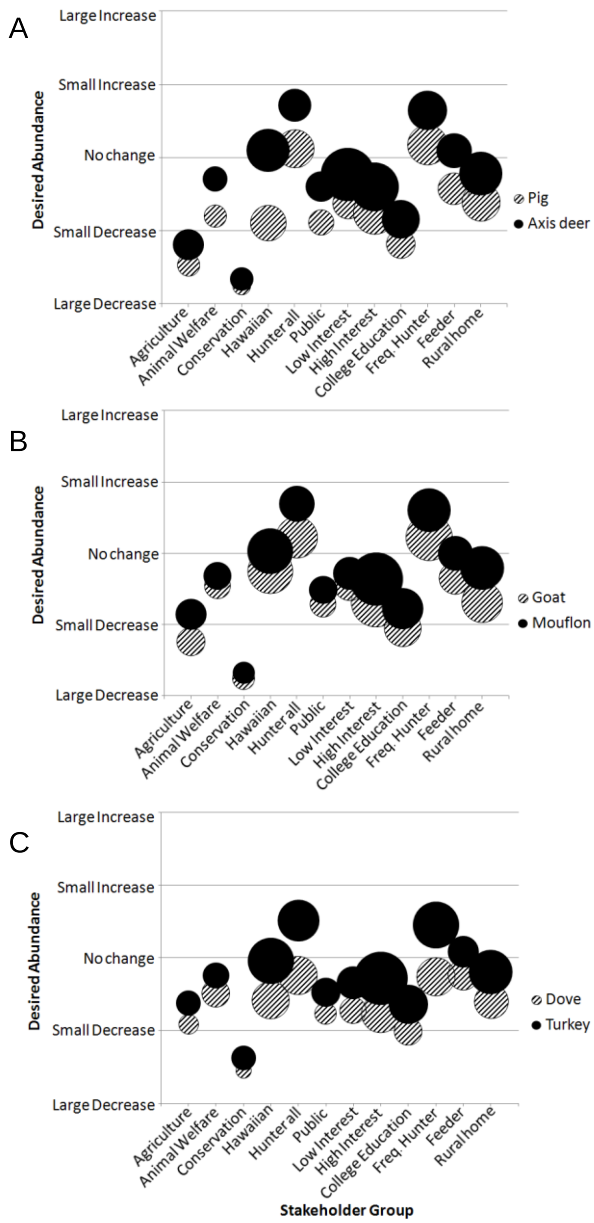


Figure 3.2 PCI results for the desired abundance of 6 game species across 12 stakeholder groups.

Results varied significantly among stakeholder groups (F-ratio = 409.9; 11df; $p < 0.001$). Bubble center equals scale mean for desired abundance. Bubble size reflects PCI value (Min PCI = 0.03: dove, conservation; Max PCI = 0.63: axis deer, low interest).

People on all the islands would like to see the number of pigs reduced. Pair wise comparisons reveal that the desired decrease on Oʻahu was greater than other islands ($P < 0.005$), but the difference was not significant between Oʻahu and Lanaʻi ($P = 1.0$) and Oʻahu and Maui ($P = 0.29$) (Figure 3.1A). Only hunters would like to see an increase in the abundance of feral pigs (Figure 3.2A). Hunters were also the only group to desire an increase in the abundance of feral goats (Figure 3.2B).

Respondents from Maui want to see the abundance of axis deer decrease, whereas respondents on Kauaʻi and Lanaʻi want the abundance of axis deer to increase. People on Molokaʻi and Hawaiʻi do not desire change in the abundance of axis deer (Figure 3.1A). Interestingly, there are no axis deer on Kauaʻi. It is possible that some respondents were thinking of black-tailed deer (*Odocoileus hemionus columbianus*), which are present on Kauaʻi, when entering their response or that respondents would like to see an increase in axis deer populations on other islands. Similarly, there are no axis deer on Oʻahu, however the majority of conservation biologists reside on Oʻahu (Table 3.2). Conservation biologists had a high level of consensus that the abundance of axis deer should be reduced (Figure 3.2A), and it is likely that their responses significantly influenced the scale mean for Oʻahu. The highest PCI values were consistently assigned to axis deer, indicating a wider range of opinions than for any of the other game species (Figure 3.2A).

Respondents from Kauaʻi, Lanaʻi, and Hawaiʻi differed significantly from those on the other islands in their desire to see mouflon abundance decrease. People on Lanaʻi desire a small increase in the abundance of mouflon, whereas people on Kauaʻi and Hawaiʻi would like to see it remain relatively constant (Figure 3.1B). Mouflon are only present on Hawaiʻi and Lanaʻi. Kauaʻi is the only island whose residents expressed a desire to see the abundance of turkeys increase (Figure 3.1C). The results from Kauaʻi and Oʻahu differed significantly ($p < 0.01$; Figure 3.1C) with the scale mean from Oʻahu indicating residents desire a decrease in the abundance of turkeys. On average survey respondents desired a greater decrease in doves than wild turkeys. The residents of all six islands would like to see zebra doves decrease (Figure 3.1C).

Table 3.2 The percentage of each stakeholder group residing on each of the six main Hawaiian Islands.

The distribution of stakeholders varied significantly among the islands (Pearson chi-square 634.01; 55df; $p<0.001$; Phi(ф)=0.36). *Non-significant variation among islands ($p > 0.05$).

Stakeholder	Hawai‘i	Kaua‘i	Lana‘i	Maui	Moloka‘i	O‘ahu
Agriculture	19.4	9.4	0.0	27.5	1.9	20.0
Animal Welfare	8.7	2.2	1.4	4.3	0.0	53.6
Conservation	16.9	7.6	0.0	9.3	1.0	43.4
Hawaiian	18.7	13.0	2.3	13.7	8.7	32.8
Hunter-All	24.3	16.4	4.1	17.9	7.9	24.9
Public	23.2	10.8	11.3	17.6	18.2	14.6
Low Interest	19.7	10.8	4.4	18.6	12.5	23.9
High Interest	19.8	11.5	3.9	15.2	5.8	31.1
Freq. Hunter	24.8	16.2	4.6	18.0	11.9	18.0
Feeder*	16.7	11.1	2.2	14.4	12.2	28.9
College Education	21.9	9.1	3.7	15.9	5.9	40.1
Rural Home	27.8	16.3	7.2	21.7	12.8	10.5
Mean age	51.2	52.1	59.3	52.2	55.3	51.2
Mean residence in HI	35.7	39.0	43.2	36.0	40.5	35.3
Income	4.1	4.2	3.6	4.4	3.5	4.8

Missing percentage did not list island of residence.

Wildlife stakeholder acceptance capacity models, comparing islands

Enjoyment at seeing or hearing game animals was the most common explanatory variable for the desired future abundance of game species, occurring in 33 out of the 36 best WSAC models (Tables 3.3 and 3.4). The majority of people on all islands enjoy seeing axis deer, and the majority on Hawaiʻi, Kauaʻi and Lanaʻi enjoy seeing mouflon. Except for respondents from Kauaʻi, people do not enjoy seeing zebra doves (Table 3.5). Enjoyment was not an explanatory variable for goats on Kauaʻi, axis deer on Maui (Table 3.3 and 3.4), and axis deer, mouflon and turkey on Lanaʻi (Table 3.3), possibly due to a lack of variation in responses to those questions (Table 3.5).

The cultural value of game species was a common explanatory variable across all six islands appearing in 31 out of the 36 best WSAC models. Culture was not an explanatory variable for turkeys and mouflon on Molokaʻi, and mouflon, pigs, and doves on Lanaʻi. Mouflon are not present on Molokaʻi, and pigs are not present on Lanaʻi. In general more respondents from Oʻahu did not assign any cultural value to game species compared to respondents from other islands (Table 3.6). On all islands except Lanaʻi more respondents assigned cultural value to pigs than any other game species. The majority of respondents did not assign any cultural value to zebra doves (Table 3.6).

The potential for game species to pose a risk to native flora and fauna was a common explanatory variable in WSAC models for Hawaiʻi (5/6 models), Maui (3/6 models), Molokaʻi (4/6 models) and Oʻahu (3/6 models). In general respondents thought that game birds presented less risk to native flora and fauna than did game mammals. Considerably more respondents from Lanaʻi stated that game birds posed a risk to native flora and fauna than respondents from any other island (Table 3.7).

Table 3.3 Best WSAC models for six game species on six Hawaiian Islands.

Island	Species	n	Model	AICc	Adj R^2	df_1	df_2	F-Ratio	P-Value
Hawaii (n_{max} =331)	Axis deer	278	Y = -0.54 + 0.36EN – 0.27CO + 0.23CU – 0.17PR – 0.16SE + 0.08EC*	641.1	0.75	6	271	142.2	<0.001
	Goat	289	Y = -0.58 + 0.33CU + 0.21EN – 0.2AP – 0.15CO – 0.14PR	682.2	0.67	5	283	115.9	<0.001
	Mouflon	291	Y = -0.61 + 0.35CU + 0.33EN – 0.18CO – 0.11AP* – 0.08HE*	704.0	0.70	5	285	137.8	<0.001
	Pig	306	Y = -0.66 – 0.32AP + 0.32CU + 0.23EN – 0.10PR* + 0.08EC* – 0.08SE*	692.8	0.70	6	299	120.8	<0.001
	Turkey	295	Y = -0.68 + 0.26EN + 0.26CU – 0.23AP + 0.13EC – 0.12PR – 0.08SE	678.6	0.65	6	288	93.6	<0.001
	Dove	292	Y = -0.78 – 0.21AP + 0.2EN – 0.18PR + 0.17CU + 0.17EC	717.5	0.49	5	286	56.9	<0.001
Kauai (n_{max} = 177)	Axis deer	149	Y = -0.33 + 0.28EN – 0.25PR – 0.23CO + 0.2CU – 019HE	363.8	0.67	5	143	60.9	<0.001
	Goat	154	Y = -0.68 + 0.28EN + 0.25CU – 0.21AP – 0.17HE	406.2	0.54	4	149	46.3	<0.001
	Mouflon	152	Y = -0.41 + 0.36EN + 0.18CU* – 0.17CO – 0.16HE* – 0.10PR*	406.9	0.56	5	146	39.8	<0.001
	Pig	160	Y = -1.12 + 0.34EN + 0.26CU + 0.12EC* – 0.11HE* – 0.10CO*	449.5	0.53	5	154	36.1	<0.001
	Turkey	150	Y = -0.31 + 0.43EN – 0.24AP + 0.19CU – 0.07PR*	379.4	0.60	4	145	56.6	<0.001
	Dove	154	Y = -0.39 + 0.38EN + 0.22CU – 0.10AP* – 0.08SE	379.5	0.52	4	149	43.2	<0.001
Lanai (n_{max} = 74)	Axis deer	67	Y = -1.36 + 0.38CU + 0.28EC*	190.7	0.19	2	64	8.8	<0.001
	Goat	58	Y = -0.66 + 0.28EN* + 0.22CU* – 0.18AP* – 0.15PR*	164.3	0.30	4	53	7.2	<0.001
	Mouflon	67	Y = -0.86 + 0.28EC – 0.25HE – 0.08CO*	181.9	0.15	3	63	4.8	0.005
	Pig	62	Y = -0.51 – 0.33AP	170.6	0.07	1	60	5.7	0.02
	Turkey	64	Y = -0.75 – 0.27EN + 0.24CU* – 0.18SE* + 0.17EC*	175.9	0.38	4	59	10.8	<0.001
	Dove	65	Y = -0.74 + 0.41EN – 0.22HE + 0.17EC*	167.8	0.49	3	61	21.8	<0.001

*Insignificant variables p > 0.05

Table 3.4 Best WSAC models for six game species on six Hawaiian Islands continued.

Island	Species	n	Model	AICc	Adj R^2	df_1	df_2	F-Ratio	P-Value
Maui (n_{max} = 252)	Axis deer	228	Y = -1.06 + 0.27CU – 0.2AP + 0.19EN + 0.14EC – 0.12CO* – 0.09HE* – 0.06SE*	600.6	0.56	7	220	42.0	<0.001
	Goat	231	Y = -1.10 + 0.36CU – 0.22AP + 0.20EN + 0.14EC – 0.08CO*	560.6	0.59	5	225	67.3	<0.001
	Mouflon	225	Y = -0.67 +0.3CU + 0.24EN – 0.23CO – 0.10HE*	610.6	0.47	4	220	51.3	<0.001
	Pig	226	Y = -0.87 + 0.33CU – 0.21CO + 0.21EN – 0.15PR* + 0.12EC* – 0.10SE	583.1	0.56	6	219	47.8	<0.001
	Turkey	225	Y = 0.10 + 0.33CU – 0.18CO + 0.18EN – 0.16AP	584.6	0.43	4	220	43.7	<0.001
	Dove	227	Y = -0.52 + 0.31CU – 0.17CO + 0.15EN – 0.14PR – 0.13SE	591.7	0.33	5	221	22.9	<0.001
Molokai (n_{max} = 130)	Axis deer	119	Y = -1.26 + 0.43EN + 0.22CU* + 0.17EC* – 0.15CO* – 0.14AP* – 0.1PR*	324.1	0.49	6	112	19.8	<0.001
	Goat	111	Y = -0.71 + 0.29EN + 0.28CU – 0.27AP – 0.11HE* – 0.09SE*	277.8	0.54	5	105	26.9	<0.001
	Mouflon	118	Y = -0.40 + 0.34EN – 0.28AP – 0.22HE	311.9	0.44	3	114	31.0	<0.001
	Pig	125	Y = -1.08 + 0.46CU – 0.21AP + 0.2EN	336.7	0.46	3	121	35.5	<0.001
	Turkey	119	Y = -0.88 + 0.34EN – 0.25HE + 0.21EC	300.8	0.44	3	115	31.6	<0.001
	Dove	120	Y = -0.98 + 0.29CU + 0.21EN – 0.15PR* – 0.15CO* + 0.14EC	285.7	0.49	5	114	23.9	<0.001
Oahu (n_{max} = 451)	Axis deer	403	Y = -0.76 + 0.33CU + 0.32EN – 0.20AP – 0.11HE	969.7	0.68	4	398	213.4	<0.001
	Goat	400	Y = -0.91 + 0.34CU + 0.30EN – 0.12PR – 0.07HE* – 0.07CO*	908.8	0.65	5	394	148.5	<0.001
	Mouflon	398	Y = -0.72 + 0.35EN + 0.24CU – 0.13HE – 0.10AP – 0.09CO	959.5	0.65	5	392	147.7	<0.001
	Pig	412	Y = -0.85 + 0.31EN – 0.18CO + 0.17CU – 0.09HE	985.7	0.54	4	407	121.0	<0.001
	Turkey	396	Y = -0.68 + 0.39EN + 0.21CU + 0.18SE – 0.12PR – 0.11AP	977.0	0.59	5	390	114.5	<0.001
	Dove	411	Y = -1.20 + 0.48CU – 0.24HE – 0.06SE + 0.02EN	989.1	0.42	4	406	75.9	<0.001

*Insignificant variables p > 0.05

Table 3.5 Percentage of survey respondents that enjoy seeing or hearing game species in the Hawaiian Islands.

Species	Hawai‘i	Kaua‘i	Lana‘i	Maui	Moloka‘i	O‘ahu
Axis deer	54.7	71.5	98.4	60.3	88.9	53.9
Goat	58.3	70.5	90.7	51.8	52.4	45.1
Mouflon	61.3	65.9	97.3	55.3	50.0	48.3
Pig	56.5	69.9	40.6	46.6	55.5	44.4
Turkey	64.9	67.1	92.2	51.2	58.3	48.2
Zebra dove	35.6	52.4	84.4	35.7	42.1	32.9

Table 3.6 Percentage of survey respondents that do not assign any cultural value to game species in the Hawaiian Islands.

Species	Hawai‘i	Kaua‘i	Lana‘i	Maui	Moloka‘i	O‘ahu
Axis deer	56.2	46.8	5.4	44.5	28.8	62.6
Goat	35.2	28.1	10.0	41.2	33.3	51.7
Mouflon	34.2	35.1	5.4	42.0	40.0	47.2
Pig	29.9	24.3	39.4	35.4	25.6	44.2
Turkey	32.5	37.7	7.2	43.2	37.5	47.5
Zebra dove	62.0	49.4	18.3	65.3	58.7	63.6

Table 3.7 Percentage of survey respondents that believe game species pose a risk to native fauna and flora.

Species	Hawai‘i	Kaua‘i	Lana‘i	Maui	Moloka‘i	O‘ahu
Axis deer	65.6	58.8	93.8	78.0	60.9	70.2
Goat	73.8	67.7	94.0	82.4	79.5	79.8
Mouflon	67.1	58.3	92.3	65.3	66.7	68.7
Pig	78.8	71.8	78.6	84.4	81.9	82.9
Turkey	30.8	29.2	81.1	38.5	40.2	39.1
Zebra dove	26.2	28.7	76.3	29.8	31.7	41.2

Table 3.8 Percentage of survey respondents that believe game species damage peoples' property or income.

Species	Hawai'i	Kaua'i	Lana'i	Maui	Moloka'i	O'ahu
Axis deer	56.5	48.5	92.6	86.6	71.3	57.7
Goat	57.9	55.0	91.3	74.3	71.1	63.7
Mouflon	40.3	33.9	82.8	47.5	42.7	45.0
Pig	80.4	79.4	69.6	87.4	77.2	81.2
Turkey	21.7	17.8	74.9	25.5	27.8	18.6
Zebra dove	15.4	22.0	65.3	19.6	21.6	23.2

Table 3.9 Percentage of survey respondents that believe game species may contaminate soil and water.

Species	Hawai'i	Kaua'i	Lana'i	Maui	Moloka'i	O'ahu
Axis deer	42.3	45.9	83.2	60.0	54.0	58.2
Goat	53.1	64.5	90.1	70.0	77.6	65.8
Mouflon	46.6	54.8	84.8	60.9	61.9	57.4
Pig	73.8	73.1	65.2	80.3	84.1	78.3
Turkey	19.4	23.5	71.1	22.8	35.7	23.6
Zebra dove	15.0	22.8	67.0	19.1	29.6	25.3

Table 3.10 Percentage of survey respondents that believe game species may pose a risk to human health and safety.

Species	Hawai'i	Kaua'i	Lana'i	Maui	Moloka'i	O'ahu
Axis deer	19.9	15.4	69.0	35.7	15.9	24.0
Goat	22.6	25.6	69.5	27.5	28.5	25.3
Mouflon	17.2	17.2	61.8	22.8	21.1	21.9
Pig	56.2	50.3	52.1	58.1	52.0	62.8
Turkey	12.1	11.8	48.4	15.4	16.5	9.2
Zebra dove	14.4	16.7	61.3	16.3	13.7	24.8

Additional common explanatory variables for WSAC models for Hawai‘i island were damage to property or income (5/6 models), and the potential for game species to contaminate soil and water (Table 3.8, 3.9). All six WSAC models for Maui listed the potential for game species to contaminate soil and water as an explanatory variable (Table 3.9). The potential risk to human health and safety was a common explanatory variable on Kaua‘i and O‘ahu (Table 3.10). For Lana‘i 4/6 WSAC models list economic value as an explanatory variable. Economic value of game species did not appear in models for pigs and goats, which have both been eradicated from Lana‘i (Tomich 1969; Campbell & Donlan 2005). Economic value of game does appear in models for Maui and Hawai‘i, but it was a weak variable over-shadowed by others.

Comparing species

The cultural value and enjoyment derived from seeing game species were the two most common and influential variables in WSAC models for pigs, goats and axis deer. Culture was a positive and influential variable for pigs on all islands except Lana‘i. The WSAC model for pigs on Lanai was exceptionally weak (Adj $R^2 = 0.07$) due to a lack of variation in the dependent variable (Table 3.3). The majority of respondents from all islands assigned some cultural value to pigs (Table 3.6). Yet, more than 70% of respondents from every island thought that wild pigs pose a risk to native flora and fauna (Table 3.7). Respondents from Kaua‘i (70.5%) and Lana‘i (90.7%) in particular enjoy seeing wild goats. More than 60% of respondents from Kaua‘i, Lana‘i, Maui, and Moloka‘i enjoy seeing axis deer (Table 3.5), and the majority of respondents from these islands assign some cultural value to them (Table 3.6). As with pigs, the majority of respondents from each island thought that goats and axis deer pose a risk to native flora and fauna (Table 3.7). More people thought goats presented a threat than did axis deer. The majority of respondents (> 53.1%) stated that goats were a source of contamination for soil and water (Table 3.9). Few people though goats presented a risk to human health and safety (Table 3.10).

As with the other game mammals enjoyment at seeing mouflon was a common explanatory variable. Mouflon occur on Hawaiʻi, and Lanai, and 61.3% and 97.3% respectively, of respondents from those islands stated they enjoyed seeing them (Table 3.5). For mouflon on Lanaʻi, WSAC models identified economic value, the potential health and safety risk to people, or the potential to contaminate soil and water as explanatory variables. On Lanaʻi 72.8% of respondents thought that mouflon had low economic value, and 17.7% that it had high economic value. Also on Lanaʻi 61.8% of people thought that mouflon presented a health and safety risk to people (Table 3.10) and 84.8% that they may contaminate soil and water (Table 3.9).

