

**METHODS FOR POPULATION CONTROL:
A CASE STUDY ON THE AXIS DEER OF MAUI ISLAND, HI**

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of
the requirements for the degree of Master of Energy and Environmental Policy

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ABSTRACT

This study is an exploration of the social, ecological, and economic components of creating a commercialized hunt of non-native axis deer (*Axis axis*) on Maui Island, Hawaii. A series of interviews and surveys were used to determine the preferred population control policy alternatives to manage overabundant axis deer. The surveys placed an emphasis on exploring the feasibility of and attitudes towards the commercialized harvest method of control because it is a new and controversial policy alternative for Maui. A survey was distributed to locally owned and operated Hawaiian businesses that may be interested in utilizing axis deer parts in their products or supplying axis deer venison to their customers. Another survey was distributed via mail and advertised in newspapers to the general public of Maui. These surveys polled participants about their axis deer control method preferences and investigated the opinions of consumers about purchasing axis deer venison and other products. A subset of these questions meant solely for hunters—primarily regarding hunter education and attitudes about population control methods-- were also distributed to the Maui hunting body through hunting clubs. Interviews with the Maui Axis Deer Working Group were also used to understand governmental preferences regarding population control.

This study is the first comprehensive documentation available to the public that explores the efforts to create and maintain successful commercialized axis deer harvesting in Maui. Survey results indicate that there is ample market

demand for axis deer products that would be available as a result of a commercialized harvest. Additionally, it was found that recreational hunting, commercialized harvesting, and fencing were the most preferred methods of populations control and it is recommended that unique blends of these methods should be used for different communities, based on local objectives.

Chapter 1

INTRODUCTION

1.1 The Axis Deer Problem of Maui, Hawaii

Eight axis deer were introduced to the Hawaiian island of Molokai as a gift to King Kamehameha from a Raja of India in 1868. Axis deer (*Axis axis*) are native to India, Nepal, Bhutan, Bangladesh, Sri Lanka, and Pakistan, where tigers, leopards, and dholes are the dominant mechanisms of deer herd health and population regulation (Maui Axis Deer Working Group, 2012b: 1). In September 1959, five deer were introduced to Maui on Kaonoulu Ranch, Puu O Kali. Later in July 1960, four additional deer were released near the 1959 release site. These deer were introduced to Maui by the Territorial Legislature for increased hunting opportunities and to provide subsistence for island residents. By 1968, the Maui population was already estimated to be between 85 and 90 animals (Subcommittee of Public Information and Deer Management Planning, 2002: 3).

Axis deer have also been introduced in Texas, Florida, California, Alaska, and New York (Maui Axis Deer Working Group, 2012b: 2). In the continental United States, axis deer are mostly found throughout Texas, where populations are around 39,000 animals. Axis deer, as a non-native species, are considered an exciting new hunting opportunity in Texas where they are a prized game animal and private landowners open up their lands for fee hunting axis deer; the deer are also farmed for their venison

(Demarais, Osborn and Jackley, 1990: 123). However, while there are positives that come from introducing exotic game species to new places, there are also many negatives, including the competition for ecological niches, controlled population spread, and disease complications (Demarais, Osborn and Jackley, 1990: 122).

Hawaii began to realize some of these issues with importing exotic species as game animals. On Molokai, just 27 years after their introduction, it was accepted that axis deer were doing grave damage to forests and grasslands (Maui County, 2000: 1). In 1898, just over 30 years since their introduction, professional hunters were hired to control the population on Molokai, marking the first attempt to control axis deer in the state (Maui County, 2000: 1). Over the course of one year, 3,500 axis deer were shot by the two professional sharpshooters from California (Maui Axis Deer Working Group, 2012b: 1). Since then, both Maui and Lanai, another island that introduced axis deer into their ecosystem, have also worked to control their populations to deal with the deer-caused ecological harm in the form of forest degradation, watershed impairment, and agricultural damage (Maui County, 2000: 1).

Hawaii is especially susceptible to the negative impacts of invasive species because it is an island ecosystem. Charles Darwin considered island species to be inherently less competitive than continental species because of the apparent success of introduced species on islands, and the greater range of selection pressures thought to be present in continental areas. Because of the relative isolation, island biotas are often considered to be missing taxonomic and functional groups, creating easy opportunities for invasive species to exploit those gaps (Allen, Duncan and Lee, 2006: 438). The

vulnerability of islands to invasive species is often attributed to lower species richness on islands compared to mainland areas of the same size. Islands are less able to resist introduced species because they have fewer native competitors, predators, and pathogens to affect invading populations (Allen, Duncan and Lee, 2006: 436). The invasion of non-native species poses one of the greatest threats to Hawaii's native ecosystems and their inhabitants. Already nearly 75% of the extinctions in the United States have occurred in Hawaii, and nearly 40% of the endangered species in the United States are Hawaiian species (Reeser and Harry, 2005: 1).

In fact, the islands of Hawaii have no native ungulates and thus the endemic organisms evolved without the need to compete with or defend against them (Reeser and Harry, 2005: 1). Because Hawaiian plants have not coevolved with ungulates, the axis deer wreak havoc on the native vegetation. The deer are also not picky eaters; they "will adapt to whatever food is around them and they are very mobile and will travel for food" (Anonymous #8, personal communication, January 30, 2014). Axis deer are a serious threat to endangered plants and there are instances where axis deer have eliminated subpopulations of endangered plant species (Anonymous #5, personal communication, January 24, 2014). A conservationist notes that while he is not sure if axis deer have driven any particular plant to complete extinction, "it is totally likely that they could and will if numbers are not checked" (Anonymous #5, personal communication, January 24, 2014).

Axis deer also damage residential and commercial agriculture. A resort reports that, in the dry season, deer are known to come down from the mountain and browse on

the resort landscaping as well as the vegetation in the neighboring community.

Occasionally, a deer in the area looking for vegetation will get spooked and will run through the hotel lobby and into the ocean, where it usually must then be helped out of the water (Anonymous #3, personal communication, January 29, 2014). Deer are also a huge economic burden on golf courses, and the resort reports that every year, each of its three golf courses spend about \$10,000 on deer mitigation (Anonymous #3, personal communication, January 29, 2014). The deer also impact the cost of fresh produce that nearby farms supply to the area; prices increase during the dry seasons when availability of the produce decreases due to deer damage (Anonymous #3, personal communication, January 29, 2014).

Deer are even a threat to cattle ranchers, whose cattle compete with axis deer for grass and other vegetation. When it gets dry, the deer often behaviorally adapt to the new weather by forming herds of one to two hundred rather than their usually forty to fifty and these increased numbers are known to be able to wipe out a pasture in one night (Anonymous #9, personal communication, February 7, 2014). As a rule of thumb in Hawaii, seven axis deer eat the equivalent of what one cow eats (Maui Axis Deer Working Group, 2012b: 2). One rancher notes that the competition between his cattle and axis deer is very costly, especially during droughts. He recalls that one year his ranch suffered from \$100,000 worth of damage to vegetation which could have been used as food for cattle (Anonymous #13, personal communication, February 3, 2014). The deer's sharp hooves also cut into their crop water drip lines, which then need to be repaired or replaced. He also notes that the deer act as somewhat of a "poacher magnet", which

creates liability and safety problems for employees and cattle (Anonymous #13, personal communication, February 3, 2014).

Axis deer can also potentially spread contagious diseases between themselves and cattle. A veterinarian at the Hawaii Department of Agriculture states that, while there are currently no cases of diseases spreading between deer and cattle on Maui, bovine tuberculosis has been found in axis deer on Molokai. Contagious diseases are not currently an issue on Maui because both axis deer and cattle populations are healthy and the veterinarian notes that, “all of the diseases that could be transmitted from deer to livestock are pretty much theoretical, but it’s a possibility” (Anonymous #10, personal communication, January 28, 2014). Because there is this possibility of the spread of disease, various past publications have reported that axis deer pose a risk to human health. A study on axis deer in India noted that the deer there can carry and transmit Leptospirosis, E. Coli, and Cryptosporidiosis, in addition to bovine tuberculosis (Maui Axis Deer Working Group, 2012b: 3). However, a follow-up study a few years later took the opposite stance that, while all animals can transmit diseases, axis deer may actually be relatively resistant to disease and parasites compared to other species (Maui Axis Deer Working Group, 2012b: 3).

Undisputed, however, is the fact that axis deer pose a safety threat to humans through deer-automobile collisions. Communities and resorts have recently begun keeping track of reported car accidents and one resort suffered from 19 deer-vehicle accidents in one year along a 1.5 mile strip of road that goes past some pastures and down to the ocean. The resort notes that there were probably even more reports that went

unreported due to minimal damage (Anonymous #3, personal communication, January 29, 2014).

Axis deer are extremely adaptable and elusive. They are known to actually adjust their feeding and watering times to the schedules of poachers and they are capable to rapid adaptive responses to various environmental and human changes (Maui Axis Deer Working Group, 2012b: 2). They graze and browse opportunistically and can even consume tree bark to the point of tree death under drought conditions. Their presence on Maui has caused damage to orchards, nurseries, and garden crops. They also trample vegetation, debark and damage trees through antler rubbing. Axis deer also destroy fences and cause erosion by creating trails and by stripping areas of vegetation, leaving an absence of mossy and ground layers which normally retain water and slow the flow of water (Maui Axis Deer Working Group, 2012b: 3). This sediment run-off leads to clouded watersheds and the smothering of coral reefs (Reeser and Harry, 2005: 1). Furthermore, the soil disturbance caused by rooting facilitates the introduction and expansion of invasive plants, and creates breeding grounds for mosquitoes that transmit avian disease to native forest birds (Reeser and Harry, 2005: 1).

The ever-increasing population of axis deer will exacerbate the various ecological and economic problems that the deer cause. Wetter weather over the past few years means more food availability for deer, which has conservationists worried about a population explosion (Anonymous #9, personal communication, February 7, 2014). Axis deer have a very high reproductive capacity, which includes a very low age of first estrous in does (4-6 months of age), high annual pregnancy rates (80%-85% of adult does

each year), very low first year mortality of fawns (partially due to a lack of predators), flexible breeding season, and a long reproductive age of does (up to 15 years) (Maui Axis Deer Working Group, 2012b: 3). Does might even drop twins when there is enough food (Anonymous #9, personal communication, February 7, 2014).

The annual economic costs associated with axis deer on Maui Island are estimated to exceed \$1 million due to the crop damage, food security issues, and deer-vehicle collisions that axis deer all cause (Maui Axis Deer Working Group, 2012c: 2). Axis deer have become such a problem on the island of Maui that recreational hunting open to members of public with a hunting license is virtually unrestricted; “any axis deer encountered on a public hunting area on Maui may be taken by the hunter regardless of the number or sex of deer taken” (State of Hawaii Department of Land and Natural Resources, 2003a: 37). Despite these lax regulations, annual growth rates are still estimated to be between 20% and 30% and some herds exceed 1,000 animals in size (Maui Axis Deer Working Group, 2012c: 2). A major challenge associated with axis deer is that they are not universally seen as a problem. Axis deer have become the preferred game mammal of many hunters; as a result, communities do not favor eradication, but instead prefer some level of management and control.

To help sort through the array of management options, the Maui Axis Deer Group was formed in 1996. This group included public and private landowners, land managers, and individual citizens to address concerns about increased negative impacts associated with Maui’s growing deer population (State of Hawaii Department of Land and Natural Resources, 2003b: 1). It was determined that more scientific data was needed, so

research was conducted to gather baseline data on the axis deer population dynamics on Maui from 1997-2000 (Subcommittee of Public Information and Deer Management Planning, 2002: 4). Results were shared with the public in the summer of 2001, and working groups were formed to make recommendations based on working groups related to natural resource management, economics, Hawaiian culture, and hunting and ethics (Subcommittee of Public Information and Deer Management Planning, 2002: 4). From this effort, it was determined that a comprehensive, island-wide management plan would be the most effective and efficient way to address the negative impacts of axis deer on Maui (State of Hawaii Department of Land and Natural Resources, 2003b: 1). The Maui Axis Deer Group then “disbanded, or went into some level of latency for many years” (Anonymous #13, personal communication, February 3, 2014).

The current Maui Axis Deer Working Group (MADWG), revived in 2010 and partially funded by the Maui County Office of Economic Development, has been picking up where the past group left off (Anonymous #13, personal communication, February 3, 2014). The MADWG now consists of a variety of stakeholders with representatives from state and local government agencies, nonprofit organizations, private landowners, hunters, and private citizens, including: Hawaii Department of Agriculture, Hawaii Department of Land and Natural Resources, Maui County Council, Maui County Mayor’s Office, Maui County Farm Bureau, Hawaiian Commercial & Sugar Co., Monsanto, Ulupalakua Ranch, Haleakala Ranch, Maui Cattle Company, Wailea Community Association, Maui Hotel and Lodging Association, Maui Invasive Species Committee, Maui Conservation Alliance, and private hunters and individuals (Maui Axis

Deer Working Group, 2012c: 1). In accordance with recommendations of the previous groups, the MADWG has established a county-wide management plan for axis deer that involves many state and county agencies and organizations. The Maui Axis Deer Working Group is one of 27 projects that is currently supported by the Invasive Species Council, a statewide interagency organization focusing on invasive species (Anonymous #6, personal communication, January 15, 2014). This support allows the group to take action and work towards fulfilling its management objectives.

The Maui Axis Deer Working Group has recently established a clear mission statement: to “better manage the growing axis deer population on Maui” (Maui Axis Deer Working Group, 2012a: 1). In order to do this, the MADWG has outlined six goals: (1) in terms of population management, the group seeks to reduce and manage Maui’s axis deer population to a level that is appropriate for human and environmental concerns, (2) the group aims to support hunting as a management tool by facilitating coordinated deer hunting on public and private lands, (3) the group seeks to manage axis deer conflict and damage by reducing the negative impacts caused to citizens, businesses, agricultural and tourist industries, and local communities, (4) the group wants to protect the watershed by controlling deer to ensure Maui forests are healthy and sustainable, (5) the groups aims to educate and communicate with the public by fostering public understanding of deer biology, economic and environmental impacts, management strategies, and hunting and control opportunities, and (6) the group needs to secure support and funding so they have the necessary resources to support effective short and long term axis deer management (Maui Axis Deer Working Group, 2012a: 1).

The Maui Axis Deer Working Group is now working on several initiatives that will allow them to complete their goals and objectives. In September of 2013, they conducted a series of aerial surveys to gain an understanding of axis deer population numbers. Three crew members and one pilot flew 17 hours over a course of eight flights. Approximately 125,000 acres were surveyed and 237 groups of deer were spotted with 3,429 individuals counted (Sproat, 2014: 3). The program DISTANCE was used to estimate population densities based on the data, resulting in a density estimate of 0.06 deer/acre (95% confidence intervals = 0.04 - 0.088 deer/acre), and an abundance estimation of 7,500 deer (range = 5,000 - 11,000) (Sproat, 2014: 3). Prior to this introductory study, no real population survey had been conducted for Maui, which makes trying to manage a population very difficult, and rough estimates were anywhere between 12,000 and 60,000 (Anonymous #14, personal communication, January 13, 2014). It is important to note that this aerial population estimate is only for the 125,000 acres of eastern Maui lands. Sproat notes that the next steps necessary for defining the population size involve capturing, collaring, and monitoring the deer population (Sproat, 2014: 3).

The MADWG is also working on a public survey that will be mailed to random Maui residents in an effort to identify Management Focus Areas. The MADWG will use information from their survey to assess public knowledge and attitudes towards deer management. They will also meet with stakeholders and state biologists to help clarify management goals and objectives for different areas of Maui (Sproat, 2014: 3). Other initiatives of the Maui Axis Deer Working Group involve increasing its ability to serve as a portal for public information. One of their most current efforts is a website that they are

preparing. This website will have information regarding axis deer and management options. As one MADWG member states, “there is a lot of misinformation out there”; this website is meant educate the public about the history of the axis deer problem and the impacts these deer have had on the state and county (Anonymous #13, personal communication, February 3, 2014). The MADWG also wants to organize and host a fencing workshop for local agricultural producers (Sproat, 2014: 3).

The management strategies planned by the Maui Axis Deer Working Group must keep axis deer at low enough densities for sufficiently long enough for the recruitment rates of native species to exceed their mortality rates. Effective recovery of forest ecosystems, in terms of native species recovering, is dependent on deer numbers being brought down and the extent of recovery depends on vegetation type and the extent of degradation. However, there are still a variety of reasons why recovery may not occur even if deer numbers decrease; sometimes ecosystems are too severely damaged to fully recover (Coomes, Mark and Bee, 2006: 345-346). While the best opportunity for recovery arises from total eradication, where one-off operations are not achievable or wanted, the only effective alternative is to manage axis deer on a sustained-control basis. By definition, control means that some invasive organisms exist, but this is by far the most common strategy employed across the world in terms of invasive species management (Coomes, Mark and Bee, 2006: 342).

Because ungulates impede the progress of conservation and the restoration of native Hawaiian ecosystems, axis deer removal, in conjunction with other management actions, is necessary to ensure the success of ecosystem restoration and preservation of

native Hawaiian ecosystems. Hawaii's management of axis deer needs to find the right balance between social and ecological efficiency in order to preserve the natural and cultural aspects of Hawaii's rich heritage (Reeser and Harry, 2005: 1). Although there are species that continue to decline due to axis deer-related problems, some species are slowly recovering as a result of habitat protection and management efforts. Continuing progress towards recovery will require the application of sound science to resource management and policy decisions (Reeser and Harry, 2005: 1).

1.2 Objectives of this Study

The purpose of this study is to aid the Maui Axis Deer Working Group in understanding Maui residents' attitudes towards and preferences about axis deer population control methods. In addition to the common management tools discussed in the literature, including fencing, contraceptives, and lethal methods, this study also focuses on the idea of a commercialized axis deer hunt. In order to truly capture residents' preferences about this method, a substantial part of this work concentrated on understanding the market demand for a venison industry. This study aims to utilize results from business, hunter, and the general public surveys to help recommend management policy that are ecologically, socially, and economically efficient.

This study contributes to existing literature in many ways. This study is the first comprehensive detailing of efforts towards commercialized axis deer harvests in both Maui and Molokai. Additionally, this study's conclusions regarding the preferred control methods for Maui, including fencing, recreational hunting, and commercialized

harvesting, have been considered some of the best control methods by wildlife management professionals, but this study is the first to document these preferences using public survey data. Finally, the survey results from this study also confirm the presumed ample interest and market demand for products that would be available from a commercialized harvest in Maui.

Chapter 2

CONTROLLING AXIS DEER POPULATIONS

2.1 A Background on Population Management

Various forms of population control are used by wildlife managers across the world to manage populations of animals for both health and size. Wild ungulates are known to impact vegetation in terms of both agricultural and forest damage, so managers seek to reduce these impacts by culling to decrease population densities in certain areas (Reimoser and Putman, 2011: 144). Additionally, as populations of wildlife ungulates increase in a given area, the perception of more human-ungulate conflicts often also increases. In many countries, society believes that managers should control ungulate populations through hunting to meet specific management objectives, which usually include trying to minimize these negative impacts caused by ungulate overpopulation (Morellet, Klein and Solberg, 2011: 106-107).

Usually harvest management involves setting quotas (Morellet, Klein and Solberg, 2011: 107). Different countries have different hunting rules for different species based on the management objectives they hope to meet. Many countries utilize seasons for game hunting; however, there is great diversity in the length and time of year of the seasons. These seasons are often for welfare purposes (to avoid the orphaning of dependent juveniles), or to restrict the harvesting of species with low population numbers

(Putman, 2011: 55-57). Seasons can range from being very restrictive (to limit the number of animals hunted), to being very liberal (to promote high hunting rates) (State of Hawaii Department of Land and Natural Resources, 2003a: 37).

National and local constraints are main factors contributing to the difficulties in delivering effective ungulate management. There are usually legislative and administrative controls that regulate hunting (Kenward and Putman, 2011: 378). For example, in Europe, game does not belong to the landowner; it either belongs to everyone or no one, depending on the country (Putman, 2011: 57). In the United States, living wildlife is owned by no one, but is held in trust by the state or federal government (Mathews, 1986: 460). Cultural attitudes may also influence the effectiveness of management in terms of impacting the number of hunters in a country, as well as impacting the acceptability of hunting to the general public (Kenward and Putman, 2011: 378).

2.2 Controlling Ungulate Populations

Hunting is by far the most common ungulate control method used around the world. Many studies have focused on determining the efficiency of hunting to control overabundant white-tailed deer in the United States, where hunting has been the primary deer management tool for decades. Regulated hunting has proven effective in rural areas, but usual logistical constraints placed on hunting in residential and urban areas can cause deer to become overabundant and incompatible with other societal interests (Williams, DeNicola and Almendinger, 2013: 137). Lethal management programs are implemented

throughout the U.S. to keep deer densities below 10 deer/km² in order to limit the number of deer-vehicle collisions, tick-associated diseases, and damage to vegetation. One study presents data from three controlled hunting programs in New Jersey and one in Pennsylvania to determine the efficacy of only regulated, recreational hunting as a means to control white-tailed deer populations in suburban areas. They estimated initial population densities in study areas to be approximately 30-80 deer/km² (where some areas were already previously subjected to regulated unorganized hunting). After 3 to 10 years of traditional hunting, along with organized hunting and liberalized regulations, population densities were estimated again, this time ranging from 17-18 deer/km² (Williams, DeNicola and Almendinger, 2013: 137). This study demonstrates that reductions in local deer densities can be achieved using regulated hunting, but the sole use of existing regulated hunting techniques in suburban areas appears insufficient to maintain deer densities of less than 17 deer/km², let alone ideal densities of below 10 deer/km². The authors recommend additional measures to reduce populations, such as sharpshooting or other strategic adjustments to regulations and policies, if long-term deer-management objectives are below 17 deer/km² (Williams, DeNicola and Almendinger, 2013: 137).

Antlerless deer harvests by sport hunters have been proposed as a potential solution to overabundance because the philopatric behavior of female deer is expected to limit the recolonization of hunted areas; however, the efficacy of this method has rarely been tested in the wild. One study sought to use a large-scale experimental design to test this method within five 20km² areas on Anticosti Island, Quebec, Canada. The objective

was to harvest 50% of antlerless deer in each site during the first year of the study in 2002, and 30% from 2003 to 2006. The authors monitored deer density, vegetation abundance, and growth, as well as deer life-history traits during 6 years in these experimental sites and in five control sites where the harvest rate was 5-7% (Simard, Dussault and Huot, 2013: 254). It was hypothesized that, because of the philopatric behavior of white-tailed deer females, increasing antlerless deer harvest during 5 years would generate low-density areas where understory forb abundance, forest regeneration, and deer body condition would increase compared with control sites with a standard hunting pressure (Simard, Dussault and Huot, 2013: 264).

Overall, 93% of harvest objectives were achieved; based on aerial survey estimates, hunters successfully harvested about 50% of antlerless deer in experimental sites in year 1 and 25% thereafter (years 2-5), which was close to the original objectives of 50% and 30%, respectively. However, despite the harvest efforts, the results showed no evidence that hunting reduced deer densities enough to favor habitat regeneration. Relative deer density varied stochastically among years and synchronously in experimental and control sites. Vegetation abundance and growth, as well as forest regeneration, also varied stochastically, but synchronously, over time at all sites (Simard, Dussault and Huot, 2013: 266). These results indicate that an antlerless harvest may need additional measures in order to truly impact population densities of white-tailed deer and to allow for vegetation regeneration in an area severely compromised by white-tailed deer.

In an attempt to catalog the most efficient control methods for suburban white-tailed deer, another study surveyed 41 state deer biologists to investigate what agencies are doing to control urban deer, which management techniques have been used in the past and are currently being used, and which techniques are believed to be most effective (Urbanek, Allen and Nielsen, 2011: 310). Results showed that urban and suburban deer population were increasing in 75.8% of states, and 97% of biologists believed that these deer were a problem in their state. The most utilized methods during the past 5 years were: archery hunts (85% of states), sharpshooting (68%), and managed firearm hunts (59%). Most biologists (88%) indicated that urban and suburban deer management in their state was overall effective. Furthermore, 91% of biologists listed deer-vehicle accidents and damage to gardens as primary reasons for managing urban deer populations. Public constituents generally agree on the primary reasons to manage deer, but their preferences regarding management options greatly vary. The authors recommend that state agencies survey constituents regarding their beliefs and concerns about deer management beyond questions that simply address the acceptability of management techniques (Urbanek, Allen and Nielsen, 2011: 310).

Similar studies have been conducted on the efficacy of hunting invasive ungulate species, as well. One study evaluated management objectives and actions to control populations of exotic axis deer and fallow deer at Point Reyes National Seashore, a protected area in California. The authors used records of numbers of each species culled from 1968 to 1996, as well as demographic data, to model each population's potential response to management actions and to the cessation of control in 1996. Model

simulations indicated that control measures hold numbers of both fallow deer and axis deer populations below their ecological carrying capacities and that both populations would reach their carrying capacities within 5 and 13 years of ceasing control, respectively (Gogan, Barrett and Shook, 2001: 1075). The authors also modeled variations of population control efforts (including only removing males and only removing females), and it was concluded that elimination of the axis deer population was feasible and a more cost-effective management alternative than continued, managed control. For fallow deer, elimination is potentially more difficult, but may still be more cost-effective than continuing control actions indefinitely (Gogan, Barrett and Shook, 2001: 1075).

A decision to maintain an ungulate population at any level below its carrying capacity requires a commitment to management actions indefinitely into the future. This model of exotic deer populations underscores the rapidity at which populations may respond to relaxation of control efforts. A full appreciation of the long-term work effort necessary to maintain ungulate numbers at a level below carrying capacity, and the threat of the possible doubling of the work effort within a decade, may lead to the selection of an alternate management goal, perhaps eradication, as the authors recommend (Gogan, Barrett and Shook, 2001: 1085).

On the other side of the spectrum from lethal control methods are non-lethal methods, such as contraceptives. Controlling population growth using fertility control has been considered for almost four decades, but nearly all research has focused on understanding effects of fertility control agents on individual animals. One study seeking

to answer questions about the efficacy of fertility control as a way to control populations of species determined that there are collateral consequences of contraception, including the fact that using fertility control can produce unexpected changes in birth rates, survival, immigration and emigration that may reduce the effectiveness of regulating animal abundance. The magnitude and frequency of such effects vary by species and are influenced by differences in social and reproductive systems, as well as connectivity of populations. In fact, some studies have shown that changes in survival and immigration due to the use of fertility control can actually wind up compensating for the reduction in births caused by contraception (Ransom, Powers and Hobbs, 2014: 259).

Fertility control can also result in artificial selection pressures on the population, possibly leading to long-term unintentional genetic consequences. The magnitude of this artificial selection is dependent on individual heritability, behavioral traits, and environmental variation (Ransom, Powers and Hobbs, 2014: 259). In order to determine the possibility of effectively controlling populations using fertility control, it is important to understand the species' life-history strategies, biology, behavioral ecology and ecological context. It has been found that the most successful cases of regulating populations using fertility control come from applications of contraceptives to small, closed populations of gregarious and easily accessed species (Ransom, Powers and Hobbs, 2014: 259).

Fertility control is especially being considered for invasive pest species, as an ethical and humane method of control. New Zealand has been experimenting with contraceptives, combined with conventional methods, to provide a long-term and cost-

effective solution to the possum problem. Stoats, with their short life span and high potential reproductive rate, are also an excellent candidate for fertility control in New Zealand (Duckworth, Byrom and Fisher, 2006: 423). New biotechnological approaches are being developed for possums and stoats: one method involves immunologically mediated interference with fertility (known as immunocontraception), and the other uses gonadotrophin-releasing hormone-toxin complexes to attack mechanisms in the hormonal control of reproduction. Potential species specificity for fertility control is likely to arise from identifying regions of the target protein which show significant species variation (Duckworth, Byrom and Fisher, 2006: 423).

Other methods being investigated include the use of non-disseminating, non-living vaccines in baits, which are likely going to be used for New Zealand's possums, and self-disseminating biological control vectors, such as those being developed in Australia for the control of wild rabbits and mice. Additionally, a biocontrol agent that spreads by natural transmission from animal to animals causing infertility would be ideal in terms of humaneness and cost-efficiency. This method is being developed for rabbits, mice, and foxes in Australia, but would also be helpful for possums in New Zealand (Duckworth, Byrom and Fisher, 2006: 425). In general, fertility control is favored by those concerned with animal welfare because it allows existing animals to live out their lives (Duckworth, Byrom and Fisher, 2006: 429).

Various population control methods have been proposed to decrease ungulate populations, but each comes with a set of positive and negative aspects. Non-lethal population control methods, like contraceptives and trap-and-transfer, are favored by

those not wishing to harm deer, but these methods are not immediately effective and are far less cost efficient lethal methods (Malcom, Van Deelen and Kesler, 2010: 263). As a result, non-lethal methods are not consistently used by government agencies. Sharp-shooting, a very effective method of culling populations, can also get very expensive for municipalities, so it may not be a viable option in many circumstances (Malcom, Van Deelen and Kesler, 2010: 263).

2.3 Wildlife Management on the Hawaiian Islands

Public acceptance is critical to the success of restoration and preservation plans on public lands in Hawaii. While experience indicates that fences may be the cheapest way to achieve ungulate control goals, the public often criticizes this method regarding its economic practicality; there are high costs associated with the construction, installation, and sustained maintenance of fencing (Reeser and Harry, 2005: 2). Part of this argument is based on the fact that some observe that 100% ungulate removal is not the only way to improve conservation resources in certain degraded ecological systems—the goal and degree of restoration needs to be considered. Complete ungulate removal is required if the goal is to reestablish the structure and composition landscape back to pre-disturbance conditions, however, anecdotal observation suggests that in severely degraded ecosystems, the removal of the majority of ungulates may lead to a partial recovery (Reeser and Harry, 2005: 2).

There is also public opposition to control strategies that are considered inhumane. People may prefer trap-and-transfer or sterilization over the trapping and shooting of

ungulates, even though the former are much more expensive and labor intensive, because they are deemed humane options. Often times, these humane methods fail to remove a significantly greater percent of the population than can be replenished by reproduction—a necessity when trying to restore the natural ecosystem (Reeser and Harry, 2005: 2). Some of these “humane” techniques could also be regarded as sustained animal harassment. Currently there are no management techniques that are widely regarded as humane, but are also effective in controlling populations. Some people take the extreme that it is unethical to harm any animal, and thus preservation of the native Hawaiian ecosystem must be achieved in a way that does not harm ungulates. Under this view, it is likely that the rarest plants and animals would be lost to ungulates. As a result, Hawaiian wildlife managers must understand the costs and benefits of ungulate control and be willing to remove some ungulates from the land in order to protect the rare biological diversity of Hawaii (Reeser and Harry, 2005: 2).

Some have also attacked ungulate removal techniques as being wasteful, mainly in terms of how wildlife managers will leave animal carcasses behind when they are killed at remote sites. Previous experience finds that attempts to remove ungulate carcasses via helicopter is extremely economically inefficient. Additionally, the field handling and removal of carcasses does not meet the USDA requirements for handling meat, so the carcasses can not be processed for public consumption. Instead, wildlife managers have concluded that it is the most cost-efficient method to leave the carcasses for nutrient recycling back into the ecosystem (Reeser and Harry, 2005: 3).

The hunting community is known for being the most resistant to ungulate population control because they claim a traditional right to hunts and they perceive the elimination of ungulates from Hawaiian forests as a threat to Hawaiian culture. However, goats, sheep, deer, European boar, and cattle were all colonial introductions onto the island, revealing that the hunting of ungulates was never a part of Hawaiian cultural tradition (Reeser and Harry, 2005: 3). Instead, the loss of native species would be an immeasurable loss to the heritage of Hawaiian people. Historical evidence finds that the gathering of native plants for wood and medicinal purposes, as well as the gathering of native bird feathers to make capes for Hawaiian royalty is a large part of Hawaiian cultural tradition. In fact, ancient Hawaiians used to fence in areas to protect their valuable natural resources (Reeser and Harry, 2005: 3).

The control of ungulates is necessary to preserve Hawaiian ecosystems, thus preserving the richness of Hawaii's heritage. Although there is still much to be learned about removing axis deer populations, many wildlife managers have been investigating the best management methods; some suggest using high fences and making sure they are mended, others suggest one-way gates and traps. For those that favor lethal methods, some managers suggest public and volunteer shooters to make initial population reductions, assuming the sites are not remote, and then sending in professional shooters with dogs and night spot lighting to kill the remaining populations (Reeser and Harry, 2005: 6). Aerial shooting with helicopters is also recommended. Finally, some managers suggested testing a "Judas" deer method; this method is known to be effective with goats, although no studies have been conducted for axis deer (Reeser and Harry, 2005: 6).

2.4 Maui Axis Deer Population Control

2.4.1 Attitudes Towards Axis Deer Control in Maui

For over a decade, Maui has been experimenting with their own preferred population control techniques. The Maui Axis Deer Working Group leads the efforts on the island and is driven by economic, environmental, health, and safety concerns. However, it was the concerns of the community that kick-started the MADWG into population control action; “what really got it going this most recent time was public outcry or public inquiry because people were seeing deer so much more frequently...starting to feel the impact of deer on their lives” (Anonymous #1, personal communication, January 15, 2014). This relationship between the MADWG and local communities is still a major factor in determining and working towards population objectives.

Due to the fact that axis deer are so cryptic and elusive, in addition to their high reproductive rates, it is generally accepted that eradication is impossible (Anonymous #13, personal communication, February 3, 2014; Anonymous #14, personal communication, January 13, 2014). However, it does not seem like eradication would be preferred anyway, because “people are interested in having axis deer available as a food source or as a game species” (Anonymous #6, personal communication, January 15, 2014). That said, there is a general consensus, supported by the Maui Axis Deer Working Group, that some level of management has to occur.

One conservationist discusses how all of Maui's interests must be accounted for when dealing with management strategies:

On Maui, there are various interests as far as the deer are concerned; so there is definitely a conservation concern from disrupting soils and browsing native plants to facilitating the spread of invasive species to system disturbance, there are definitely public safety concerns from car collisions as well as the potential for the spread of diseases through deer feces. There are certainly agricultural concerns from browsing crops and contaminating crops, again from deer feces. But there is also interest in deer as a food source and as a game species. (Anonymous #6, personal communication, January 15, 2014)

There is “no clear and obvious objective that everyone supports”, because there are multiple partners involved in deer management and everyone has different ideas (Anonymous #11, personal communication, January 23, 2014). There are some conservation areas on the island where there is zero tolerance and “any deer is too many” (Anonymous #5, personal communication, January 24, 2014). However, there are also highly degraded areas that are highly unlikely to be restored to native ecosystems. These areas can support more deer, but conservationists still do not want to see erosion damage or vegetation damage from grazing; “I would like to see them at a level where they are not a severe hazard to any particular species, but also where they do not greatly affect the biodiversity” (Anonymous #5, personal communication, January 24, 2014).

In general, the Maui Axis Deer Working Group seeks to support management that protects the environment, limits the agricultural impacts of deer, and minimize threats to public safety, such as collisions with deer on the road (Anonymous #6, personal communication, January 15, 2014). It is important to remember, that Maui is an island ecosystem:

A big point of consideration is that this is not like managing deer overpopulation on the mainland where it's a native species in a largely native continental ecosystem, this is an introduced species in an area that is not evolved for ungulate browsing or grazing pressures at all; that's a really big difference in terms of the impacts that [axis deer] have on the landscape. (Anonymous #5, personal communication, January 24, 2014)

While eradication is not the management objective of the Maui Axis Deer Working Group, it still needs to control populations. Currently, populations are said to be “beyond and acceptable level”, where even though people generally support having deer, the impacts are getting to be too much, “the system is clearly out of balance” (Anonymous #1, personal communication, January 15, 2014). Now, the intent is to bring deer populations back down to a more manageable level using “an informed, science-based decision, coupled with a community-driven of acceptability” (Anonymous #1, personal communication, January 15, 2014).

Different communities will dictate the level of acceptability given their various interests, ranging from hunting to farming; some communities do not currently have deer so they seek to remain deer-free (Anonymous #1, personal communication, January 15, 2014). As a result, different communities will have different objectives in terms of deer populations and will prefer different deer control methods (Anonymous #14, personal communication, January 13, 2014). Part of what the Maui Axis Deer Working Group is working on is trying to help communities determine their population objectives; “the intent of the [MADWG] group is to help individuals and communities accomplish what they want to do” (Anonymous #1, personal communication, January 15, 2014). The Maui Axis Deer Working Group is unique in its effort to have a community-driven approach to management and their first step is to find out how the public feels and base their

management strategies off that (Anonymous #7, personal communication, January 16, 2014). They offer this community participation because they feel that, historically, “it can be perceived that government just comes into a community with a prescribed plan” and they realize management impacts everyone on the island (Anonymous #1, personal communication, January 15, 2014). The MADWG notes that while “they have experts, they want to include communities in the management of the population” (Anonymous #7, personal communication, January 16, 2014).

2.4.2 Maui Axis Deer Population Control Methods

Throughout the island of Maui, individuals, conservationists, resort owners, farmers, ranchers, and hunters are all engaging in axis deer population control. Although the Maui Axis Deer Working Group has not performed any feasibility studies on the various control methods, they are considering a range of options, including hunting, aerial control, and sterilization (Anonymous #7, personal communication, January 16, 2014).

Some believe that lethal control is the only effective option; “traditional lethal control is what it will boil down to...I don’t see any other options really being realistic” (Anonymous #1, personal communication, January 15, 2014). There are a range of lethal options that can be used to in different circumstances and for different control goals. The most basic is Maui’s licensed recreational hunting, where hunters may take any number of deer they find while on public hunting areas, regardless of the sex of the deer (State of Hawaii Department of Land and Natural Resources, 2003a: 37). The problem, however,

is that, due to the relative small amount of public land on Maui, most deer are located on private land. As a result, there are calls for private landowners, mostly farmers and ranchers with large tracts of land, to open up their land to these licensed hunters as a way to make more axis deer accessible to hunters (Anonymous #8, personal communication, January 30, 2014). However, this is not always embraced by landowners because of the potential liability issues (Anonymous #14, personal communication, January 13, 2014). Some believe that an increase in available hunting lands would also encourage people to hunt; it has been found that the number of gun club members on Maui has become static and it is believed that more hunters are needed to control the deer because there are currently not enough recreational hunters to impact population numbers (Anonymous #9, personal communication, February 7, 2014). Private landowners would benefit from the deer removal and recreational hunters would have no weapons or bag limits; the only limitation is that they must have a hunting license and they must hunt within the legal hunting hours (Anonymous #12, personal communication, February 4, 2014).

The State also offers help to landowners who want to seriously control the deer populations on their land. The Department of Land and Natural Resources can issue Wildlife Control Permits, which allow any individual who can show property damage from axis deer (though often utilized by farmers and ranchers) the right to harvest axis deer at night. This is unique because a normal hunting license restricts hunting hours, but a Wildlife Control Permit allows for hunting beyond the normal legal hunting hours. Night hunting is often extremely successful, allowing landowners to remove more deer from their property at a time (Anonymous #12, personal communication, February 4,

2014). Maui County also offers the services of National Rifle Association advanced-trained sharpshooters to landowners who need help with deer removal. This team of sharpshooters belongs to the Maui Axis Deer Harvesting Co-op, a group funded by the Maui County Office of Economic Development working on the commercialized harvest effort (discussed below). While the sharpshooters are waiting for advancements on the commercialized harvest, their skills have been put to use by the County for private land deer control. So far, these sharpshooters have hunted approximately 500 deer and, although the meat is not USDA certified and cannot be used for public consumption, the shooters take the meat for themselves or friends so there is no waste (Anonymous #8, personal communication, January 30, 2014).

Aerial control is strongly being considered as a control option because it allows for extensive axis deer removal from remote areas and it is very effective. A main challenge with this method, however, is the expense; it costs approximately \$1,000/hour to rent a helicopter, plus the costs of two controllers (the shooters) and a pilot. Another issue is that, in order to use the helicopter, the County must have some kind of federal or state affiliation (Anonymous #1, personal communication, January 15, 2014).

Non-lethal methods are also being considered—especially fencing, which is currently used all over the island. Fencing is noted to be one of the most effective management options and is especially great for conservation areas (Anonymous #5, personal communication, January 24, 2014). Many managers recommend 8 foot high fences, but believe that 10 foot fences are preferable because axis deer are known for their impressive jumping abilities (Anonymous #12, personal communication, February

4, 2014). However, while fencing is very effective, it can get expensive, especially for farmers who sometimes cannot afford it (Anonymous #12, personal communication, February 4, 2014). Estimates for 8 foot deer fencing range from \$23 to \$30 per foot, which is only for the construction and does not include material costs (J. Atwood, personal communication, January 17, 2014).

Contraceptives have been brought up in control conversations, but it is known for being a very expensive option (Anonymous #14, personal communication, January 13, 2014). Some do not believe it is a feasible option for a place like Maui; there are too many deer over a tough landscape, so contraceptives would not be effective on an island-wide scale (Anonymous #11, personal communication, January 23, 2014). As a result, it is considered an option, but it is “low on the possibility list” (Anonymous #1, personal communication, January 15, 2014). A veterinarian at the Hawaii Department of Agriculture describes the three methods that contraceptives could be administered: injecting directly hands-on, injecting through a ballistic bullet, or administering through the feed using baiting (Anonymous #10, personal communication, January 28, 2014). He notes that:

With baiting, there are environmental issues because other animals could be exposed to it. The problems with hands-on administration of it are mostly the costs; you have to handle every single animal. Ballistic administration with a bio-bullet is more feasible than direct handling, but you’d still have to shoot a significant number of the animals in order for it to be effective. (Anonymous #10, personal communication, January 28, 2014)

The veterinarian adds, “I don’t see that kind of control working” (Anonymous #10, personal communication, January 28, 2014). Trap-and-transfer is another non-lethal

option, but it may not be feasible with axis deer. Although the method works well with goats, axis deer are notoriously hard to capture and if they are held trapped for too long, they are known to panic and can hurt themselves. The objective of all considered methods is to be humane as possible, so this method may not work if the deer have to be transported a far distance. Additionally, trap-and-transfer does not actually decrease the number of total deer; it just moves the deer to a different, more suitable, location (Anonymous #11, personal communication, January 23, 2014).

Some of these control methods can be used in conjunction with one another to increase their efficacy. For example, trap-and-transferring could potentially be used to remove deer from residential locations, private lands, or rough terrain, and to transport the deer to an area that is hunter-friendly (Anonymous #1, personal communication, January 15, 2014; Anonymous #14, personal communication, January 13, 2014). Fencing plus a lethal management tool is also known to be a good option for conservation areas (Anonymous #5, personal communication, January 24, 2014). For areas where the State wants to eliminate deer, they will start with fencing the area, then go inside and shoot the deer within the enclosure, which is extremely effective (Anonymous #11, personal communication, January 23, 2014).

Private businesses have their own sets of preferred axis deer removal methods. The manager of a resort and community association notes that he uses different control strategies in different areas. There are several golf courses in the area he manages and he notes that for the courses that border ranchland, and are far from housing, his association hires Maui police officers to act as sharpshooters to hunters a few times a week. The

sharpshooters can usually only hunt one or two deer a night before they start to scatter, but sometimes the shooters will come out twice a night (often once at 10pm and then again at 4am) to try again. The carcasses are either taken home by the police officers for their meat or are disposed of; they cannot be donated because of processing challenges and health department issues. Although these hunters can hardly make a dent in the herds, the hunters do scare the deer off for a period of time before they start returning to the greens (Anonymous #3, personal communication, January 29, 2014). The manager notes that for golf courses closer to homes, there used to be hunting, but residents were concerned about hunting too close to homes, especially because the accompanying poachers would come in after the hired hunters and they were “a little freer with their shots” (Anonymous #3, personal communication, January 29, 2014). As a result, hunting is not permitted on those courses anymore.

One golf course constructed a 5 mile long deer fence, but this was very expensive. The manager is also looking into how to protect farmers from deer damage and he notes there is no way a farmer could afford fences around their property. He is, however, looking into the option of electric hog fences, which are less expensive and he hopes that hotels would be willing to help test electric fences and then maybe golf courses and farms would be interested if they fences prove to be effective (Anonymous #3, personal communication, January 29, 2014). These electric fences consist of three wires that sit at 18, 36, and 54 inches from the ground, and another wire strikes through and it offset from the three horizontal lines of wiring. Costs are estimated to be approximately \$3,000 per acre and can be hooked up to solar-charge batteries. A solar company has already offered

to donate a solar panel for the first test in the community area. Assuming this option is effective, it would be great for small farmers because of the low cost (Anonymous #3, personal communication, January 29, 2014).

The manager briefly discussed how the hotels and communities in his management area deal with keeping deer off of their property, although he mentioned that deer problems are far less frequent at the hotels because of the number of people around. He notes that patrols are out around the clock every day of the week and they keep an eye out for deer gathering, but “there is not much they can do about [the deer] because [they are] around all the homes...can’t go shooting them or shooing them; if we try to shoo them they’d go out into the road which is dangerous, so we have to be careful” (Anonymous #3, personal communication, January 29, 2014).

A large farming operation located on Maui utilizes a combination of several methods to ensure that their land is protected from deer damages. A representative that, “for years, farmers have been fearing this axis deer population explosion” (Anonymous #4, personal communication, February 5, 2014). The farm’s first line of defense is keeping the deer off of the property. They do this by keeping people on site because axis deer do not want to be around humans, so they will stay away if somebody is walking around and watching the boundaries of the farm. The farm also utilizes 8 foot tall, woven wired livestock fencing with electric wires along the top. If axis deer make it onto the property, the farm’s “second layer of defense is [their] U.S. Department of Agriculture contract. They come in with their wildlife experts and they actually capture these animals if they make it onto the farm and they take them off the property. That’s a lot of

additional costs...which doesn't even account for crop damage!" (Anonymous #4, personal communication, February 5, 2014)

The representative notes that the large farming company, in general, has a no weapons policy due to the high numbers of employees that are always around; they strive for the safest work environment possible. However, in areas with very high population densities, the company does allow the USDA to use lethal population control methods. Even though there are employees and other non-government contract eradicators (like hobby hunters) who would be willing to come onto the property to dispatch animals, the farm prefers to pay wildlife experts to help manage the deer, even if it costs a lot more (Anonymous #4, personal communication, February 5, 2014). The methods seem to be working because the representative notes that the company has no crop damage or costs due to their preemptive approach to deer management; although the preemptive management does cost money, these upfront costs are less than dealing with damage that could occur (Anonymous #4, personal communication, February 5, 2014).

Even though this farming operation has somewhat "solved" their deer problems, they still understand need to stay engaged because they view farming as a community, and they believe everyone needs to work together to address the problem because deer don't respect property lines. The representative states that all Maui farmers and ranchers need to be involved to be successful against deer. It is for this reason that they work with neighboring ranches and sugar cane farmers to monitor and control populations. They strongly believe in collaboration and the need to look out for each other (Anonymous #4, personal communication, February 5, 2014).

A Maui rancher also shared opinions about deer management on his cattle ranch. He described that in some area, fencing is used. He notes that on his ranch, they use 6 foot tight-locked game fence because his personal view is that the extra cost for the 8 foot fence is not worth it; “there aren’t too many deer that will challenge a 6 foot fence” (Anonymous #13, personal communication, February 3, 2014). He says that he only uses tight-locked fences because usual hog wire fences will not stop axis deer. Tight-locked means the vertical and horizontal wires are woven together and you cannot splay them apart. He notes that deer will always first try to go through a fence before they go over it. Even with standard-size 42 inch hog wire, axis deer “just keep banging on it and get their head and then shoulder through until they can get their bodies through. Sometimes they won’t make through, it’s a horrible thing to watch”. He prefers the tight-lock because the deer will try to hit it once, realize they have not made a dent, and then will try to go over it (Anonymous #13, personal communication, February 3, 2014). When asked about electric fencing, he mentioned he doesn’t think electric fences would hold deer because electric fences only work with docile and well-managed animals. He was very suspicious of using “hot wires” to contain deer, because “deer have no problem going through them, they run so fast if they’re spooked...they’re going to run right through it” (Anonymous #13, personal communication, February 3, 2014).

The rancher also uses lethal control including internal control programs and a highly incentivized hunting program, culling programs sanctioned by the state that involve night hunting with lights, and he is working on other means for high volume control, like considering sharp shooting (Anonymous #13, personal communication,

February 3, 2014). His internal hunting program is open to shareholders of the ranch, employees of the ranch, and their guests, and between 80 and 100 people take advantage of this program. There are no bag limits and participants need to sign up to hunt on some areas of the ranch and other areas do not require a sign-up. The ranch is also currently in the pilot state of using a bounty program to incentivize hunting. The rancher notes that he collected data to compare harvest numbers between the bounty program and normal recreational hunting program; while he is still analyzing data, the trend is showing greater participation and more kills in the bounty program (Anonymous #13, personal communication, February 3, 2014). A final hunting program that has been in effect on the ranch over the past few years is hunting using the ranch's Wildlife Control Permit. This program utilizes the same core group of hunters as the other programs, but allows for harvest at night with the use of lights. Night hunting almost always increases hunters' number of kills and this program has been very successful in the past few years. All of these hunting programs are internally funded by the ranch (Anonymous #13, personal communication, February 3, 2014).