WSAC models for turkeys were dominated by three variables: enjoyment at seeing wild turkeys, the cultural value of turkeys, and the potential for turkeys to present a risk for native flora and fauna. The majority of respondents from each island except Oʻahu enjoy seeing wild turkeys (Table 3.5). Similarly, the majority of respondents thought that wild turkeys had some cultural value (Table 3.6). Approximately, one third of respondents stated that turkeys may pose a risk to native species (Table 3.7). Similarly, models for zebra doves were dominated by enjoyment derived from seeing doves and cultural value assigned to doves. But in contrast to the other game species, especially turkeys, their responses reflect that the majority of respondents do not enjoy seeing zebra doves (Table 3.5) and do not assign them any cultural value (Table 3.6). On Kauaʻi, Maui, and Oʻahu the frequency with which people see doves was a negative explanatory variable for desired abundance with 76.6%, 61.2% and 77.0% of respondents respectively stating that they see zebra doves at least once per week.

Discussion

The future desired abundance and perceived value of game species varied among the six main Hawaiian Islands. Axis deer, mouflon, and wild turkeys were more desired than wild pigs, goats, and zebra doves. Mouflon and axis deer are both exotic species to the U.S. and Hawaiʻi, technically and figuratively, unlike feral goats and wild pigs, which are non-native but common domestic and wild animals. Axis deer are attractive (Graf & Nichols 1966), popular with trophy hunters, and provide a high quality venison. Wild pigs on the other hand are an abundant free-ranging ungulate in the U.S. causing millions of dollars worth of damage to agriculture and the natural environment (Seward et al. 2004). Similarly, zebra doves are very common in Hawaiʻi, especially in urban and suburban areas. According to Christmas bird count data the abundance of zebra doves increased logarithmically in the Hawaiian Islands between 1939 and 1989 (Ralph 1990). Zebra doves are listed in the top 10 bird species generating complaints of crop damage by members of the Farm Bureau in Hawaiʻi (Koopman & Pitt 2007) and present an air-strike hazard. Over 10,000 zebra doves were shot around Lihue Airport, Kauaʻi, in 1992 (Pyle & Pyle 2009b). Although zebra doves are listed as a game birds, little hunting of this species currently occurs in Hawaiʻi (Pyle & Pyle 2009b). However, it is illegal to hunt turkeys on Kauaʻi or Oʻahu (DLNR 2012a), where they are encountered occasionally but are not abundant despite repeated attempts to re-establish them following an epidemic of blackheads (*Histomonas*) (Pyle & Pyle 2009b; Schwartz & Schwartz 1949). On Hawaiʻi, however, wild turkeys are in the top ten bird species generating complaints of crop damage by members of the Farm Bureau (Koopman & Pitt 2007). Large seed producers spend nearly a million dollars per year hazing gallinaceous birds that are damaging crops, while on adjacent lands sport hunting organizations and state agencies continue to introduce game birds (Koopman & Pitt 2007).

Enjoyment derived from seeing or hearing game species, and the cultural value assigned to game species were dominant variables across islands and species. Zebra doves were the only species that the majority of respondents did not enjoy seeing or hearing and were not considered culturally valuable. Therefore managers may need to consider that people enjoy interacting with wildlife when designing future management plans for introduced game species. Future research should investigate whether people enjoy seeing Hawaii's smaller more elusive native species as much as larger non-native game species and whether facilitating interactions with native species may alleviate some of the conflict generated by reducing the abundance of non-native species.

The majority of respondents assigned some cultural value to pigs, goats, mouflon, and turkeys. Pigs are a favored hunting quarry in Hawaiʻi and a source of subsistence for many people. Subsistence hunting is defined by the federal government as the customary use of wild resources for a variety of purposes. Contemporary subsistence hunting in the U.S. is part of a mixed subsistence-cash economy with food products generally being distributed through noncommercial networks of sharing and exchange (Bosworth 1995). While pig hunting was probably not a cultural activity for historical native Hawaiian communities, consuming pig is traditional (O'Connor 2008) and pig hunting is a component of contemporary culture in Hawaiʻi. Given that the majority of people want pig numbers to decline and that hunters are likely to be unsupportive of government officials acting to reduce the abundance of pigs, the best management strategy may be to open as much land as possible to pig hunters and to actively encourage hunters to pursue pigs that are causing conflict or damage. Pig hunters' desire for a greater abundance of pigs may be appeased if their ability to interact with wild pigs was increased. Increasing hunter access to private land may also help alleviate some of the hunter-agriculture conflicts mentioned above.

In general hunters and Lanaʻi residents were the only stakeholder groups to desire an increase in the abundance of game species. The majority of Lanaʻi (~98%) is privately owned by Larry Elison, which employs 22% of the population (Cocke 2011). Several hunting outfitters lead guided hunts on Lanaʻi for mouflon and axis deer. Many game ranches receive upwards of $1,000 per trophy buck taken during a guided hunt (Anderson 1999). Unlike on the other islands game have direct economic value on Lanaʻi. Survey results also indicate that there are very few conservation biologists or agriculturalists on Lanaʻi (Table 3.2). These two stakeholder groups consistently wanted the abundance of game species to decrease, however, their opinion not represented on Lanaʻi. In contrast to their desire for an increase in game abundance, residents of Lanaʻi seem to be aware of the potential negative impacts of game species (Tables 3.7 through 3.10).

WSAC models for Oʻahu and Kauaʻi suggest that residents are concerned about human health and safety. On Oʻahu this concern may be because many people have very little experience with wildlife. The majority (70%) of Hawaiʻi's human population resides on Oʻahu and 99% of Oʻahu's population lives in urban areas (US Census Bureau Geography Division 2010). Less than 30% of Oʻahu's population ever deliberately interacts with wildlife (Kempthorne et al. 2006).

On Maui, the potential for game species to contaminate soil and water was a more common explanatory variable in WSAC models than concern for human health and safety. The East Maui Watershed Partnership (created in 1991) and the West Maui Mountains Watershed Partnership (created 1998) actively work to protect native rainforest, the primary fresh water source over 148,000 acres (HAWP 2012) or approximately 32% of the island. These two groups may be influencing the values of Maui's residents or the activity and success of these groups may be because residents of Maui already value water resources.

WSAC models for Hawaiʻi island suggest that residents both value game species and are concerned about the impact they may have on the environment. The majority of respondents stated that they enjoy seeing game species, assign some cultural value to all game species except zebra doves and axis deer, and simultaneously believe that game species present a risk for native species. Axis deer were probably not considered culturally valuable because they were only introduced to Hawaiʻi in 2011 (DLNR 2011). Hawaiʻi has a strong hunting culture. It was Hawaiʻi based hunters that pushed DLNR to allow hunters to manage game species (Giffin 1975a; b). My results suggest that human-wildlife conflict on Hawaiʻi may be the result of conflict between a contemporary cultural activity and relatively recent information on the impact of game species. Using hunters to help alleviate the impacts of game species may be a method of alleviating this conflict. However control programs that use hunters need to be carefully monitored and enforced, and they need to use incentives that ensure goals are met in a timely fashion otherwise hunters will only remove select individuals from the population (Guynn & Schmidt 1984; Giles & Findlay 2004; Stephens et al. 2008).

Management implications

Game species have been a source of human-wildlife conflict in the Hawaiian Islands for over 200 years. Management goals for game species have oscillated between conflicting value systems in reaction to public attitude towards the environment and changes in the cultural, political, economic climate of the Hawaiian Islands (Duffy 2010). WSAC models and PCI analysis of survey data from across the Hawaiian Islands reveal significant differences in the desired abundance and perceived value of game species among the residents of each of the 6 main islands. One of the greatest challenges for wildlife professionals working in the Hawaiian Islands is using a centralized management system to manage wildlife on discrete islands with unique cultures and identities. Policies that are accepted by the residents of one island may be opposed by the residents of another island. Based on the results of this research I recommend that wildlife management agencies design individual management plans for each island taking into consideration the values of the residents of each island.

Chapter 4 Who wants feral cats in the Hawaiian Islands and why?

Abstract

Feral cats are abundant throughout the world and pose a threat to native wildlife. Human-wildlife conflict regarding how feral cats should be managed has increased recently. To address this conflict, my goal was to understand the beliefs and desires held by stakeholders regarding feral cats. My first objective was to assess the wildlife stakeholder acceptance capacity for feral cats using the Hawaiian Islands as a model system. My second objective was to use the potential for conflict index (PCI) and consensus convergence (CC) models to identify an order of preference for seven feral cat management techniques. In 2011 I disseminated a survey to 5,407 Hawai‘i residents including agriculturalists, animal welfare advocates, conservationists, native Hawaiians, hunters, and the public. Approximately 46% of pre-identified stakeholders and 20% of the public responded to the survey with 1,510 surveys in total being returned. PCI results reveal a high level of consensus that the abundance of feral cats should be decreased. Despite this result 12% of respondents would like to see feral cat populations persist. The five most common explanatory variables for respondents’ stated desires and the responses associated with those variables were: 84% of respondents do not enjoy seeing feral cats; only 12% of respondents assign an intrinsic value to feral cats, 73% of respondents believe feral cats threaten native fauna, 69% of respondents see feral cats frequently, and 44% of respondents’ noticed an increase in feral cat abundance. The majority of respondents (78%) support removing feral cats from the natural environment permanently. CC models with data from 1,388 respondents revealed live capture and lethal injection to be the most preferred technique and trap-neuter-release to be the least preferred technique. Few people support the presence of feral cats and the majority would prefer to see feral cats removed from the natural environment rather than managed via *in-situ* techniques.

Introduction

The field of human dimensions of wildlife attempts to understand and clarify peoples' perspectives on wildlife management programs and issues in order to systematically incorporate them into decision making, replacing assumptions with knowledge (Decker & Enck 1996). Human dimensions studies are frequently instigated by human-wildlife conflict, that is, conflict between people and wildlife or conflict among people over wildlife. Human-wildlife conflict occurs when the ecological needs and behaviors of wildlife negatively affect the goals of humans or when the goals of humans negatively affect the needs of wildlife (Madden 2004). These conflicts can arise when wildlife threaten human health and safety or whenever one group of people benefits from the presence of wildlife, while another group pays a cost (Stokes et al. 2006). Human-wildlife conflict escalates when people feel that the needs or values of wildlife or other people are given priority over their own needs. If wildlife professionals fail to address human-wildlife conflict then people may turn to legal and legislative processes to over-turn their decisions (Teel et al. 2002). Eventually, conservation initiatives suffer, the economic and social well-being of people is impaired, and support for conservation declines (Madden 2004).

A first step to mitigating human-wildlife conflict is to gain an understanding of public sentiment regarding the species of interest. Public officials need to represent their constituents and hence political support will be more forthcoming for management goals that are supported by the public. Resource managers, outreach specialists, and educators can greatly benefit from understanding why people support some plans and not others as they can use the information to address underlying issues by developing more effective outreach or educational materials, and to direct institutions research goals, management plans or policy.

One species that has caused a great deal of human-wildlife conflict around the world, and in the US in particular, is the domestic cat (*Felis catus*). For instance, a proposal to define free roaming feral cats as an unprotected species in

Wisconsin in 2005 at the annual spring Conservation Congress resulted in statewide arguments between stakeholder groups and a death threat (Lepczyk 2005). Likewise, in Texas, a man was acquitted of animal cruelty after shooting a feral cat that was hunting endangered piping plovers (*Charadrius melodus*) (Barcott 2007) and in 2009 a coalition of conservation groups sued the City of Los Angeles to halt the practice of trap-neuter-release until a review of the program under the California Environmental Quality Act could be completed (American Bird Conservancy 2010).

Human-wildlife conflict exists between conservation professionals working to remove cats from the natural environment and those people that feed feral cats or advocate for trap-neuter-return (TNR; Longcore et al. 2009). Feral cats threaten native animals through predation or disease dissemination. For example, feral cat populations have been linked to reduction in bird diversity (Sims et al. 2008), extirpation of insular species (Medina et al. 2011), and toxoplasmosis (*Toxoplasma gondii*) infections in monk seals (*Monachus schauinslandi*) (Honnold et al. 2005), and dozens of species of birds (Work et al. 2002; Dubey 2010). TNR advocates claim that feral cats do not contribute to decline in native fauna nor spread disease (Longcore et al. 2009). Arguments between these stakeholder groups are occurring without any knowledge regarding true public understanding and sentiment for feral cats.

Several tools exist for analyzing human-wildlife conflict and identifying stakeholders' preferred solutions to a problem. Wildlife stakeholder acceptance capacity (WSAC) analysis measures peoples' perceptions of the abundance of wildlife, the perceived impact of wildlife and peoples' desires for future changes in the abundance of wildlife (West & Parkhurst 2002; Lischka et al. 2008). WSAC analysis provides insight into why stakeholders desire a stated change in the abundance of a species. Similarly, the potential for conflict index (PCI) is a method of identifying the typical desire for a stakeholder group and the diversity of opinions within that group (Manfredo et al. 2003). Consensus convergence models replicate negotiation behavior seen in focus groups and may be used to rank a number of solutions to a problem (Regan et al. 2006).

Feral and free-roaming cats have been present in the Hawaiian Islands for hundreds of years (Tomich 1969) and are common in both urban and rural areas throughout the year. Many of these feral cats live in colonies that were created or facilitated by people that feed the cats. Most cat colonies are located in urban or suburban areas, but others are located near locations housing endangered species such as Pearl Harbor National Wildlife Refuge and Keaīwa Heiau State Recreation Area. The existence of cat colonies is affecting legislation. For example, State of Hawaiʻi Senate Bill SB13 (2011) proposed designating trapping feral cats by any means a misdemeanor. In Kauaʻi County, Resolution 2011-51 proposed replacing euthanasia of feral cats with TNR. The large number of cat colonies in Hawaiʻi combined with the number of legislative bills/resolutions submitted that support TNR as an appropriate method of management for feral cats leaves the impression that a large segment of society supports the presence of feral cats in the islands and *in-situ* management techniques.

Given the human-feral cat conflict that exists my goal was to understand the beliefs, values, and desires of stakeholders regarding feral cats. To address this goal, my first objective was to assess the Wildlife Stakeholder Acceptance Capacity (WSAC) for feral cats using the Hawaiian Islands as a model system. My second objective was to use the potential for conflict index (PCI) and consensus convergence models to identify how stakeholders perceive seven feral cat management techniques and to determine an order of preference.

Methods

I administered a mail and internet survey between July and September, 2011 using the tailored design method (Dillman et al. 2009). The survey was disseminated to 5,407 people from six pre-identified stakeholder groups: hunters (n = 1650), conservation professionals (n = 698), agriculturalists (n = 373), animal welfare activists (n = 277), native Hawaiians (members of a Hawaiian Civic Club; n = 49), and the general public (n = 2360). The survey contained questions about 14 species of introduced terrestrial vertebrates. These 6 stakeholder groups have been involved in previous cases of human-wildlife conflict in Hawai‘i (Josayma n.d.; Adler 2001; Subcommittee on Public Information and Deer Management Planning of Maui Axis Deer Group 2002). I identified potential individuals to survey among these six groups using direct solicitation, internet searches, and assessment of organization membership lists. I used a list of random mailing addresses purchased from AccuData Integrated Marketing, stratified by zip-code, to contact the general public. The 46 question survey was emailed via SurveyMonkey™ to people listed as conservation professionals, agriculturalists, animal welfare activists, or native Hawaiians, while a hard copy of the survey was mailed to the general public and hunters because too few email addresses were obtainable for these two groups. Since the electronic distribution of a survey is free I surveyed as many pre-identified stakeholders as could be contacted. 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). Each survey recipient was sent a cover letter with the initial copy of the survey, a reminder postcard or email, and then a second copy of the survey. Only 14 questions from the survey referred to feral cats (Table 4.1). Other questions requested demographic and behavioral information, some of which were used here to define stakeholder groups, or information on other terrestrial vertebrates present in the Hawaiian Islands.

Table 4.1 Survey questions and available responses used to generate data for wildlife stakeholder acceptance capacity (WSAC) models, potential for conflict index (PCI), and consensus convergence models (CCM) for the presence and management of feral cats in the Hawaiian Islands.

		Question (Symbol)	Available Responses
WSAC and PCI	12)	Feral cats are enjoyable to see/hear in the wild in HI? (EN)	5-point bi-polar with responses: Strongly disagree; disagree; neither agree nor disagree; agree; strongly agree
	13)	Whether or not I see a feral cat, I benefit from knowing that they persist in HI? (IN)	
	14)	Feral cats damage people's property or source of income? (PR)	
	15)	Feral cats pose a health or safety risk for people? (HE)	
	16)	Feral cats pose a risk for native animals or plants? (AP)	
	17)	Feral cats may contaminate or degrade the soil or water? (CO)	
	18)	In the last 2 years has the number of feral cats increased in your area? (TW)	
	19)	Feral cats are culturally important or valuable animals? (CU)	4-point uni-polar with response: Not valuable; slightly valuable; somewhat valuable; very valuable
	20)	Feral cats are economically important or valuable animals in HI? Do they generate income or revenue? (EC)	
	21)	How frequently do you see feral cats in the area where you live? (SE)	5-point uni-polar with responses: Never seen one; seen once per year; seen monthly; seen weekly; seen daily
	11)	In the future I would like the number of feral cats in the wild to increase or decrease? (Y)	5-point bi-polar with responses: Strongly disagree; disagree; neither agree nor disagree; agree; strongly agree
CCM	12)	Which of the following methods of managing free-roaming cats do you favor or oppose? Live capture and adoption; live capture and lethal injection; live capture and lethal gunshot; trap-neuter-release; lethal traps; predator proof fence; sharp shooter with firearm	9-point scale with responses ranging between strongly favor and strongly oppose (not all response options were given a text label)

Table 4.1 Continued

		Question (Symbol)	Available Responses
Contingency questions	13)	Would you like populations of feral cats to continue to persist in the Hawaiian Islands	Yes; No; Unsure
	14)	Would you support the removal or relocation of feral cats from areas with populations of threatened or endangered species?	Yes, remove permanently; Yes, relocate cats at least 1/3 mile or 500m away; No, fed cats do not kill other animals; Unsure`
Demographic and behavioral questions	15)	How interested are you in wildlife issues?	5-point uni-polar with response: Not interested; Mildly interested; Moderately interested; Strongly interested; Very strongly interested
	16)	What level of education have you completed?	Some high school; High school graduate or GED; Some college; Associates degree in college; Bachelor's degree; Master's, professional or doctoral degree
	17)	Please describe the area where you currently live.	Rural area or farm; Small town (<25,000 people; Suburban area 25,000 to 100,000 people; Urban > 100,000 people
	18)	Which race do you most identify with?	Asian, Black, Caucasian, Hispanic, Native Hawaiian, Pacific Islander, Mix race or other.
	19)	How often do you feed Feed cats?	4-point uni-polar with responses: Never; Rarely (once per year); Occasionally (monthly); Frequently (weekly)
	20)	How often do you feed wild birds?	
	21)	How often do you watch wildlife?	
	22)	How often do you hunt?	
	23)	How often do you hike?	
	24)	How often do you volunteer for conservation programs?	
	25)	How often do you participate in Hawaiian cultural activities?	

The survey response rate (Table 4.2) was calculated as the number of completed surveys divided by the initial number of surveys disseminated minus the number of undeliverable surveys. Upon completion of the survey, I attempted to contact 5% of the non-respondents via telephone to request participation in a short non-response survey.

Table 4.2 Survey response rate for each pre-identified stakeholder group and the percentage of the public that meet the characteristics of each pre-identified and post hoc stakeholder group.

	Stakeholder Group	# of Respondents	Response rate (%)	% Public within group
Pre-identified	Agriculture	162	48.8	8.6
	Animal Welfare	277	54.8	25.9
	Conservation Professionals	698	47.7	55.8
	Hunter all levels	482	34.1	24.0
	Public	396	20.0	100
	Hawaiian (Civic group member)	49	46.8	15.2
Post hoc	Hawaiian (all)	290	-	15.2
	Hunt frequently	368	-	8.4
	College education	726	-	41.9
	Feed wildlife frequently	131	-	7.0
	Low interest in wildlife	316	-	41.0
	High interest in wildlife	697	-	22.0
	Rural home	964	-	82.5

Survey recipients were initially assigned to a stakeholder group based on their affiliation with an organization (e.g., people with hunting licenses are hunters). However, because people can fall into multiple stakeholder groups (e.g., conservation professional and hunter), I increased the number of the stakeholder groups following *post hoc* cluster analysis of socio-demographic and behavioral data (Brophy et al. 2006). Specifically, I used k-means cluster analysis with the Caliniski and Harabasz algorithim (Calinski & Harabasz 1974) and corrected Akaike's Information Criterion (AICc; Q-Analysis Software for Market Research©;

Numbers International Pty Ltd 2007-2012) to identify the optimal number of clusters within a dataset that included information on survey respondent's interest in wildlife, education level, home location, and tendency to feed wildlife, watch wildlife, hunt, hike, volunteer for conservation programs, or participate in Hawaiian cultural activities (Table 4.1). The cluster analysis identified six *post hoc* stakeholder groups with relatively unique characteristics. Rather than maintain groups as identified by cluster analysis, which minimizes the ability to compare studies, I sorted and analyzed the whole data set according to the characteristics identified by the cluster analysis. I also selected native Hawaiians as an additional *post hoc* stakeholder group (individuals reported their ethnicity; Table 4.1, Q18) because I were unable to pre-identify a sufficient number of native Hawaiians (Table 4.2). WSAC models were built for both pre-identified (except Hawaiian Civic Group Members) and *post hoc* stakeholder groups.

To identify the beliefs and values that were commonly held by stakeholders regarding feral cats I used multiple regression (SYSTAT® 13 Statistics, SYSTAT Software, Inc 2009) to compare how people's desired change in the abundance of feral cats (dependent variable (Y): Table 4.1, question 11) related to people's beliefs about the impacts of feral cats and attitudes towards the presence of feral cats (independent variables: Table 4.1, Q 1-10) (Christoffel 2007; Lischka et al. 2008). I tested all linear model combinations. I did not test for interactions or transform the data because the data were collected using Likert scales (Norman 2010). The four best WSAC models were identified via AICc values (Anderson 2008) and model weights for each pre-identified and *post hoc* stakeholder group.

The disparity in respondents' desired abundance for feral cats was also analyzed, independently of the questions assessing beliefs and values, using the potential for conflict index (PCI). The PCI ranges from 0 (minimal potential for conflict) to 1 (maximum potential for conflict). The maximum potential for conflict occurs when responses are equally divided between the two extreme values on a Likert scale (e.g., 50% highly unacceptable and 50% highly acceptable) (Vaske et al. 2010). Graphically, the scale mean in PCI analysis is represented by the center point of bubbles on a bubble graph and PCI values are represented by bubble size.

The survey also included contingency questions unrelated to WSAC analysis (Table 4.1). The data were analyzed via Kruskal-Wallis and Mann-Whitney nonparametric tests with Conover-Inman pairwise comparisons. All analyses initially compared data separately for each of the main Hawaiian Islands (Hawai‘i, Kaua‘i, Lana‘i, Maui, Moloka‘i, and O‘ahu). Data were pooled if there was no significant difference among islands.

The results of the WSAC analysis are useful for defining management goals for feral cats whereas consensus convergence models (CCMs) may be used to rank methods of managing cats when peoples' opinions of each method vary (Lohr et al. in press). I identified seven management techniques for feral cats: live capture and adoption; live capture and lethal injection; live capture and lethal gunshot; TNR; lethal traps; predator-proof fence; and sharp shooter. Survey recipients were asked to state if they approved or disapproved of each technique using a 9-point Likert scale ranging between 1 (strongly favor the technique) to 9 (strongly oppose the technique) (Table 4.1). The data were re-coded to a scale ranging between -4 (strongly oppose) and 4 (strongly favor) for PCI analysis of the average approval rating of each technique. Kruskal-Wallis tests were used to assess differences between groups.

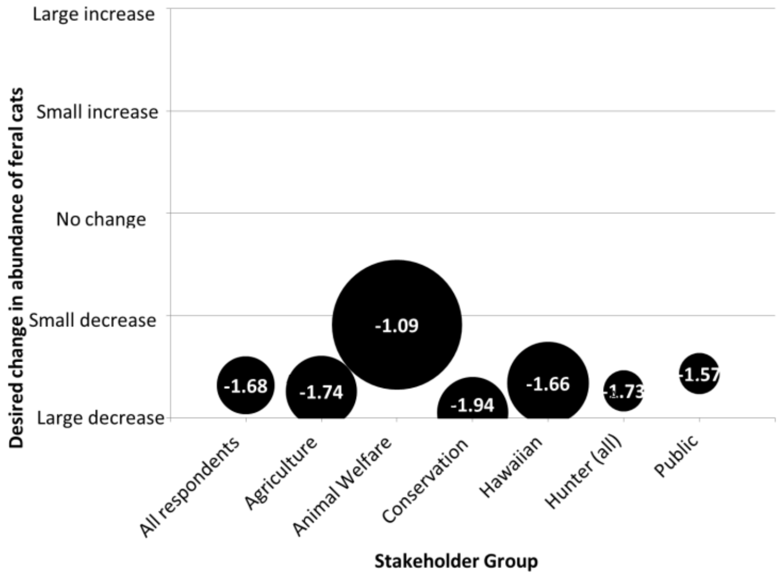
Once the disparity in respondents' views regarding the acceptability of each management technique was identified I used CCMs to develop a consensual ranking of the seven management techniques for each stakeholder group and for all survey respondents collectively. CCMs are designed to replicate the negotiation behavior seen in focus groups (Lehrer & Wagner 1981). The original Lehrer and Wagner (1981) CCM requires that a group of stakeholders assign weights to a list of management options, with heavier weights being applied to more preferred options. It also uses information, supplied by the stakeholders, on the amount of cooperation experienced between any two stakeholders during an initial group discussion of the management options to calculate the best compromise. Regan et al. (2006) modified the original Lehrer and Wagner (1981) model by assuming that the amount of cooperation between stakeholders may be calculated using the deviation among weights applied to each management option by each stakeholder. Specifically, Regan et al. (2006) assumed that stakeholders with similar arrays of weights, or similar opinions, are more likely to cooperate during a decision-making process. I converted the original Likert data (ranging from 1 to 9) into weights ranging between 0 (least preferred technique) and 1 (most preferred technique) via the linear weight variable slope model: $\text{Weight}_r = (100\text{-}s_n(r\text{-}1))/100$ (Alfares & Duffuaa 2009). These weights were entered into the CCM described by Regan et al. (2006).

Results

On average 46% of the pre-identified stakeholders responded to the survey compared to 20% of the public with a total of 1,510 surveys being completed (Table 4.2). Some survey recipients opted-out of the email survey (7.8%) and 14.9% of mail surveys were undeliverable. The non-response survey revealed that survey respondents and non-respondents 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 cluster analysis identified six *post hoc* stakeholder groups (Cronbach's α = 0.5; R_{rank} = 0.54): people with little or no interest in wildlife; people with a high interest in wildlife; people that hunt frequently (once per month or more); people that feed wildlife (both feral cats and birds) frequently (once per month or more); people whose current home is located in a rural area or small town (<25,000 people), and, people with a college education (Table 4.2). Results from the survey of the general public suggest that 25.9% of the population either donates money or volunteers for an animal shelter, but only 7% of Hawai'i's residents feed both feral cats and wild birds frequently (Table 4.2). Upon further investigation 8.6% of the population feed feral cats frequently, whereas 20.6% of people frequently feed wild birds.

All stakeholder groups, including animal welfare activists and people who feed wildlife frequently, would like to see a moderate decrease in the abundance of feral cats in the Hawaiian Islands (Figure 4.1). The PCI was near zero (≤0.1) for all stakeholder groups, indicating a high level of consensus among the public that the number of feral cats should be reduced. On average 86.9% of respondents would like to see a decrease in the number of cats; 12% would like the number of cats to remain the same; and 1% would like to see an increase in the number of feral cats. Even among cat feeders, 67% of respondents would like to see the number of feral cats reduced (27% no change, 0% increase). Likewise, 68.3% of people involved with animal welfare organizations would like to see the abundance of cats decrease (26.7% no change, 5.0% increase). Respondent's desire for the future abundance of feral cats was similar among the main Hawaiian Islands ($K = 4.30$; $P = 0.51$). Despite a common desire to see the abundance of feral cats decrease, 12% of all survey respondents, on average, stated that they would like to see populations of feral cats persist in the Hawaiian Islands (Figure 4.2). Whereas 50% of people involved with animal welfare organizations and 46.3% of feeders would like to see feral cats persist. Desire to see populations of feral cats persist varied significantly among the islands ($K = 13.80$; $P = 0.02$) with fewer people on Lana‘i wanting feral cats than any of the other islands.

A



B

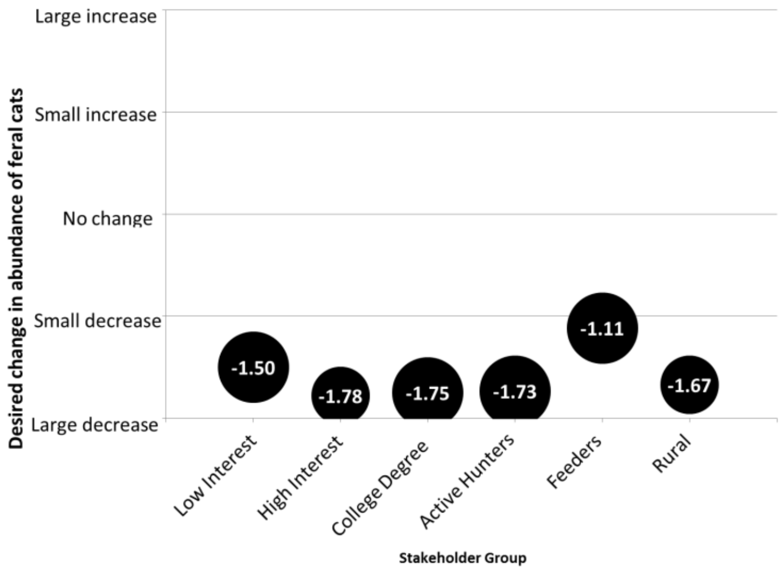


Figure 4.1 Average desired change in the abundance of feral cats in the Hawaiian Islands: A) Pre-identified stakeholder groups; B) Post hoc stakeholder groups.

The center point of each bubble and bubble label represents the scale mean (-2 = larger decrease; 2 = large increase). Bubble size represents the potential for conflict index (PCI) value: larger bubbles indicate greater potential for conflict or less consensus among survey responses (min = 0.01; max = 0.05).

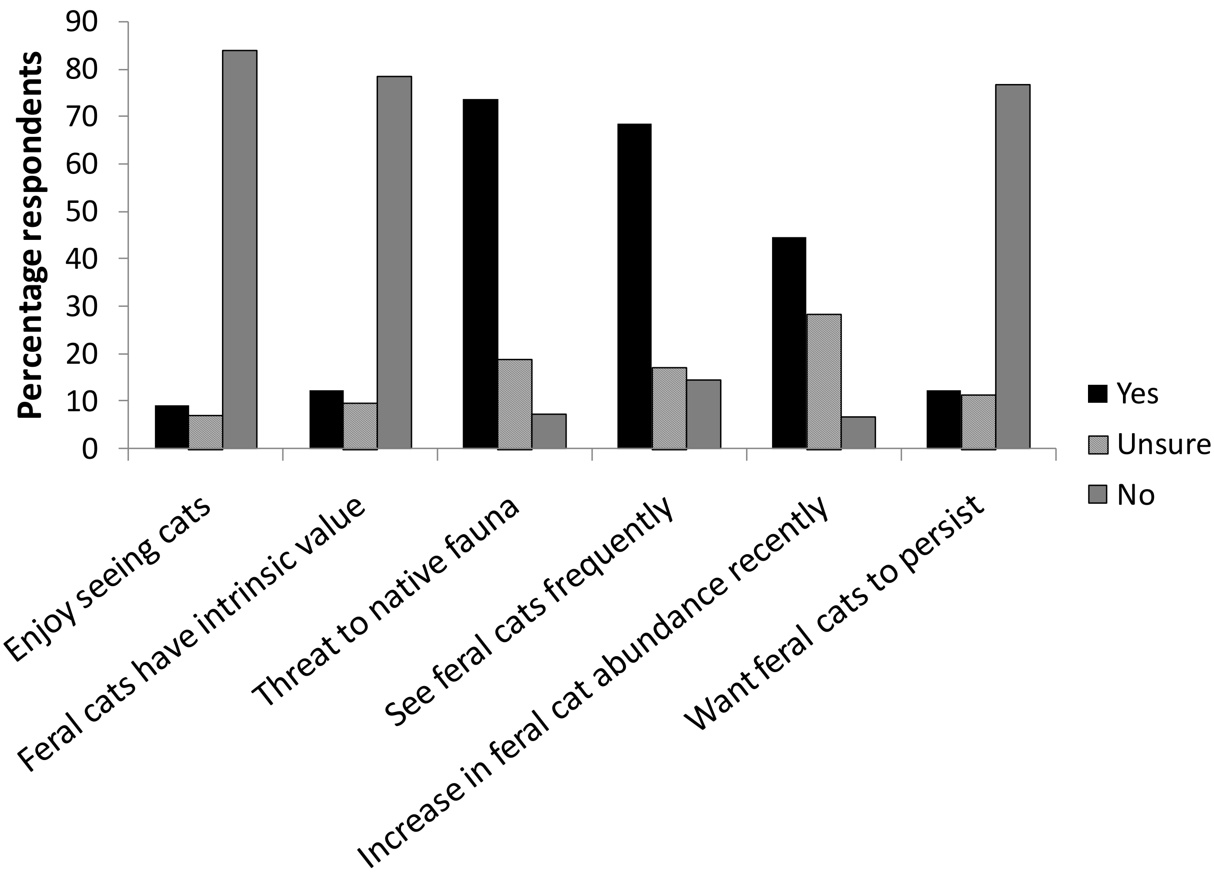


Figure 4.2 Results of the 5 most common explanatory variables for respondents' desire for the future abundance of feral cats plus the results of a contingency question asking if respondents' would like to see populations of feral cats persist in the Hawaiian Islands.

The data for the 5 explanatory variables were collected via a 5-point likert scale (Table 1) and have been collated into three categories.

Whether or not respondents' enjoyed seeing feral cats (EN) was an explanatory variable in 10/12 WSAC models (Table 4.3). On average 9.2% of people enjoyed seeing feral cats, 6.8% neither liked nor disliked seeing feral cats, and 84% disliked seeing feral cats (Figure 4.2). Similarly, the intrinsic value of feral cats (IN) was an explanatory variable in 9/12 WSAC models. On average 12.3% of respondent's stated that whether or not they see a feral cat, they benefit from knowing they persist in the Hawaiian Islands, whereas 78.5% stated that they do not benefit from knowing that feral cats persist in Hawai'i.

The potential for feral cats to present a risk to native fauna was the third most common explanatory variable, appearing in 8/12 models. On average 73.5% of respondents stated that feral cats pose a risk for native fauna, 18.7% neither agreed nor disagreed that feral cats present a risk, and 7.1% stated that feral cats do not pose a risk to native fauna. Three other potential impacts of feral cats on the natural environment, the potential to contaminate soil or water, impact on human health and safety, and potential to damage human property or income, each only appeared in two or three models with 58.2%, 66.4%, and 55.7% of respondents agreeing that feral cats cause each of these impacts, respectively.

Respondents' interactions with feral cats influenced their future desired abundance of feral cats, as the frequency with which respondents see feral cats was an explanatory variable in 8/12 models, and respondents' perception of recent changes in the abundance of feral cats was an explanatory variable in 7/12 models. On average only 5.3% of respondent's stated they had never seen a feral cat, 9.1% saw them once per year, 17.1% saw them monthly, 25.5% saw them weekly, and 43.1% of respondent's saw or heard feral cats on a daily basis. On average 44.7% of respondents stated that the abundance of feral cats had increased in the last 2 years, 28% stated that abundance had remained the same, and 6.7% stated that abundance had decreased (Figure 4.2). A Kruskal-Wallis test with Conover-Inman pairwise comparisons ($K = 44.87$; $P < 0.01$) revealed that significantly

Table 4.3 WSAC models identified for each stakeholder group. Symbols refer to questions outlined in Table 4.1.

	Best Model	K	Adj R^2	AICc	∆AICc	Log (*L*)	w_i	p
Agriculture	Y = -1.14 + 0.265SE – 0.07IN*	4	0.13	209.49	0	-54.39	0.41	<0.001
	Y = -1.07 + 0.20IN + 0.11EN* – 0.06SE*	5	0.14	209.74	0.24	-55.23	0.30	<0.001
	Y = -1.311 + 0.27IN	3	0.12	210.75	1.25	-55.37	0.18	<0.001
	Y = -1.23 + 0.21IN + 0.12EN	4	0.13	210.77	1.28	-56.29	0.18	<0.001
Animal Welfare	Y = -1.19 +0.33EN + 0.15EC – 0.02SE*	5	0.47	217.85	0	-24.65	0.64	<0.001
	Y = -1.28 + 0.33EN + 0.15EC	4	0.48	220.64	2.79	-26.16	0.39	<0.001
	Y = -1.29 + 0.22EN + 0.15EC + 0.12IN*	5	0.48	221.33	3.48	-26.83	0.28	<0.001
	Y = -1.28 + 0.28EN + 0.15EC – 0.08CO*	5	0.48	221.89	4.02	-26.59	0.21	<0.001
Conservation	Y = -1.64 – 0.19AP – 0.06IN + 0.05SE*	5	0.05	229.69	0	-184.48	0.31	0.003
	Y = -1.70 – 0.16AP + 0.15CU – 0.06IN + 0.04SE	6	0.05	229.74	0.05	-185.37	0.30	0.004
	Y = -1.99 + 0.18CU* – 0.07IN + 0.04SE*	5	0.04	230.47	0.78	-184.14	0.21	0.005
	Y = -1.66 – 0.19AP – 0.08IN + 0.04SE* + 0.03CO*	6	0.05	230.70	1.01	-184.96	0.19	0.005
Hunter all	Y = -1.10 + 0.21CU + 0.12EN + 0.10IN – 0.06SE – 0.06AP – 0.06TW – 0.04HE*	9	0.31	927.18	0	-302.87	0.29	<0.001
	Y = -1.10 + 0.22CU + 0.12EN + 0.11IN – 0.07AP – 0.06SE – 0.06TW	8	0.31	927.27	0.09	-301.93	0.28	<0.001
	Y = 1.10 + 0.21CU + 0.12EN + 0.10IN – 0.06SE – 0.06AP – 0.05TW* – 0.04CO*	9	0.31	927.42	0.24	-302.77	0.26	<0.001
	Y = -1.10 + 0.2CU + 0.12EN + 0.11IN – 0.06SE – 0.06AP – 0.06TW – 0.02PR*	9	0.31	928.20	1.02	-302.42	0.17	<0.001

*Non-significant variables p > 0.05

Table 4.3 Continued

	Best Model	K	Adj R^2	AICc	∆AICc	Log (*L*)	w_i	p
Hawaiian	Y = -1.02 + 0.31CU + 0.26EN – 0.07TW* - 0.06HE* - 0.06AP* - 0.06SE*	8	0.51	358.17	0	-137.61	0.28	<0.001
	Y = -1.02 + 0.32CU + 0.25EN – 0.07AP* - 0.07TW* - 0.06CO* - 0.06SE*	8	0.51	358.34	0.17	-137.54	0.26	<0.001
	Y = -1.04 + 0.33CU + 0.26EN – 0.09HE* – 0.07TW* – 0.06SE*	7	0.51	358.53	0.36	-136.52	0.23	<0.001
	Y = -1.03 + 0.32CU + 0.27EN – 0.09AP – 0.08TW* - 0.06SE*	7	0.51	358.56	0.39	-136.51	0.23	<0.001
Public	Y = -0.99 + 0.13EN + 0.10IN + 0.09CU* – 0.08SE – 0.06CO* – 0.06AP* – 0.04PR*	9	0.31	1034.89	0	-219.13	0.34	<0.001
	Y = -0.98 + 0.14EN + 0.10CU + 0.10IN – 0.08SE – 0.07AP – 0.07CO	8	0.30	1035.18	0.30	-218.10	0.29	<0.001
	Y = -0.98 + 0.13EN + 0.10IN + 0.10CU – 0.08SE – 0.06AP – 0.06CO* – 0.04HE*	9	0.30	1036.03	1.15	-218.63	0.19	<0.001
	Y = -1.01 + 0.13EN + 0.11IN + 0.10CU – 0.08SE – 0.08CO – 0.06PR	8	0.30	1036.09	1.20	-217.71	0.18	<0.001
Low interest	Y = -0.74 + 0.34EN – 0.10TW – 0.09AP – 0.09SE	6	0.36	352.72	0	-96.25	0.30	<0.001
	Y = -0.75 + 0.34EN – 0.09TW – 0.09SE – 0.09CO*	6	0.36	353.03	0.31	-96.11	0.25	<0.001
	Y = -0.87 + 0.27EN + 0.11CU* – 0.11TW – 0.09SE – 0.09AP*	7	0.37	353.15	0.43	-96.99	0.24	<0.001
	Y = -0.75 + 0.32EN – 0.10TW – 0.09SE – 0.07AP* – 0.06CO*	7	0.36	353.37	0.65	-96.90	0.21	<0.001
High interest	Y = -1.42 + 0.13CU + 0.12IN + 0.11EN + 0.10EC – 0.05AP	7	0.42	903.34	0	-401.39	0.44	<0.001
	Y = -1.45 + 0.13IN + 0.13CU + 0.10EC + 0.10EN – 0.04HE*	7	0.41	904.66	1.32	-400.82	0.23	<0.001
	Y = -1.46 + 0.14CU + 0.13IN + 0.10EC + 0.10EN – 0.04CO*	7	0.41	904.80	1.46	-400.76	0.21	<0.001
	Y = -1.45 +0.13IN + 0.13CU +0.10EC +0.09EN – 0.03HE* – 0.02CO*	8	0.41	905.67	2.33	-401.27	0.13	<0.001

*Non-significant variables p > 0.05

Table 4.3 Continued

	Best Model	K	Adj R^2	AICc	∆AICc	Log (*L*)	w_i	p
College education	Y = -1.31 + 0.13CU + 0.12IN + 0.11EN – 0.09AP – 0.02TW*	7	0.37	785.54	0	-323.16	0.81	<0.001
	Y = -1.32 + 0.13CU + 0.12IN + 0.10EN – 0.08AP – 0.03HE* – 0.01TW*	8	0.37	786.48	0.94	-323.64	0.24	<0.001
	Y = -1.37 + 0.13CU + 0.12IN + 0.11EN – 0.09AP – 0.03TW* + 0.02SE*	8	0.37	786.77	1.23	-323.52	0.20	<0.001
	Y = -1.32 + 0.12CU + 0.12IN + 0.11EN – 0.08AP – 0.02TW* – 0.02IN*	8	0.37	786.98	1.44	-323.43	0.18	<0.001
Active hunters	Y = -1.30 + 0.19CU + 0.10EN + 0.08IN – 0.08PR – 0.07TW – 0.07HE	8	0.30	481.89	0	-168.85	0.31	<0.001
	Y = -1.35 + 0.17CU + 0.09EN* + 0.09EC – 0.08TW – 0.07PR + 0.07IN* – 0.06HE*	9	0.31	481.97	0.08	-169.74	0.30	<0.001
	Y = -1.46 + 0.20CU + 0.11EC* + 0.09IN – 0.08TW – 0.08PR – 0.07HE	8	0.30	482.76	0.87	-168.48	0.20	<0.001
	Y = -1.28 + 0.19CU + 0.10EN + 0.08IN – 0.07TW – 0.07PR – 0.06HE* – 0.04AP*	9	0.30	482.97	1.08	-169.31	0.18	<0.001
Feeders	Y = -1.23 + 0.25EC + 0.23IN + 0.22EN – 0.15HE* – 0.14TW*	7	0.52	132.57	0	-24.60	0.32	<0.001
	Y = -1.23 + 0.25EC + 0.21EN – 0.13TW*	5	0.50	132.73	0.16	-22.35	0.29	<0.001
	Y = -1.18 + 0.24EC – 0.2TW + 0.17PR + 0.16EN* + 0.12IN*	7	0.51	133.45	0.88	-24.22	0.20	<0.001
	Y = -1.15 – 0.27TW + 0.24EC + 0.22IN + 0.17PR	6	0.50	133.63	1.06	-23.03	0.19	<0.001
Rural	Y = -1.12 + 0.20EN + 0.07EC + 0.07IN – 0.05TW – 0.05AP – 0.04CO* - 0.04SE	9	0.33	1053.81	0	-431.48	0.33	<0.001
	Y = -1.13 = + 0.20EN + 0.08EC + 0.07IN – 0.05TW – 0.04AP* - 0.04SE – 0.03CO* - 0.03PR*	10	0.33	1054.20	0.39	-432.21	0.27	<0.001
	Y = -1.13 + 0.20EN + 0.08EC + 0.07IN – 0.05TW - 0.05AP – 0.04SE – 0.03PR*	9	0.33	1054.48	0.67	-431.19	0.24	<0.001
	Y = -1.15 + 0.19EN + 0.07EC + 0.06IN – 0.05TW – 0.05AP – 0.04SE – 0.04CO + 0.03CU*	10	0.33	1055.11	1.30	-431.81	0.17	<0.001

*Non-significant variables p > 0.05

more respondents in the animal welfare group (18.6%) than any other stakeholder group believed that the abundance of cats had decreased in the past 2 years. Similarly, 13.4% of feeders stated that the abundance of cats had decreased, but their response was not significantly different from the responses of other stakeholder groups ($p > 0.06$).