The State of Hawaii also utilizes its own preferred methods of axis deer removal on Maui. As mentioned previously, when the State identifies an area as needing to be free of deer, they will first put up a fence to "make sure once the deer are out, they stay out" and this ensures that control does not need to be continuous (Anonymous #11, personal communication, January 23, 2014). Then the State will encourage recreational hunters to hunt in that area to remove deer; their preference is always to use public hunting wherever possible. However, their worst-case-scenario method to take out remaining deer

is to drive deer into an area where it is easy for hired sharpshooters to dispatch them. Although they prefer not to use the contract hunters, they will if absolutely necessary (Anonymous #11, personal communication, January 23, 2014). The State is also “experimenting with and willing to try ways for driving deer out of areas, ways that are non-lethal”. But it is noted that this can be tricky with axis deer because they do not herd easily and they spook easily and can harm themselves, so wildlife managers have to be careful (Anonymous #11, personal communication, January 23, 2014).

The best management practices for Maui will likely involve a combination of these control methods. As one rancher states, “I don’t think there’s a silver bullet for dropping the [population] numbers drastically anytime soon, but at least what I think that we’re doing is identifying the particular problems on a regional basis and learning how to address those specific concerns of the various communities” (Anonymous #13, personal communication, February 3, 2014). The current Maui Axis Deer Working Group public survey will aid in understanding the types of deer management that communities want to see; the survey is essentially seeking to pinpoint, “What would [citizens] be comfortable with allowing [the MADWG] to do?” (Anonymous #8, personal communication, January 30, 2014). The best control methods will need to be ecologically, socially, and economically effective, but they must also address the “public perception issues”, because, as one community member notes, “they look like Bambi, they have the little white spots” (Anonymous #3, personal communication, January 29, 2014).

Humaneness will likely be a large factor because axis deer are large mammals; when it comes to invasive species control, “conversations [about controlling axis deer]

are very different because it's a living animal...if this were a miconia plant (a highly invasive plant) there would be no question—everyone would want to see it eradicated” (Anonymous #4, personal communication, February 5, 2014). Although some have ethical issues with harming deer, they have to keep in mind that the decreasing of population numbers is necessary for ecosystem restoration:

When looking at it in terms of population biology, you have to remove a certain percentage of animals in order for control to be effective...Regardless of the means you're using for control, you need to make sure that you're removing a number of them that exceeds their reproduction to get to your targets. If you're not, you're not going to make a dent in their populations. (Anonymous #11, personal communication, January 23, 2014)

Chapter 3

COMMERCIALIZED HARVESTS

3.1 Commercialized Harvest Background

3.1.1 What is a Commercialized Harvest?

While the aforementioned control methods have generally been the most commonly accepted management techniques for overabundant or invasive species in the United States, Maui has recently begun experimenting with a different form of lethal control, one that is fairly controversial within the U.S.—the implementation of a commercialized axis deer harvest.

In the United States, a commercialized harvest has been brought up in theory most often regarding white-tailed deer along the east coast. In those areas, like in Maui, recreational hunting is the primary method that wildlife agencies use to decrease deer populations. However, with the number of hunters declining across the United States, the potential for recreational hunting alone to control populations is unrealistic (Vercauteren, Anderson and Van Deelen, 2011: 185). In addition to declines in the number of hunters, one study shows that hunters are very reluctant to exceed their personal thresholds of deer that they can process for their own use, despite additional opportunity, such as no bag limits (Holsman and Petchenik, 2006: 179). These two factors may contribute to the fact

that recreational hunting, as a whole, often cannot keep overabundant ungulate populations in balance. However, this past research can also be viewed as reason to believe a commercialized hunt may succeed; perhaps the financial incentives will be strong enough to persuade hunters to harvest over their personal thresholds.

A major challenge of implementing a commercialized harvest anywhere in the United States is the fact that many hunters see a commercialized hunt as a threat to deer populations, and thus do not support it. Hunters have been known to view management decisions that call for lower deer densities to be counter to their interests, even though management may actually result in healthier herds (Giles and Findlay, 2004: 269; Ward, Stedman and Luloff, 2008: 219). Allowing hunters to profit from a commercial harvest provides a financial incentive to hunt, which may entice hunters to harvest enough deer to control populations. However, some hunters may refuse to engage in a system where they are made "population managers". One study in Pennsylvania found that 65% of surveyed hunters did not generally believe that white-tailed deer are causing harm to the ecosystem, or that current white-tailed deer populations are a problem, and thus did not support the Pennsylvania Game Commission's efforts to lower the deer population (Ward, Stedman and Luloff, 2008: 222). While hunters in Maui may have similar sentiments (which will be investigated in the survey portion of this study), the situation with axis deer on Maui is inherently different because axis deer are an invasive species.

As a more drastic change to normal recreational hunting, even with no bag limits and other lax regulation, the commercialized harvest is a promising modification because the opportunity for hunters to sell deer meat may act as an incentive to harvest more than

the hunter usually would use for personal consumption. Despite the theoretical potential a commercialized harvest holds for deer management, it has been met with much controversy from both the government wildlife agency and citizen hunter viewpoints. However, theory and research suggest that hunter willingness to harvest may become saturated regardless of opportunity and hunters may withdraw participation if they perceive management for lower deer densities to be counter to their interests (Giles and Findlay, 2004, 269; Ward Stedman and Luloff, 2008: 219).

Other potential challenges of implementing commercialized harvests are the development of an outlet for wild deer products and development of a regulatory structure that sustainably conveys wild deer from the public trust to private ownership and ultimately to commerce (Vercauteren, Anderson and Van Deelen, 2011: 185). Both of these issues will be discussed in more depth later, but there are solutions to the regulatory structure issue and finding demand within the market should not be a problem; deer are a healthy, natural, green, locally-produced protein. While there will certainly be some challenges associated with a commercialized harvest, including the privatization of wildlife, potential overexploitation, food safety, competition with existing commodities, law enforcement, and the challenges of changing laws, regulations, and attitudes, all of these issues can be addressed. Additionally, there are many benefits to a commercialized harvest, including reduced overabundant populations of deer, a new source of organic protein, the promotion of economic growth and entrepreneurship, and public engagement and appreciation (Vercauteren, Anderson and Van Deelen, 2011: 185). A commercial

harvest should be thought of as just another tool that could be used to help control deer populations (Vercauteren, Anderson and Van Deelen, 2011: 188).

As mentioned previously, a commercialized axis deer harvest will likely be less controversial than one implemented for white-tailed deer because of their invasive status. Commercialized harvests are successfully implemented internationally as a method of pest control for other invasive species. Additionally, studies show that recreational hunting and commercialized harvesting can be utilized together and they are not mutually exclusive—it is dependent on the management goals set for the area. In New Zealand, commercialized harvests for invasive mammals are regulated according to three potential objectives: eradication, regulation at low density, or regulation at high density (Forsyth, 2006: 189). For example, feral goats were purposely eradicated from offshore islands, red deer are regulated at low density using helicopter-based commercial hunting, and helicopter-based commercial hunting has reduced the density of Himalayan tahr in some areas by over 90 %, enabling recreational hunters to subsequently regulate this population at low density (Forsyth, 2006: 189).

Another study investigated the seven taxa of introduced deer in New Zealand, which are officially regarded as pests, but are also considered valuable by hunters and commercial harvesters, who often argue against the need to population control. In response to the hunters' argument that it would be more cost-effective to enhance existing private hunting efforts than to use state-employed cullers to kill deer, the authors combined predator-prey and economic theory to predict how net revenue (carcass value minus cost of harvesting it) for a commercial helicopter-based venison-recovery operation would

vary with deer density. The model was then adapted to simulate the cost of state-funded deer control and the net satisfaction obtained by ground-based recreational hunters (Nugent and Choquenot, 2004: 481). It was found that the payment of incentives to commercial harvesters was usually more cost-effective than state-funded culling and the payment of incentives to recreational hunters were usually not as effective unless time costs could be reduced at little monetary cost. Additionally, ground-based cullers were more effective than helicopter-based hunters at attaining low deer densities in dense forest (Nugent and Choquenot, 2004: 481). This study implies that commercial hunting can be cost-effectively manipulated to enhance control of deer populations, but neither commercial nor recreational hunting is likely to be a cost-effective alternative to state-funded control where very low densities are required in inaccessible areas. Although these models were developed for deer control in New Zealand, they are applicable to any situation in which harvesting is used as a form of population control for native or invasive species (Nugent and Choquenot, 2004: 481).

3.1.2 Conflicts with the North American Model for Wildlife Conservation

Because axis deer are invasive and because populations are so overabundant, there has not been much discussed controversy in Maui about the potential for a commercialized axis deer harvest. However, as this harvest slowly becomes a reality and grows into a larger industry, there will undoubtedly be public outcry about this controversial population control method. In discussions now about a commercialized white-tailed deer harvest, government officials are reluctant to adopt a commercialized

harvest strategy because it appears to conflict with the Wildlife Public Trust Doctrine and the North American Model of Wildlife Conservation and these paradigms and attitudes have been held since the end of market hunting and wildlife exploitation at the turn of the twentieth century. However, many proponents of such a harvest argue that commercialized hunting can be implemented to fit with the principles of these paradigms.

The Wildlife Public Trust Doctrine and the North American Model of Wildlife Conservation are the basis for all of the wildlife management decisions since the mid-1900s (Mathews, 1986: 460). It is important to understand these paradigms and philosophies in order to grasp why a commercialized hunt generates such controversy among government wildlife agencies. Some government officials view a commercialized harvest as a threat to these paradigms, but a commercialized hunt can be utilized while holding true to most aspects of the wildlife Public Trust Doctrine and the North American Model of Wildlife Conservation, while finally shedding the parts of these paradigms that are now outdated.

The Wildlife Public Trust Doctrine is a series of principles that is considered the keystone of the North American Model of Wildlife Conservation and it represents the common law foundation for trust status of wildlife resources in the United States. It states that wildlife that is alive is owned by the state and that, as trustee, the state has no power to transfer trust ownership of live assets to private concerns (Mathews, 1986: 461). Once wildlife is dead, however, ownership can be transferred to an individual. The state also has the duty to fulfill trust responsibilities, for example by using police power, and cannot wait idly while resources are being depleted. Finally, the federal government assumed

trust duties is the jurisdiction includes treaty, federal property, or interstate or international commerce (Mathews, 1986: 461).

Current principles of American wildlife policy are based on four aspects: firm public ownership, equal access for all citizens, the removal of wildlife from the marketplace, and policies must be democratic and treat wildlife as though they have some intrinsic value (Mathews, 1986: 460). It is from these principles that the North American Model of Wildlife Conservation was born. The NAMWC incorporates seven principles regarding how wildlife should be managed. It states that wildlife is a public trust resource and an international resource. It also states that hunting laws are created through the public process and everyone has the opportunity to hunt. However, wildlife should only be killed for a legitimate purpose and there should not be markets for commercial game meat. Finally, sound science is viewed as the proper way to manage wildlife resources (Mathews, 1986: 460).

In the United States, there can be concurrent jurisdiction over resources. Because both federal and state regulations exist today, conflicts are inevitable. Federal actions must be authorized by a constitutional clause; in terms of wildlife, the main clauses are the treaty clause, the property clause, and the commerce clause (Mathews, 1986: 461). Statutes created under the treaty power can control any wildlife species as long as individual rights and liberties are not disregarded. The property clause is also important as it grants the federal government the power to control its own land and allows the federal government to control activities elsewhere that impact federal land (Mathews, 1986: 461). The commerce clause is the most far-reaching and as a result of the clause,

most wildlife species are declared articles of commerce and subject to federal regulation (Mathews, 1986: 461).

States are given the power to regulate wildlife under police power. Under the negative or dormant commerce clause, a state law cannot unnecessarily burden commerce, thus federal legislation on wildlife will preempt interfering state laws (Mathews, 1986: 461). Federal preemption can occur if the intent of Congress is clear in the statute and legislative history, if the federal regulation is so pervasive it does not allow for any state control, if the nature of the subject area requires uniform regulation, and if the state law is an obstacle to accomplishing the full purposes and objectives of Congress. If there is no federal action, states are free to regulate wildlife as long as it does not violate a constitutional prohibition, however, states do not have exclusive jurisdiction over wildlife. State regulations may also be upheld if they make the federally granted right more difficult, but not impossible, to perform (Mathews, 1986: 462).

The status of wildlife changes when an individual captures or kills it; until then, wildlife is considered the common property of all the people. While this was originally meant to be the common property of the people of each state, this belief has changed to view wildlife as the common property of all United States citizens because of wildlife movement across state boundaries. State control over wildlife can be justified by the fact that states may be better able to respond to local management issues because of their better knowledge of the local environment compared to a centralized bureaucracy like the federal government (Mathews, 1986: 463).

It is easy to see that government officials find a commercialized harvest as messy and controversial-- it contradicts some fundamental paradigms that wildlife agencies have been working with for over fifty years. It is also a legally complex situation, which leads to reluctance from officials. That said, a commercialized hunt could still be legal and support many of the principles of the NAMWC. Legally, a commercialized deer harvest would fall under federal jurisdiction as the meat would be an article of commerce. However, states would have to manage their own populations to keep the harvests sustainable and biologically viable.

The NAMWC prevents game meat from being sold in a marketplace, however this is not law, merely a model we currently use. Furthermore, a commercialized harvest matches many of the NAMWC principles, including using sound science for management and hunting for a legitimate reason (meat). The United States must evolve past the outdated portions of this paradigm, and update the model to match the biological reality that some species of wildlife are actually negatively impacting the ecosystem and need to be controlled. A commercialized harvest is an option that may cull the number of such wildlife and create a source of healthy, natural, local meat to be sold in grocery stores.

3.2 Current International Examples of Commercialized Harvests

3.2.1 New Zealand

Other countries have been utilizing commercialized hunts to control their introduced pest species for decades. In New Zealand, pest controllers, recreational

hunters, and commercial harvests all share some objectives, but also have different ideas about how animal populations should be managed. Additionally, oftentimes the biology and economics that underpin these varying objectives are not straightforward (Parks, 2006: 408). New Zealand spends at least NZ\$ 40 million per year managing the worst mammalian pests to protect conservation values, and at least another NZ\$ 60 million per year on those that also affect agricultural production. However, management of these pests must take into account the different goals of pest controllers, recreational hunters, and commercial harvesters (Parks, 2006: 409).

Most importantly for the commercial harvester, the harvest must deliver a profit. In general, there are three sorts of conservation outcomes that result from a commercialized harvest: (1) the sustained harvest is sufficient to reduce to population density below some level at which the animals' impact on conservation resources is acceptable, (2) the sustained harvest does not reduce the pest animal enough to protect conservation resources, but it saves the pest control agency from having to pay for that part of the control effort, and (3) the harvest provides no benefit to conservation (Parks, 2006: 441). Several species are also sought by commercial hunters either alone (such as possums) or in competition with recreational hunters (such as red deer, feral pigs, chamois, and Himalayan tahr) who also see the animals as a valuable resource (Parks, 2006: 409).

Most of the commercialized harvesting in New Zealand is for red deer, which currently has a population size of about 200,000, which is about 10% of its original population size before commercialized harvesting began. Large-scale culling as a means

of pest control began in the 1930s and lasted until 1961, averaging 28,000 animals killed per year (Parks, 2006: 411). Since the 1960s, official control is limited to a few key conservation sites and is not nearly as intensive with a few hundred animals killed per year at the most. Red deer are considered a popular recreational hunting resource and about 40,000 are hunted per year. The commercialized harvesting of red deer, most for export to Europe, began in 1958 and predominantly utilized ground hunting, often serviced by aircrafts and helicopters to position hunters and transport carcasses. From the mid-1960s to the mid-1970s, at least 2 million deer were shot from helicopters and nearly 100,000 deer were captured to stock deer farms (Parks, 2006: 411).

Between 1988 and 1999, the annual harvest of deer from the commercialized harvest varied between 13,000 and 32,000, where almost all of the variation can be explain by the price of venison (Parks, 2006: 411). A potential constraint on the commercialized harvest of red deer is the availability of processing facilities. These factories usually also kill and process farmed deer, a NZ\$210 million per year industry, but they require separate processing facilities if they are to handle wild-shot deer. In 2002 and 2003, commercialized red deer harvests were only 8,305 and 2,203 deer, respectively, due to worries about harvesting from pesticide-treated areas. Overall, however, the annual commercial harvest of red deer has average 20,000 animals (Parks, 2006: 412).

The alpine grasslands in New Zealand, especially in areas like Fiordland National Park, have greatly benefited in terms of conservation from the commercial exploitation of deer because in these areas, the deer are the main introduced herbivore present. However,

the conservation benefit in forest habitats has been minimal, despite greatly reduced deer densities, because of the “predator pit” that deer have created (Parks, 2006: 413). In these forests, deer previously living in forests (at very high densities) removed most of the palatable plants within browsing range. The current forest populations of deer rely on leaf-fall from palatable canopy trees for their diet, meaning that any seedlings that are more palatable than leaf-fall are immediately eaten by residual deer densities. Additionally, even the removal of these residual densities does not necessarily reverse the changes deer have caused to the ecosystem. Studies have shown that browse-induced changes in plant communities have altered litter quality and soil properties such that, even if deer are removed, the ecosystem can follow a variety of trajectories, ranging from near recovery to deterioration (Parks, 2006: 413).

The Himalayan tahr is another species controlled through, among other methods, a commercialized harvest. Current populations are around 10,000 animals, but between 1937 and 1970, about 25,000 were culled by government agencies; currently, the government culls between 1,000 and 2,000 animals per year, mostly from national parks. Additionally, each year recreational hunters kill around 750 tahr. Between when commercial harvesting for tahr began in 1971 and 1982, 39,000 animals were harvested; between commercialized hunting pressures, culling, and recreational hunting, in 1982 there were fewer than 5,000 animals (Parks, 2006: 414). Commercialized hunting stopped in 1982 because of pressure from recreational hunters, but was restarted once a tahr control plan was put in place that gave recreational hunters first harvesting rights. Overall, the annual commercial harvest of tahr from 1994 to 2003 has averaged around

400 animals. Commercial harvesting has resulted in direct conservation benefit in the form of a general improvement of the alpine snow tussocks, the tahr's primary food. However, unless the commercial harvest is sustained, these benefits will not last because recreational hunters have not currently been able to kill enough tahr to stop populations from increasing (Parks, 2006: 415).

Possoms are another example of a species that New Zealand commercially harvests. After sustained control operations conducted by the government, possum populations are still probably over 50 million. Possoms are concerning to wildlife managers because, not only are they a conservation pest, but they are also vectors of bovine diseases, particularly bovine tuberculosis. It is estimated that between 1966 and 1982, commercial fur hunters reduced possum densities by 49% to 63% in accessible areas (Parks, 2006: 415). Currently, the average annual commercial harvest is less than 3 million animals, which, if sustained, will probably not be sufficient to eliminate bovine tuberculosis and is inadequate to protect vulnerable biodiversity. The current commercialized harvest provides no conservation benefit and substantial government and private control efforts are needed to protect the ecosystem (Parks, 2006: 416).

Some have argued the logic of using commercial and recreational harvesting to control pest species because these methods place a value on the animal, which can then compromise optimal pest control strategies. There is much debate in the animal management sector in New Zealand; pro-hunting groups lobby against some pest control (for example, culling male trophy tahr), pro-control groups generally support commercial exploitation of pest species (probably because they do not believe the harvests are

organized enough to manage populations for higher animal densities, which would benefit the harvesters but not the controllers), and pro-control groups generally oppose recreational hunters (because hunters may actually be effective in lobbying for higher animal densities) (Parks, 2006: 417). These conflicts will remain and, although national legislation views introduced species as pests, national policy statements tend to be more pragmatic and encourage different species densities in different locations. In terms of pest control, commercialized harvests are, at best, seen as a useful component to pest controllers, and, at worst, irrelevant (Parks, 2006: 417).

3.2.2 Australia

In terms of commercialized harvesting, Australia is most well known for their feral goat and feral pig industries. The quantity of goat meat that has been exported from Australia steadily increased from the 1980s to the early 1990s, reaching between 8,000-15,000 tons per year (Forsyth and Parkes, 2004: 28). Thirty three countries imported goat meat from Australia in 1992, but four countries imported the majority: Taiwan, the Caribbean, Canada, and the United States. In 2004, the United States was importing almost 40% of Australia's goat meat (Forsyth and Parkes, 2004: 34). In Australia, the decision to harvest feral goats is made at the property level by the landlord, who can either harvest himself or contract the work out. Therefore, the attitudes of the individual landowners towards goats are a key variable in the industry; some view goats as competitors with their livestock, others see goats as a resource for meat or controlling

weeds, and others simply ignore the goats, even when harvesting them could be profitable (Forsyth and Parkes, 2004: 36).

Feral goats are harvested by trapping, mustering, aerial shooting, or ground shooting (Forsyth and Parkes, 2004: 27). It has been found that the number of goats that are commercially harvested is a function of the average price paid per goat the previous month and there is no evidence of a threshold price paid per goat below which goats are not commercially harvested (Forsyth, Parkes and Woolnough, 2009: 101). However, fewer goats are harvested with increasing rainfall, indicating that goats may be easier to harvest in the drier months when they must drink from artificial water sources. Additionally, there may be a greater incentive to harvest goats in drier months when there is greater perceived competition with goats (Forsyth, Parkes and Woolnough, 2009: 108).

Supply issues, market issues (mainly driven by Taiwan and the U.S.), and government and landholder attitudes are all factors that affect the sustainability of the feral goat industry. It has been found that the official governmental view that goats are pests was often reflected by farmers; this can either positively impact the industry, ensuring that all landowners harvest the feral goats on their property, or it can negatively impact the industry by limiting the goat population size (Forsyth and Parkes, 2004: 43). The commercial harvesting of feral goats utilizes the animals as a resource, making management more acceptable than culling and creating waste, and requires little to no government investment. Commercial harvests may provide conservation benefits to the environment (although no study has yet to attempt to determine if harvesting provides benefits in terms of plant recovery), but harvesting may also compromise optimal

solutions for those who view goats as pests if it maintains goat populations at unacceptable densities (Forsyth and Parkes, 2004: 55-56). It is recommended that the government should encourage landowners who are not commercially harvesting goats to do so by promoting its financial benefits and providing tax incentives available for investment in the infrastructure to harvest goats (Forsyth and Parkes, 2004: 69).

The commercial harvesting of feral pigs began in Australia in 1980 after legislative changes allowed for the exportation of game meat. There are currently two main types of commercialized pig harvesters: those who trap, shoot, and sell pigs “opportunistically” to defray the costs of their sport, and there are professional hunters who hunt pigs to supplement their income (Forsyth and Parkes, 2004: 46). Almost all feral pig meat is exported, with little being sold domestically; the dominant export market is the European Union, with small quantities exported to Japan (Forsyth and Parkes, 2004: 48). Shooters usually operate in the late afternoon and continue into the night, when spotlights are used to locate pigs. There is strong evidence that the quantity and quality of feral pigs available for harvesting varies greatly as a consequence of variation in rainfall. The primary price determinant is most likely the demand for the product within Europe and the supply of feral pigs is likely to be determined by the abundance, condition, and vulnerability of feral pigs to harvesting. The seasonal change in the quality of feral pigs, with body condition declining as food availability declines, also influences supply (Forsyth and Parkes, 2004: 53).

3.3 A Commercialized Harvest in Hawaii

3.3.1 The United States Department of Agriculture's Requirements

The United States is not fully prepared for commercialized harvesting at the same scale as those conducted in New Zealand and Australia. Due to the North American Model for Wildlife Conservation, commercialized wildlife harvests have not been theoretically revisited until fairly recently. Those who have explored the possibility of a commercialized harvest in the United States have been met with serious challenges in terms of health regulations. These stringent regulations regarding food safety and inspections by the United States Department of Agriculture make cost-efficiency very difficult for commercialized harvesters. In the Code of Federal Regulations, Title 9, Animals and Animal Products, specifically Chapter III, Food Safety and Inspection Service, describes the requirements necessary to kill, process, and handle meat that is to be sold to the public. These requirements must be met for traditional domestic livestock producers and commercial “exotic” wildlife harvesters, alike; however, some extra precautions are taken for wildlife that are unnecessary for domestic livestock.