Potential enjoyment at seeing feral cats did not appear in the WSAC models for conservation professionals (Table 4.3). However, the models for conservationists were very weak (Adj. $R^2 = 0.04$-0.05) due to a lack of variation in the dependent variable. The WSAC models for agriculturalists were also very weak for the same reason. The four best models for four stakeholder groups (animal welfare, high interest, feeders, and rural) listed feral cats as a source of revenue or income (EC) as an explanatory variable. On average 6.9% of respondents stated that feral cats could be a source of revenue or income. Of the four stakeholder groups for which EC was an explanatory variable: 15%, 4.4%, 15.9%, and 7.3% of respondents respectively agreed that feral cats could be a source of revenue or income.

For 11 of the 12 stakeholder groups several WSAC models fit the data well and were assigned ΔAICc values less than 2 (Table 4.4). Closely ranked models typically contained a similar suite of variables with an additional insignificant or ‘pretending’ variable (Anderson 2008). I did not average the best models as it made interpretation of the results difficult.

The majority (average 78%) of people support the idea of permanently removing feral cats away from areas with threatened or endangered fauna (Table 4.5). On average 10.1% would prefer to see feral cats relocated away from the specified area, whereas a very small number (3%) of people (3%) believe that feral cats that are being fed do not kill other animals. Responses varied significantly among pre-identified and *post hoc* stakeholder groups ($K = 354.0$; $P < 0.001$).

Significantly fewer people that are involved in animal welfare (*K* = 199.1; *P* < 0.001) and significantly fewer people that feed wildlife (*K* =148.7; *P* < 0.001) would prefer to see cats removed permanently. People in animal welfare (14%) also have a tendency to believe that fed cats do not kill other animals. Responses were similar among the islands (*K* = 7.76; *P* = 0.25).

Table 4.4 Summary of wildlife stakeholder acceptance capacity models for 12 stakeholder groups.

Stakeholder Group	# Models with ∆AICc < 2	Parameters included in best models with ∆AICc < 2*									
		EN	IN	PR	HE	AP	CO	TW	CU	EC	SE
Agriculture	7	●	●			●	●				●
Animal Welfare	1	●								●	●
Conservation	15		●	●	●	●	●	●	●	●	●
Hunter all	11	●	●	●	●	●	●	●	●	●	●
Hawaiian	17	●	●	●	●	●	●	●	●	●	●
Public	7	●	●	●	●	●	●		●		●
Low interest	16	●		●		●	●	●	●	●	●
High interest	3	●	●		●	●	●		●	●	
College education	5	●	●	●	●	●	●	●	●		●
Active hunters	13	●	●	●	●	●	●	●	●	●	●
Feeders	7	●	●	●	●		●	●	●	●	
Rural	11	●	●	●	●	●	●	●	●	●	●

*Questions associated with each parameter are listed in Table 4.1.

Table 4.5 Percentage of respondents to select each of the available responses to the contingency question, 'would you support the removal or relocation of feral cats away from areas with threatened or endangered fauna?'

Stakeholder Group	Yes, remove cats permanently	Yes, relocate cats >500m away	No, fed cats don't kill other animals	Unsure
All respondents	78.2	10.8	3.0	8.1
Agriculture	85.6	6.8	1.5	6.1
Animal Welfare	35.5	41.1	14.0	9.4
Conservation	98.1	1.5	0	0.4
Hunter all	83.9	6.7	1.9	7.4
Hawaiian	77.9	7.6	2.4	12.1
Public	66.8	15.3	3.8	14.1
Low interest	65.5	13.9	4.5	16.1
High interest	84.4	8.9	2.7	4.0
College education	83.6	9.1	2.8	4.6
Active hunters	85.9	5.9	1.9	6.3
Feeders	43.5	35.1	9.2	12.2
Rural	77.3	11.1	2.8	8.8

PCI analysis revealed that all stakeholder groups either approved of or had no opinion regarding the use of live capture and adoption or predator proof fences (Figure 4.3). The opinions of people involved in animal welfare and people that feed wildlife about any of the management techniques were similar (minimum p = 0.53; Table 4.6). These two groups were the only ones to moderately disapprove of live capture and lethal injection, live capture and lethal gunshot, and lethal traps. Four groups (animal welfare, feeders, the general public and rural residents) disapproved of the use of sharp shooters. Inman-Conover pair wise comparisons revealed that the approval rating for sharp shooters did not vary significantly among most of the stakeholder groups (Table 4.6). The majority of stakeholder groups (8/12) disapproved of the use of TNR (public and low interest group mild approval $P = 0.96$; animal welfare and feeder moderate approval $P = 0.92$; Table 4.6), and (10/12) approved of live capture and lethal injection. The public mildly approved of many of the available techniques except live capture and lethal gunshot, lethal traps, and sharp shooters which each received mild to moderate disapproval (Figure 4.3B). Conservation professionals approved of all of the techniques except TNR, which received moderate disapproval. The PCI revealed moderate levels of conflict within each of the 12 stakeholder groups regarding the average approval rating for each of the seven management techniques (average = 0.47; range = 0.26-0.65).

CCMs for individual stakeholder groups produced results similar to PCI analysis (Table 4.7) with most preferred techniques receiving the highest weight and the least preferred technique receiving the lowest consensual weight. Specifically, 6/12 stakeholder groups gave TNR the lowest weight whereas 8/12 stakeholder groups gave live capture and lethal injection the highest weight. A single CCM for all survey respondents collectively revealed TNR to be the least preferred technique (weight = 0.574) and live capture and lethal injection to be the most preferred technique (weight = 0.802).

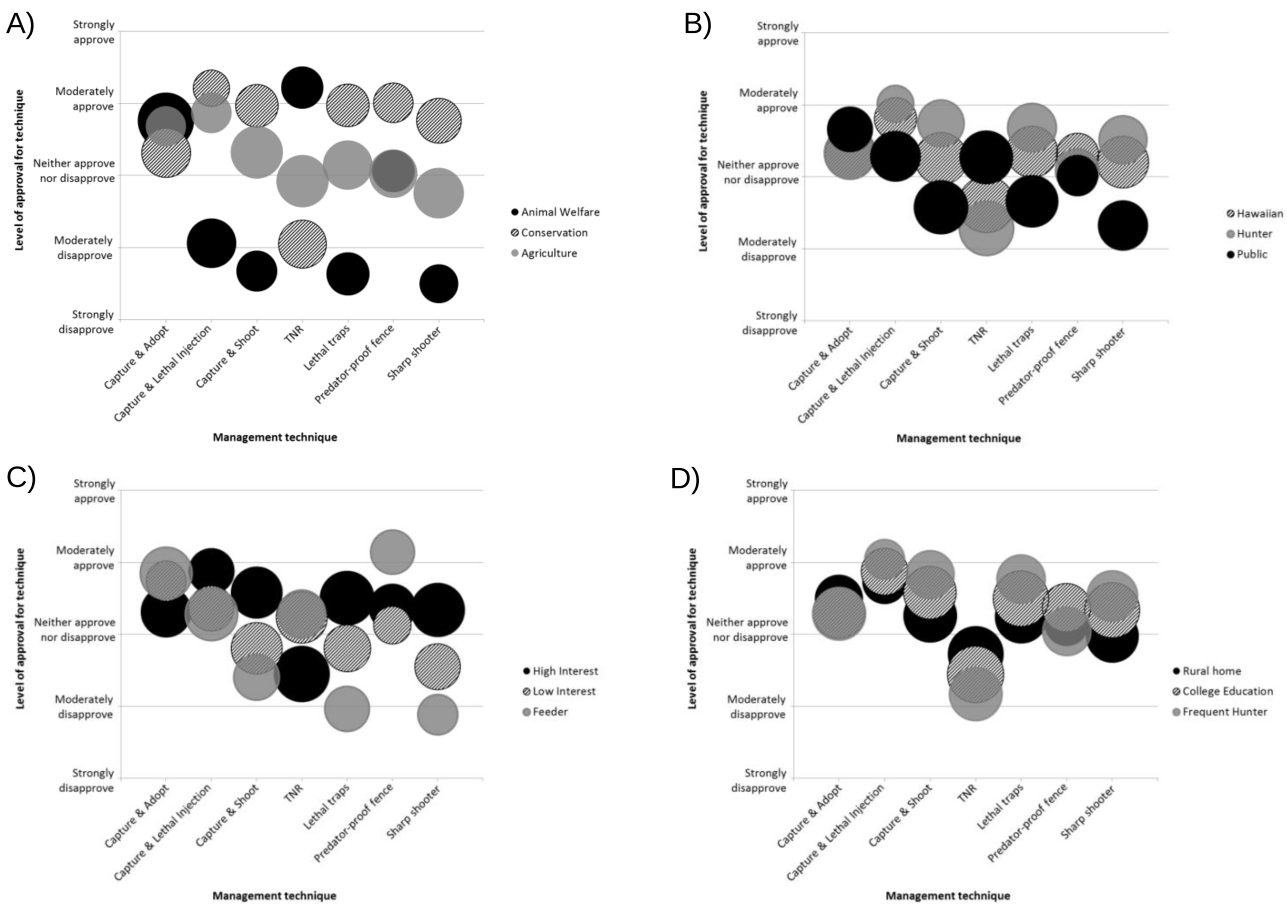


Figure 4.3 PCI results for seven feral cat management techniques and 12 stakeholder groups.

Center point of each bubble represents the scale mean, bubble size represents PCI value (average = 0.47; range = 0.26-0.65). Scale used to measure level of approval ranges between -4 (strongly oppose) to 4 (strongly approve).

Table 4.6 P-values from pair-wise comparisons of the approval ratings, calculated via PCI analysis, for seven management techniques for feral cats. Statistics include Kruskal-Wallis non-parametric tests with Conover-Inman pair-wise comparisons.

Kruskal-Wallis test statistic = 50.73; 11df; p < 0.001

Technique 1: Live Capture and Adopt	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
Animal Welfare	0.275	0.002	0.004	0.002	0.269	0.002	0.463	0.755	0.003	0.002	0.027
Agriculture		0.038	0.065	0.051	0.855	0.042	0.558	0.181	0.053	0.040	0.335
Conservation			0.878	0.696	0.003	0.670	0.001	0.002	0.770	0.717	0.061
Hawaiian				0.854	0.009	0.866	0.003	0.003	0.916	0.883	0.134
Hunter all					0.002	0.975	0.001	0.002	0.930	0.951	0.069
Public						0.001	0.574	0.164	0.003	0.001	0.072
High Interest							<0.001	0.001	0.948	0.974	0.041
Low Interest								0.301	0.001	<0.001	0.021
Feeder									0.002	0.001	0.018
Freq. Hunter										0.970	0.085
College Education											0.037

Table 4.6 Continued

Kruskal-Wallis test statistic = 266.27; 11df; $p < 0.001$

Technique 2: Live Capture and Lethal Injection	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
Animal Welfare	0.001	<0.001	<0.001	<0.001	0.009	<0.001	0.008	0.536	<0.001	<0.001	<0.001
Agriculture		0.272	0.890	0.467	0.172	0.698	0.215	0.019	0.375	0.698	0.905
Conservation			0.281	0.548	0.001	0.271	0.003	0.001	0.740	0.271	0.068
Hawaiian				0.509	0.079	0.792	0.113	0.009	0.399	0.792	0.734
Hunter all					0.002	0.563	0.006	0.001	0.785	0.564	0.142
Public						0.006	0.910	0.109	0.002	0.006	0.035
High Interest							0.015	0.002	0.416	0.999	0.345
Low Interest								0.102	0.005	0.015	0.072
Feeder									0.001	0.002	0.006
Freq. Hunter										0.416	0.106
College Education											0.345

Table 4.6 Continued

Kruskal-Wallis test statistic = 389.93; 11df; p < 0.001

Technique 3: Live Capture and Lethal Gunshot	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
Animal Welfare	0.024	<0.001	0.015	<0.001	0.131	0.001	0.065	0.714	<0.001	0.001	0.004
Agriculture		0.203	0.998	0.303	0.193	0.479	0.397	0.090	0.234	0.479	0.973
Conservation			0.151	0.648	0.001	0.347	0.008	0.004	0.857	0.347	0.059
Hawaiian				0.233	0.132	0.408	0.332	0.071	0.173	0.408	0.972
Hunter all					0.001	0.571	0.009	0.003	0.770	0.572	0.081
Public						0.002	0.569	0.365	0.001	0.002	0.025
High Interest							0.023	0.010	0.411	0.999	0.207
Low Interest								0.222	0.007	0.023	0.165
Feeder									0.004	0.010	0.039
Freq. Hunter										0.411	0.059
College Education											0.206

Table 4.6 Continued

Technique 4: Trap-Neuter-Release	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
	Kruskal-Wallis test statistic = 343.65; 11df; p < 0.001										
Animal Welfare	0.151	0.005	0.043	0.006	0.207	0.011	0.205	0.923	0.005	0.011	0.030
Agriculture		0.178	0.599	0.250	0.625	0.388	0.665	0.222	0.201	0.386	0.677
Conservation			0.369	0.685	0.016	0.398	0.025	0.014	0.869	0.401	0.136
Hawaiian				0.525	0.214	0.776	0.252	0.082	0.422	0.773	0.795
Hunter all					0.017	0.607	0.029	0.020	0.799	0.612	0.188
Public						0.038	0.957	0.310	0.014	0.038	0.144
High Interest							0.063	0.033	0.462	0.994	0.394
Low Interest								0.305	0.024	0.062	0.200
Feeder									0.016	0.033	0.073
Freq. Hunter										0.466	0.144
College Education											0.390

Table 4.6 Continued

Kruskal-Wallis test statistic = 371.15; 11df; p < 0.001

Technique 5: Lethal trap	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
Animal Welfare	0.136	0.006	0.053	0.009	0.232	0.015	0.180	0.831	0.008	0.015	0.037
Agriculture		0.242	0.720	0.356	0.523	0.508	0.673	0.250	0.310	0.508	0.807
Conservation			0.369	0.653	0.018	0.397	0.045	0.026	0.792	0.397	0.147
Hawaiian				0.552	0.231	0.779	0.356	0.128	0.477	0.779	0.823
Hunter all					0.022	0.645	0.064	0.039	0.852	0.644	0.227
Public						0.045	0.786	0.418	0.022	0.045	0.148
High Interest							0.119	0.059	0.538	0.999	0.427
Low Interest								0.340	0.058	0.119	0.310
Feeder									0.034	0.059	0.116
Freq. Hunter										0.538	0.198
College Education											0.430

Table 4.6 Continued

Kruskal-Wallis test statistic = 121.64; 11df; p < 0.001

Technique 6: Fence	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
Animal Welfare	0.974	0.234	0.761	0.959	0.948	0.654	0.961	0.899	0.986	0.650	0.899
Agriculture		0.174	0.710	0.919	0.976	0.580	0.924	0.916	0.951	0.575	0.848
Conservation			0.274	0.079	0.064	0.206	0.107	0.221	0.090	0.209	0.070
Hawaiian				0.705	0.606	0.893	0.725	0.673	0.689	0.888	0.759
Hunter all					0.848	0.473	0.999	0.839	0.959	0.466	0.888
Public						0.378	0.864	0.923	0.898	0.373	0.728
High Interest							0.531	0.576	0.481	0.991	0.492
Low Interest								0.845	0.963	0.525	0.904
Feeder									0.865	0.573	0.783
Freq. Hunter										0.475	0.854
College Education											0.484

Table 4.6 Continued

Technique 7: Sharp shooter with firearm	Agriculture	Conservation	Hawaiian	Hunter all	Public	High Interest	Low Interest	Feeder	Freq. Hunter	College Education	Rural
	Kruskal-Wallis test statistic = 399.64; 11df; p < 0.001										
Animal Welfare	0.274	0.026	0.104	0.032	0.400	0.045	0.294	0.843	0.035	0.045	0.102
Agriculture		0.267	0.623	0.348	0.612	0.456	0.814	0.425	0.349	0.457	0.764
Conservation			0.502	0.729	0.034	0.514	0.089	0.075	0.778	0.513	0.199
Hawaiian				0.663	0.223	0.847	0.381	0.209	0.651	0.848	0.728
Hunter all					0.035	0.722	0.108	0.095	0.960	0.721	0.254
Public						0.054	0.725	0.609	0.046	0.055	0.189
High Interest							0.163	0.126	0.708	0.998	0.398
Low Interest								0.479	0.123	0.164	0.423
Feeder									0.097	0.126	0.230
Freq. Hunter										0.707	0.280
College Education											0.400

Table 4.7 Consensual weights for seven feral cat management techniques for 12 stakeholder groups and all survey respondents collectively. Largest weight indicates the most preferred technique.

	Stakeholder Group	N	Capture and adopt	Capture and lethal injection	Capture and shoot	TNR	Lethal trap	Predator proof fence	Sharp shooter
Pre-identified	Agriculture	132	0.78	0.82	0.72	0.62	0.67	0.65	0.59
	Animal Welfare	98	0.82	0.43	0.36	0.90	0.35	0.66	0.33
	Conservation	257	0.71	0.89	0.85	0.43	0.79	0.66	0.76
	Hunter (all)	485	0.72	0.85	0.81	0.47	0.79	0.66	0.76
	Hawaiian	197	0.71	0.82	0.70	0.55	0.72	0.71	0.69
	Public	397	0.79	0.71	0.54	0.70	0.56	0.64	0.49
Post-hoc	Low Interest	314	0.80	0.72	0.60	0.69	0.60	0.67	0.54
	High Interest	673	0.71	0.84	0.78	0.51	0.76	0.72	0.72
	Feeder	75	0.83	0.50	0.41	0.90	0.40	0.62	0.38
	Freq, Hunter	351	0.71	0.86	0.83	0.45	0.81	0.65	0.76
	College Ed.	709	0.75	0.81	0.73	0.57	0.72	0.70	0.66
	Rural	918	0.75	0.80	0.70	0.57	0.70	0.67	0.64
	All respondents	1388	0.75	0.80	0.70	0.57	0.70	0.67	0.64

Discussion

Our results indicate that there is strong support among the residents of Hawai‘i for overarching management goals that aim to reduce the abundance of feral cats in the Hawaiian Islands. The vast majority of people (~87%) want to see the number of feral cats decrease. However, strong support for reducing the abundance of feral cats does not mean Hawai‘i’s residents will support an eradication program. On average 12% of people want populations of feral cats to persist in the Hawaiian Islands and as many as 50% of those people involved in animal welfare in Hawai‘i would like to see feral cats persist. However, only 25.9% of Hawai‘i’s residents actively support animal welfare organizations (Table 4.2). I recommend that management goals be carefully worded, avoiding terms like eradication or control and replacing them with reduced abundance or density, which my data suggest better represent the desires of the majority of the public. The public may also be more inclined to support management goals if plans explicitly state that public opinion surveys were used to help define the goals of the plan. Similarly, political support for a comprehensive management plan may be more forthcoming if public opinion is listed as a basis for a plan's goals and objectives. Other studies have found that US citizens want a role in wildlife policy formation, and that demands for public involvement in policy making arises from a perception of government failure to represent the people (Heberlein 1976; Reiter et al. 1999).