The humane slaughtering of all animals is required by the USDA. Animals must be deemed calm and healthy by a certified ante-mortem inspector before they are slaughtered, so if the animals must be driven into a shooting area, this must occur with minimum excitement (9 CFR 313.16, 2013). In addition to this being humane, calm and healthy animals also allow for the accurate placement of the bullet. The delivery of the bullet or projectile must be directly to the head in order to provide immediate

unconsciousness by a single shot. The animal must be shot in such a manner that it is rendered unconscious with minimal excitement and discomfort (9 CFR 313.16, 2013).

“Exotic” animals, referring to any reindeer, elk, deer, antelope, water buffalo or bison, fall under the voluntary inspection service, which is slightly different than the process for domestic livestock. In the case of commercialized harvests, a field ante-mortem inspection is required; this refers to an ante-mortem inspection of an exotic animal away from the official exotic animal establishment’s premises (9 CFR 352.1, 2013). All exotic animals and exotic meats must be handled in an approved official exotic animal establishment to ensure separation and identity of the exotic animals or exotic animal meat until they are shipped from the official exotic animal establishment to prevent commingling with other species (9 CFR 352.2, 2013). Any exotic animal producer who desires field ante-mortem inspection service must receive approval regarding the field ante-mortem designated area from the Regional Director (9 CFR 352.4, 2013).

The humane handling of an exotic animal during the ante-mortem inspection must be in accordance to the previously mentioned provisions, for example, the animal must pass inspection and be deemed healthy in order to be approved for slaughter and animals must be calm and undisturbed when shot. Additionally, it is required that a single head shot that renders the animal immediately unconscious and immediately after the animal is stunned or killed, it shall be shackled, hoisted, stuck and bled (9 CFR 352.10, 2013). The exotic animal ante-mortem inspection process differs from the domestic livestock process in that all slaughtered and bled exotic animals must be tagged with a “U.S. Suspect” tag

in an ear by the ante-mortem inspector prior to loading on the transport vehicle, where the carcasses will be taken to an official exotic animal establishment (9 CFR 352.10, 2013). It is required that all carcasses labeled with a U.S. Suspect tag (therefore, all exotic animal carcasses) undergo a post-mortem inspection. This post-mortem inspection, conducted by an approved post-mortem veterinarian, must be as expedient as possible, and must be within the same day as field slaughter to minimize the changes in the carcass which can affect the post-mortem examination (9 CFR 352.11, 2013). Once approved, the carcass may be processed.

3.3.2 Molokai's Commercialized Axis Deer Harvest

These stringent USDA requirements are quite costly for commercial harvesters because they pay hourly rates for the ante-mortem inspectors and post-mortem veterinarians. However, one man on the island of Molokai has already conducted several successful, cost-efficient, commercialized axis deer hunts. Desmond Manaba, of Molokai Wildlife Management, is currently the only commercialized axis deer harvester in all of Hawaii. He decided to enter the industry when he found that, on Molokai, the carcasses of culled axis deer were left to rot. He found this wasteful, which goes against Hawaiian tradition (D. Manaba, personal communication, February 10, 2014).

He is now a commercialized axis deer harvester and has spent about a year and a half working on perfecting his business model. As previously mentioned, an ante-mortem inspection is necessary to harvest wildlife meant for public consumption, so he started his journey by going through the proper channels to apply for a USDA ante-mortem

inspection. One of the prerequisites is that he is a deer rancher; this is required by the USDA to get a license for an ante-mortem inspection because the USDA wants to make sure that you can cover the costs associated with the inspections (D. Manaba, personal communication, February 10, 2014). This is also beneficial for Molokai Wildlife Management because Manaba's breeding herd of penned deer allows him to supplement wild harvests with a few farm-raised deer to fill his orders, if necessary. This is especially helpful because there is always a chance that something can go wrong out in the field; maybe there is an issue with the weather or maybe the deer are not at the location that was expected. Using the deer in the pen to supplement numbers from wild harvest makes sure each hunt is still economically feasible and orders still get filled (D. Manaba, personal communication, February 10, 2014).

Molokai Wildlife Management conducted their first commercialized harvest in the summer of 2012, which was immediately deemed successful due to its economic efficiency. Since then, they have continued to conduct feasibility studies to make their harvests more profitable and successful; they use a "learn as we go" mentality (D. Manaba, personal communication, February 10, 2014). They have conducted 12 or 13 hunts, total, but a few in the beginning were strictly practice hunts to practice shooting and to gain information about the axis deer venison market; in these hunts, the meat was not commercially for sale, but was given to certain chefs and other markets so Manaba could understand his market better. During these practice hunts, approximately 150 deer were hunted before Molokai Wildlife Management launched their real "for sale" commercial hunts. Of these 12 or so hunts, as of January 2014, Molokai Wildlife

Management has had nine successful commercial hunts where the meat was sold commercially. Their hunts have become increasingly more successful; their first commercial hunt resulted in 7 deer harvested and they are now harvesting between 20 and 25 per hunt. So far, Molokai Wildlife Management has been conducting about one harvest a month because their slaughter plant can only hold a limited number of animals in their freezer, where there is competition for freezer space with livestock (D. Manaba, personal communication, February 10, 2014).

Each commercial hunt follows the same protocol. Hunts only occur on private land because, in order to get the USDA ante-mortem inspection, the frontline supervisor has to get maps from the landowners. The hunting area maps are studied by the USDA and they also make sure there is permission from the landowners stating that they want to hire Molokai Wildlife Management to harvest deer from their land. The USDA will then send someone to go to the ranch to check out the land and make sure there are water and food troughs because they “want to make sure that the deer are eating and drinking the same food as the cows” (D. Manaba, personal communication, February 10, 2014). After the USDA inspects the area and approves it, Molokai Wildlife Management works with the ranch owner to decide which day work best to schedule a harvest. Molokai Wildlife Management then requests an ante-mortem inspection for that day. This request works its way through the USDA chain to make sure the necessary people are aware of it and can attend the ante- and post-mortem inspections and then the date is confirmed. Manaba notes that it is difficult, and inefficient, to cancel these inspections because of all of the planning involved, so he often requests ante-mortem inspections for two ranches on the

same date in case the weather is bad or there are no deer at the one ranch, they can then change places and go to the other ranch with minimal trouble (D. Manaba, personal communication, February 10, 2014).

Harvesting occurs between 3am and 6am when the animals are most relaxed, which is best for the meat quality, and this also helps the shooters make accurate single, humane headshots. Because of this short time frame for hunts, Manaba notes that a serious challenge for his harvest is when the ante-mortem inspector comes to the hunt late because this severely cuts into his limited time to harvest in the field. Spot lights are necessary to make the headshots, but they also spook the deer, so Manaba describes that his team will turn on the light to shoot, causing the deer to run, but when the light is quickly turned back off, the deer will stop (D. Manaba, personal communication, February 10, 2014). This process is repeated as many times as possible. If a deer is not hit with a head shot, that deer will not be approved by the ante-mortem inspector for slaughter and must be disposed of. However, Manaba notes that this is not a problem for his team; he recalls a hunt in January 2014 where his team shot 22 deer and there was not a single missed shot. The shooters occasionally had to shoot the same deer twice, where the deer was shot in the head, but still was moving around so it had to quickly be shot again to be humane; but there were no misses (D. Manaba, personal communication, February 10, 2014).

After the hunt, the ante-mortem inspector will tell the post-mortem veterinarian inspector that the hunt was successful and he is needed at the slaughtering plant. The Molokai Wildlife Management crew transports the carcasses to the slaughter plant where

they are inspected by the post-mortem veterinarian and are slaughtered. The hides are stripped off the carcasses to be sold and, if they are fast enough, the innards (such as the liver and heart) can be sold as well. However, if the post-mortem veterinarian feels, based on the temperature of the organs, that the carcasses were handled too slowly, he will not allow the innards to be sold. The meat must be processed within 32 hours and if all is successful, the meat can then go to market (D. Manaba, personal communication, February 10, 2014).

With all of the requirements in this process to get wild-harvested deer to market, it is clear how the costs add up; Molokai Wildlife Management must pay for its own harvesting crew, the right to harvest on the private property, as well as the cost of all of the USDA inspectors, which are usually around \$400 per harvest (D. Manaba, personal communication, February 10, 2014). Each hunt, Manaba brings in a team of about five men as part of his crew. He has two harvesters who do the shooting and these men are paid \$300 per harvest because of their skill level; they must be excellent with their shots because they need to deal with moving targets at the nighttime and shoot from various trajectories, but still get headshots. Manaba notes that “it makes a big difference if you have good shooters” (D. Manaba, personal communication, February 10, 2014). He also brings three men who serve as retrievers, spot-lighters, bleeders, skimmers, and sometimes drivers; these men are paid \$150 per harvest. Molokai Wildlife Management also pays the private ranchers who allow him to harvest a cut from his profits, even though the landowners also benefit from the removal of the deer. He notes he loves being able to help his community; recently some ranchers were going to have to lay workers off

because the cattle industry has suffered from deer competition with cattle. However, because of Molokai Wildlife Management's harvests, ranches get their cut from the harvest and now those workers still have jobs (D. Manaba, personal communication, February 10, 2014).

Paying the various USDA inspectors is by far Manaba's greatest cost and it is a hard challenge to overcome (D. Manaba, personal communication, February 10, 2014). Ante-mortem inspectors are paid about \$70 an hour and each harvest lasts approximately four billable hours, averaging around \$280 per harvest. The post-mortem inspection costs \$50 up to 20 deer, and \$100 if there are over 20 deer. There are also slaughter fees of about \$40 per deer; however, Manaba has been able to decrease these costs by selling the deer skins. He can sell the skins for \$20 if they are of good quality or about \$15 if they are not as nice. So rather than slaughter fees of \$35 to \$40 per deer, the price decreases to \$15 to \$20 per deer. On average, Manaba notes that his bill for the slaughter plant is around \$330, but it can go up if something goes wrong. Finally, Manaba has to deal with a processing fee, although if his vendor who is buying the deer is working directly with the slaughter plant, the vendor will pay the processing fee. This billing is more streamlined and allows Manaba to bill the vendor for the deer meat and the processing fee together (D. Manaba, personal communication, February 10, 2014). On average, per hunt, Manaba's cost reach approximately \$1,780, assuming about \$400 in combined ante- and post-mortem inspection costs, \$600 for two harvesters, \$450 for three other team members, and \$330 in slaughter fees.

Molokai Wildlife Management currently sells his venison for \$8 per pound in order to get it into the mass market, although this price has somewhat fluctuated and reached a maximum of \$11 per pound. He found that when prices were between \$10 and \$11 per pound, it was difficult for the middlemen to make any profit given the demand. He notes now, however, he has one vendor on the island of Hawaii who sells his venison for \$16 per pound, making an impressive cut for being the middleman (D. Manaba, personal communication, February 10, 2014).

In less than two years, Molokai Wildlife Management has harvested 150 deer for donation, 150 deer for demos and to help with marketing, and about 140 for commercial sales (D. Manaba, personal communication, February 10, 2014). Currently, Manaba is working on his marketing campaign. While marketing was tough in the beginning, he is working strategically to market sure that the market is ready. He has been marketing on television shows and is generally just trying to get axis deer venison to the public through farmers markets, chefs, and even by selling to the mainland. Manaba is now trying to conduct two harvests per month and he believes he has a market available where he could eventually get to three or four harvests per month, harvesting 80 to 100 deer per harvest (D. Manaba, personal communication, February 10, 2014). Before this expansion, however, he wants to make sure the market is ready for axis deer venison. He also has the supply to achieve this goal because new ranches with severe deer problems have been contacting him. While he prefers to harvest on his own ranch so he gets the full profit, Manaba likes helping other ranchers with their deer problems. Ranchers work with Molokai Wildlife Management because they need help removing deer from their

property. Manaba notes that he can tailor his harvesting to meet the ranch's management needs. For example, if a ranch also caters to recreational hunters, Molokai Wildlife Management can harvest only females and smaller deer, leaving the bucks for recreational hunters who want the trophy while still decreasing the overall deer population on the ranch (D. Manaba, personal communication, February 10, 2014).

Manaba is also working on a new technology to help with ante-mortem inspections that are not possible because the sites are too close to residences. He is conducting the research and development now and it has been in the works for two years. His invention is a 60 foot by 60 foot net to shoot over axis deer herds. This net could essentially capture a whole herd and the net can be remotely triggered from Manaba's house. The deer can then be transported to a ranch or a pen where harvesting is allowed. He envisions either selling the technology to interested buyers or allowing people to hire Molokai Wildlife Management to use the nets for them (D. Manaba, personal communication, February 10, 2014). This would be ideal for residential areas where normal lethal population management is not permitted.

Manaba is currently experimenting with the deer transportation because, he notes, deer cannot stay tied up for long before panicking and potentially injuring themselves. He is testing how deer fare in transport containers when kept in the dark; tests with one or two deer at a time did not work well, but he has found that moving the whole herd together works better because when they are all touching each other they feel safe (D. Manaba, personal communication, February 10, 2014). Manaba wants to get this technology to a point where it can be used before the ante-mortem inspection. He

currently has several water holes on his property and he has cameras set up so he can monitor how many deer are by the watering hole. Ideally, he would like to be able to sit inside and watch the cameras, waiting for 20 to 25 deer to gather together around the watering hole, and he could then trigger the net and call in the ante-mortem inspector when needed (D. Manaba, personal communication, February 10, 2014).

Manaba has offered his services as a deer rancher who can schedule ante-mortem harvests to ranchers on Maui, although nobody has yet to take advantage of his service. He notes that, “Maui just needs to open up their minds...just go do it—enough talk” (D. Manaba, personal communication, February 10, 2014). Interestingly, Molokai Wildlife Management has vendors on Maui, so Manaba is actually selling Molokai deer to Maui residents (Anonymous #14, personal communication, January 13, 2014). Molokai Wildlife Management is clearly ahead of the Maui ranchers in terms of the venison industry, but Manaba is actually helping Maui ranchers out by essentially creating the axis deer venison market on Maui. By the time Maui ranchers start commercially harvesting deer, Maui restaurants and grocery stores will already know the demands of their market, for example, the cuts of meat customers want. Meanwhile, at that point, Molokai Wildlife Management will not be able to compete with Maui ranchers because of the inter-island shipping costs (Anonymous #14, personal communication, January 13, 2014).

3.3.3 Creating a Commercialized Axis Deer Harvest on Maui

The Maui Axis Deer Harvesting Co-op attempted their first and only hunt in October of 2012. The Harvesting Co-op, also funded by the Maui Office of Economic Development, but a completely separate entity from the Maui Axis Deer Working Group, spent only a few months transitioning from their idea to create a commercialized hunt to the actual implementation (Anonymous #7, personal communication, January 16, 2014; Anonymous #9, personal communication, February 7, 2014). However, this may have been a little rushed because the hunt was not economically efficient; only two animals were harvested and one was a body shot, so it was not approved by the USDA inspector (Anonymous #8, personal communication, January 30, 2014).

A meat processor involved in that first Maui commercialized hunt shared of his experiences regarding the harvest. He describes how the inspectors first must approve an individual animal to harvest by making sure it is not sick; he makes sure the eyes are bright and not dull or sunken, and the animal must be holding its head high. Axis deer on Maui are known for being a healthy herd, so “99.9% of the time the animal will be healthy” (Anonymous #2, personal communication, January 10, 2014). This visual inspection is done with the assistance of a spotlight and, so he does not spook the animals by speaking, the inspector will use hand signals to show which deer he approves for harvest. The use of this spotlight, however, means that there is a possibility that the animals will come to fear the spotlight coming on, associating it with the gunshots. It is especially important to make sure this does not happen in areas with large concentrations of deer because they will frighten each other. To avoid this mass panic, harvesters are

working on different methods to acclimate deer to the spotlight coming on without the deer getting scared. The goal is to make the animals comfortable in their environment and condition them to accept the spotlight. This could potentially be done by using automatic feeders that spray corn to draw the deer in, then a solar powered battery spotlight would flicker on and off in the area, acclimating deer to the light so they are not frightened by it (Anonymous #2, personal communication, January 10, 2014).

People have also started looking into new ways that the hunters and inspectors can silently, visually communicate in the darkness; this needed so that the inspectors understand which deer the hunter is planning to harvest so that it can be approved first. There have been discussions about possibly using laser pointers to identify an animal for harvest; this would guarantee that the hunter and the inspector are looking at the same animal (Anonymous #2, personal communication, January 10, 2014). The processor adds that harvesters are also experimenting with the most efficient team size; “going out with five or six hunters is inefficient and loud and creates a high stress environment for the deer” (Anonymous #2, personal communication, January 10, 2014). He believes using two hunters is probably best because they can still be quiet while harvesting enough deer to make the hunt cost-efficient.

Unfortunately, the one deer that was successfully harvested with the USDA-approved head shot was processed and meant to be shipped to a high-end restaurant customer, but the shipping crew forgot to plug in the refrigerated unit, so the whole shipment (mostly beef and the one deer’s worth of venison) was lost (Anonymous #2, personal communication, January 10, 2014). The other carcass, killed using a body shot,

had to be disposed of through a municipal dump. The processor notes that this is one of the problems with bringing in the USDA to inspect the hunt; because the USDA needs to make sure that people will not get sick, they are extremely diligent in making sure that animals that are not properly harvested (i.e., with a head shot) are disposed of and not accidentally shared with the general public. Had the USDA not been present, this deer killed with a neck shot could have been brought home and eaten by one of the harvesters, but once the USDA is involved in the hunt, anything not killed with a head shot must be properly disposed of (Anonymous #2, personal communication, January 10, 2014).

The processor also notes steps that need to be taken now in order for a harvest to be successful in the future and he believes a successful hunt can happen; he currently has \$1,500 worth of venison labels just waiting to be used (Anonymous #2, personal communication, January 10, 2014). He believes the key is that axis deer venison must be introduced slowly into the market place because it takes time to get new products featured on menus; he estimates this process of establishing the market should take between six months and a year. The venison must also be properly priced for the market and keeping costs low for everyone is a necessity. Most importantly, the processor thinks the method of harvesting needs to be perfected and private landowners need to get on board, allowing for maximized cost-efficiency.

Opening private land to commercialized harvesting and perfecting harvesting methods to a point where the number of deer harvested per night is maximized will allow costs to be minimized. There are so many steps and people involved in the commercialization process that keeping costs low for everyone is vital. The process

begins with the harvesters and inspectors who are present when the deer are hunted. The harvesters have two hours to get the carcasses to the slaughter plant. The quicker the carcasses get to the plant, the better; after being shot, gases build up in the deer's stomachs. The gas build-up depends on the temperature and cool body temperatures minimize the gas—another reason night-time hunts are preferable (Anonymous #2, personal communication, January 10, 2014). Once at the slaughter plant, the USDA post-mortem veterinarian must approve the carcasses before they are skinned and eviscerated. The carcasses then go into a cooler overnight and are brought to the processor's for processing. The processor must look at the quality and age of the carcasses coming in before deciding how to process the meat.

All carcasses that come in to get processed are not the same; different deer have different qualities of meat. Young deer can be processed into fine venison chops for high-end restaurants, while an old buck would probably need to be ground into a venison patty. These venison patties may be a good option for restaurants catering to tourists because there may be an appeal to try a burger made from local venison. A challenge with venison burgers is that they can get dry if overcooked, so some chefs are experimenting with mixing beef fat into the patty to add some moisture into it (Anonymous #2, personal communication, January 10, 2014). First, the Harvesting Co-op wants to focus on marketing to high-end restaurants, hoping that having axis deer venison features at these locations will make the statement that “venison is in” (Anonymous #2, personal communication, January 10, 2014). The processor notes that high-end restaurants have high operating costs so harvesting costs must be kept down in order to

keep venison prices low. Then they can move on to venison patties or burgers for more touristy locations. Ideally, the processor mentioned he would like to see a price point of \$2.50 per pound for carcasses as the price that processors would pay the harvesters for their kills. On Maui, the system is set up so that processors pay the harvesters, who pay the slaughter plants. Grants from the Maui County Office of Economic Development are meant to try to keep these slaughter costs down (Anonymous #2, personal communication, January 10, 2014).

The processor believes the current goal should be to understand the number of animals and the amount of meat available on a weekly basis; this is necessary so that restaurants can actually be supplied with the meat that will be on their menus (Anonymous #2, personal communication, January 10, 2014). The processor adds that “the market is there, it just needs to be cultivated and done correctly” and harvesters should wait to make their move to the commercial sector until venison is available in a consistent volume so that they immediately establish a reliable reputation. A rancher adds that he knows plenty of groceries and restaurants willing to buy venison at high costs, but they need to be sure there is always enough supply to keep their market satisfied (Anonymous #13, personal communication, February 3, 2014). In order to get to this consistent volume, the Harvesting Co-op must perfect their methods of harvest by documenting how long hunts take, how many deer are hunted per hour and at which sites, and similar important information (Anonymous #2, personal communication, January 10, 2014). This inherent difficulty in sustaining an industry based on supplies from culling wildlife animals makes some question if a venison operation may only be successful if it

is a farm-based rather than wildly-harvested operation (Anonymous #13, personal communication, February 3, 2014).

But the processor has been experimenting with ways to build consistency in order to get his product into restaurants. He would like to try a system where one day a week is reserved for axis deer processing; “for example, if Wednesday is my deer day, when a load of deer carcasses comes in on another day, it’ll go immediately into the freezer. Then on Wednesday we can fabricate all of the venison for that week” (Anonymous #2, personal communication, January 10, 2014). This would “build predictability” for restaurants so they know they can run a venison special once a week; “the more consistently we can deliver, the more valuable the product becomes” (Anonymous #2, personal communication, January 10, 2014). This would also help with the coordination of man-power, especially in the slaughter plants. In the current system, men can be brought in to skin a certain number of carcasses, but there is no real guarantee that the carcasses will be there because the hunt may not be successful. Additionally, slaughter plants may be staffed to handle a certain number of carcasses, but three times as many deer are harvested than expected (Anonymous #2, personal communication, January 10, 2014). Setting aside one day a week to handle venison, at least in the beginning, will help build consistency leading to better cost-efficiency for those involved in the harvest and the market.

In addition to this need for a steady supply of deer for the market are the needs for increased processing capabilities and more cost-efficient USDA inspections. For both of these costs, enough deer need to be processed in order to make the harvest economically

viable (Anonymous #1, personal communication, January 15, 2014). The difficulty of harvesting enough deer is compounded by the fact that axis deer are a hard species to work with; they are elusive, acrobatic and “if you try to contain them in an area in order to shoot as many of them as you can to achieve the economies of scale necessary to offset these inspection costs, they’ll kill themselves trying to get out of the pen” (Anonymous #13, personal communication, February 3, 2014).

The USDA inspection costs are considered one of the greatest challenges associated with the commercialized harvests because of the cost of the inspectors’ time and the fact that there are a limited number of inspectors who can make it to Maui (Anonymous #1, personal communication, January 15, 2014). A rancher described the challenges associated with the federal regulations for the game meat inspections as a “major bottleneck” and a great impediment to trying to establish a commercialized harvest on Maui (Anonymous #13, personal communication, February 3, 2014). Some people are looking at ways to potentially use cameras to decrease the cost of ante-mortem inspections; eliminating the need to pay for the inspector to travel to the island and work for four hours in the middle of the night (Anonymous #14, personal communication, January 13, 2014). It is noted that the three main aspects the USDA is concerned with at the ante-mortem inspection are: (1) that the animal was shot with a humane head shot, (2) that the animal was healthy when it was shot, and (3) that the animal was bled properly and placed on a clean truck bed for transportation. Actions are being taken to determine if the USDA would accept not having an ante-mortem inspector present at the time of the hunt if those three criteria could be established with the use of a camera (Anonymous

#14, personal communication, January 13, 2014). This would greatly reduce costs for the commercialized harvester.

One proponent of a commercialized harvest views the biggest challenge as the need for collaboration from various ranchers who are interested in commercialized harvesting. Because deer move between properties and different ranches, collaboration between ranches seems like the only way for everyone to benefit. In fact, this idea of collaboration will be explored in a new certificate program offered to Maui ranchers at the nearby University of Hawaii, Maui College. There will be representatives from just about every ranch on Maui and these participants will develop Excel models to show how collaboration will help everyone's profits in hard numbers; the instructor encourages the sharing of resources, like the mobile slaughter unit (Anonymous #14, personal communication, January 13, 2014). The course will also use game-camera data from participating ranches to understand the deer population dynamics. There are also plans for hiring ante- and post-mortem inspectors for a real commercialized hunt in April as the culmination of the course (Anonymous #14, personal communication, January 13, 2014).

Desmund Manaba, of Molokai Wildlife Management, has also offered to lecture in the course and share somewhat proprietary information with the Maui ranchers; the instructor hopes that this will encourage collaboration among ranchers. This sharing of ideas between ranchers and a successful harvester will allow everyone to see that this commercialized harvest can and does work, and it allows other people to jump on the harvest bandwagon; it is no longer hypothetical (Anonymous #14, personal communication, January 13, 2014). The instructor notes that farm politics are going to be

the make-or-break of the venison industry on Maui and people need to look at it holistically and understand the whole system; collaboration is crucial to the success of the venison industry (Anonymous #14, personal communication, January 13, 2014).

Large-scale marketing is proving to be another challenge for those interested in commercialized harvesting, even though many locals are already very aware of axis deer venison as a healthy and delicious alternative to beef. This challenge is not surprising, however, because studies exploring the attitudes of exotic ungulate producers across the United States have found that limited information and a lack of knowledge concerning marketing issues were the major concerns indicated by the respondents concerning the development of the exotic venison industry (Mjelde, Conner and Stuth, 1992: 478).

Although the respondents were mostly from Texas and were selling farmed exotic meat, the marketing challenges for exotic game meat are similar because both differ from traditional American beef.

Many believe that there is a market, in the United States and globally, for an axis deer industry (Anonymous #1, personal communication, January 15, 2014). This is mostly because of how tasty axis deer venison is; the venison is described as a “lean, non-gamey, [and] cholesterol-free meat” (Maui Axis Deer Working Group, 2012b: 2). Additionally, it is noted that other parts of the deer are as valuable, if not more so, than the venison and there are many potential markets for hides, antlers, and even the blood meal for fertilizers (Anonymous #14, personal communication, January 13, 2014). All of this adds to the appeal of an industry centered around axis deer; it truly has the potential

to be a “zero waste operation” and there can be uses found for virtually every part of the harvested deer (Anonymous #14, personal communication, January 13, 2014).

People all over the world are generally attracted to the idea of a grass-fed, local source of protein, but game meat is often tough and can be considered an acquired taste; axis deer venison is “so unlike what people are used to...it’s extraordinary” (Anonymous #14, personal communication, January 13, 2014). Chefs at various Maui resorts are especially eager to have axis deer venison available as a menu item so they can share this tender, Hawaiian food source with tourists (Anonymous #3, personal communication, January 29, 2014). Others believe there is demand for axis deer venison, but on a much smaller scale; “I think there is a demand [for venison] and the meat tastes really good, but for it to take a major role-- the way that beef does—I can’t see it. It’s just more of a niche market” (Anonymous #7, personal communication, January 16, 2014). While this conservationist believes this market can be expanded, he does not think that a commercialized harvest will be able to act as a mechanism to really make an impact in controlling populations, even though that would be ideal (Anonymous #7, personal communication, January 16, 2014).

This line of thinking—the question of whether a commercialized harvest will actually serve as a population control method—is another aspect that needs to be taken into account in the creation of a commercialized axis deer hunt on Maui. The commercial harvest was originally presented as a population management strategy, but there are debates as to whether or not it will be effective, and still others worry about the incentives that are being created as a result of commercializing axis deer. Most experts find it “highly

unlikely that [commercialized harvesting] can be used as a significant population reducing mechanism”, especially because of the strict USDA requirements; they believe that, from a population biology standpoint, it is not a feasible mechanism to control populations because removing a few dozen deer a week is simply not enough (Anonymous #5, personal communication, January 24, 2014). Instead, many view a commercialized harvest as a “complementary effort” to other population control methods, like aerial control, and they believe that the commercialized harvest needs to be coupled with another effort to bring deer numbers down (Anonymous #1, personal communication, January 15, 2014).

Many believe that, although there is a lot of interest in axis deer as a marketable commodity, the hurdles, such as the inspection costs, make it unlikely that this harvesting will explode into a huge industry, making it difficult for a commercialized harvest to decrease population numbers alone (Anonymous #1, personal communication, January 15, 2014). Additionally, even if an operation figures out how to make a commercial harvest economically efficient and sustainable, that one operation will probably not be enough to really impact deer populations; the harvest is often viewed as “an excellent pursuit, and there is an opportunity for success”, but it will not be enough to be used as a sole method for population control (Anonymous #1, personal communication, January 15, 2014). Even processors involved in the commercialized hunt see a commercialized harvest supplementing another method. The processor notes that, in order to really decrease populations (which he views as necessary for ecosystem health) simply culling deer will not make a long-term difference because it will have to be done again in the

future. However, if a large number of deer were killed by recreational hunting efforts, and a venison market were introduced, this make be able to keep populations in check (Anonymous #2, personal communication, January 10, 2014).

There are also concerns about a commercialized harvest because of the incentive structures: commercializing the resource could lead to extremes of increased populations or complete eradication. One land manager notes that there are mixed precedents for how well these commercialized harvests work internationally and “there can be an inherent conflict of interest when you’re trying to control a species but yet there’s a great benefit to having them be there” (Anonymous #11, personal communication, January 23, 2014). He adds that bounty programs for certain species can work, but there is also “an inherent incentive to make sure there continues to be a number of those animals available for harvest” (Anonymous #11, personal communication, January 23, 2014). Others worry that Maui must take lessons from New Zealand to learn how to commercially harvest a species without allowing the commoditization to lead to the eradication of the species (Anonymous #14, personal communication, January 13, 2014).

One biologist finds the venison industry to be a good idea, “as long as it takes place within the context of a system that prioritizes minimizing environmental, agricultural, and public health risks associated with deer” (Anonymous #6, personal communication, January 15, 2014). He adds:

Any time you commoditize a species that has a negative environmental impact you run the risk of setting up a system where that species is preserved for its financial value and then it continues to have an environmental impact. With deer on Maui, I think there are so many deer that you can commoditize a portion of them, but still prioritize minimizing the overall population for preserving the environment and agriculture.

There are enough deer there that you can target multiple goals.
(Anonymous #6, personal communication, January 15, 2014)

Recently, the Maui Axis Deer Harvesting Co-op has not progressed much in terms of actually organizing more USDA hunts that the Office of Economic Development is funding. They are currently working on methods to attract and then trap deer in octagonal pens, but they are having difficulties with this because deer are often trapped too close to residential areas, and the USDA inspectors will not allow harvesting in such locations. As a result, the Harvesting Co-op is now focusing on determining how to transfer trapped deer to a suitable harvesting area (Anonymous #8, personal communication, January 30, 2014).

Given all of these challenges, “many Maui ranchers [who are interested in commercialized harvesting] are in a wait-and-see mode” (Anonymous #13, personal communication, February 3, 2014). Furthermore, when conversation is turned to the potential for commercialized harvesting by average recreational-type hunters, most believe that, at least under the current system, it is not feasible. The “highly technical” nature of USDA-approved commercialized harvesting is thought to be too much for normal hunters; “there’s more to it than just going out and getting a head shot” (Anonymous #2, personal communication, January 10, 2014). These commercialized harvests need highly coordinated and skilled hunters, they need to be specialized, and they need the resources to pay the USDA inspectors and fund other aspects of the hunt, like game cameras to document deer movement (Anonymous #2, personal communication, January 10, 2014). In the current system, this is far too expensive; however, if the system can be updated to allow technology to make the USDA approval

process cheaper, perhaps more interested parties could afford venturing into the axis deer industry. It certainly seems as though commercialized harvests will only be able to act as a means of population control if enough harvests are hunting.

Chapter 4

SURVEY RESEARCH: ATTITUDES TOWARDS POPULATION CONTROL AND A VENISON INDUSTRY

4.1 Literature Review

4.1.1 Understanding Attitudes about Wildlife Management Using Surveys

Surveys have consistently been the main tool utilized to understand public opinions about wildlife management and the results of these surveys provide a strong basis for presenting and defending proposed policies (Johnson, Johnson and Edwards, 1993: 218). Understanding public opinions, specifically the opinions of wildlife users, like hunters, is vital for any wildlife agency because no matter how biologically sound a wildlife policy seems, it will only be effective if the public accepts it (Johnson, Johnson and Edwards, 1993: 218).

A study in Sweden sought to test the hypothesis that the consumption of game meat is a causal factor in generating positive attitudes toward hunters and hunting, a potentially important determination because the sustainability of hunting is key to control game populations. A random sample of 1,067 Swedish residents were mailed a survey during 2009 to test the association between non-hunters' frequency of game meat consumption and their attitudes toward hunting (Ljung, Riley and Heberlein, 2012: 2).

They found that game meat was consumed at least once per year in 65% of non-hunters' households and that 80% of non-hunters expressed favorable attitudes toward hunting. Game-meat consumption and social relationships with hunters were the key factors associated with positive attitudes toward hunting (Ljung, Riley and Heberlein, 2012: 4). Because the findings suggest that game meat consumption is an important reason that hunting is well-accepted in Swedish society, the authors suggest an increase in the distribution and availability of game meat to non-hunters will increase the likelihood of sustained positive attitudes towards hunters and hunting, leading to the possibility of making hunting a more effective management option for the control of abundant wildlife. In Sweden, meat from wild game can be freely bought, sold, and traded, so the authors hope that the results can be considered as catalysts for discussion about the sale of game meat in countries where it now is illegal (Ljung, Riley and Heberlein, 2012: 6).

Because of their overabundance, much research has been conducted on attitudes about white-tailed deer in the continental United States, especially in terms of hunting to decrease populations. One study used a bivariate analysis of public support for two different management options, those that might affect local deer numbers directly ("deer reduction") or alter human behavior to reduce deer impacts ("behavior-change"). Multiple regression analyses tested predictors of support for deer reduction options (hunting, contraception, removal, and no action or "letting nature take its course") and willingness to change one's own behavior (self-protection, yard re-planting, planting native plants) (Johnson, 2014: 33). Data was collected from the 277 responses returned

from 478 surveys mailed throughout New Jersey (Johnson, 2014: 34). It was found that support for deer reduction was correlated with wanting fewer deer, positive attitudes about hunting, and opinions about the effects of not taking any action. Support for behavior-change was correlated with distrust of the government, general environmental attitudes, and beliefs about deer impacts. Additionally, controlling for other variables, it was found that women supported hunting more and no action less than men (Johnson, 2014: 33).

Another study assessed suburban homeowners' and bowhunters' acceptance of lethal and non-lethal white-tailed deer management strategies. Additionally, the authors sought to determine homeowner willingness to pay for deer management and how long they would be willing to wait for relief to address conflicts caused by deer overabundance. The study area was the town of Greenwich, Connecticut, where the authors used a Connecticut Wildlife Division mail survey to assess bowhunter support and willingness to use crossbows or bait for deer hunting, if legalized (n = 159). Mail surveys were also used to assess homeowners' concerns, perceptions, expectations, and support for deer and deer management strategies in Greenwich; homeowners were also asked about lethal and non-lethal management strategies and their willingness to allow hunting (n = 456) (Kilpatrick, Labonte and Barclay, 2007: 2096).

It was found that most homeowners supported using lethal strategies to reduce and manage deer populations and, of the lethal strategies, bowhunting was preferred. The establishment of a special crossbow season outside the existing archery season received the greatest support by bowhunters and was also acceptable to homeowners (Kilpatrick,

Labonte and Barclay, 2007: 2099). Homeowners were generally unaware of the cost (94%) or effectiveness (92%) of birth control agents to manage free-ranging deer populations. Additionally, as landscapes progressed from rural to more urban areas, hunting access, human-wildlife conflicts, and homeowner willingness to pay for deer management decreased. Most homeowners were willing to wait 3 to 5 years to achieve a desired reduction in the deer population at no cost to them, regardless of the management strategy. However, as costs increased, homeowner willingness to wait decreased. Due to the fact that exposure, tolerance of deer, and willingness to pay for management varies by landscapes, towns with diverse landscapes should consider developing regional, rather than town-wide, plans to manage overabundant deer populations (Kilpatrick, Labonte and Barclay, 2007: 2100).

Another study tested the effects of tailoring information about wildlife management to the concerns of stakeholders. This study used information about white-tailed deer contraception to understand how individuals' attitudes may be influenced by different types of information. Two mail surveys were sent to the same residents of Irondequoit, New York, 19 months apart. The first pre-treatment survey measured attitudes towards contraception and identified respondents' concerns about contraception. The second survey provided a post-treatment measure of attitudes and was distributed in three versions: two containing different types of information about contraception and one without information was sent to the control group. It was found that the information addressing stakeholder concerns was most likely to influence attitudes (Lauber and Knuth, 2004: 322). As a result, the authors recommend that agencies frequently survey

their constituents about their attitudes and concerns towards wildlife and control methods so that agency communication can be tailored to address the particular concerns of each important stakeholder group (Lauber and Knuth, 2004: 330).

In addition to accepted control methods, managers also require information from their constituents about the acceptance of a certain deer capacity. In one study, Illinois residents in a suburban county where deer have been proactively managed since 2001 were surveyed to determine what characteristics and beliefs regarding deer contributed to public perceptions of the deer density. A regression model was used to identify variables that contributed to a respondent's perception of deer density and nearly half of the respondents perceived the number of deer as "perfect" (Urbanek, Nielsen and Davenport, 2013: 94). The best fit model indicated a respondent's perception of changes in deer density, damage to personal property, and the respondent's general feelings regarding deer influenced the perceptions of too many or too few deer (as opposed to the perfect number). In conclusion, the authors believe that if managers ask these kinds of questions on an annual basis, citizens should become more salient to deer damage and deer numbers, which may eventually unify public perceptions of deer density (Urbanek, Nielsen and Davenport, 2013: 94).

Recently, wildlife managers have begun to survey the general public about invasive species management because public attitudes as to what is considered acceptable especially vary where control of invasive species is involved (Koichi, Cottrell and Sangha, 2013: 97). Where there is most research regarding native wildlife management, the acceptability of control methods for non-native animals is lacking. Although the

removal of invasive species is often considered desirable in the name of biodiversity conservation, it is important for managers to understand and take into account public sentiment in their policies and practices regarding introduced wildlife management (Fraser, 2001: 33; Koichi, Cottrell and Sangha, 2013: 98).

A study based out of New Zealand cataloged 859 responses from a mailed questionnaire about perceptions regarding invasive species. Respondents were asked about their attitudes towards sightings of various species during visits to national parks or large forest areas. As expected, respondents responded negatively to sightings of wasps and possums, mostly likely because of the well-documented problems these species cause for native New Zealand flora and fauna. However, respondents generally approved of sightings of larger species, particularly chamois and deer, despite their status as pests. This suggests that New Zealanders value some introduced species for a variety of reasons (Fraser, 2001: 34).

There were general patterns about how respondents perceived types of introduced animals: smaller species were categorized as pests by 71% to 94% of respondents, depending on the species. Larger species, particularly deer, chamois, thar, and feral horses, were only categorized as pests by 4% to 27% of the respondents; they were more often considered resources (26% to 44%), or as a combination of pests and resources (24% to 51%) (Fraser, 2001: 4). For these larger species, respondents favored the “manage as a resource” (47% to 54%) or “control at low numbers” (24% to 35%) options, except for deer, where 81% of respondents favored the “manage” option.

Overall, 95% of respondents preferred to see controlled animals put to some commercial use (Fraser, 2001: 35).

In terms of control methods, for deer, feral pigs, and feral goats, shooting was the method of control viewed as the most acceptable method (75% to 98%). However, for the smaller mammals such as possums, rabbits, and feral cats, poisoning was the most commonly favored method (44% to 52%). The vast majority of respondents (88%) believed that control methods should be held to some minimum standard of humaneness for all species (Fraser, 2001: 35). The authors recommend that policy makers understand their public's concerns regarding wildlife and wildlife management so that they can formulate policies and public education based on the public's needs and values they seek to protect (Fraser, 2001: 37).

Another survey study, based out of Australia, sought to understand the locals' and tourists' acceptability of feral pig control methods, mainly trapping, hunting, fencing, and poison baiting, in Australia's Wet Tropics World Heritage Area (the WTWHA). A household study using systematic random sampling was used to investigate local residents' receptions of pig control methods; tourists were also surveyed using a systematic random sampling approach (Koichi, Cottrell and Sangha, 2013: 99). It was predicted that the level of acceptability of a control method would differ across stakeholder (i.e., resident and tourist) groups and methods considered inhumane would be less supported. The acceptability of each of the four control methods was investigated using 5-point scales: "strongly supported", "supported", "neutral", "opposed", or "strongly opposed". Respondents were also given the option to express their views about

why they supported or did not support a method in an open-ended question (Koichi, Cottrell and Sangha, 2013: 99).

The two stakeholder groups were compared and results indicate that local residents, in general, support feral pig control more than tourists. As expected, both groups identified similar factors, such as humaneness, as being important. However, locals more strongly considered factors such as effectiveness and direct social and/or economic benefits from control. More specifically, tourists were likely to hold different attitudes towards the control methods compared to local residents because the majority of tourists visiting the WTWHA were unaware of the presence of feral pigs, and thus were not aware that feral pigs are a problem. Conversely, local communities regarded pigs as one of the most serious threats to the WTWHA (Koichi, Cottrell and Sangha, 2013: 99). As a result of this study, it can be concluded that the types of stakeholder groups determine the acceptability of the control methods (Koichi, Cottrell and Sangha, 2013: 97).

4.1.2 Web-based Surveys

A review of wildlife management literature shows that the vast majority of survey work in this field involves mailed surveys. Although web-based surveys cost less, obtain responses more quickly, and provide more efficient data management compared to mail surveys, the potential inability to reach a random, representative sample of the public raises concerns about their validity and reliability. To explore the differences in responses between these two methods, one study surveyed recreational users of Virginia wildlife

management areas with either a web-based or mail instrument, based on the user's preference for contact. Results found that the response rates for both modes were comparable, but the web-based surveys were more complete and were returned more rapidly than the mail surveys were (Carrozzino-Lyon, McMullin and Parkhurst, 2013: 219).

The web-based option was more often selected by participants who were younger, located in a more urban area, and who were more educated. Although surveys administered using only web-based questionnaires are likely to be susceptible to demographic bias problems, the survey mode did not appear to influence the validity and reliability of attitudinal information from recreational users; the attitudes towards land management practices and wildlife value orientations did not differ between web-based and mail respondents (Carrozzino-Lyon, McMullin and Parkhurst, 2013: 219). Web-based respondents were statistically younger, with a mean age of 46.8 years compared to the mail respondents' mean age of 50.3 years, however, a meaningful difference probably did not exist seeing as the most respondents for both modes were middle-aged men (Carrozzino-Lyon, McMullin and Parkhurst, 2013: 229).

Because web-based surveys cost less to implement and generate faster responses, researchers may choose to use mail surveys less often, especially as postage costs increase and more communication occurs electronically (Carrozzino-Lyon, McMullin and Parkhurst, 2013: 230). However, there are still administrative challenges associated with finding a representative sample of broad, heterogeneous populations. There are dozens of companies now available that offer researchers the ability to purchase survey

responses taken by respondents from pre-selected lists, but these may or may not be representative samples. This study combated these issues associated with web-based surveys by utilizing a local phonebook to reach respondents—the same way a mail based survey would reach respondents. However, instead of including a paper copy of the survey and a stamped return envelope, a one-page pamphlet was included, instructing respondents to go to the web-based survey. This method allowed for a random sample, but also saved on postage and generated quick responses.

4.2 Survey Design, Implementation, and Data Collection

4.2.1 Business Survey

The purpose of this survey was to gain an understanding of how local Hawaiian businesses would respond to having venison and other axis deer parts available as a result of a commercialized harvest. This survey was designed to explore the potential supplies and demands of axis deer parts once it becomes available in the marketplace.

An extensive internet search was used to identify a wide variety of businesses local to the islands of Hawaii that could potentially utilize meat or some other part of an axis deer within their products or services. Businesses were included in the survey sample only if they were locally-owned and operated. For the purposes of this study, it was assumed that companies local to the islands of Hawaii would be the most willing to incorporate axis deer meat or parts into their products and services because the species is present on many of the islands and well-known throughout the state. Additionally, local

businesses were only included in the sample if they fell into one or more of twelve business types, which could be impacted by a commercialized axis deer harvest based on the products the business offers or the services it provides.

Hunting guides, who are employed by individual hunters to help lead game hunts and recommend hunting sites, were one identified category that could be impacted by a commercialized harvest. In 2013, there were nine hunting guides registered within Maui County, based out of six distinct companies (State of Hawaii Department of Land and Natural Resources, 2013). Hunting guides were targeted as a category because their work could be affected by how hunters react to the implementation of a commercialized harvest. They could also potentially be directly impacted by changes in axis deer populations as a result of a commercialized harvest.

Meat processors were the second business type identified for this survey. As previously discussed, individuals serving as meat processors for the current commercialized harvest were interviewed in an earlier phase of this project. As a result, those meat processors were not contacted to take this business survey. However, a block of questions were included about meat processing in case an individual served as a processor in addition to working as a hunting guide, which is common in the trade.

Grocery stores and meat markets/delis were two other business categories. These two business types were included because in the future they could potentially sell USDA certified axis deer venison as ground meat, steaks, ribs, or other cuts of meat to customers in their stores. Similarly, restaurants/cafes were included as another business type because they could potentially offer axis deer venison dishes to customers. Chefs were

included as a sixth business type because they could prepare venison dishes for their customers in a variety of settings, for example at restaurants, catered events, or pre-prepared home meals.

The seventh business type targeted for the business survey was meat suppliers. Unlike meat processors, which could also serve as suppliers as well, meat suppliers were defined as companies that solely sell meat to stores and restaurants in bulk and do not process the meat themselves. These suppliers would not have to deal with the USDA certification process themselves, but would have to ensure that they are buying USDA certified meat from other processors up the supply chain.

Zoos/animal sanctuaries were an eighth type of local business that could utilize axis deer meat or parts. Carnivores at zoos currently often receive a diet that includes cheap types of meat and they also receive chew toys and enrichment in the shape of large bones. Axis deer antlers, hooves, bones, and carcasses could be appropriate enrichment toys for large carnivores, in addition to the venison as a primary food source. Similarly, pet food companies were targeted as a local business type because axis deer meat could be incorporated into both dog and cat foods. Raw, meaty bones are also sometimes considered a healthier option for dogs (as they are lauded for being more similar to a wolf's all-natural, high protein diet) and axis deer bones could provide the same benefits as beef bones for a cheaper price as they are so abundant, unlike cows, on the islands. Dogs may also enjoy chew toys made from axis deer hooves, antlers, and bones. For both of these business types, the axis deer meat and parts would not have to be USDA certified

as it is meant for animals, making the logistics of using the axis deer meat for these purposes much simpler.

The final three business types were related to artisan industries that could utilize axis deer parts in their trades. The one leather smith that advertised his work online was targeted to take the survey as leather smiths may benefit from a potentially increased supply of deer carcasses for their tanning projects. Similarly, several of Hawaii's jewelers were contacted about taking the business survey to see if there was an interest in using beads made from axis deer antlers in their pieces. In the same vein, bead sellers/manufacturers were contacted about their interest in potentially creating, or minimally, selling, bulk bags of axis deer antler beads to be used by jewelers.

An extensive list of email addresses of local Hawaiian businesses falling within these twelve categories was collected using the internet search and follow-up calls to businesses to identify a suitable email address to which the online survey could be sent. After testing email addresses and removing those that were no longer available, the list of potential survey respondents, within all twelve categories, consisted of 135 companies. The small potential sample size of 135 businesses is due to the fact that some businesses originally found in the internet search did not have an email address listed. These businesses were called, but many (particularly small meat markets/delis and grocery stores) did not have email addresses. As a result, these businesses were targeted for the survey. Furthermore, some businesses that were contacted via a phone call in order to identify their email addresses did not have any employees who spoke English, as there are many Japanese markets and delis in certain areas. As a result, these businesses, even

if they had an email address, could not be reached. All 135 companies were sent an introductory letter and the survey link via email and were also emailed four reminders to take the survey over the course of September to December 2013.

It is important to note that many of these companies could fall within more than one category, which is why the business survey was designed to allow companies to label themselves into one or more categories. The survey's logic then displayed the appropriate questions based on the categories the businesses selected for themselves. For example, it is common that a jewelry maker is also a bead seller or manufacturer, so the individual taking the survey would mark both appropriate categories and the survey would only display the questions pertinent to jewelry makers and bead sellers, without asking duplicate questions. All survey respondents, regardless of business type, were asked a set of questions in the beginning of the survey relating to their annual number of customers and where the majority of the customers were citizens, whether from Hawaii, states besides Hawaii, or other countries. All respondents were also asked a series of demographic questions at the end of their category-customized surveys including age, gender, education, business revenue, and location of the business.