Concern or knowledge regarding the impacts of feral cats on the natural environment did not appear to be the dominant reason for respondents' desire to see the abundance of cats decrease. Of the top 5 most common explanatory variables, the potential for cats to be a threat to native fauna is the only variable that refers to the impact of feral cats on the natural environment. The WSAC models imply that respondents' desires are more heavily influenced by their feelings about and interactions with their surroundings than the biological or physical impacts of feral cats. Other variables that refer to the potential impact of cats did appear in lower ranked models, but the variables were frequently non-significant and contributed little to the explanatory power of the model. For example, the four best ranked WSAC models for the animal welfare group all contained enjoyment derived from seeing feral cats (EN) and the economic value of feral cats (EC) as explanatory variables. These two variables provide most of the explanatory power for these models. Frequency at which respondents see feral cats (SE), the intrinsic value assigned to feral cats (IN), and the potential for feral cats to contaminate soil or water (CO) also appeared in the best ranked WSAC models for the animal welfare group (Table 4.3), but these variables were not significant and do not contribute much to the explanatory power of the models. A similar pattern occurred for WSAC models for all 12 stakeholder groups, with two or three variables providing most of the explanatory power and a mix of additional variables that contributed little to the explanatory power of the models.

Cats are the definitive host for *toxoplasmosis gondii*, a parasite of both animals and humans (Work et al. 2000; Littnan et al. 2006). Toxoplasmosis has been shown to be able to survive in soil and water for several months (Ruiz et al. 1973; Lindsay et al. 2003). Colony cats interact with each other more often than truly feral cats which facilitates the transmission of disease among individuals (Mendes-de-Almeida et al. 2007). The Centers for Disease Control and Prevention (CDC; Centers for Disease Control 2012) state that toxoplasmosis is one of the 'neglected parasitic infections' because little attention has been devoted to the surveillance, prevention, or treatment of the disease. In Hawai'i, only 10 cases of toxoplasmosis infection in humans were recorded per year between 2001 and 2010 (Hawai'i Department of Health 2011). However, more than 20% of the US population is infected with the parasite (Centers for Disease Control 2012). If people are informed that they can contract toxoplasmosis from contaminated soil (Cook et al. 2000) or water and colonies of cats create concentrated points of contamination (Afonso et al. 2008) then people may become more concerned about colonies of feral cats, especially if colonies are based on public recreational land.

The majority of the survey respondents were in favor of removing feral cats from the natural environment rather than employing *in-situ* management techniques like TNR. Respondents would prefer to see feral cats adopted or euthanized via lethal injection rather than shot. Respondent's aversion to live capture and lethal gunshot may be because gunshot wounds are frequently associated with violent, painful death or it may be because people are worried about human health and safety. The use of predator-proof fences to prevent reinvasion of sensitive sites by feral cats was more acceptable than continually trapping and shooting them.

The results of my non-response survey suggest that despite the low response rate from the public (Table 4.2) that my data may fairly represent the opinions and values of the residents of Hawaiʻi. My survey was designed to gather information on stakeholders' beliefs regarding a broad range of possible advantages and disadvantages associated with feral cats and other introduced terrestrial vertebrates in the Hawaiian Islands. Some of the questions assessing beliefs (e.g., do feral cats have economic value) were designed with game animals in mind rather than feral cats and hence created interesting results. Further studies may be needed to clarify stakeholders' beliefs regarding feral cats as several WSAC models were closely ranked for each stakeholder group.

Management implications

Only a small segment of society supports the presence of feral cats and protecting native fauna from cat predation is a priority for most people. The majority of respondents' do not enjoy seeing feral cats and would prefer to see their abundance decline. Respondents desire to see cat abundance decline was influenced by the frequency with which people see cats and the belief that cat abundance had increased recently rather than potential environmental impacts of feral cats. These results suggest two courses of action for wildlife and outreach professionals. One, use the findings that the majority of respondents do not enjoy seeing feral cats and reports that cat abundance has increased in recent years to support the goals of localized management plans and garner public support for reducing the abundance of feral cats prior to taking action. Two, develop outreach materials to inform the public of the potential for feral cats to contaminate soil and water, and spread disease, as well as prey upon native fauna.

Respondents' expressed a preference for management plans that permanently remove feral cats from an area without the use of firearms. Public officials are interested in representing the majority of their constituents. Therefore, it is recommended that management plans, and wildlife policies should formally measure public opinion on highly contentious issues prior to public comment periods when vocal minorities can exert undue influence on the direction of decisions.

Chapter 5 Patterns of hypothetical wildlife management priorities as generated by consensus convergence models with ordinal ranked data

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Abstract

Managing wildlife in a publically acceptable fashion is challenging and frequently results in conflict among stakeholders. Several methods of group decision making or decision-making models have been suggested by philosophers and applied scientists to address such conflict. I propose a modification to the data collection process for consensus convergence models (CCM) that may allow wildlife managers to incorporate the priorities of hundreds of stakeholders into management decisions. Previous CCM have relied on small focus groups that represent the broader community to supply data. I propose collecting data via surveys using rank-ordinal data, which will allow managers to assess the priorities of the broader community rather than relying on representatives. By using survey (especially electronic) data rather than focus groups CCM may be modified into a tool that provides informatic solutions to environmental management. Before the proposed modification of the CCM is applied to any wildlife management decisions, several questions pertaining to how various components of a CCM affect the prioritization of management options must be addressed. I used hypothetical CCM to assess how the number of stakeholders, viewpoints, and level of opposition between viewpoints influences the results of a CCM. I found that while the number of stakeholders alone does not influence the results, the number of unique viewpoints does influence the prioritization of management options. If only two extremely opposed groups of stakeholders are engaged in a conflict, CCM will not aid decision-making because the model forces the two sides to compromise and meet in the middle. If an intermediate group is added to the model, then the CCM will favor the intermediate viewpoint,

as the diametrically opposed viewpoints balance out each other. CCM are vulnerable to outliers, which can be mitigated by a large sample of stakeholders. However, CCM also lose clarity as the sample size increases. Therefore, the number of stakeholders included in the model should be determined a priori by power analysis. I conclude that CCM are an advantageous tool for analyzing complicated conflict with numerous viewpoints because they can digest information from hundreds of stakeholders, but that investigators should take care to collect data from a representative sample of stakeholders, including under-represented stakeholders, to avoid problems associated with a forced consensus.

Introduction

Wildlife managers are regularly required to determine appropriate population levels for wildlife species and implement management actions to achieve the desired population levels (West & Parkhurst 2002). In the United States these decisions and actions are matters of public policy for three reasons. First, wildlife are a publicly owned resource (Freyfogle & Goble 2009). Second, wildlife habitat typically occurs on a complex mix of public and private lands. Third, governance is a democratic process. Wildlife management decisions, particularly over-arching policy decisions, therefore, are ultimately based on public acceptance (Zinn et al. 2000).

Determining if a wildlife management decision has public acceptance is challenging. A decision may be deemed acceptable by one or more stakeholder group(s) and rejected by other stakeholder group(s). While a consensus strictly means that all relevant stakeholders agree on an item of interest, in practice it often refers to situations where the majority of a group agrees (Tjosvold & Field 1983). The majority view, if it can be determined, could have considerable influence on wildlife policy, especially if it is the over-whelming majority of interested constituents. However, wildlife policy is frequently influenced by a small minority of active stakeholder groups (Nie 2004), especially when a large proportion of the general public is either uninterested or unaware of the issues. Hence, a primary challenge for a wildlife manager is reconciling competing interests, or stakes, in the wildlife resource (Decker & Chase 1997). Methods that allow managers to define the majority view, or identify the compromise that will offend the least people and balance the views of specific stakeholder groups are necessary to ensure that any wildlife management decision is publically acceptable.

A number of approaches exist to incorporate stakeholder input into wildlife management plans (Decker & Chase 1997). Until the 1970s, wildlife managers frequently adopted an authoritative top down approach, which served a narrow constituency. The authoritative approach generated some successful management plans, but in other cases it was over-ruled by stakeholders working through local representatives (Decker & Chase 1997; Nie 2004). Today, several other methods are employed by wildlife agencies across the US. A passive-receptive approach to wildlife management means wildlife managers rely on the initiative of stakeholders to voice their concerns, which occasionally results in a biased perspective of stakeholders' opinions (Decker & Chase 1997). In the inquisitive approach, managers use surveys to systematically inquire about stakeholders' concerns. Surveys may provide managers with information on under-represented stakeholders and their demands for wildlife management (Mankin et al. 1999; Teel et al. 2002). For example, survey data have been used to calculate the social carrying capacity for wildlife that interacts with the general public, such as white-tailed deer and non-urban public in Michigan (Lischka et al. 2008). Managers using the transactional approach may initiate meetings in which stakeholders engage with one another directly to articulate their perspective on a wildlife management problem and to negotiate on solution(s) or policies (e.g., (Josayma n.d.; Yaffee & Wondolleck 2000). Transactional processes may be time-consuming and costly in the short-term, and unfortunately may guarantee neither consensus on management actions, nor a resolution to the initial conflict

(Regan et al. 2006). If the problem requires the input of a large number of stakeholders, then reaching consensus via negotiation can be nearly impossible.

A variation on the transactional approach is the consensus convergence model (CCM) (Lehrer & Wagner 1981). Building a CCM requires that a group of stakeholders assign weights to a list of management options or decision criteria, with heavier weights being applied to more preferred options or valued criteria. For example, I have listed a series of management options for removing feral cats from an area (Table 5.1). This process generates one array of weights per stakeholder or stakeholder group and thus multiple arrays of weights (e.g., 4 arrays in Table 5.1) are collected for a series of management options. The multiple arrays are then converted into a single array of consensual criterion weights by the CCM which forces a compromise. I define a forced compromise or consensus as a consensus generated by a third party rather than by the stakeholders as in the transactional approach. The original Lehrer and Wagner (1981) CCM uses information, supplied by the stakeholders, on the amount of cooperation experienced between any two stakeholders during an initial group discussion of the management options to calculate the best compromise. Regan et al. (2006) modified the Lehrer and Wagner (1981) model by assuming that the amount of cooperation between stakeholders may be calculated using the deviation among weights applied to each management option by each stakeholder. They assumed that stakeholders with similar arrays of weights, or similar opinions, are more likely to cooperate during a decision-making process.

The limitation of both the Lehrer and Wagner model and the Regan et al. model is that they rely on a transactional approach, and hence a relatively small number of stakeholders to assign weights to an array of management options. Any group that employs a transactional approach is prone to dominant personalities and special interests (e.g., political agendas; (Ridgley & Mills 2009). A dominant personality is an influential group member whose opinions affect the views of other group members (Berg 1994).

Table 5.1 Example of a CCM for four stakeholder groups and seven management options for feral cats.

Ranked data were treated as per the modified CCM outlined in this paper. An initial CCM was used to generate consensual criterion weights within each stakeholder group (listed values), and then a secondary CCM was used to converge the data into a single array of consensual criterion weights for all stakeholders. Each stakeholder group was given equal weight when calculating the final consensual criterion weight despite variation in number of group members.

	Initial Weight				Consensual Criterion Weight
Management Option	**Agriculture N=132**	**Animal Welfare N=100**	**Conservation N=257**	**Hunter N=486**	**All Stakeholders**
Live capture & Lethal injection	0.82	0.42	0.89	0.85	0.762
Live capture & Adopt	0.78	0.82	0.71	0.72	0.757
Predator-proof fencing	0.65	0.65	0.85	0.66	0.699
Live capture & Lethal gunshot	0.72	0.36	0.85	0.80	0.698
Lethal trap	0.67	0.35	0.85	0.79	0.680
Sharp shooter	0.59	0.33	0.80	0.75	0.629
Trap-Neuter-Release	0.62	0.91	0.43	0.47	0.596

Note: While the initial weights are based on preliminary data the results outlined in this table are inconclusive and only intended to support readers interpretation of the questions listed in Regan et al. (2006).

Pre-existing conflicts between stakeholders that are unrelated to the task may also bias the weights a stakeholder applies to the management options. The transactional approach also typically selects a small number of stakeholders to represent the broader stakeholder base. If the representatives do not accurately portray the opinions of the broader stakeholder base, then the results generated by the transactional approach may be compromised.

In today's age of technologically advanced communication more people can be involved in a decision-making process. Internet and email based surveys can be generated and disseminated to thousands of people at relatively low cost. Similarly, thousands of data points can be analyzed relatively quickly using computers. Therefore, many stakeholders that could not reasonably participate in a transactional approach could be asked to weight or rank the management options in a CCM via a questionnaire survey. Dialogue among knowledgeable representatives would still be necessary for defining appropriate management options or decision criteria for a wildlife management problem; however by collecting weights or ranks of the options via individual surveys the influence of dominant personalities during the weighting/ranking process may be reduced. Therefore, if Regan et al.'s (2006) CCM model were modified such that criterion weights/ranks are collected via surveys rather than through a transactional approach such as focus groups, then the views of many more stakeholders could be incorporated in the decision-making process.

Soliciting exact weights from stakeholders is challenging. Weights are highly dependent on the elicitation method (Schoemaker & Waid 1982) and the elicitation of these exact weights imposes a precision that may be absent in the minds of the stakeholders. While a stakeholder may be uncomfortable assigning precise weights, the individual may be reasonably confident in ranking criteria (Barron & Barrett 1996). The elicitation of weights is a cognitively demanding task (Larichev 1992). Therefore, people that are less experienced with formalizing their priorities for decision-making purposes may have more difficulty assigning exact weights to criteria. The solicitation of ranked data that can be converted to weighted data is expected to reduce the associated challenges.

Before the proposed modification of the CCM is applied to any wildlife management decisions, several questions, which were mentioned by (Regan et al. 2006), regarding how various components of a CCM affect the final distribution of consensual criterion weights must be addressed. Specifically:

1. How does the distribution of criterion weights across individuals affect the consensual criterion weight?
2. How does the number of stakeholders within a group impact the consensual criterion weight? (See Table 5.1).
3. Should homogeneous groups be used? A homogeneous group could be defined as a group that contains one advocate per management option, which results in each option being ranked as the number one preferred criterion by one group member.
4. Do clusters of opinions result in different consensual weights than homogeneous groups?
5. Should stakeholders with intermediate views between two extremes be included, or are stakeholders with extreme views sufficient?
6. Conversely, should stakeholders with extreme views be included if the bulk of the group is like-minded?

The purpose of this research is to ascertain how the structure (e.g., size, level of homogeneity) of a stakeholder group influences the consensual criterion weights generated by a CCM.

Material and Methods

We varied the parameters of a hypothetical CCM to address each of the six questions (Table 5.2). First, the rank for each management option or criterion in the model was assigned randomly. The ranks for each criteria were then converted to weights using five different formulae, where w is the weight, and r is the rank, and n is the number of criteria. The same sets of ranked criteria were used to test each formula. Formulae have been modified such that all weights range between 0 and 1.

Normalized rank-order centroid (Barron & Barrett 1996):

$w_r = 1/n \sum_{j=r}^{n} \frac{1}{j}$, r-1, …, n.

Geometric weight (Lootsma 1999): $w_r = (100/(\sqrt{2})^{r-1})/100$

Reciprocal weight (Stillwell et al. 1981): $w_r = (100/r)/100$

Linear weights fixed slope (Stillwell et al. 1981): $w_r = 100(n+1-r)/10$

Linear weights variable slope (Alfares & Duffuaa 2009):

$w_r = (100-s_n(r-1))/100$

Table 5.2 Parameters of the consensus convergence models developed to answer questions raised by Regan et al. (2006).

Question	Model Name	# CCM	# Criteria/ model	# Stakeholders/ model	# Viewpoints (V)	# Stakeholders/ viewpoint (S)
1	**Weighting schemes**	5	10	10	random	n/a
2	**Random**	5	10	10, 20, 50, 100, 200	random	n/a
	Subsequent	5	10	10, 20, 50, 100, 200	10	1, 2, 5, 10, 20
3&4	**Homogeneous**	1	10	10	10	1
	Clustered 2v*5p	1	10	10	2	5
	Clustered 5v*2p	1	10	10	5	2
5	**Subsequent, preceding, and alternating**	3	10	9, 9, 9	3	3
6	**Majority + Extreme**	1	10	10	2	20% extreme
	Majority + Extreme	1	10	20	2	30% extreme
	Majority + Extreme	1	10	10	2	40% extreme

Initially, one CCM, with 10 criteria and 10 stakeholders, was constructed for each of the five formulae to test how the distribution of criterion weights affects the consensual criterion weight (Question 1; Table 5.2). All the model outputs, the consensual weights and consensual ranks, were compared using Wilcoxon signed rank test, the equivalent of a nonparametric paired t-test (ά = 0.05) in Systat 13®. After the results were used to assess question 1, all ranks were converted to criterion weights using the linear weights variable slope formula as recommended by Alfares and Duffuaa (2009). All CCM were built in Microsoft Excel in accordance to methods outlined in Regan et al. (2006).

To investigate question two, 10 CCM were constructed for varying numbers of stakeholders (Table 5.2). Ten criteria were ranked randomly for the stakeholders in five of the models (henceforth 'random' models). In the other five models, the criteria were ranked randomly for the first ten stakeholders, and then those rankings were repeated for subsequent groups of ten stakeholders added to the model (henceforth, 'proportional' models).

Nine other CCM were developed (Table 5.2) to address questions 3 through 6. In the 'homogenous' model, each criterion was ranked number 1 by one of the stakeholders with subsequent criteria ranked sequentially. In the 'clustered 2v*5p' model, two groups of 5 stakeholders each ranked the criteria such that group one's array was a mirror image of group two's array. In the 'clustered 5v*2p' model, five groups of stakeholders were used, each composed of two people with identical opinions. The first stakeholder group ranked the first criterion as number one and the subsequent criteria sequentially. The second group ranked the third criterion as number one and the subsequent criteria sequentially, cycling around to rank criteria one and two as the 9th and 10th most important criteria. The pattern was repeated for the remaining three groups.

Three different 'intermediate plus extreme' models were constructed (Table 5.2). In each of these models, two groups of three stakeholders ranked the criteria such that the first group's array was a mirror image of the second group's array. These two groups represent the two diametrically opposed, or extreme, viewpoints in a conflict. The intermediate group of three stakeholders either ranked criterion six as number one, and ranked subsequent criteria sequentially (henceforth labeled ‘subsequent’); or they ranked criterion number five as number one, and then ranked preceding criteria sequentially (henceforth labeled ‘preceding’); or they ranked criterion five as number one, criterion six as two, criterion four as three etc. (henceforth labeled ‘alternating’).

In the final three ‘majority plus extreme’ models, the majority ranked the sixth criterion as number one, and subsequent criteria in the order they were listed. The two extreme points of view were ranked as above. In these three models 60%, 70%, or 80% of the stakeholders were in the majority group, and 20%, 30%, or 40% of the stakeholders were in the extreme stakeholder groups, respectively.

Results

Question 1: How does the distribution of criterion weights affect the consensual criterion weight?

The consensual criterion weights varied significantly among the five criterion weights formulae ($p \leq 0.022$). The linear fixed model generated the greatest range in weights for the 10 criteria (range: 0.382), whereas the rank-order centroid model generated the smallest range of weights (range: 0.089). The consensual ranks for the criteria did not vary significantly amongst the models, hence the lines in figure 5.1 are effectively parallel ($p \geq 0.53$). The consensual ranks for the two linear models were identical. Since the weights do vary significantly among the models, the ‘linear weight variable slope’ model described by Alfares and Duffaa (2009) is used for further investigation because it makes allowances for models with varying numbers of management options or decision criteria, and hence is a tool that can be used in a variety of situations.

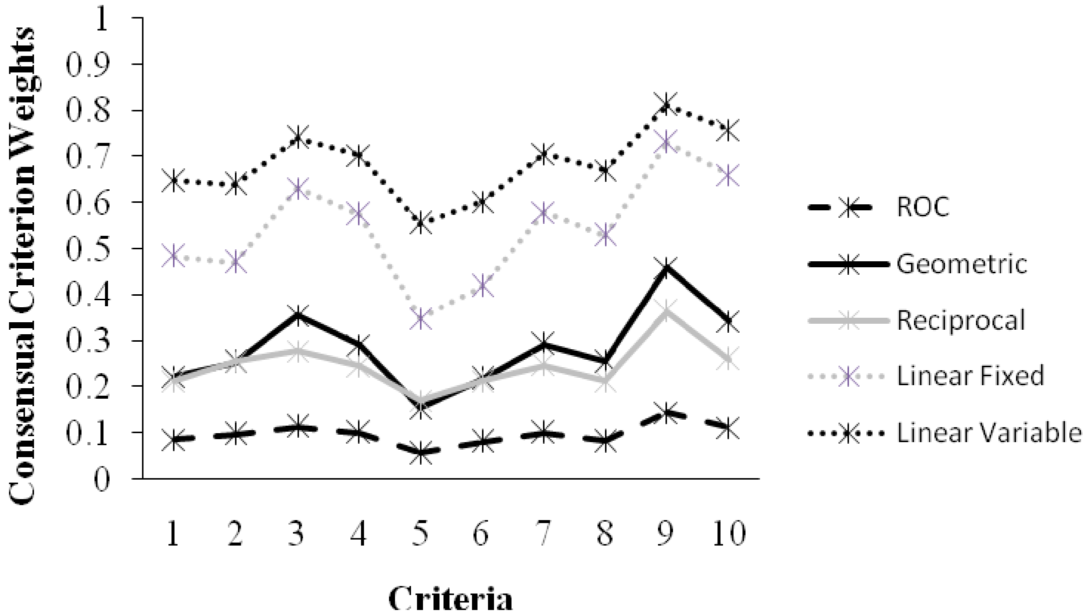

Figure 5.1 Consensual criterion weights for 10 criteria with criterion weights generated by five different formulae.

Question 2: How does the number of stakeholders within a group impact the consensual criterion weight?

We tested the influence of group size with five random and five proportional models. The consensual ranks and consensual criterion weights did not vary among the five 'proportional' models ($p = 1.0$). Both the ranks ($0.51 \geq p \leq 0.87$) and weights ($0.72 \geq p \leq 0.96$) did vary among the 'random' models albeit not significantly. In this experiment the proportional models have an increasing number of stakeholders with identical values, whereas the random models have an increasing number of stakeholders with unique values. CCM are not influenced by the number of stakeholders alone, but by the amount of unique data incorporated into the model. The range of consensual criterion weights in the random models decreased as the number of stakeholders increased (Figure 5.2). Therefore, as more stakeholders were included in the model, more decimal places and iterations of the consensus convergence model were required to differentiate the consensual weights or ranking for each of the criteria.

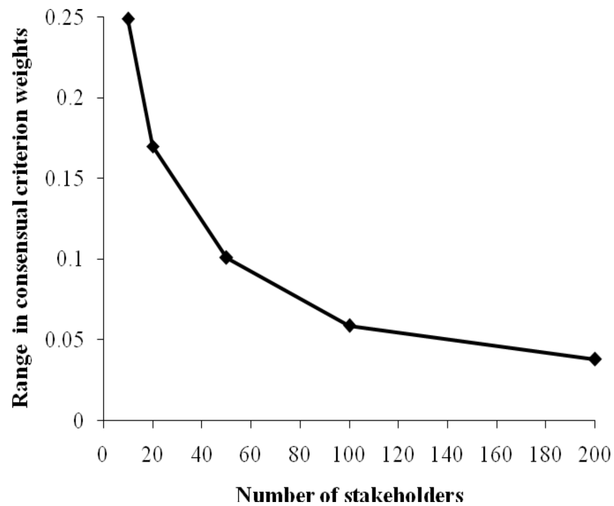

Figure 5.2 The range in consensual criterion weights for ‘random’ models decreases as the number of stakeholders increases.

Question 3: Is it important to always ensure homogeneous groups?

Initially, I defined a homogeneous group as a group that contains one advocate per management option. If the diversity of opinions held by the stakeholders in the group is homogeneous, then a CCM will assign the same weight, and hence the same rank (i.e. all criteria are ranked #1) to each management option, making it impossible to prioritize the options. The consensual criteria weights will reflect the equation used to convert the initial ordinal rank data into weights. Therefore, investigators should not strive to gather data from a homogenous group of stakeholders characterized by one advocate per management option.

Alternatively, a homogeneous group could be defined as a collection of representatives from the same stakeholder group. The results generated by a CCM for this definition of a homogenous group would depend on the initial variation in ranks for the management options among representatives and the total amount of data entered into the model. The CCM results for a collection of representatives from the same stakeholder group may be a more objective method of incorporating a stakeholder group's opinion into a decision making process than selecting a single advocate.

Question 4 and 5: Do clusters of opinions result in different consensual weights than homogeneous groups? Should stakeholders with intermediate views between two extremes be included, or are members with extreme view sufficient?

The number of opinion clusters influences whether the resulting consensual criterion weights will differ from the consensual weights generated by a homogenous group. If only two extreme opposing points of view are included in the group then the CCM will force both groups to compromise and meet in the middle. The model gives all of the options the same weight, and hence the same rank (Figure 5.3: Clustered 2v*5p). Therefore, if only two extremely opposed and equally prevalent groups of stakeholders are engaged in a conflict, the majority vote may be more appropriate than a CCM for decision-making. CCM are a more appropriate tool for problems with multiple solutions, or multiple viewpoints that are unequally represented to decision makers via advocacy groups.

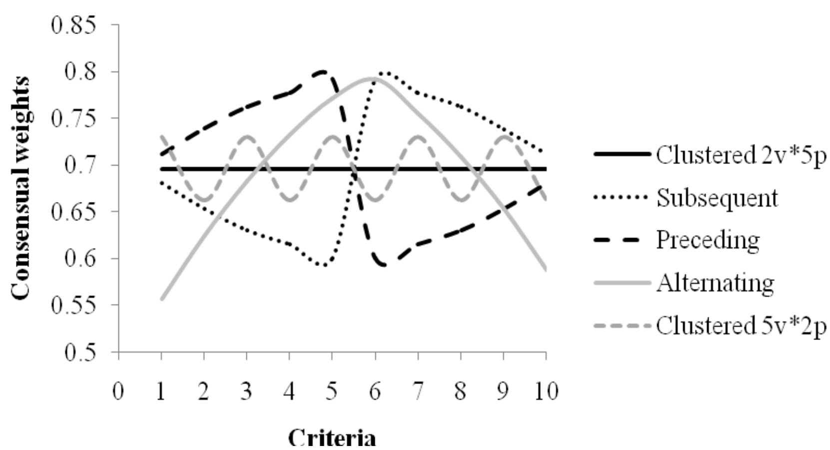

Figure 5.3 Consensual weights for a model that includes two extreme points of view (Clustered 2v*5p), a model that includes 5 points of view (Clustered 5v*2p), plus three models that include two extreme points of view and one intermediate point of view (Subsequent, Preceding, and Alternating).

If a third stakeholder group with an intermediate point of view is included in the model then the consensual weights begin to differ. The consensual criterion weights of the subsequent, preceding, and alternating models were not significantly different (p > 0.63). In these three models, the consensual weights reflect the ranks assigned by the intermediate group because the two extremely opposed groups balance out each other's opinions.

When a CCM was used to resolve the opinions of five groups of stakeholders (Figure 5.4: Clustered 5v*2p) with evenly distributed opinions, the consensual weights alternated between two values. Since every second criterion was ranked number one by one group of stakeholders, every second criteria was ranked as number one by the CCM. In essence, this model behaved the same as the homogenous model, except every second criterion was ranked number one, instead of every criterion being ranked number one.

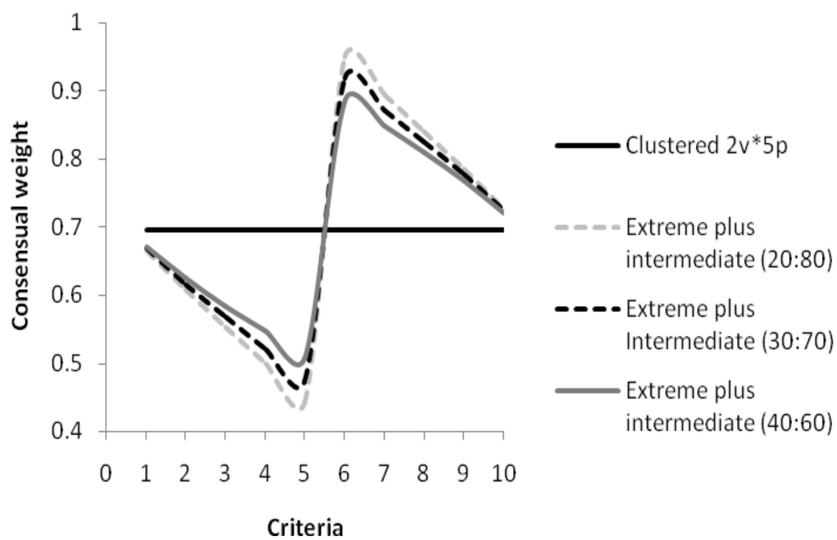

Figure 5.4 One model with two extreme opposing points of view, and three models with the majority of stakeholders holding intermediate opinions (60, 70, or 80% of stakeholders), plus a corresponding minority with extreme points of view (40, 30, or 20% of stakeholders). CCM force two extreme opposing points of view to compromise and result in all decision criteria or management options being assigned the same weight and rank.

Question 6: Conversely, should stakeholders with extreme views be included if the bulk of the group is like-minded?

If the majority of the stakeholders are like-minded then the consensual ranks will conform to the majority's opinion. However, the consensual weights are affected by the proportion of people supplying data for the CCM that aligns itself with the majority opinion. The range of consensual weights was greatest when 20% of the stakeholders held extreme views as compared to when 30% or 40% of the stakeholders held extreme views (Figure 5.4). Therefore, a small number of stakeholders with extreme views can greatly influence the consensual weights generated by a CCM. Consensual weights are sensitive to outliers, which may be mediated by increasing the number of people supplying data for the CCM (i.e., sample size).

Discussion

The field of wildlife management is rife with conflict. Depending on the type of wildlife management in question, a diversity of views can exist that cannot easily be brought to consensus via negotiation. For example, the opinions held by animal rights advocates versus the opinions held by environmentalists regarding the management of feral cats could be described as polar opposites and entrenched (Longcore et al. 2009). Similarly, preliminary data from a CCM for four stakeholder groups and seven management options for feral cats (Table 5.1) reveal that animal welfare advocates will assign considerably lower weights to management options that involve euthanizing feral cats and would prefer the use of trap-neuter-release, whereas the other stakeholders appear to prefer lethal techniques. Interestingly, the consensual criterion weights presented in Table 5.1 list trap-neuter-release as the least desirable option for managing feral cats despite each stakeholder group being given equal weight in the model. The prevalence of hunters, conservationists and agriculturalists suggests that these four stakeholder groups should not be given equal weight during decision making. Future research will assess whether building CCM for each stakeholder group has more value than pooling all available data.

Some philosophers consider that striving for consensus may be ill-advised. Dissensus drives us to find new and possibly better solutions to a problem, while consensus can stall progress (Rescher 1984). However, the US and many other nations are governed as a democracy, based on majority rule. Management decisions are made by community or agency leaders. If a leader makes a decision that goes against the majority's opinion then it may be challenged, if not overturned (Muth et al. 2006). In some instances a wildlife agency has lost the ability to effectively manage wildlife under its jurisdiction because it made a decision that did not reflect the opinion of the majority of its stakeholders (Decker et al. 2001). Unpopular decisions and the resulting disputes or legal challenges waste the limited resources available for wildlife management. Therefore, tools are needed that allow an agency to either determine the majority's opinion or, in cases with no clear majority, the most acceptable compromise.

Many techniques can be used to reach consensus among stakeholders including mediation (Josayma n.d.) or group negotiation. Unfortunately, a group of stakeholders involved in an informal negotiation can become distracted by pre-existing opinions of the other people in the group. Grudges, agendas, and the complexity of wildlife management decisions decrease the likelihood that a group will reach consensus. Recognition of these issues resulted in the development of CCM, which has the additional advantage of allowing the investigator to incorporate the opinions of many more stakeholders than could be included in informal proceedings. The public may feel that the more stakeholders that can be involved in a decision, the more robust the decision. If a representative in an informal negotiation poorly relates the opinions of his or her stakeholder group in the negotiation then any resulting consensus may become irrelevant when that decision is announced to the wider community and found unsuitable.

Unfortunately, no model, no matter how elaborate, is an exact reflection of reality (Anderson 2008). For example, while ordinal rankings do not allow stakeholders to express a degree of preference (Cook & Seiford 1978), they may be a more appropriate method for measuring the preferences of stakeholders that rarely think about the issue and find it difficult to express their degrees of preference. Therefore, a model derived consensus may not accurately reflect the results of a consensus derived by informal negotiation techniques. However, models should not be avoided, but rather more accurate models developed. Wildlife managers need to use their expert judgment to determine if the advantages of using a model outweigh the disadvantages associated with model accuracy. In the case of CCM, my research suggests that incorporating the views of many stakeholders will not be beneficial if the conflict to be addressed involves two entrenched and opposing points of view. However, wildlife conflicts are rarely this clear-cut. Background research, focus groups or mediation will probably reveal variation in stakeholders' opinions or unconventional stakeholder groups that add depth to the conflict and increase the advantages of objective decision-making models. Similarly, the advantages of decision-making models will increase as the number of competing decision variables increase.

For the five formulae I assessed, the consensual ranks did not vary significantly, unlike the consensual weights, which did vary significantly. The advantages and disadvantages of the formulae are discussed by their respective authors, and will not be repeated here. However, it can be stated that the formula used to convert ranked data to weights will influence the results of a CCM, and should be chosen carefully based on the intended purpose of the consensus model. If the purpose of the CCM is to generate consensual weights for use in decision hierarchies or networks then investigators should keep in mind that the range of weights generated by the CCM may affect the results of their decision models. If the purpose of the CCM is to generate consensual ranks then the method used to generate weights is less critical.

CCM lose clarity as the number of stakeholders increases, in that the range of consensual weights decreases as the number of stakeholders increases (Figure 5.2). Therefore, unless the investigator would like to use many decimal places and run many iterations of the model, the upper limit to the number of stakeholders should be defined by an appropriate form of power analysis (e.g. p179, Vaske (2008)). The advantage to using the CCM rather than informal methods of negotiation is that the model can digest the preferences of hundreds of stakeholders, something that could not be achieved by the best facilitator with an unlimited budget. Similarly, my CCM simulations revealed that the investigator should not aim for homogenous groups, or leave out minority stakeholders. Minority stakeholders may not influence the consensual ranking of the criteria, but they do influence the consensual weights. Therefore, unless a consensual ranking is the sole purpose of the consensus convergence model, investigators should not avoid minority groups otherwise they risk biasing their results. As with any scientific study investigators should aim to select a representative sample of stakeholders.

One of the biggest challenges of the Lehrer and Wagner model is that it asks stakeholders to weigh the opinions of other stakeholders in the group subjectively (Lehrer & Wagner 1981). Regan et al. (2006) partially resolve this issue by deriving these weights from the disparity among stakeholders' opinions. Other authors have argued against the appropriateness of this method. Martini (2010) suggested that network derived weights may better reflect the dynamics of a particular group, and provide better predictions of how a stakeholder's weights will change during a negotiation. Unfortunately, obtaining network derived weights requires that an investigator gather stakeholders as a group, and assess stakeholders' relationships and positions of power, prior to building a model that predicts the group's future dynamics. If an investigator needs to gather stakeholders as a group, a more efficient use of time may be to let them negotiate, rather than have them interact so that you can predict the outcome of a negotiation.

Network derived weights whilst appropriate for political conflict, may not be appropriate for dealing with wildlife management conflict. Wildlife management issues typically involve many stakeholder groups, some of which may have many leaders and factions that are not easily represented by a single spokesperson. The advantage offered by the CCM is that it gives every stakeholder equal weight and removes the bias of leading personalities, whereas the network derived weights aim to replicate the bias of leading personalities. Since wildlife are owned by the people in the US, and held in trust by the state government (Freyfogle & Goble 2009), and all people are created equal, then a goal of incorporating the values of as many people as possible into wildlife management plans, with equal weight given to each person's opinion may be most appropriate.

Conclusions

We have proposed a modified version of the CCM that may allow wildlife managers to incorporate the priorities of hundreds of stakeholders into management decisions. The characteristics of this CCM are such that while the number of stakeholders alone does not influence the results of the model, the number of viewpoints does influence the consensual criterion weights. If only two extremely opposed groups of stakeholders are engaged in a conflict, or if the selected group of stakeholders generates a homogenous mix of priorities, CCM will not aid decision-making because the model forces a compromise without negotiation. The CCM will favor a third and intermediate viewpoint over two diametrically opposed viewpoints. If a small proportion of the stakeholders hold extreme views they can disproportionately influence the results of a CCM. I conclude that CCM are an advantageous tool for analyzing complicated conflict with numerous viewpoints because they can digest information from hundreds of stakeholders, but that investigators should take care to collect data from a representative sample of stakeholders, including unconventional stakeholders, to avoid problems associated with a forced consensus.

Chapter 6 Identifying the people's most preferred management technique for feral cats in the Hawaiian Islands

Abstract

Feral cats are abundant in many parts of the world and pose a threat to native wildlife. Human-wildlife conflict regarding how feral cats should be managed has increased recently. In Hawai‘I, previous research has revealed that the majority of Hawai‘i's residents would like to see the feral cat abundance reduced but that opinions differ regarding which techniques acceptable for achieving this. This paper describes a model designed using the analytical hierarchy process (AHP) that combines rankings of decision criteria by Hawai‘i's residents with expert knowledge of the costs and benefits associated with seven techniques for reducing feral cat abundance. I 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 trap-neuter-release was ranked as the worst technique.

Introduction

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). As such, many wildlife managers seek to reduce their abundance. However, cats are also one of the most popular pets in many countries, including the US (APPMA 2009). Human-wildlife conflict regarding how feral cats should be managed has increased in recent years (Longcore et al. 2009; Bird et al. 2010).

Policy makers may strive to use public opinion as a guide for policy (Green et al. 1997). In the US wildlife are a public resource (Freyfogle & Goble 2009), and hence the public has some 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). Polls can measure many different things, from voting intentions to beliefs. However, public opinion polls cannot readily direct a respondent's attention to tradeoffs among costs and benefits, to second-best possibilities, and to unexpected risks (Weissberg 2001) associated with a management alternative. Since the public is generally uninformed of the costs and benefits associated with a wildlife management technique the results of opinion polls (e.g., Table 6.1) have limited use.

Table 6.1 Summary of survey results in which 1,386 residents of Hawai'i ranked seven feral cat management techniques on a 9-point likert scale (1 = strongly favor; 5 = neither favor nor oppose; 9 = strongly oppose).
The 'average' result was calculated as arithmetic mean, and geometric mean of all responses and via consensus convergence model (CCM) in which larger values indicate most preferred technique. Techniques are ranked from 1 to 7, with 1 being most preferred (Lohr et al. unpublished).

	Live capture and lethal injection	Live capture and adoption	Live capture and lethal gunshot	Lethal trap	Predator-proof fence	Sharp-shooter	Trap-Neuter-Release
Arithmetic mean	3.63	4.01	4.48	4.52	4.53	5.00	5.54
Geometric mean	2.53	2.81	3.13	3.16	3.37	3.65	4.07
CCM weight	0.80	0.75	0.70	0.69	0.67	0.64	0.57
Rank	1	2	3	4	5	6	7

Wildlife managers are typically presented with complex decisions, for example balancing trade-offs between the fishing industry and the conservation of dolphins (Conroy et al. 2008). 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). However, 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 & Bailey 2000; Huettmann 2005).

Decision models that break complex decisions down into comprehensible tradeoffs have been developed. The analytical hierarchy process (AHP), for example, is a modeling 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 AHP is a flexible modeling system that may be used by a single decision maker to facilitate transparency in decision making, by a team of experts to balance biotic, abiotic, sociological, and fiscal inputs, or by a group of non-experts to prioritize decision components using personal judgments or qualitative data. AHP has been successfully applied to decision-making in a diverse array of situations including environmental impact statements, fire research, comparing riparian vegetation policy, and wildlife management (Schmoldt & Peterson 2000; Ramanathan 2001; Herath & Prato 2006; Hurley et al. 2009).

In this study I 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; Medina et al. 2011; Bonnaud et al. 2011). Previous research revealed that the vast majority of residents (85%) in Hawaiʻi would like to see the abundance of feral and free-roaming cats greatly reduced (See Chapter 4).

When residents were asked to rank seven management techniques (live capture and adoption, live capture and lethal injection, live capture and lethal gunshot, TNR, lethal traps, predator-proof fence, and sharp shooter) that may currently be employed to reduce the abundance of cats, the results revealed that on average, they approve of most of these techniques (Table 6.1). However, the results differed considerably among the various stakeholder groups, which included conservationists and animal welfare advocates (Chapter 4). Animal welfare advocates 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 trap-neuter-release and approved of live capture and lethal injection, live capture and lethal gunshot, lethal traps, and sharp shooters (Chapter 4).

My goal was to use the AHP to build a model that would identify the best technique for managing feral cats in the Hawaiian Islands. To address this goal I designed a model that would combine public opinion based on several decision making criteria with expert knowledge of the costs and benefits of various techniques.

Methods

I met first with four wildlife managers and decision makers to build a decision hierarchy (Figure 6.1). During the meeting I identified the seven techniques listed above that may currently be employed in Hawai‘i to reduce feral cat abundance. I did not include any techniques that are still being developed (e.g., immunocontraception; Courchamp & Cornell 2000; Gorman et al. 2002; Levy et al. 2004; Levy et al. 2005) because these techniques cannot be employed in the near future and hence unnecessarily complicate the decision making process. The group also identified eight decision criteria that illustrate many of the costs and benefits associated with each of the seven management techniques (Figure 6.1). For example, if the goal of a management plan is to reduce feral 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. Since the decision criteria were to be compared using survey data I minimized the number of criteria and sub-criteria in the model. 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 Hawai‘i, in which ~85% of survey respondents stated that they would like to see feral cat abundance decline (Chapter 4).