4.2.2 Hunter Survey

The study population of hunters was found using various hunting group online bulletin boards and through networking with axis deer hunting guides. Additionally, the Maui Axis Deer Working Group forwarded this study information to the leadership of various hunting groups on Maui, who forwarded the information to group members. The

survey instrument was only available online, but it could be accessed using the forwarded URL link in an email or by visiting a website that was set up for the sole purpose of housing the URL link. This webpage was easy to search for online and its URL was easier to type into a browser than the full URL of the survey.

The purpose of this survey was to seek the opinions of hunters about axis deer population control and the potential venison industry on Maui. Hunters on Maui are very aware of how the government manages axis deer because they are a favorite game species on the island. As a result, this survey sought to focus on hunters as a group to understand their attitudes towards potential changes that might affect their hunting. This hunting survey asked questions regarding whether the respondent had hunted axis deer, their preferred hunting methods, success in hunting axis deer, knowledge of axis deer, and preferred control methods.

4.2.3 Resident Survey

The resident survey was designed to understand consumer-side demand for products related to a venison industry in Maui. Although the survey was online-based, information about the survey was distributed over a series of mediums and the goal was to reach a sample size of 200 responses. On January 13, 2014, an article entitled “New survey finds 8,000 axis deer in E. Maui: Separate effort looks into viability of a venison market”, by Chris Sugidono, was published in the *Maui News*, a local Maui newspaper. This paper highlighted the recent axis deer population survey efforts by the Maui Axis Deer Working Group and also gave information about this resident survey. The article

noted the purpose of the survey work and listed the link to the online survey so that readers could participate in the survey. The article was published in print and online.

Another effort to bring attention to this residential survey was made by the *Maui Now* newspaper. *Maui Now* posted a Facebook status about the survey on January 15, 2014 stating, “If you'd like to have a say in axis deer population control here on Maui, fill out this 10 minute survey on control and harvest methods you approve of (anonymously). It's via the University of Delaware and the information may be shared with governmental groups and the Maui Axis Deer Working Group”, and provided a link to the survey.

The final method of distribution involved using the Maui Yellowbook to randomly select 1,000 people to mail about the residential survey. Approximately five people were randomly selected per “Business and Resident: 2014-2015” page by including every tenth entry listed on a page in the mailing list; if the tenth entry was a business, they next residential entry listed was included. Once a list of 1,000 names and addresses were collected, one-page letters were mailed to these Maui residents. These letters explained the background and purpose of the resident survey and listed the link to visit to reach the online survey.

The first two questions ensured that those who answered the survey either currently live in Maui or lived there within the past two years. The first series of questions asked if the respondent has suffered from damage relating to axis deer and if they think populations should be increased, decreased, or remain the same. The next series of questions were about the commercialized harvest: do they anticipate problems with a commercialized harvest and would they be interested in purchasing products such

as meat, pet food, or jewelry from harvested axis deer. The next series asked about their preferred methods of control where they can rank which methods they prefer. The residential survey also contained the questions from the hunter survey as a subset if the respondent answered that they were a hunter registered and Maui who had not already taken the hunter survey. The final questions are to collect demographic information.

4.3 Survey Results and Discussion

4.3.1 Business Survey

Of the 135 separate businesses within the twelve selected categories, 22 individual businesses completed the survey in full, representing 32 total responses from all business types (Table 1; Table 2). This is due to the fact that businesses were able to be categorized in more than one business type. In fact, results show that 40.91% of businesses that responded to the survey categorized themselves as applying to more than one type of business (Table 1). Hunting guides, restaurants/cafes, and chefs responded the most frequently. Each of the twelve categories was represented by at least one response, except for the one leather smith, who did not respond. Although meat processors were not explicitly targeted, one hunting guide who responded also categorized himself as a meat processor (Table 1).

Table 1. Breakdown of responses by business type.

Business Type(s)	Responses
Hunting Guide	3
Hunting Guide; Meat Processor	1
Restaurant/Café	3
Chef	1
Meat Supplier	2
Zoo/Animal Sanctuary	1
Pet Food Company	1
Bead Seller/Manufacturer	1
Grocery Store	1
Restaurant/Café; Chef	4
Meat Market/Deli; Restaurant/Café; Chef	1
Pet Food Company; Meat Supplier	1
Jewelry Maker; Bead Seller/Manufacturer	2
Total	22

Table 2. Breakdown of contacted businesses versus those that responded.

Business Type	Number Contacted*	Number Replied	Percentage of Respondents
Hunting Guide	6	4	18%
Meat Processor	---	1	5%
Grocery Store	11	1	5%
Meat Market/Deli	28	1	5%
Restaurant/Café	19	8	36%
Chef	2	6	27%
Meat Supplier	5	3	14%
Zoo/Animal Sanctuary	2	1	5%
Pet Food Company	11	2	9%
Leather smith/tanner	1	0	0%
Jewelry Maker	39	2	9%
Bead Seller/Manufacturer	11	3	14%
Total	135	32	100%

*organized by primary business type

These 22 responses can be broken down into two separate categories: hunting guides (and the hunting guide/meat processor) and all other businesses. This distinction is important because these “other businesses” were targeted to see if they would be interested in incorporating axis deer meat or products in their businesses—whether to sell or to use. Hunting guides, however, were targeted because the commercialized hunt may impact their business in terms of the quantity of customers and the experience their customers receive.

Overall, out of the businesses that could sell axis deer meat, including grocery stores, meat markets/ delis, restaurants/cafes, chefs, meat suppliers, and combinations of these businesses, 10 out of the 12 that responded to the survey noted they would be interested in offering axis deer meat in their stores or in their dishes. All three of the pet food companies and zoos that were sampled that could utilize axis deer meat and other parts of the deer responded that they would be interested in including at least some part of the axis deer in their animal food or treats. Finally, for businesses focusing on crafts, such as jewelry makers or bead sellers/manufacturers, 2 out of the 3 sampled were interested in including axis deer antler beads in their jewelry and bead lines.

4.3.1.1 Hunting Guide Responses

Three of the responses came from hunting guides and one came from a hunting guide/meat processor (Table 1). For all four businesses, the breakdown of their customer-bases was similar: Hawaiian citizens accounted for under 40% of their customers, citizens of other U.S. states accounted for approximately 50-80%, and international

citizens accounted for usually under 10%. Two of the guides had been active for seven years, both serving approximately 5 to 30 customers per year. The price per axis deer hunt were similar for these guides, with both charging \$400 for a half-day of hunting, and one noted another option of \$650 for a full-day hunt which included meals and free field processing, packaging, and island shipping. Both of these guides noted that serving as a hunting guide is not their main source of income and they do it to teach new hunters. One noted that she often focuses her hunts on teaching new hunters who cannot afford to hunt out in the field. The other mentioned he “enjoy[s] the hunt and teaching newbies to bow hunt” and he offers free hunts on a per case basis. A different guide had been active for 21 years and he noted serving 150 customers per year while earning \$100,000 net revenue per year solely on axis deer hunts. He charged hunts based on the axis deer hunted: \$750 for two does or \$3,300 for trophy bucks. The guide/meat processor had been a guide for 15 years and served between 10 and 15 customers per year; he left the costs of his hunts blank. However, he did note that he is not a U.S.D.A. certified processor, and, although he left several questions blank, he responded that he does process game meats. Because of the lack of responses about his meat processing side of his business, he will be grouped in with the rest of the solely hunting guides without further distinction.

The guides noted a range of how often they saw axis deer during their hunts. Two guides mentioned it probably had to do with where they were hunting and whether it was private or public land, with one stating the deer are “mostly on private ranch lands that do not freely allow hunters”. One noted seeing 4-10 deer per hunt whereas others noted 20-

30 deer per hunt. The number of deer hunted by customers per month also varied greatly from 1-2 per month to about 18 per month.

When asked the multiple choice question “If hunters you guide could sell the axis deer they hunted for a profit, how do you think your current customers would react?”, all four guides agreed that “current customers would not change their behavior”. They were given the option to choose that current customers would hunt much more often, a little more often, would not change their behavior, would hunt a little less often, would hunt much less often, or they do not know. The guides were also asked “If hunters you guide could sell the axis deer they hunted for a profit, how do you think new customers would react?”, with “new” referring to customers who have never hunted with a guide before. Their response options were: there would be a large increase in new customers, a small increase in new customers, it would not impact the number of new customers at all, there would be a small decrease in new customers, a large decrease in new customers, or they do not know. For this question, two guides responded that hunters being able to sell the deer they hunt would not impact the number of new customers, while the other two guides responded that it would lead to a small increase in new customers.

The next question asked, “Currently, it is illegal to sell meat and other products from wildlife, however, if commercial harvest became legalized for axis deer, the sale of these items would be permitted. Licenses would be issued to hunters to commercially harvest axis deer and the hunters could then sell the carcasses to processors. Do you foresee any problems with legalizing the commercial harvest of axis deer?”, with response options of: I foresee many and/or serious problems, I foresee few and/or minor

problems, I do not foresee any problems, and I do not know. Respondents were given the option of adding a comment in addition to their multiple choice answer. Two hunting guides responded that they do not foresee any problems, while one commented that axis deer “are one of the cleanest animals, no ticks no fleas”. One guide responded that he foresees a few and/or minor problems, citing access to deer herds as a potential issue: “Most deer are on the large ranches and golf courses, these are off limits to almost everyone”. One guide responded he foresees many and/or serious problems, noting that “illegal poaching and liability would heavily increase on private land, which would be a safety issue”.

Guides were also asked to respond to the statement: “My business would benefit from customers being able to sell their harvest for a profit.”, where they could strongly agree, agree, neither agree nor disagree, disagree, strongly disagree, or say they do not know. Respondents also had the option of commenting on their multiple choice answer. Responses greatly varied to this question. One guide stated he strongly agreed, commenting: “I know lots of guys who would love to have a chance to hunt deer but no one will open lands for them”. Another guide agreed, but noted that “warm climate and fresh meat is the road block”, and the meat is hard to transport quickly and safely. Another guide stated he neither agreed nor disagreed, but he mentioned he would “like to see the meat being used on the eradication hunts”. The last guide disagreed, noting that “illegal poaching would occur”.

Hunting guides were asked to choose an option about how they feel about current axis deer populations on the island of Maui: there are way too many axis deer, there are

too many deer, there are the right amount of deer, there are too few axis deer, there are way too few deer, or they do not know. Two guides responded that there are too few axis deer, one responded that there are too many deer, and one did not respond. Similarly, guides were asked to respond to the statement, “As a hunting guide, I believe axis deer populations should be controlled”, where control included recreational hunting as a form of population control, but hunting simply for recreation was not included. The guides could choose that they strongly agreed, agreed, neither agreed nor disagreed, disagreed, strongly disagreed, or they did not know. Three guides responded that they agreed and one disagreed.

Guides were also asked how aware their customers were of the problems caused by axis deer overpopulation on the island of Maui. They could respond: most are very aware, most are fairly aware, most are fairly unaware, most are very unaware, or they do not know. Answers greatly varied with one guide responding “most are very aware”, another responding “most are fairly aware”, another responding “most are very unaware”, and another who did not know. Hunting guides were asked to follow up with another question asking “Do you think that educating your customers about the problems caused by the overpopulation of axis deer on Maui Island would affect how they hunt axis deer?”. They could respond: yes, to a large degree, yes, to a small degree, no, or they do not know. There was more consensus with this question as three guides responded “no” and one said “yes, to a small degree”.

Hunting guides were also asked two questions about their opinions on various axis deer control methods. The methods that were considered in these questions were:

fencing, trap and transfer, contraceptives, recreational hunting, hired sharp shooting, commercial harvesting, or take no action (meaning axis deer population numbers should remain unchanged). In the first question (the “scale question”), guides were asked to rate each control method on a scale from 1-5, with 1 representing a method they completely supported, 3 one they were neutral about, and 5 being a method they do not support at all. In the next question (the “rank question”, guides were asked to rank these seven population control methods by dragging them into order, with the number 1 slot indicating the method they most supported and the number 7 slot indicating the method they least supported. These two questions were both visible at the same time while guides were taking the survey to maximize consistency between the questions.

One guide answered the scale question answered the scale question in only 1s and 5s, indicating he was completely for and completely against the various options. The marked fencing, recreational hunting, and commercial harvesting as methods he completely supported and trap and transfer, contraceptives, and hired sharp shooting as methods he did not support at all. “Take no action” was left unanswered in the scale question. In the rank question, the guide ranked fencing as his number one choice, followed by recreational hunting and commercial harvesting. Trap and transfer, contraceptives, and hired sharp shooting filled in slots 4-6, with “take no action” in slot number 7.

Other answers were not quite as consistent. In the scale question, one guide responded that trap and transfer and recreational hunting were methods that he completely supported. He viewed fencing and “take no action” as methods he was neutral

towards and he did not support contraceptives, hired sharp shooting, or commercial harvesting at all. However, in the ranking question, he marked fencing as his number one method, even though this was previously marked as “neutral” in the scale question. The rest of his answers were consistent, however, with trap and transfer and recreational hunting taking his 2nd and 3rd ranking slots. The rest of his ranking question answer, in order, consisted of: “take no action”, commercial harvesting, contraceptives, and hired sharp shooting.

Another guide responded that recreational hunting was a method he completely supported, while trap and transfer and hired sharp shooting received 2s. Commercial harvesting and “take no action” received 3s, and fencing and contraceptives were methods he did not support at all. However, the answers from the ranking question were not consistent with those from the scale question. In the rank question, the guide indicated that he preferred recreational hunting, hired sharp shooting, commercial harvesting, and “take no action” in the top four slots, respectively. He then placed trap and transfer in the 5th slot, even though this method received a 2 in the scale question (higher than commercial harvesting and “take no action” in the scale question). Fencing and contraceptives were ranked in the 6th and 7th slots.

Another guide marked fencing, trap and transfer, and recreational hunting as methods he completely supported in the scale question. Commercial harvesting and “take no action” were listed as 4s and contraceptives and hired sharp shooting were methods he did not support at all. In the ranking question, he was consistent in that his first four slots were recreational hunting, fencing, trap and transfer, and “take no action” (listed in

order). However, he then listed contraceptives in the 5th slot and commercial harvesting in the 6th slot, even though he gave commercial harvesting a more supportive score in the scale question. He then listed hired sharp shooting as the method he least supported.

Over all, recreational hunting was a preferred method noted by hunting guides: it was always marked as a completely supported method in the scale question (mean score = 1.00) and was consistently in the top 3 methods in the ranking question (mean ranking = 1.75) (Table 3 and Table 4). Conversely, contraceptives was always marked as a least supported method in the scale question (mean score = 5.00) and never made it higher than the 5th slot in the ranking question (mean ranking = 5.75) (Table 3 and Table 4). All other methods varied in their scale score and ranking based on the hunting guide, although fencing was consistently generally supported with a mean scale score of 2.50 and a mean ranking of 2.50. Similarly, hired sharp shooting was consistently generally unsupported, falling second-to-last in both questions with a mean scale score of 4.25 and a mean ranking of 5.50 (Table 3 and Table 4).

Table 3. Number of answers per scale score and average scale scores of various control methods by hunting guides.

Method	1 (completely support)	2	3 (neutral)	4	5 (do not support at all)	Mean
Fencing	2	0	1	0	1	2.50
Trap and Transfer	2	1	0	0	1	2.25
Contraceptives	0	0	0	0	4	5.00
Recreational Hunting	4	0	0	0	0	1.00
Hired Sharp Shooting	0	1	0	0	3	4.25
Commercialized Harvesting	1	0	1	1	1	3.25
Take No Action	0	0	2	1	0	3.33

Table 4. Number of answers per rank and average rank of various control methods by hunting guides.

Method	1 (most supported)	2	3	4	5	6	7 (least supported)	Mean
Fencing	2	1	0	0	0	1	0	2.50
Trap and Transfer	0	1	1	1	1	0	0	3.50
Contraceptives	0	0	0	0	2	1	1	5.75
Recreational Hunting	2	1	1	0	0	0	0	1.75
Hired Sharp Shooting	0	1	0	0	0	1	2	5.50
Commercialized Harvesting	0	0	2	0	1	1	0	4.25
Take No Action	0	0	0	3	0	0	1	4.75

As a final question, hunting guides were given the option of including any additional thoughts about the survey. Two of the guides took advantage of this option, both choosing to comment on access issues which are a challenge for reaching the majority of axis deer not on public lands. One noted that “having archery areas near golf courses” and trapping and relocating deer to open access areas would help hunters reach more deer to hunt. Similarly, the other guide suggested trapping and transferring deer from properties that do not allow access to those that do would be helpful. He specifically recommends a system that involves releasing deer on to “large ranch property that is poor for cattle”. These ranches would have high fences to contain the deer and then a drawing system or lottery could be used “to allow hunters a chance to hunt using fees to pay for the trap and transfer and land owner use fees”. He also suggests setting up a grid system where hunters must stay in select areas during hunting, allowing landowners to set water and food sites to draw deer to certain locations to help hunters.

4.3.1.2 Other Business Responses

Of the remaining 18, non-hunting guide, businesses that could potentially incorporate axis deer meat or products in their businesses, 15 responded that they were interested in either selling or utilizing axis deer products. It is important to note that the majority of the businesses surveyed indicated that they cater to customers who prefer organic and local products. Twelve of the 13 businesses for which the question applied noted they cater to customers preferring local products and 11 of the 13 businesses for which the question applied noted they cater to customers preferring organic products. For the pet food companies both of the two businesses for which the questions applied noted they cater to customers preferring organic and local pet products.

The one grocery store that was sampled noted that it serves about 200,000 customers per year, over 90% of who are Hawaiian residents. The respondent indicated that the store could be described as catering to customers who prefer to buy both local and organic products. The respondent also noted that he was “very aware” of the problems associated with axis deer overpopulation. The store does not currently sell venison, but the respondent answered that he would be interested in selling axis deer meat in the future, adding the comment that a commercialized hunt sounds like a “good way to control the deer population”. Specifically, the respondent noted that he would be interested in buying ground axis deer meat from a meat supplier or processor for up to \$3.00 per pound and would sell it for approximately \$5.00 per pound. The respondent answered “maybe” when asked if customers would be interested in buying the deer meat, but noted that most customers are “fairly aware” of the problems associated with axis

deer overabundance. When asked if he thought educating customers about axis deer overpopulation problems would impact if customers bought axis deer meat, the respondent answered “maybe” and he responded that he was not interested in holding an information session at his store about axis deer management and a commercialized hunt, but he was interested in having a pamphlet at the store about axis deer.

Three businesses that categorized themselves as restaurants/cafes responded to the survey. All noted that they mainly serve Hawaiian residents, but one indicated also having a high percentage of patrons from other U.S. states. All of the restaurants/cafes said that they cater to customers preferring local and organic products and they all had an average dinner price between \$10 and \$20. None of the respondents’ restaurants/cafes currently offer venison dishes, but all three indicated that they were “somewhat aware” of the problems caused by axis deer overabundance.

When asked “Would you be interested in including axis deer meat in your dishes?”, respondents could choose: yes, especially after hearing about axis deer overpopulation, yes, although my answer is unrelated to the overpopulation problem, or no. Two answered “yes, although my answer is unrelated to the overpopulation problem”. Both included optional comments. One added, “I would love to do some homemade venison stew pot pies featuring local venison”, while the other noted that “we’ve had buffalo for years and we used to carry ostrich, elk, and venison. Once the economy tanked, it was too expensive or these “boutique” suppliers went out of business”. Both of these restaurants/cafes stated that they believed customers would be interested in buying axis deer venison dishes, but that these customers were very unaware of axis deer

overpopulation problems. The one restaurant/café that was interested in both an axis deer in-store seminar and pamphlet stated that they thought educating their customers about axis deer overpopulation problems would lead them to buy axis deer dishes. The other restaurant/café that answered they did not know if educating customers about axis deer would affect axis deer venison sales indicated that they were not interested in either a seminar or pamphlet. That establishment added the comment that they think customers “will purchase for the taste or healthy benefits over other meats, NOT because of an overpopulation in the islands”.

The one respondent who said his restaurant/cafe would not be interested in offering deer venison added the comment: “we definitely support eating local and organic and if we were to serve meat at Choice we would definitely be using axis deer...however we are a fully vegan local eating establishment”. This café also noted that they would not be interested in holding information seminars or have pamphlets available about axis deer and they added that customers would not be interested in deer meat dishes.

The one chef who worked solely for individuals and families catered to customers preferring local and organic products and had average dinner prices of \$60.00 and higher. The chef does not currently offer venison and answered that he was “somewhat aware” of problems from axis deer overabundance. When asked if he would be interested in including axis deer venison dishes, he responded “Yes, although my answer is unrelated to the overpopulation problem”. He additionally commented that “a chef should always be open to serving good food and that just might include deer if offered...”. The chef noted that he was not sure if customers would be interested in deer dishes and he thought

that most of his customers are very unaware of deer overpopulation problems. When asked if he thought educating customers about axis deer on Maui would influence if they would be interested in venison he responded “I do not know” and he was not interested in having pamphlets about axis deer available.

Four respondents described their businesses as involving a restaurant/café and a chef. This may include chefs at restaurants and cafes, or those who work at a restaurant/café and also have a separate job as a chef for catering events. Three respondents answered that they cater to customers preferring local and organic products; while one respondent answered he caters to customers preferring local, but not organic products. One respondent answered he works at a restaurant/café, works for individuals and families, and also works catering weddings. The average dinner price at his restaurant/café is \$50.00, but his average meal prices as a catering chef range from \$50.00 to \$100.00. The remaining three respondents all work only at restaurants/cafes; one chef only sells breakfast and lunch at his establishment so the average prices are \$17.00 to \$18.00, whereas the other two chefs’ dinners average between \$30.00 and \$36.00. All four respondents indicated that they do not currently offer venison dishes.

The responses from the chefs about their awareness of the problems associated with axis deer overabundance were greatly varied. Two noted they were very unaware, one was somewhat unaware, and one was very aware. All four chefs were interested in offering axis deer venison, although two responded “yes, especially after hearing about axis deer overpopulation” and two responded “yes, although my answer is unrelated to the overpopulation problem”. All four chefs added optional comments. One stated, “I like

all types of proteins and have been trying to get hunter friends to bring meat from there for a couple of years”. One chef who noted his answer was unrelated to overpopulation problems added, “Although I care about the overpopulation, my reason is to put a different and unique product on our menu”. The two who answered that overpopulation problems affected their answers commented: “If it is good for the environment, good for business and good for the consumer it seems like a win-win situation” and “I feel that this would make great utilization of an animal that has gotten out of control”.

All four chefs believed that their customers would be interested in axis deer venison dishes and there was a general consensus that their customers were not familiar with axis deer overpopulation problems as three chefs answered most customers are very unaware of these issues and one answered most customers are fairly unaware. However, three chefs responded that they did not know if educating customers about overpopulation problems would impact their interest in venison and one answered “yes” that education would impact their interest. Three chefs responded that they would be interested in holding a seminar about axis deer management and the venison industry and three responded that they would be interested in providing customers with a pamphlet of information about the deer; all four were interested in at least one of the customer education tools. One chef added a final additional comment stating that he “would love to have an opportunity to buy local venison that has been approved by USDA. Price would be a major factor in my decision to buy”.

One respondent described her business as involving a meat market/deli, a restaurant/café, and a chef. It was later noted that the business was a catering business,

specializing in weddings, with a store component. The average dinner meal is priced at \$65.00 and the business is known for catering to customers who prefer local and organic products. The business does not currently offer a venison dish, but the respondent indicated she was very aware of the problems associated with deer overabundance and she was interested in offering an axis deer venison dish, especially because of the issues with overpopulation. She indicated that she would be willing to buy various cuts of venison at the following prices: loin at \$6.50/lb, rump at \$4.50/lb, ribs at \$4.50/lb, shoulder at \$3.50/lb, flank at \$3.50/lb, and ground meat at \$3.50/lb. She commented, “I love deer and know that my cliental would like deer as part of their meals if given the chance” and she added that the axis deer are “local and very tasty”.

She noted that she believed customers would be interested in buying axis deer venison both in the store and as dishes at her catering events and that she thought most customers are fairly aware of the overpopulation problems. While she was not sure if educating customers about axis deer would influence their interest in venison, she was interested in both holding a seminar on axis deer and having a pamphlet available to her customers.