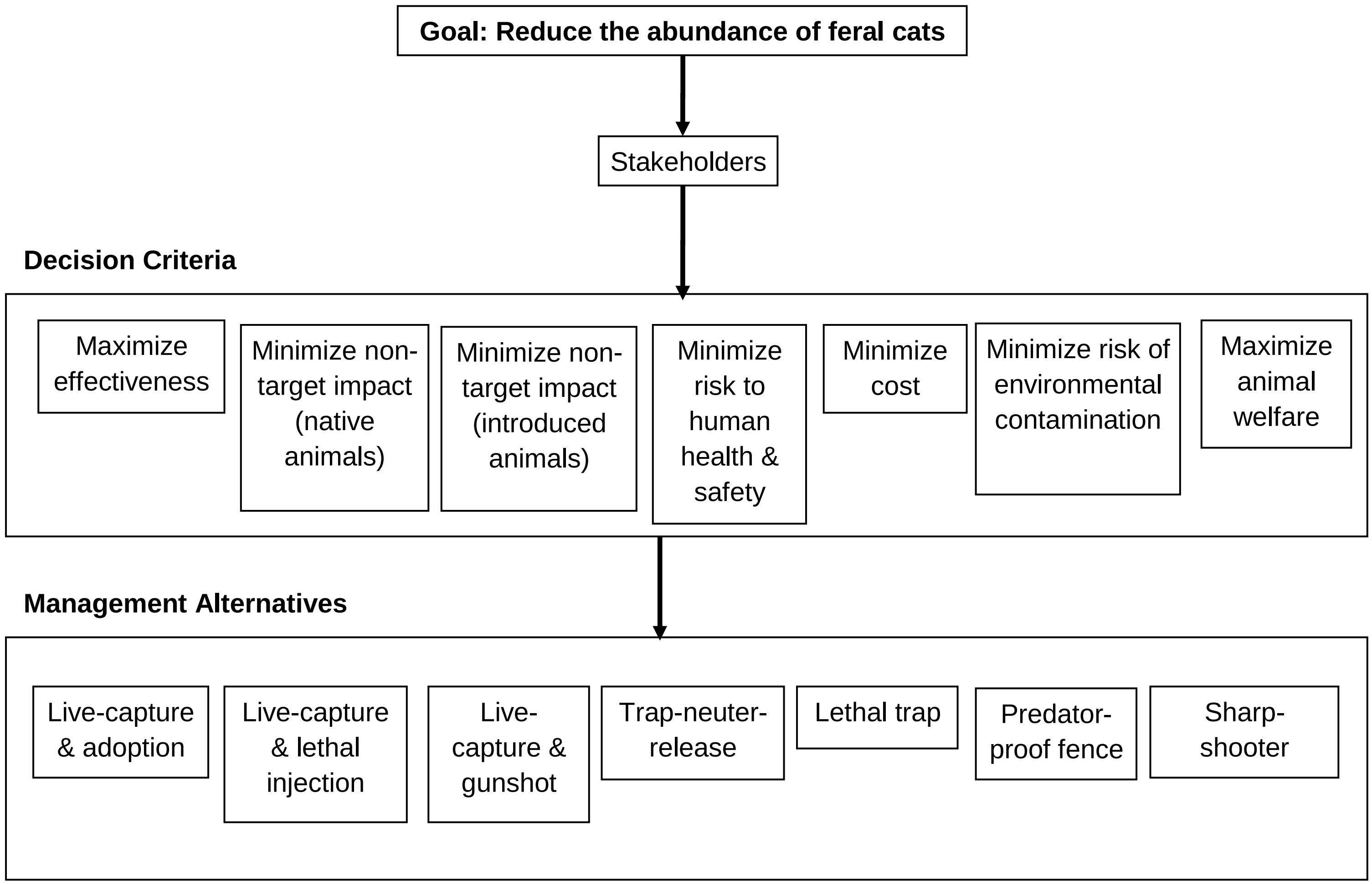

Figure 6.1 Decision hierarchy for ranking seven feral cat management techniques and identifying the most preferred management technique

I incorporated information from the decision hierarchy workshop into a state-wide survey. I administered a mail and internet survey between July and September 2011 using the tailored design method with three mailings (Dillman et al. 2009). The survey was disseminated to 5,407 people from six pre-identified stakeholder groups that in previous years have been involved in cases of human-wildlife conflict in Hawai‘i (Josayma n.d.; Adler 2001; Subcommittee on Public Information and Deer Management Planning of Maui Axis Deer Group 2002; Hess et al. 2004; Koopman & Pitt 2007) as follows: hunters (1,650), conservation professionals (698), agriculturalists (373), animal welfare activists (277), native Hawaiians (members of a Hawaiian Civic Club; 49), and the general public (2,360). I identified survey recipients using direct solicitation, internet searches, and assessment of organization membership lists. I used a list of random mailing addresses purchased from AccuData Integrated Marketing, stratified by zip-code, to contact the general public. The survey was emailed to pre-identified stakeholders via SurveyMonkey™ , while a hard copy of the survey was mailed to the general public and hunters because sufficient email addresses were unobtainable. 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 6.2). 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 46% of the pre-identified stakeholders responded to the state-wide survey compared to 20% of the general public. Upon completion of the survey, I attempted to contact 5% of the non-respondents via telephone to request participation in a short non-response survey. Partial responses to survey questions were eliminated from the final data set.

Table 6.2 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?

Decision Criteria	Number
Native non-target animals: Possible harm to other native animals	
Cost: Amount of money required to implement the method	
Introduced non-target 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	

Finally, in August 2012 I conducted in-person surveys with 11 wildlife professionals with experience managing feral cats. The AHP typically requires the use of interactive software in conjunction with a meeting of professionals in order to make pair-wise comparisons between decision components. AHP pair-wise comparisons may also be collected via survey questions (Saaty 2008). Unfortunately, despite the minimal decision hierarchy (Figure 6.1) the standard questionnaire created during AHP would result in approximately 140 questions which, based on feedback during the decision hierarchy workshop, proved to be prohibitively long for wildlife professionals. Therefore, I created a survey with seven matrix style questions that allowed the wildlife professionals to compare all seven management techniques simultaneously in terms of each decision criteria (Table 6.3). The survey data were coded with numbers 1 through 9 with the technique that best meets the criteria given a 9 (Saaty 2008). I calculated the ratio that represented each pair wise comparison as follows: let A_i, A_j, …A_n, be the set of management techniques. Comparisons between pairs of management techniques are represented by: $A = [a_{ij}]$, i, j = 1, 2 …n. The entries a_{ij} are governed by the following rules: $a_{ij} > 0$, a_{ji} = — , $a_{ii} = 1$ for all i. I 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). I 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. I 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). I also used Kruskal-Wallis tests to assess for variation among stakeholder groups regarding ranks assigned to each decision criterion.

Table 6.3 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.

Management Technique	**Very Low Cost**		**Low Cost**		**Moderate Cost**		**Expensive**		**Very Expensive**
Live Capture and Adoption	○	○	○	○	○	○	○	○	○
Live Capture and Lethal Injection	○	○	○	○	○	○	○	○	○
Live Capture and Gunshot	○	○	○	○	○	○	○	○	○
Trap-Neuter-Release	○	○	○	○	○	○	○	○	○
Lethal Trap	○	○	○	○	○	○	○	○	○
Predator-Proof Fence	○	○	○	○	○	○	○	○	○
Sharp-shooter	○	○	○	○	○	○	○	○	○

Results

There were 1,369 responses to the state-wide survey, excluding partial responses. The non-response survey revealed that survey respondents and non-respondents 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 most of the decision criteria varied among stakeholder groups (Table 6.4). 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 stakeholder groups (K = 4.1; P = 0.54). The average rank for the remaining five decision criteria varied significantly among the stakeholder groups. In general, ‘humaneness’, was considered slightly to moderately important and ‘cost’ was considered neither important nor unimportant, ‘impact on introduced non-target species’ was considered slightly unimportant, whereas ‘impact on native non-target species’ was considered moderately important, and ‘effectiveness of the technique at reducing feral cat abundance was considered moderately to very important (Table 6.4).

The average rank applied by wildlife managers for each of the seven feral cat management techniques in terms of each of the decision criteria illustrates the characteristics of each of the management techniques (Table 6.5).Trap-neuter-release is considered the least effective technique for reducing the abundance of feral cats, whereas lethal traps are the most effective technique. Trap-neuter-release is also considered the technique 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 non-target species, and the least humane technique. A predator-proof fence preventing immigration of cats into an area is considered the most humane, but the most expensive. Lethal traps are considered the least expensive. A sharp-shooter is least likely to negatively impact either native or introduced non-target species. The three techniques that involve live-capture and euthanasia received moderate scores in terms of all seven decision criteria (Table 6.5).

Inconsistency values were below 0.1 for all of the stakeholder groups (Table 6.4). Therefore, the survey data was deemed acceptable for use in the AHP model (Figure 6.1). Similarly, inconsistency values were below 0.1 for responses to the in-person survey of wildlife professionals (Table 6.5).

Table 6.4 Geometric means (SD) for each decision criterion for the six stakeholder groups.

Data are from 1,369 respondents of the state-wide survey. 1 = extremely unimportant; 9 = extremely important. Kruskal-Wallis test statistic (K) was used to assess variation among stakeholder groups.

			Stakeholder Group						
Decision Criteria	**K-statistic (5df)**	**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 non-target 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 non-target 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)

Table 6.5 Geometric mean (SD) for each feral cat management technique in terms of each decision criterion as assessed by 11 wildlife managers (n = 11) with experience reducing feral cat abundance in Hawai‘i. Effectiveness; impact; risk; cost; probability 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**	**Sharp shooter**
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 non-target 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 non-target 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)

Sensitivity analysis revealed that the ultimate ranking of the management techniques was not sensitive to changes in rankings assigned to the decision criteria. Ratios generated by the pair-wise comparisons of each of the decision criteria were all $0.4 \leq a_{ij} \leq 2.7$. Limited variation in a_{ij} is an artifact of the diverse rankings applied by survey respondents to each of the decision criteria (Table 6.4), which forces the geometric mean to the center of the scale. AHP ranked lethal traps as the best and trap-neuter-release as the worst management techniques for achieving the goal of the model 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 (Table 6.1). Live capture and lethal injection was ranked as the best technique by the public, whereas the AHP model ranked it the fifth best technique. The ranking of the alternatives was identical for each of the six stakeholder groups (Table 6.6).

Table 6.6 Ultimate priorities and rank assigned to each of the seven feral cat management techniques by each of the stakeholder groups when public priorities and expert knowledge are combined in AHP. Results were the same for each stakeholder group.

Alternatives	Normalized priorities	Rank
Lethal Trap	0.18	1
Live Capture and Adoption	0.10	6
Live Capture and Gunshot	0.17	4
Live Capture and Lethal Injection	0.16	5
Predator-Proof Fence	0.17	2
Sharp-Shooter	0.17	3
Trap-Neuter-Release	0.05	7

Discussion

AHP ranked lethal traps as the best and trap-neuter-release as the worst management techniques for achieving the goal of the model which was to reduce the abundance of feral cats (Table 6.6). Wildlife managers considered lethal traps the most effective and humane technique, and the least expensive technique that is least likely to cause environmental contamination (Table 6.5). Lethal traps were the optimal alternative for the majority of the decision criteria.

The output from the sensitivity analysis suggests that changes in the public's values or priorities will have little influence on the ultimate selection of a management technique for feral cats. However, 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 ($0.4 \leq a_{ij} \leq 2.7$). In other words there was insufficient variation in the average rank assigned to each of the decision criteria (Table 6.4) for the public's values or priorities to influence the selection of the optimal management technique. When I experimentally doubled the range of the ratios (i.e., $0.4 \leq a_{ij} \leq 2.7$ increased to $0.2 \leq a_{ij} \leq 5.2$) generated by comparing decision criteria the inconsistency index increased from <0.01 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 manipulation of the data confirms that the public's priorities have little influence on the ultimate selection of a management technique for feral cats because when individual's rankings of the decision criteria are averaged then all of the decision criteria effectively become equally important. Since the decision criteria were equally important the AHP model selected the optimal management technique based on information relating to the costs and benefits of each technique.

Priorities vary among people, even within a stakeholder group. None of the stakeholder groups appear to have a consistent set of priorities. Elected officials 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. Changes in policy rarely correlate with frequent item-specific opinion polls, but do tend to track stable opinion changes on salient issues (Page & Shapiro 1983). Similarly, natural resource managers, especially those employed by government are expected to represent the interests of society. Natural resource managers are tasked with managing natural resources for the benefit of current and future residents, of Hawai‘i in the present case. Stakeholders across the US want to be more involved in the decision-making process for the management of natural resources (Brown et al. 2001). Like elected officials, natural resource managers will find incorporating the priorities and opinions of stakeholders into their decision-making process difficult if 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. 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 during the decision-making process on their own expert knowledge and accepted ‘best practice’ regarding the costs and benefits of the available management techniques.

The AHP model described here illuminates two courses of action for natural resource management. One, 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.

Two, outreach materials generated by natural resource agencies, especially wildlife agencies rarely contain information on the costs and benefits of various management techniques (DOFAW & ABC n.d.). The public cannot be expected to understand the decisions made by natural resource managers unless they are provided with information on the costs and benefits of the various management techniques. Marketing science and interactive media (i.e. the world wide web) have developed tools such as the comparison matrix that improve the quality and efficiency of peoples' purchase decisions (Haubl & 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. The same tools could be used to educate the public about various management techniques and allow stakeholders to identify the tool that best meets their priorities.

Caveats need to be considered when interpreting the results of the AHP model. The question presented in Table 6.2 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 6.2 (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 AHP model, I recommend using shorter surveys for future decision-making models that intend to combine public opinions with expert knowledge. Additionally, the AHP model outlined here does not reflect the pressure special interest groups can place on decision-makers. Many animal welfare advocates, for example, would disagree with the results presented in Table 6 despite the fact that the average opinion of identified animal welfare advocates ranked lethal traps as the best management technique for reducing the abundance of feral cats. The AHP model described here is a tool for incorporating average public opinion into the decision-making process.

Chapter 7 General discussion

The purpose of this dissertation was to gather baseline data on the human dimensions of several species of introduced terrestrial vertebrates. When I compare the results for subsets of these species some interesting trends are revealed. Whether or not survey respondents enjoyed seeing or hearing wildlife was a common and dominant explanatory variable for respondents stated desire for the future abundance of game species and feral cats (Chapters 3, and 4). For game species, the majority of respondents stated that they did enjoy seeing or hearing game animals (Chapter 3). The future desired abundance for game was diverse with hunters desiring an increase in the abundance or game while other stakeholder groups desired no change in abundance or a decrease in the abundance of game. In comparison, the majority of respondents stated that they do not enjoy seeing or hearing feral cats and wanted to see a large decrease in the abundance of cats (Chapter 4). In general enjoyment derived from seeing or hearing wildlife was moderately to strongly correlated with respondent’s desired abundance for each species.

These results raise the question: do residents of Hawai‘i enjoy seeing or hearing native wildlife, and if so could facilitating interactions with native species alleviate some of the conflict generated by reducing the abundance of non-native species? The 2006 National survey of fishing, hunting and wildlife-associated recreation suggests however that less than 20% of Hawai‘i’s population ever deliberately interacts with wildlife (Kempthorne et al. 2006). Similarly, Hawai‘i ‘s wildlife professionals believe that many Hawaiian residents have little connection to, or knowledge, of native wildlife (Leonard Jr 2008). Several studies suggest that ecotourism, defined as tours in natural areas that frequently involve educational interpretation of the natural environment, can influence people’s attitudes and behaviors towards conservation (Zeppel & Muloin 2008; Powell & Ham 2008). Marine ecotourism is fairly common in Hawai‘i. Terrestrial based ecotourism is less common. Many of Hawaiʻi's native terrestrial birds are restricted to remote, high-elevation forests where access is difficult or impossible, so the opportunities to see native forest birds are limited. Similarly, many of the wildlife refuges in Hawaiʻi are closed to the general public for the majority of the year. The casual wildlife observer is far more likely to see introduced species such as zebra doves, common myna, mongoose, sharma, Java finch, and red-eared sliders than native fauna. I would like to see future research investigate whether people enjoy seeing Hawaiʻi's smaller more elusive native species as much as larger non-native game species and whether the potential to interact with native species can influence tolerance for introduced species.

Another question raised by this research is how should we define stakeholder groups? I defined stakeholder groups by two methods: pre-identified stakeholder groups were based on descriptions of people involved in cases of human-wildlife conflict in Hawaiʻi (See Chapter 1); whereas *post hoc* stakeholder groups were defined by cluster analysis of 9 socio-demographic and behavioral variables with desired abundance of wildlife as the dependent variable. In Chapter 6 the values held by people in each pre-identified stakeholder group were too diverse to influence the results of the AHP model. This suggests a need to refine or redefine the stakeholder groups. Other sociological traits, such as value orientations, or rank assigned to decision criteria may create more consistent clusters of stakeholders. Hawaiʻi is an exceptionally diverse state with a highly transient population, making it an excellent location to further research on defining wildlife stakeholder groups.

A third question raised by this research is how do we implement the results of human dimensions studies? In Hawaiʻi a few individuals have been capable of derailing or at least delaying the implementation of a management plan for years (Warner & Kinslow 2011). This pattern of behavior suggests that even when an over-whelming majority (e.g., 85% respondents want feral cat abundance to decrease; Chapter 4) of the population is in agreement with a management goal, that a few individuals may be able to solicit an injunction against implementation of the plan, especially if that plan traverses multiple islands, communities or land ownership categories. In Chapter 3 I recommend designing separate management plans for each island as limiting the geographic scope of a plan may reduce the diversity of opinions encountered and hence the likelihood of human-wildlife conflict. Similarly, I believe separate management plans could be designed for each land category (e.g., State of Hawaiʻi Department of Parks and Recreation, or Natural Area Reserves, or agricultural land). All of these separate plans need to fall under a comprehensive umbrella plan that explicitly outlines goals in terms of the persistence or acceptable density of a species across the landscape to ensure that various government agencies work in unity. Wildlife can cross political boundaries. To minimize the probability of human-wildlife conflict (e.g., conflict between agriculturalists and hunters when granivorous game birds are released near agricultural fields) management plans must consider the desires of neighboring land managers or owners. All management plans should include explicit time-frames, achievable goals, and outcome based assessment.

There are relatively few studies on the human dimensions of introduced or invasive species. Human dimensions studies of large predators (Organ & Ellingwood 2000; Teel et al. 2002; Kaczensky 2004; Gore et al. 2005; Honda 2009; García-de la Fuente et al. 2009), species that present a health and safety risk for people (Morgan & Gramann 1989; Christoffel 2007), game species (Minnis 1996; Stout et al. 1997; West & Parkhurst 2002; Lischka et al. 2008), and endangered species are more common (Tisdell et al. 2007; Liukkonen et al. 2009). Yet, humans are heavily involved in the introduction and proliferation of introduced wildlife. In some cases humans deliberately or accidentally introduce a species to a new area (Ward 2011). People may then seek to proliferate an introduced species or re-define an introduced species as a native species to protect it from control or eradication programs. These actions are counter-productive to my attempts to conserve the natural environment as they disrupt ecosystem processes if not degrade ecosystems (Veitch & Clout 2002; White et

al. 2008). Understanding why some people, spread, proliferate, and defend introduced species will aid my ability to control or eradicate them, and hence protect the unique and rare aspects of localities like the Hawaiian Islands.
The reasons behind why stakeholders support one wildlife management plan and disapprove of another are not always obvious. As discussed in Chapter 4 I expected that support for the control of feral cats in the Hawaiian Islands would be limited. There are several animal welfare groups in Hawaiʻi that support *in situ* management techniques for feral cats and actively promote their values to legislators. The activity of these groups gives people the impression that a large portion of Hawaiʻis residents support the presence of free-roaming and feral cats. Research revealed that the vast majority of survey respondents were actually in support of decreasing the abundance of feral cats. Public opinion is difficult to gage through public forums as a limited number of stakeholders will dedicate the time to submit comments on management plans, or attend public meetings (Johnson et al. 1993; McComas 2003). Similarly, public forums can be misleading as dominant personalities suppress the opinions and ideas of more submissive personalities (Regan et al. 2006).

To effectively manage wildlife I need to understand the biology, ecology, and human dimensions of wildlife. Knowledge of the biology and ecology of a species are essential for defining management goals and time-lines, and identifying appropriate tools for achieving those goals. For example, captive breeding of pandas (*Ailuropoda melanoleuca*) become increasingly successful, and hence the conservation objectives become more obtainable, as my knowledge of the biology, ecology, and behavior of pandas increases (Zhi et al. 2000). Similarly, understanding the biology of marsupials native to Western Australia aided the development of 1080 (sodium mono-fluroacetate) as a tool for managing introduced foxes (*Vulpes vulpes*) (McIlroy 1981; McIlroy 1982; McIlroy 1984; McIlroy 1986; Calver et al. 1989; Martin & Twigg 2002). In the US and many other countries wildlife are considered a public resource in that government agencies are charged with managing wildlife in trust for the people (Freyfogle &

Goble 2009). As such, people have some influence over how wildlife are managed, either through political pressure or the judicial system (United States District Court District of Hawaiʻi 1979; Manfredo et al. 1999). Unsurprisingly, people will be most outspoken about species that are deemed iconic and species that generate human-wildlife conflict (Bath & Buchanan 1989). Human-wildlife conflict occurs when the ecological needs and behaviors of wildlife negatively affect the goals of humans or when the goals of humans negatively affect the needs of wildlife (Madden 2004). Similarly, human-wildlife conflict can occur between people, whenever one group of people benefits from the presence of wildlife, while another group pays a cost (Stokes et al. 2006). If human-wildlife conflict escalates then people may turn to legal and legislative processes to over-turn the decisions of wildlife professionals (Teel et al. 2002) and eventually, support for conservation declines (Madden 2004). Since wildlife are a public resource and the public may have some influence over how wildlife are managed then the funding and success of wildlife management programs is closely linked to public support for conservation or other wildlife management objectives. In many cases I need biological knowledge to design an effective management plan, and I need knowledge of the human dimensions surrounding a species to garner the political and financial support for implementing a management plan.

Formal human dimensions studies can provide the information that is difficult to derive from public forums. Human dimensions studies typically collect information on how people affect or are affected by wildlife, and how people would like wildlife to be managed (Decker et al. 2001). The field of human dimensions is very diverse also including studies on human beliefs and attitudes; stakeholder satisfaction with recreational opportunities; economic value of wildlife resources; communication and persuasion; and incorporating stakeholders into the decision-making process. The general goal of human dimensions studies is to replace assumptions regarding human value and perceptions of wildlife with quantitative data. Human dimensions data may be used to design management goals and identify management techniques that are generally acceptable to wildlife stakeholders and hence do not incite human-wildlife conflict. Similarly, human dimensions data may be used to design mitigation plans for existing human-wildlife conflict or educational materials for uninformed wildlife stakeholders. I believe that the data presented in this dissertation could have a considerable impact on the design and implementation of future management plans for introduced terrestrial vertebrates in the Hawaiian Islands.