Two businesses described themselves as meat suppliers, where only one indicated they cater to customers preferring local and organic products. One business noted they supply meat to restaurants/cafes, grocery stores, and chefs and they offer a range of beef, pork, game meat, cured meat, and smoked meats. They specified that 80% of their sales are beef with ground meat consisting of 10% of their sales. They listed that their prices range from \$1.80/lb for ground beef to \$40.00/lb for wagyu beef. They also offer farmed

venison for about \$20.00/lb and they sell about 1,000 lbs per year, totaling \$10,000 annually. The other meat supplier has accounts with restaurants/cafes, meat markets/delis, grocery stores, and individuals and families. They sell a variety of beef, pork, poultry, and seafood, with prices ranging from \$0.53/lb to \$12.49/lb. They indicated they do not currently offer venison.

The one supplier indicated that they would be interested in buying axis deer venison because they currently sell farmed New Zealand venison, but it is not a big seller. They were interested in axis deer venison because “a local, wild product would have a lot more customer interest”. This supplier indicated that they would be willing to buy various cuts of venison at the following prices: loin at \$15.00/lb, ribs at \$16.00/lb, shoulder at \$6.50/lb, flank at \$7.00/lb, and ground meat at \$4.00/lb. The supplier noted they would be willing to sell those cuts at the following prices: loin at \$17.00/lb, ribs at \$18.25/lb, shoulder at \$7.50/lb, flank at \$8.00/lb, and ground meat at \$5.00/lb. The other seller indicated that he was not interested in supplying axis deer venison because there is “no demand for it”.

One respondent categorized her business as a pet food company and meat supplier. She noted the business receives and sells 700 to 1,000 pounds of beef per week and her customer base is over 90% Hawaiian citizens. She supplies meat to individuals and families and she caters mostly to pet owners looking for organic and local pet food and she offers dry food, wet food, bones, raw meat, and treats for dogs, cats and chickens. About 95% of her total sales are for her pet food where meaty bones (neck bones, ribs, and soup bones) make up about 40% of sales, lean meats (skirt meat, cheek meat, and

hearts) make up about 40% of sales, and organ meats (liver, kidney, tracheas, and tripe) make up about 15 % of sales. About 5% of her sales consist of steaks and roasts for humans.

She noted she does not currently offer venison, but she was interested in buying axis deer meat or parts to include in her pet food because “the best diet for carnivorous pets includes a variety of meats. Venison would be an additional source of animal proteins and fats in Hawaiian pets’ diets”. When the respondent was asked if she would be interested in purchasing axis deer meat and for what price she responded,

Yes, we purchase beef from local cattle processors and some sheep, goat and wild beef from local hunters. For pets, we buy cuts that are less often used in the human diet, such as kidneys, livers, tracheas, green tripe, cheek meat, lungs, spleens, neck bones, and ribs. I assume that restaurants and grocery stores would take the prime cuts of venison, leaving similar parts to pets. On average, we pay \$0.65 to \$2.00 for USDA-inspected beef parts. We pay \$1.00 to \$1.50 for hunted, feral meat, but we take only lean meat and some meaty bones, not organ meat. If axis deer meat were available, I assume we would pay prices in this range.

The respondent was also interested in other axis deer parts for her pet food. She noted she was interested in including meaty axis deer bones in her line of products stating that she currently pays \$1.00 per pound for beef, sheep, and goat meaty bones, so she would pay the same for axis deer meaty bones. She also noted that “large dogs can eat whole deer heads, but pet owners may not like to face whole deer heads. We would have to explore how many other parts of deer we can sell to pet owners”. She was not interested in including axis deer bones stripped of meat or antlers in her product line.

The respondent noted that she was interested in buying various cuts of axis deer meat at the following prices: ribs at \$1.10/lb, shoulder at \$1.30/lb, flank at \$1.30/lb, and

ground meat at \$2.00/lb. She added that she would be willing to sell those cuts at the following prices: ribs at \$1.15/lb, shoulder at \$1.40/lb, flank at \$1.40/lb, and ground meat at \$2.20/lb. She commented, “if a Maui meat processor can provide pet-quality venison...we would be delighted to add venison to our offerings. Pet owners would appreciate adding more variety to our pets' raw-meaty-bones diets”.

Another respondent indicated that they were solely a pet food company that caters to pet owners looking for organic and local pet food. They sell treats for dogs and cats and noted that they were interested in buying axis deer meat or parts for their treats because their business uses “any locally grown produce, but it has to be grass fed or organic only. No GMOs, hormones, preservatives, or anything artificial”. The respondent indicated that they were interested in buying axis deer meat, meaty bones, bones stripped of meat, antlers, hooves, livers, and hearts all for \$1.00 per pound. The respondent added the option comment, “Please let me know when you start culling. I am looking forward to expanding my product line!”.

One respondent worked at a zoo/animal sanctuary that keeps 126 total animals and 5 animals that eat frozen animal protein (1 tiger, 2 Hawaiian owls, 3 Hawaiian hawks). The respondent indicated that they currently purchase beef and chicken for these carnivorous animals, but they would be interested in purchasing axis deer meat for their tiger “if the price were substantially cheaper than before or chicken and if the meat was inspected”. The respondent indicated the zoo was not interested in buying carcasses, meaty bones, bones, antlers, hooves, or other axis deer parts.

Two respondents categorized their businesses as jewelry makers and bead sellers/manufacturers. Both indicated that their customers are predominantly from U.S. states other than Hawaii. One business carries rings, earrings, necklaces, bracelets, and anklets ranging from \$20 to \$60, while the other carries earrings, necklaces, and bracelets ranging from \$10 to \$40. One business indicated that, while she does not often use beads in her jewelry, she should be interested in using axis deer antler beads in her jewelry because she “already carries jewelry made from cattle bone, carved in traditional Polynesian designs, which are very popular. This may be a good direction to go in, as well as beads”. She noted that she thought her customers would be interested in jewelry made from axis deer beads and she would also be interested in selling packages of pre-made beads made out of antlers. The other business stated that, while she often uses beads in her work, she was not interested in including axis deer antler beads in her jewelry nor would she be interested in selling packages of pre-made axis deer antler beads because she does not “think there is a demand for that”.

One business categorized itself as a bead seller/manufacturer with a customer base comprised of over 90% Hawaiian citizens. The respondent indicated that he would be interested in selling packages of pre-made axis deer antler beads, but he did not have the equipment to create his own beads if given axis deer antlers. He would be willing to pay \$1.00 for a one-pound package of antler beads, but he did not know for what price he would then sell that package to a craft store.

4.3.2 Hunter Survey

Responses were collected from members of hunting clubs, as well as customers of the Maui hunting guides. Additionally, some respondents who had taken the resident survey noted that they were hunters; these responses were inputted into this hunter data set because the surveys were identical. Two responses were labeled as incomplete within the Qualtrics software, so those were discarded from the data set, leaving a total of 45 responses. Respondents were allowed to skip questions while taking the survey, so although not every respondent answered every question; the vast majority of questions were answered by all 44 respondents. All respondents were currently registered hunters on Maui and all questions regarding axis deer hunting and control methods were specifically noted to be in the context of the island of Maui.

The majority (53.33%) of hunters noted that, compared to five years ago, they perceive that there are more axis deer on Maui (Figure 1). When asked about how this increased population should be managed, a combined total of 55.56% of hunters believed that populations should be either decreased or greatly decrease, but 37.78% noted that they think populations should remain as they are (Figure 2). The vast majority of hunters (82.22%) noted that they were very aware of the problems that are associated with axis deer overpopulation (Figure3).

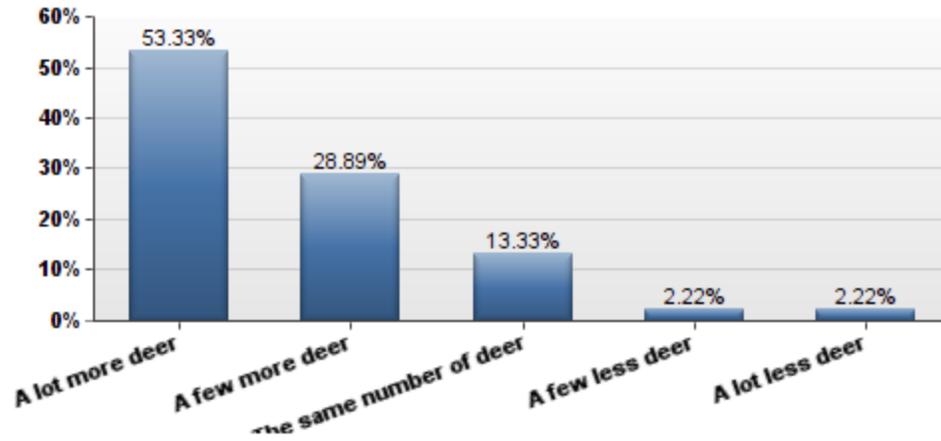


Figure 1. Hunters' beliefs about how axis deer populations have changed between five years ago and today.

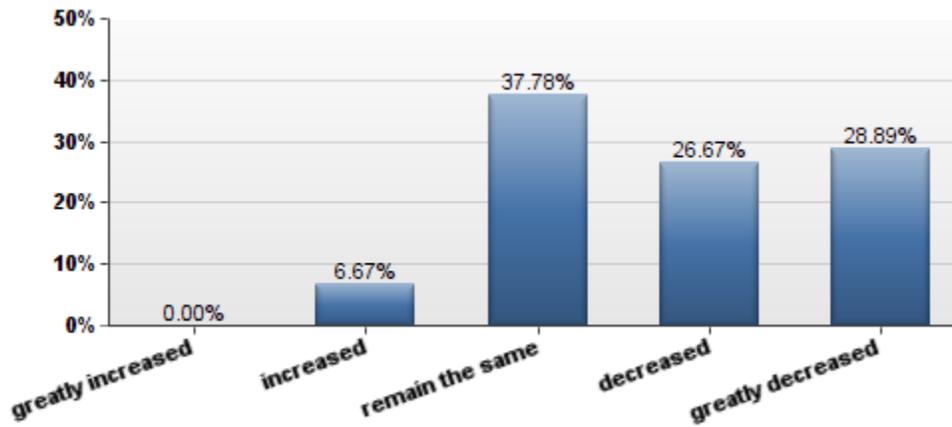


Figure 2. Hunters' beliefs about how current axis deer populations should be managed.

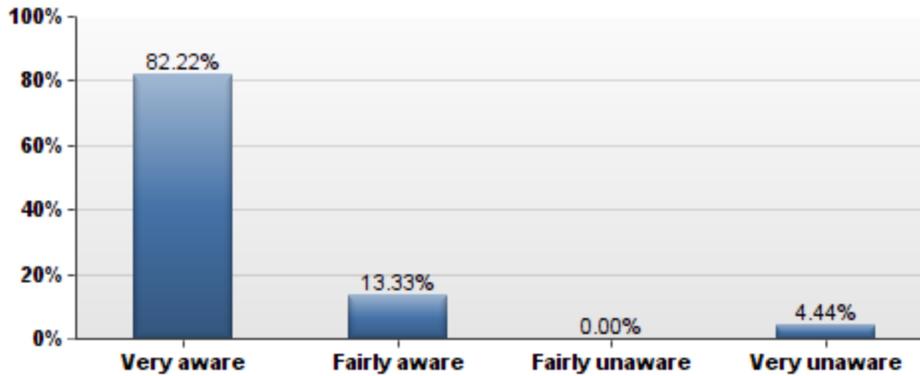


Figure 3. How aware hunters believe they are regarding axis deer population problems.

When asked to describe their hunting patterns within the past two years, the majority of hunter (60.00%) indicated that they primarily hunt axis deer, but also hunt a few other species; only 11.11% of hunters solely hunt axis deer. Additionally, 11.11% of hunters surveyed indicated that they never hunt axis deer (Figure 4). These hunters who never hunt axis deer were redirected within the survey to questions about management and hunting attitudes; they were not asked questions specific to where, how, and why they hunt axis deer.

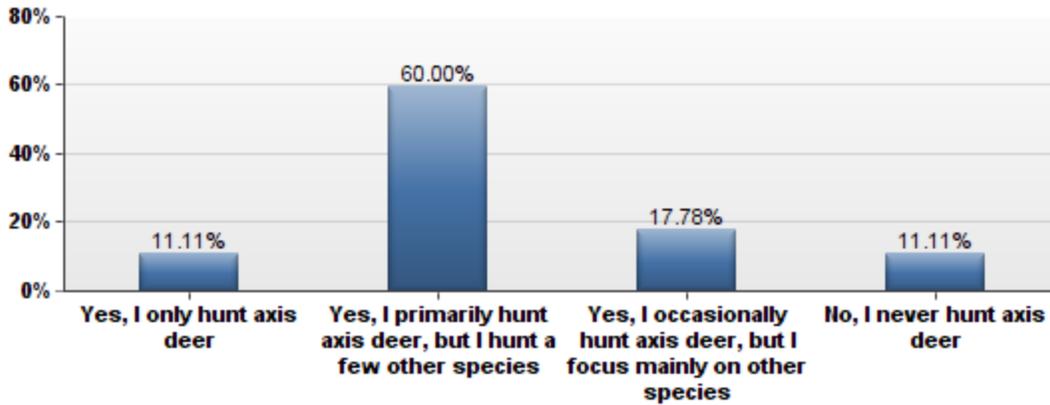


Figure 4. How often hunters hunt axis deer.

Of the hunters who at least occasionally hunt axis deer, 39.47% noted that they have hunted more than 30 days over the past two years on Maui (Figure 5). These hunters were also asked what sporting devices they have used in the past two years to hunt axis deer; multiple devices could be selected, but the vast majority (92.50%) utilize rifles for their hunting (Figure 6).

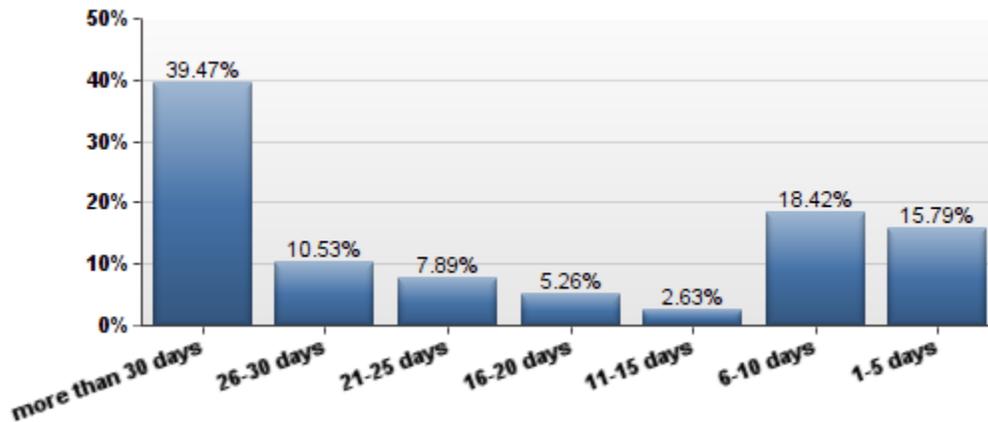


Figure 5. How many days hunters hunted axis deer in the past two years.

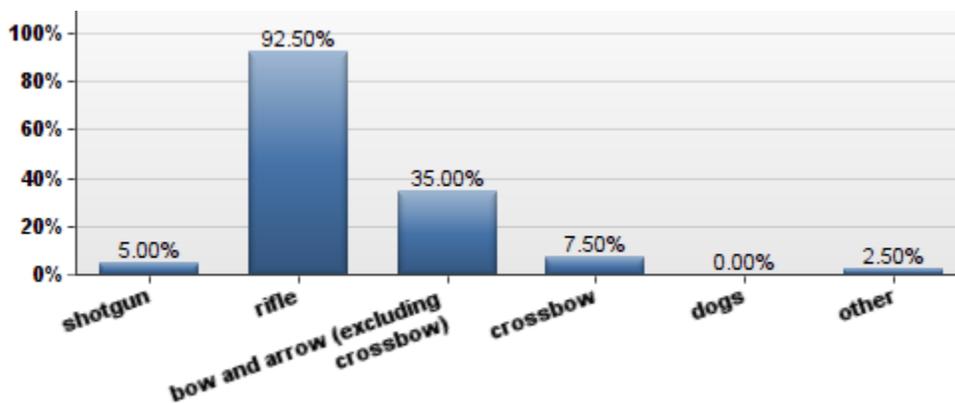


Figure 6. Sporting devices used by hunters to hunt axis deer in the past two years.

Hunters who at least occasionally hunt axis deer were also asked about their thoughts on the proposed hypothetical commercialized hunt where hunters who are interested in selling harvested carcasses could make a profit from their hunting. Approximately 30% of hunters noted that they do not foresee any problems with legalizing this kind of commercialized hunt, although 40.00% indicated they foresee a few and/or minor problems and 26.67% indicate they foresee many and/or serious problems (Figure 7). In the optional comments section, most comments noted potential issues with trespassing and poaching on private land. Another main area of concern was with ensuring meat safety; some noted the necessity of quickly processing the meat to ensure safety; one hunter commented, “My biggest concern is the regulation of the processing and harvest of the product and the accesses to the properties to harvest them”.

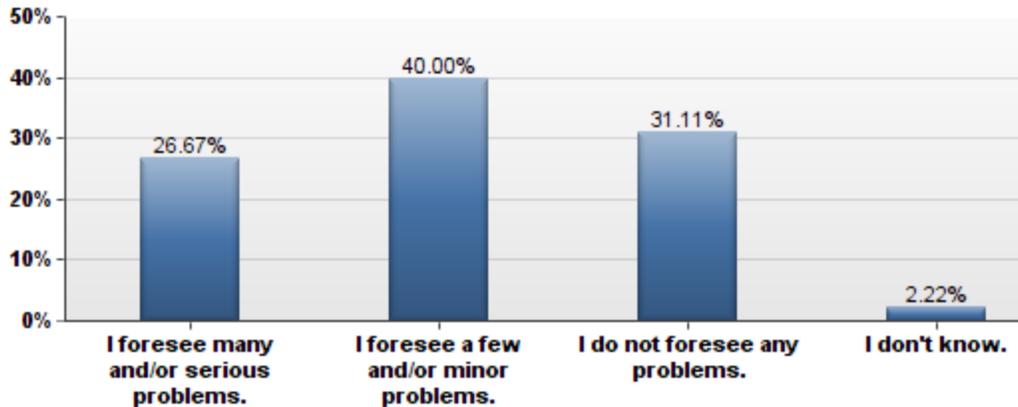


Figure 7. Hunters' beliefs about potential problems with a legalized commercialized hunt.

These hunters were then asked if they would be interested in participating in such a commercialized harvest and 46.15% indicated that they would be interested (Figure 8). Most people who took advantage of the optional comment area noted that they were interested because they saw this as an opportunity to decrease deer populations, leading to helping restore the native ecosystem. One hunter stated, “My opinion on this is that the whole idea or focus of deer hunting on Mau'i is controlling the population, not the commercialization of the harvest, it just so happens it's an incentive for the hunters. Controlling the population is to help prevent damages to crops and people's property”. Others commented on the fact that such a commercialized harvest would be a great way to utilize a valuable resource and not be wasteful. Again, there were comments noting concerns about meat handling and training necessary for quick processing to make sure the meat is safe.

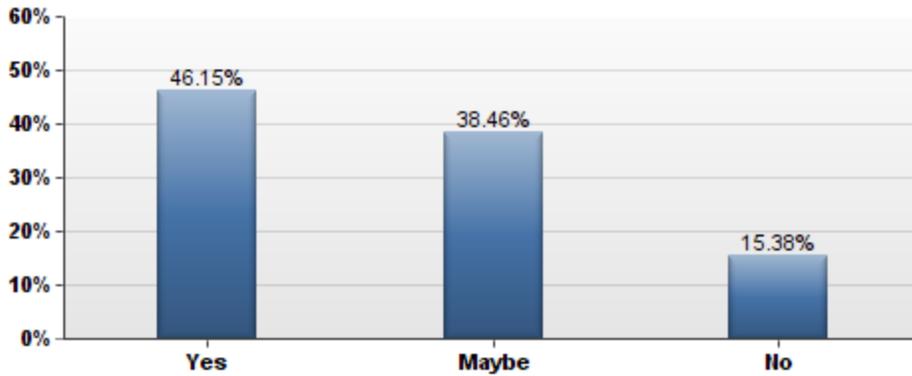


Figure 8. Hunters' interest in participating in a potential commercialized harvest.

Regardless of if they were interested in participating in a commercialized harvest or not, these hunters were also asked if their hunting behaviors would change if they could profit off of the deer carcasses they sold. A combined total of 58.34% indicated that they would either hunt much more often or a little more often and 36.11% noted they would not change their behavior at all (Figure 9). These hunters were also asked to respond to the statement: "I would benefit from being able to sell my axis deer harvest for a profit". Only a combined total of 35.00% either strongly agreed or agree with the statement and 42.50% neither agreed nor disagreed with the statement (Figure 10). In the optional comments section, many hunters noted that, although they hunt for the meat for their families, they like the idea of selling excess meat; "Once my freezer is full and my neighbors' freezers had meat, it would be really cool to sell it locally". Others did not like the idea of making hunting into an economic experience; "Hunting is personal and challenging experience between the deer and myself". Other hunters questioned their ability to make a profit because of the costs associated with axis deer harvesting; "By the

time you factor in what your time is worth, coupled with expenses such as 4 wheel drive vehicle, gas, and ammo (if you can get any) you'd be lucky to cover your expenses on most days!”.

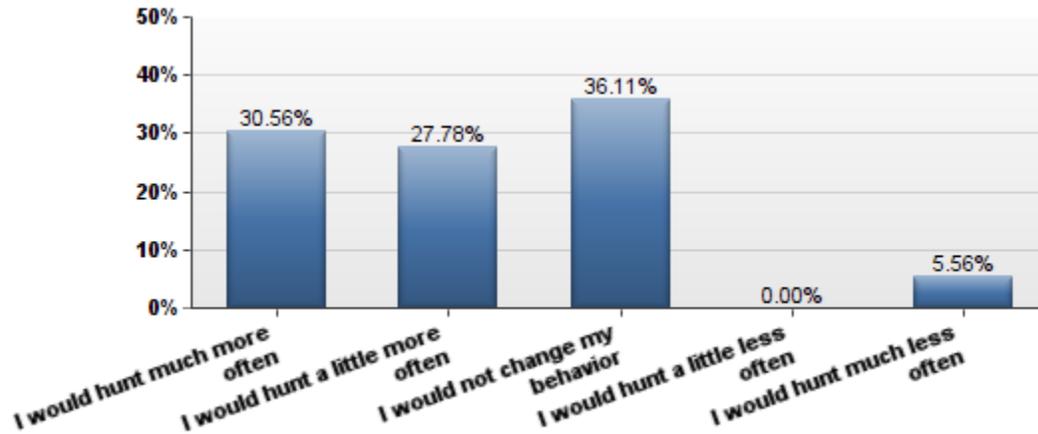


Figure 9. How hunters’ behavior would change if a commercialized hunt were legalized and they could profit off of deer carcasses they harvested and sold.

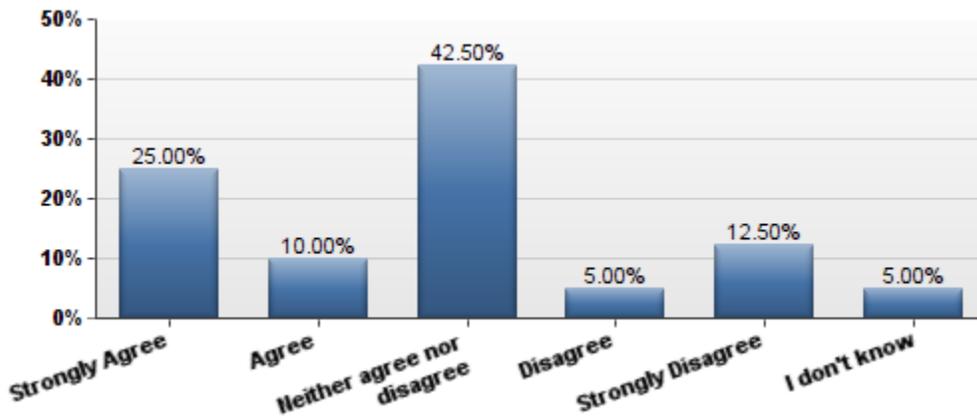


Figure 10. Hunters responded to the statement: “I would benefit from being able to sell my axis deer harvest for a profit”.

Axis deer hunters were also asked a series of questions about how and why they hunt. The majority of deer hunters (85.00%) indicated that they never utilize the services of a hunting guide when they hunt axis deer (Figure 11). Additionally, the majority of deer hunters (77.50%) noted that their primary reason for hunting deer was for the meat and 80.00% of deer hunters hunt on private land (Figure 12; Figure 13).