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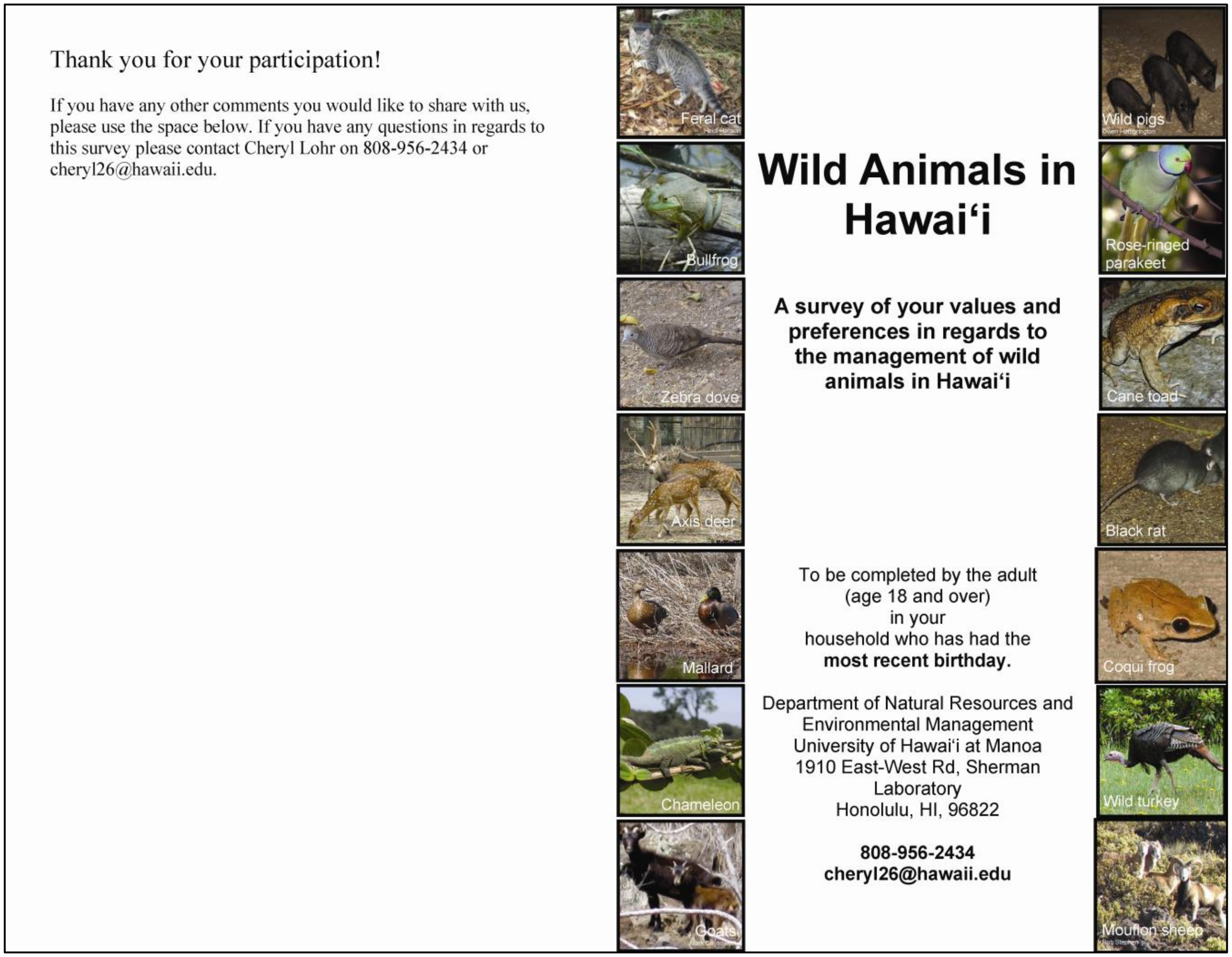
Appendix A) Survey materials

Figure A.1 16 page survey booklet sent to wildlife stakeholders and residents of Hawai‘i



Thank you for your participation!

If you have any other comments you would like to share with us, please use the space below. If you have any questions in regards to this survey please contact Cheryl Lohr on 808-956-2434 or cheryl26@hawaii.edu.

Wild Animals in Hawai‘i

A survey of your values and preferences in regards to the management of wild animals in Hawai‘i

To be completed by the adult (age 18 and over) in your household who has had the **most recent birthday.**

Department of Natural Resources and Environmental Management
University of Hawai‘i at Manoa
1910 East-West Rd, Sherman Laboratory
Honolulu, HI, 96822

808-956-2434
cheryl26@hawaii.edu

Wildlife activities
First, we would like to ask you about your activities and interest in wild animals.

1. How often do you participate in these activities? Please check the most appropriate box.

	Never	Rarely Once a year	Occasionally Every 6 months	Frequently Monthly
Hike				
Hunt				
Watch (e.g., bird watching) or photograph wild animals				
Feed un-owned cats				
Feed wild birds				
Volunteer for conservation (e.g., clean -up a beach or remove invasive plants)				
Volunteer at an animal shelter				
Participate in native Hawaiian cultural activities				

2. How interested are you in local issues pertaining to wild animals? Please check one box.

☐ Not at all
☐ Mild: I read stories/articles or watch documentaries on wild animals when I see them
☐ Moderate: I occasionally look for information on wild animals in Hawai'i
☐ Strong: I regularly seek additional information on wild animals in Hawai'i
☐ Very strong: I occasionally attend meetings about wild animals in Hawai'i or submit my opinion to legislature about issues pertaining to wild animals

3. Would you read a column in the local newspaper or magazine designed to answer the public's questions about the management of wild animals in Hawai'i? Check one box.

☐ Definitely yes ☐ Probably yes ☐ Unsure ☐ Probably not ☐ No

If no, why not? ____________________

4. In the last 12 months, did you donate money to, or buy a membership from one of the following types of organizations? Please check all boxes that apply.

☐ A conservation organization (e.g., The Nature Conservancy)
☐ A hunting organization (e.g., Pig Hunter Association of O'ahu)
☐ An animal welfare or animal rights organization (e.g., Humane Society of the US)
☐ An agricultural organization (e.g., Agricultural Leadership Foundation Hawai'i)
☐ A hiking club
☐ A wildlife organization (e.g., The Wildlife Society)
☐ A Hawaiian Civic Club

42. How would you describe the area where you spent all or most of your childhood? Please check one box.

☐ Rural area or farm ☐ Suburban area (25,000 to 100,000 people)
☐ Small town (less than 25,000 people) ☐ Metropolitan area (more than 100,000)

43. What is the highest level of education that you have completed? Please check one box.

☐ Some school completed, but no high school diploma
☐ High school graduate or GED
☐ Some college, but no degree
☐ Associates degree in college
☐ Bachelor's degree
☐ Master's, professional, or doctoral degree

44. Which race do you most identify with?

☐ Asian
☐ Black
☐ Caucasian
☐ Hispanic
☐ Native Hawaiian
☐ Pacific Islander
☐ Mix race or Other: Please state your race. ____________________

45. What country were you born in? ____________________

46. What is your average annual household income? Please check one box.

☐ Less than $10,000 ☐ $75,000 to $99,999
☐ $10,000 to $24,999 ☐ $100,000 to $149,999
☐ $25,000 to $49,999 ☐ $150,000 to $199,999
☐ $50,000 to $74,999 ☐ $200,000 or more

47. Would you like to receive a summary of the results when this research is completed?

☐ Yes ☐ No

If yes, please write your email address here. ____________________

33. Please state how important it is for the authorities to address the concerns of the following groups of people in relation to the management of wild animals. Please use numbers 1 through 9 to express your opinion, (1 = extremely important, 5 = somewhat important, 9 = extremely unimportant).

	Number
Agriculturalists (e.g., farmers/ranchers)	
Animal welfare organizations	
Conservation Biologist, manager or scientist	
Hunters	
Landowners or homeowners	
Native Hawaiians	
People who use natural areas for recreation (e.g., hikers, bird-watchers)	
People who gather products (e.g., fruit, flowers, or wood) from natural areas	
Pet owners	

Background information
To more fully understand your responses to the previous questions, we need to know a few things about your background. Remember that your responses are completely confidential and that neither your name nor address will be directly linked to your responses in any way.

34. Are you: ☐ Male ☐ Female

35. Are you retired? ☐ Yes. Go to question 36.
☐ No. What is your primary occupation? ___________________

36. How many years have you lived in the Hawaiian Islands? ___________ years

37. In what year were you born? 19______

38. What is your zip code? _______________

39. Do you own a pet? ☐ Yes. Go to question 40. ☐ No. Go to question 41.

40. How many pets live on your property? Please fill in a number for each of the listed animals. If none, please write 0.

________Dogs
________Cats
________Birds
________Fish
________Reptiles (e.g., lizards, chameleons)
________Amphibians (e.g., frogs, newts)
________Small mammals (e.g., rabbits, chinchilla)
________Livestock (e.g., horses, sheep etc.)

41. How would you describe the area where you currently live? Please check one box.

☐ Rural area or farm
☐ Small town (less than 25,000 people)
☐ Suburban area (25,000 to 100,000 people)
☐ Metropolitan area (more than 100,000)

Game Management
The next 6 questions will ask you for your opinion on game management in Hawai'i.

5. You have been given the task of changing the number of game mammals (**PIGS, AXIS DEER OR GOATS**) 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 = most important, 5 = somewhat important, 9 = least important).

	Number
Public opinion of the method: Is it a positive or negative opinion	
Animal welfare: Humane treatment of game mammals	
Environmental contamination: Possibility of soil or water contamination	
Culture: Impact of the method on native Hawaiian culture	
Cost: Amount of money required to implement the method	
Human health and safety: Could people be hurt by the method	
Effectiveness: Is the method likely to work	
Introduced non-target animals: Possible harm to other introduced animals	
Native non-target animals: Possible harm to other native animals	

6. Do you support the idea of hunting? Please check all boxes that apply.

☐ I support recreational hunting
☐ I support hunting as a tool to decrease the number of game animals
☐ No
☐ Unsure

7. Would you support the idea of creating fenced game/hunting enclosures and controlling or eradicating game mammals outside of those areas? Check all boxes that apply.

☐ Yes, if they were private game farms
☐ Yes, if they were free to licensed hunters
☐ Never
☐ Unsure

8. Have you spent any money in the last year to reduce or repair the damages caused by wild animals on your property? If yes, please specify the type of animal/s and the amount of money spent in dollars ($) in the following space. You may use the back page of this survey if you require extra space to write your answer.

____
____
____
____
____

9. Would you support the use of food based contraceptives (e.g., Ovocontrol) for reducing the number of pigeons and doves in urban areas? Please check one box.

- ☐ Yes
- ☐ No
- ☐ Yes, but I doubt Ovocontrol will reduce the number of pigeons/doves
- ☐ Unsure

10. You have been given the task of changing the number of game birds (**TURKEYS OR DOVES**) 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).

	Number
Effectiveness: Is the method likely to work	
Introduced non-target animals: Possible harm to other introduced animals	
Human health and safety: Could people be hurt by the method	
Cost: Amount of money required to implement the method	
Culture: Impact of the method on native Hawaiian culture	
Public opinion of the method: Is it a positive or negative opinion	
Native non-target animals: Possible harm to other native animals	
Environmental contamination: Possibility of soil or water contamination	
Animal welfare: Humane treatment of animals	

The next 9 questions will ask you about your awareness and beliefs about 14 kinds of wild animals found in Hawai'i. Please check the most appropriate response for each of the animals. A picture of each of the listed animals is available on the front cover of the survey.

11. Are these animals native or introduced to the Hawaiian Islands?

	Native	Introduced	Unsure
Axis deer			
Black rat			
Bullfrog			
Cane toad			
Cat (wild)			
Coqui frog			
Goat (wild)			
Jackson's chameleon			
Mallard duck			
Mouflon sheep			
Pig (wild)			
Rose-ringed parakeet			
Wild turkey			
Zebra dove			

Small Wild Animal Management
The next 4 questions will ask you for your opinion on the management of small wild animals.

29. You have been given the task of changing the number of **RATS OR MICE** 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).

	Number
Culture: Impact of the method on native Hawaiian culture	
Public opinion of the method: Is it a positive or negative opinion	
Animal welfare: Humane treatment of animals	
Effectiveness: Is the method likely to work	
Human health and safety: Could people be hurt by the method	
Cost: Amount of money required to implement the method	
Native non-target animals: Possible harm to other native animals	
Introduced non-target animals: Possible harm to other introduced animals	
Environmental contamination: Possibility of soil or water contamination	

30. Would you support the aerial application of rat bait pellets in remote areas when hunting seasons are closed? Please check one box.

- ☐ Yes
- ☐ No. If no, why not? ________________________________

31. Do you use any tools to reduce the number of coqui frogs on your property?

- ☐ Yes. If Yes, which tools do you use? ________________________________
- ☐ No

32. You have been given the task of changing the number of **COQUI FROGS OR CHAMELEONS** 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).

	Number
Cost: Amount of money required to implement the method	
Introduced non-target animals: Possible harm to other introduced animals	
Effectiveness: Is the method likely to work	
Animal welfare: Humane treatment of animals	
Human health and safety: Could people be hurt by the method	
Public opinion of the method: Is it a positive or negative opinion	
Culture: Impact of the method on native Hawaiian culture	
Native non-target animals: Possible harm to other native animals	
Environmental contamination: Possibility of soil or water contamination	

27. In question 26 you stated how you would like the number of wild animals to change. What priority would you assign to the development of a management plan designed to meet your stated desire for each of these animals?

Animal	Unsure	Low Priority	Medium Priority	High Priority
Axis deer				
Black rat				
Bullfrog				
Cane toad				
Cat (wild)				
Coqui frog				
Goat (wild)				
Jackson's chameleon				
Mallard duck				
Mouflon sheep				
Pig (wild)				
Rose-ringed parakeet				
Wild turkey				
Zebra dove				

28. Do you want these animals to continue to live in the wild in Hawai'i?

Animal	Yes	No	Unsure
Axis deer			
Black rat			
Bullfrog			
Cane toad			
Cat (wild)			
Coqui frog			
Goat (wild)			
Jackson's chameleon			
Mallard duck			
Mouflon sheep			
Pig (wild)			
Rose-ringed parakeet			
Wild turkey			
Zebra dove			

12. Are these animals culturally important or valuable animals to you?

Animal	Not valuable	Slightly valuable	Somewhat valuable	Very valuable
Axis deer				
Black rat				
Bullfrog				
Cane toad				
Cat (wild)				
Coqui frog				
Goat (wild)				
Jackson's chameleon				
Mallard duck				
Mouflon sheep				
Pig (wild)				
Rose-ringed parakeet				
Wild turkey				
Zebra dove				

13. Are these animals economically important or valuable animals in Hawai'i? Do they generate income or revenue?

Animal	Not important	Slightly important	Somewhat important	Very important	Unsure
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

14. I enjoy seeing or hearing these animals in the wild in Hawai'i.

Animal	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

15. Whether or not I see one of these animals, I benefit from just knowing that they persist in the Hawaiian Islands.

Animal	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

25. In the last two years, has the number of each of these animals increased or decreased in your area?

Animal	Large decrease	Small decrease	No change	Small increase	Large increase	Unsure or none present
Axis deer						
Black rat						
Bullfrog						
Cane toad						
Cat (wild)						
Coqui frog						
Goat (wild)						
Jackson's chameleon						
Mallard duck						
Mouflon sheep						
Pig (wild)						
Rose-ringed parakeet						
Wild turkey						
Zebra dove						

26. In the future, I would like the number of these animals in the wild to:

Animal	Large decrease	Small decrease	No change	Small increase	Large increase
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

23. You have been given the task of changing the number of birds (**DUCKS OR PARAKEETS**) 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).

	Number
Human health and safety: Could people be hurt by the method	
Culture: Impact of the method on native Hawaiian culture	
Introduced non-target animals: Possible harm to other introduced animals	
Native non-target animals: Possible harm to other native animals	
Effectiveness: Is the method likely to work	
Animal welfare: Humane treatment of animals	
Environmental contamination: Possibility of soil or water contamination	
Cost: Amount of money required to implement the method	
Public opinion of the method: Is it a positive or negative opinion	

Wild Animal Populations
The next 5 questions will ask you how many wild animals exist in the area where you live. Please check the most appropriate response for each of the animals. A picture of each of the listed animals is available on the front cover of the survey.

24. How frequently do you see or hear each of these animals in the area where you live?

Animal	Unsure	I have never seen or heard one	I see or hear them annually	I see or hear them monthly	I see or hear them weekly	I see or hear them daily
Axis deer						
Black rat						
Bullfrog						
Cane toad						
Cat (wild)						
Coqui frog						
Goat (wild)						
Jackson's chameleon						
Mallard duck						
Mouflon sheep						
Pig (wild)						
Rose-ringed parakeet						
Wild turkey						
Zebra dove						

16. These animals damage people's property or source of income.

Animal	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

17. These animals pose a health or safety risk for people.

Animal	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

18. These animals pose a risk for native animals or plants.

Animal	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

19. These animals may contaminate or degrade the soil or water.

Animal	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Axis deer					
Black rat					
Bullfrog					
Cane toad					
Cat (wild)					
Coqui frog					
Goat (wild)					
Jackson's chameleon					
Mallard duck					
Mouflon sheep					
Pig (wild)					
Rose-ringed parakeet					
Wild turkey					
Zebra dove					

Feral Animal Management

The next 6 questions will ask for your opinion on the management of wild domesticated animals.

20. 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).

	Number
Native non-target animals: Possible harm to other native animals	
Cost: Amount of money required to implement the method	
Introduced non-target 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	
Culture: Impact of the method on native Hawaiian culture	
Human health and safety: Could people be hurt by the method	
Public opinion of the method: Is it a positive or negative opinion	

21. Which of the following methods of managing free-roaming **CATS** do you favor or oppose? Please use numbers 1 through 9 to express your opinion. You may use the same number more than once, (1 = Strongly favor, 5 = neither favor nor oppose, 9 = strongly oppose).

	Number
Live capture and adoption: Live capture via cage traps or leg-hold traps	
Live capture and lethal injection: Live capture via cage traps or leg-hold traps	
Live capture and lethal gunshot: Agency employed staff trapper and shooter	
Trap-Neuter-Release: Cats are trapped, sterilized and released at trap location	
Lethal traps: Traps designed to kill targeted animals quickly	
Predator proof fence: Cats are removed from inside the fenced area	
Sharp shooter with firearm: Agency employed shooter which is on foot	
Live capture leg-hold traps: Hold an animals foot or leg without damaging it	
Live capture cage traps: Cage with a spring loaded door	

22. Would you support the removal or relocation of cat colonies from areas with populations of threatened or endangered species? Please check one box.

- ☐ Yes, remove cats permanently
- ☐ Yes, relocate cats and feeding station at least 500m or 1/3 mile away
- ☐ No, fed cats don't kill other animals
- ☐ Unsure

Figure A.2 Reminder postcard (front and back) mailed to hunters and the general public

Return to:
Cheryl Lohr, Sherman Lab, University of Hawai'i at Mānoa, 1910 East-West Rd, Honolulu, HI, 96822

Reminder

Wild Animals in Hawai'i Survey

A few weeks ago we sent you a survey booklet regarding the management of wild animals in the Hawaiian Islands.
The results of this survey will influence how wild animals are managed in Hawai'i.
We value your opinion and would greatly appreciate it if you would fill out the survey and send it back to us in the pre-paid envelope before September 15th, 2011.
Please contact Cheryl Lohr on 808-956-2434 or cheryl26@hawaii.edu if you need another copy of the survey.

This survey went to native Hawaiians, hunters, and people involved in animal welfare, agriculture, and conservation.

Make sure your opinion on the management of wild animals in Hawai'i is heard!

Due date: 09/15/2011

College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Figure A.3 Questions presented during non-response telephone survey.

On a scale of 1-5 how interested are you in issues about wild animals in Hawai‘i?
O Not Interested O Mildly O Moderately O Strongly O Very Strongly

Do you support the idea of hunting?
O Recreational hunting O Hunting as a tool to decrease the number of animals
O No O Unsure

Would you support the removal or relocation of cat colonies from areas with populations of threatened or endangered species?
O Yes, remove cats permanently O Yes, relocate cats 500m or 1/3 mile away
O No, fed cats don’t kill other animals O Unsure

How often do you participate in the following activities?

	Never	Once year	Once 6 months	Monthly/ more
Hike				
Hunt				
Watch/photo wildlife				
Feed un-owned cats				
Feed wild birds				
Volunteer conservation				
Volunteer Animal Shelter				
Hawaiian cultural activities				

What age category do you fall into?
O Teens O 20s O 30s O 40s O 50s O 60s

What is the highest level of school you have completed?
O Less than high school O High school/GED O Some college but no degree
O Associate degree O Bachelor degree O Graduate degree

Was there a specific reason that you chose not to respond to our survey on wild animals in Hawaii? (Please mark all responses that apply.)
I know very little about wild animals in Hawaii
I did not understand the questions in the survey
I do not have time to answer surveys
I did not receive a survey
I do not like answering surveys
The survey looked too long and/or complicated
The survey did not allow me to express my opinion completely
Against company/agency policy to respond to surveys received at a work address
Other (please specify)