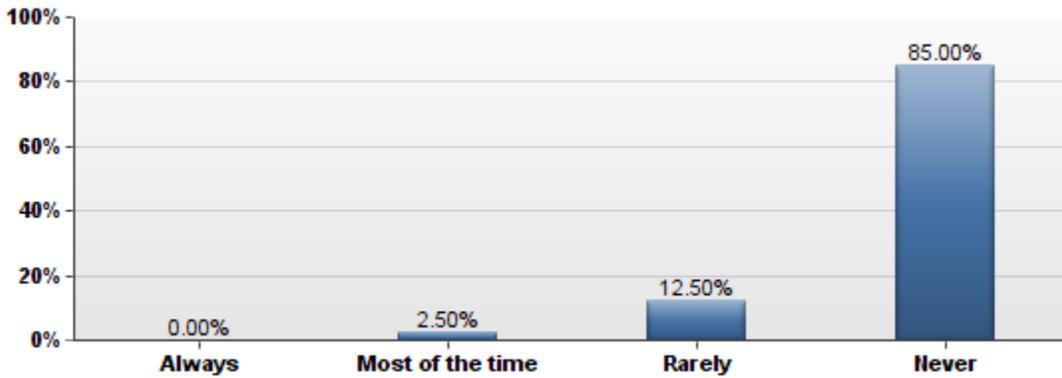


Figure 11. How often hunters utilize the services of a hunting guide when they hunt axis deer.

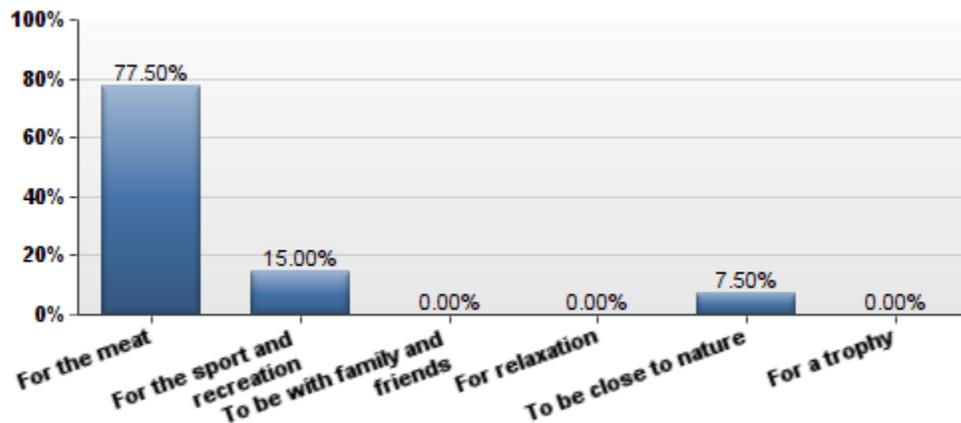


Figure 12. Hunters' most important reason for hunting axis deer in the past two years.

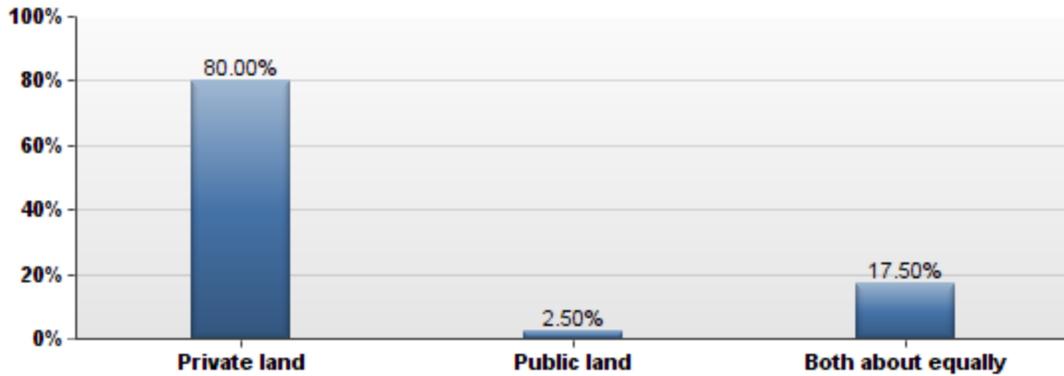


Figure 13. The type of land that hunters primarily used for hunting axis deer in the past two years.

All hunters, even those who indicated that they never hunt axis deer, were asked the following questions about axis deer management and control options. A combined total of 62.50% of respondents indicated that they thought educating other hunters about axis deer overpopulation problems would impact how they hunt axis deer (Figure 14). All respondents were also asked to note how they felt about various axis deer population control methods. Hunters were asked to indicate their level of support for a series of control methods (fencing, trap and transfer, contraceptives, recreational hunting, hired sharp shooting, commercial harvesting, and take no action) where they could mark a score on a scale of 1 (completely support) to 5 (do not support at all) for each method. Overall, recreational hunting was the most supported with an average scale score of 1.27 and contraceptives were the least supported with an average scale score of 4.05 (Table 5). Fencing and commercial harvesting, with respective average scale scores of 2.27 and 2.49, were the second and third most supported methods. The other control methods had average scale scores of greater than 3 (the neutral value), indicating that, in general, they

were “not supported” (Table 5). In the following question, hunters had to rank each of the seven methods, forcing respondents to order the methods based on preference. For this ranking question, recreational hunting was again the most supported method with an average ranking of 1.83, although take no action (populations should remain the same) was the least supported with an average ranking of 5.74 (Table 6). Again, fencing and commercial harvesting, with respective average rankings of 2.69 and 3.67, were the second and third highest ranked methods (Table 6).

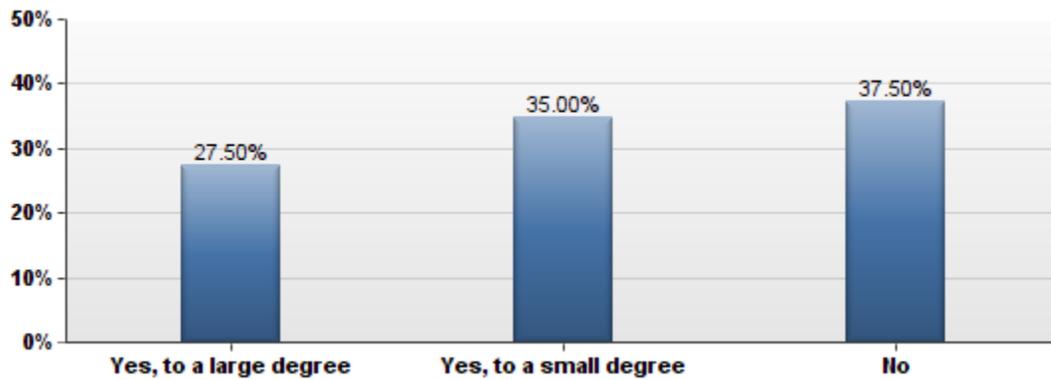


Figure 14. Hunters’ opinions regarding if educating other hunters about the problems caused by the overpopulation of axis deer on Maui would affect how they hunt axis deer.

Table 5. Number of answers per scale score and average scale scores of various control methods by hunters.

Method	1 (completely support)	2	3 (neutral)	4	5 (do not support at all)	Mean
Fencing	23	3	10	2	7	2.27
Trap-and-Transfer	11	3	5	3	23	3.53
Contraceptives	5	0	10	2	27	4.05
Recreational Hunting	39	2	3	0	1	1.27
Hired Sharp-shooting	10	4	10	4	16	3.27
Commercial Harvesting	18	8	6	5	8	2.49
Take No Action	6	4	8	1	26	3.82

Table 6. Number of answers per rank and average rank of various control methods by hunters.

Method	1 (most supported)	2	3	4	5	6	7 (least supported)	Mean
Fencing	10	11	9	8	2	2	0	2.69
Trap-and-Transfer	0	5	5	13	7	9	3	4.45
Contraceptives	1	1	5	5	10	15	5	5.07
Recreational Hunting	24	9	3	4	2	0	0	1.83
Hired Sharp-shooting	0	6	6	4	15	7	4	4.55
Commercial Harvesting	4	9	10	6	4	5	4	3.67
Take No Action	3	1	4	2	2	4	26	5.74

Overall, 68.18% of respondents own land on Maui and 31.82% do not own land on Maui; the majority of respondents (63.33%) own less than three acres (Figure 15). Those who indicated that they own land were asked if they had ever experienced axis deer damage and 50.00% noted they had and 50.00% noted they had not. When asked what type of damage the respondents had experienced, 73.33% indicated damage to landscaping or the yard and 53.33% indicated damage to crops (Figure 16). Of those who noted “other” damage, many respondents used the comment space to indicate that they had experienced damage to fences.

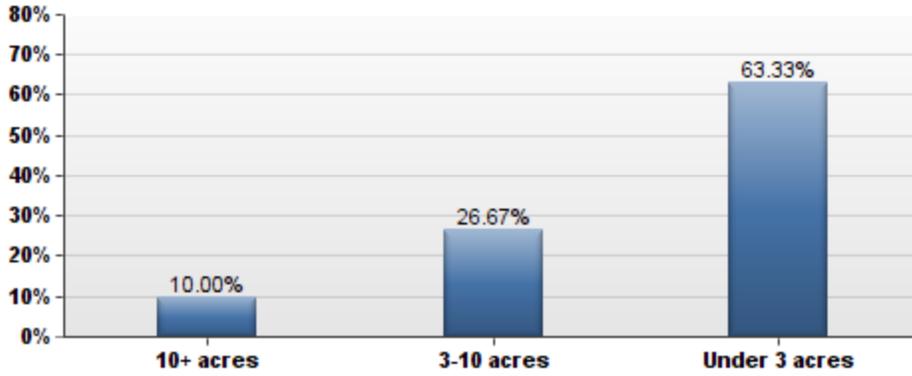


Figure 15. Amount of land owned by hunters who own land.

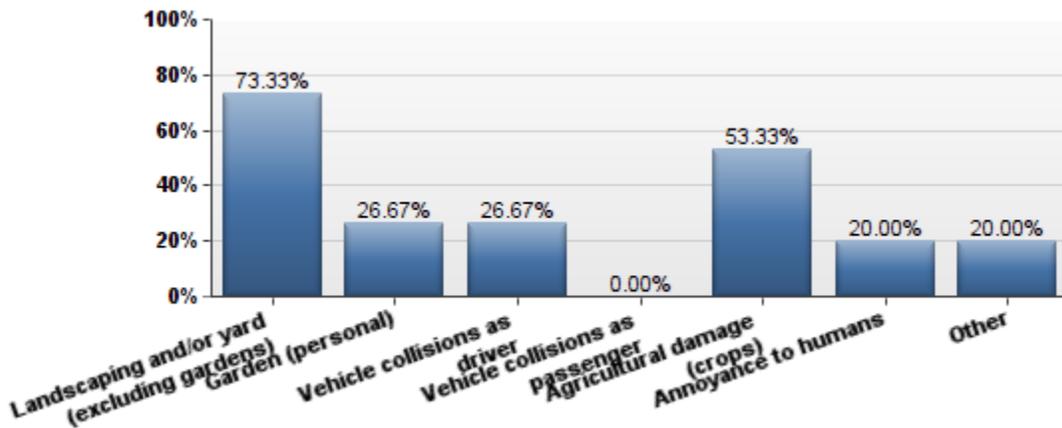


Figure 16. Types of damage recorded by hunter landowners who reported axis deer damage.

The collected demographic information indicates that 93.18% of respondents were male and 6.82% were female. The ages of respondents were fairly evenly distributed across the given age categories, although there were few respondents age 18 to 24 years old and no respondents under 18 years of age (Figure 17). In terms of education, all respondents had minimally a high school degree or equivalent, and 45.46%

of respondents had a bachelor’s degree or graduate degree (Figure 18). Additionally, most given categories of pre-tax 2012 incomes were represented (except for the \$250,000 and above), and the mode (30.23%) was the \$50,000 to \$74,999 range (Figure 19). The vast majority of respondents (97.78%) permanently reside on Maui and approximately 2% of respondents permanently reside on another Hawaii Island; no respondents indicated a permanent residence in another U.S. state nor a country other than the United States. Respondents were asked if they had additional comments at the end of the survey and two themes emerged. Many respondents noted that most deer are on private land, which makes any kind of hunting-based management difficult. Additionally, some respondents mentioned that the focus should be on hunting bucks for deer control; “Sadly 90% of hunters shoot the bucks. This has been proven throughout the world to fail. We ALL should be shooting as high as 20 does to 1 buck. The meat from does is also far superior to bucks”.

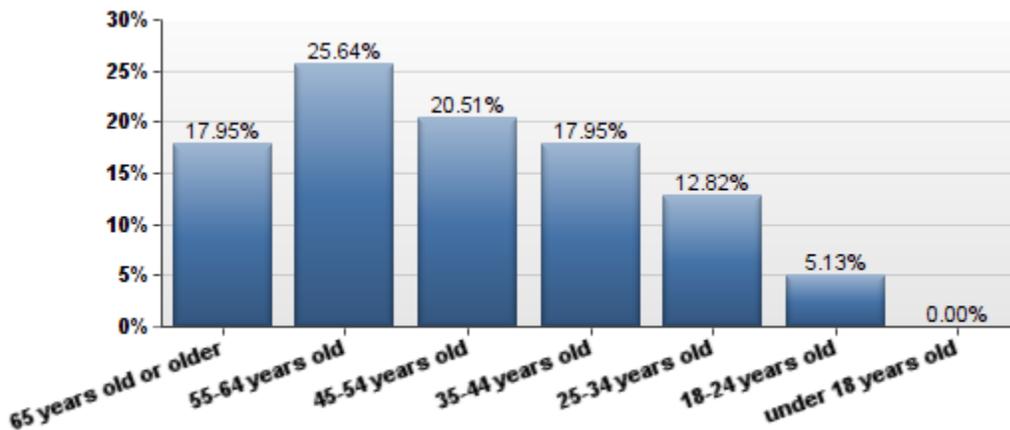


Figure 17. Age breakdown of hunters.

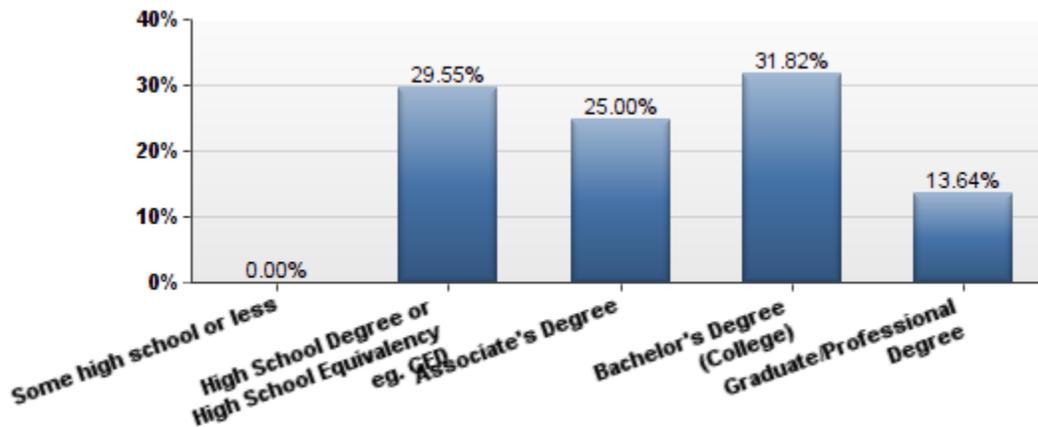


Figure 18. Highest education background of hunters.

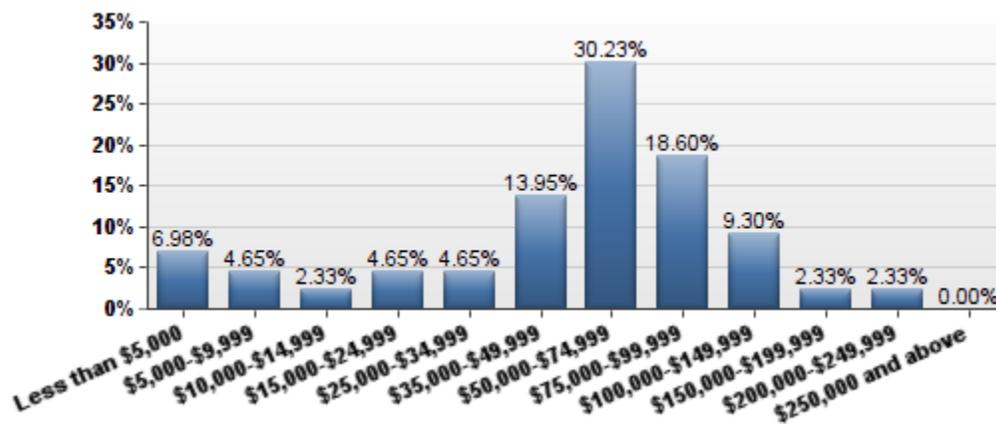


Figure 19. Annual pre-tax 2012 income of hunters.

I used these results to create a model to describe the types of hunters who hunt axis deer for more than 30 days in a two year period. The model describes hunters who hunt deer for more than 30 days as a function of beliefs about current deer populations, interest commercialized hunting, and demographic information. For this model, all variables were made into binary variables using results from the survey; the model is a

binary logistic model. The model describes that the hunters who spent *over 30 hunt days* = $B_0 + B_1(\text{belief that there are more deer now than 5 years ago}) + B_2(\text{belief that deer populations should be decreased}) + B_3(\text{awareness of overpopulation problems}) + B_4(\text{primarily or only hunt axis deer}) + B_5(\text{interested in participating in a commercialized hunt}) + B_6(\text{would hunt more often in response to a commercialized harvest}) + B_7(\text{would benefit from a commercialized harvest}) + B_8(\text{55 years of age or older}) + B_9(\text{male}) + B_{10}(\text{education of a bachelor's or graduate degree}) + B_{11}(\text{income of \$75,000 or higher}) + u.$

The dependent variable, *over 30 hunt days*, represents hunters who hunted axis deer for more than 30 days in a two year period, as opposed to hunters who spent 30 days or fewer hunting deer in a two year period. The independent variables were also all binary variables. Hunters counted within the *belief that there are more deer now than 5 years ago* variable believe that there are a lot more or a few more deer present in Maui compared to five years ago, as opposed to respondents who believe that there are the same, a few less, or a lot less deer present in Maui compared to five years ago. Hunters who believe that deer populations should be either decreased or greatly decreased were represented by the *belief that deer populations should be decreased* variable, whereas those who believe populations should remain the same, be increased, or be greatly increased were not included. Hunters counted within the *awareness of overpopulation problems* variable labeled themselves as very aware or fairly aware of problems caused by deer overpopulation, as opposed to those who labeled themselves as fairly unaware or very unaware of overpopulation problems.

Hunters who either only hunt axis deer or primarily hunt deer were included in the *primarily or only hunt axis deer* variable, whereas those who occasionally hunt deer were not included. The *interested in participating in a commercialized hunt* variable represented hunters who indicated they were interested in participating in a commercialized deer harvest, as opposed to those who indicated they were not interested or may be interested in participating. Hunters who noted they would hunt much more or a little more if a commercialized harvest were established were included in the *would hunt more often in response to a commercialized harvest* variable, and those who noted that they would not change their hunting behavior, would hunt a little less, or would hunt a lot less if a commercialized harvest were established were not included. Similarly, hunters who strongly agreed or agreed that they would benefit from a commercialized harvest were represented in the *would benefit from a commercialized harvest* variable, and those who neither agreed nor disagreed, disagreed, or strongly disagreed that they would benefit from a commercialized harvest were not represented.

For the demographic variables, those included in the *55 years of age or older* variable were either 55 years old or older and those who were not included were below the age of 55. Males were included in the *male* variable, as opposed to females, and those represented in the *education of a bachelor's or graduate degree* noted they earned a bachelor's, graduate, or professional degree and those who indicated they had completed some high school or less, earned a high school degree, or earned an associate's degree were not included. Finally, respondents who earned an annual income of \$75,000 or more

were included in the *income of \$75,000 or higher* variable, whereas those who earned less than \$75,000 per year were not represented by the variable.

Results of the regression indicate that no independent variables were found to be significant; this may be due to the very small sample size (Table 7). However, the signs on the coefficients can help describe the hunters who hunt axis deer more than 30 days in two years, to some degree. For example, it can be concluded that respondents who hunt axis deer more than 30 days in two years do not find that there are more axis deer on Maui currently, compared to five years ago (Table 7). Additionally, respondents who hunt axis deer more than 30 days in two years do believe that deer populations should either greatly decreased or decreased and they are very aware or fairly aware of problems caused by overpopulation (Table 7). Respondents who hunt axis deer more than 30 days in two years also either only hunt axis deer or primarily hunt axis deer. Interestingly, there are opposite signs on the *interested in participating in a commercialized hunt* variable and the *would hunt more often in response to a commercialized harvest* and the *would benefit from a commercialized harvest* variables. This is somewhat conflicting in that it indicates that respondents who hunt axis deer more than 30 days in two years are not interested in participating in a commercialized hunt, but they would hunt more if a commercialized harvest were put in place and they do believe that they would benefit from a commercialized harvest. Demographically, respondents who hunt axis deer more than 30 days in two years are age 55 or older, are female, have an educational degree lower than a bachelor's degree, and have an annual income of greater than \$75,000 (Table 7).

Table 7. Regression results for respondents who hunt axis deer more than 30 days in two years.

Independent Variable	Coefficient	Std. Error	P-value
belief that there are more deer now than 5 years ago	-1.451	1.439	0.313
belief that deer populations should be decreased	0.144	1.592	0.928
awareness of overpopulation problems	21.133	40192.960	1.000
primarily or only hunt axis deer	21.387	14549.916	0.999
interested in participating in a commercialized hunt	-1.500	1.285	0.243
would hunt more often in response to a commercialized harvest	0.046	1.900	0.981
would benefit from a commercialized harvest	0.156	2.462	0.949
55 years of age or older	0.859	1.275	0.500
male	-1.369	2.330	0.557
education of a bachelor's or graduate degree	-1.437	1.260	0.254
income of \$75,000 or higher	1.270	1.178	0.281
constant	-39.923	42745.458	0.999

**significant at the 1% level

*significant at the 5% level

This model can be helpful in making axis deer management decisions because it provides attitudinal and demographic information about frequent hunters—an important stakeholder group in deer management on Maui. Using this model, wildlife management agencies, like the Maui Axis Deer Working Group, can specifically address attitudes and opinions that frequent hunters have and they can use this information to educate frequent hunters and fill in knowledge gaps. It appears that frequent hunters are educated about the problems that overabundant axis deer populations cause, which explains why they also generally agree that populations should be decreased (Table 7).

However, this binary logistic model also indicates that hunters who spend less than 30 days hunting axis deer over the course of two years are generally more unaware of problems caused by axis deer overpopulation and they do not believe that populations need to be decreased (Table 7). This could be considered an opportunity to increase

education to this sub-group of hunters, especially because 62.50% of survey respondents indicated that they thought educating other hunters about axis deer overpopulation problems would impact how they hunt axis deer either to a large degree or a small degree (Figure 14). Other variables appear to be logically consistent with respondents who hunt deer 30 or fewer days in two years: it could be expected hunters who spend fewer days hunting deer only occasionally hunt deer, as opposed to only or primarily hunt deer. Additionally, it makes sense that hunters who less frequently hunt axis deer may not benefit from a commercialized harvest and may not increase how much they hunt if a commercialized harvest were to be established (Table 7). Future work could expand this model by surveying respondents about different beliefs and knowledge gaps so educational outreach could focus on these areas.

I also ran a test to explore the correlations between several variables in this hunter data set and several variables were correlated. In addition to several of the variables noted earlier in the model, I included the *do not foresee problems with a commercialized hunt* variable which represents respondents who did not foresee problems with legalizing a commercialized hunt, as opposed to respondents who foresee many and/or serious problems or few and/or minor problems with legalizing a commercialized hunt. Respondents' belief that populations should be decreased was correlated at the 0.05 level with the belief that that are more deer currently present on Maui than compared to five years ago (Table 8). Additionally, the fact that respondents do not foresee problems with legalizing the hypothetical commercialized harvest is correlated at the 0.01 level with the belief that populations should be decreased (Table 8). Respondents' belief that

populations should be decreased is correlated at the 0.05 level with both an interest in participating in a commercialized harvest and the belief that respondents would benefit from a commercialized harvest (Table 8). The fact that respondents do not foresee problems with legalizing the hypothetical commercialized harvest is correlated at the 0.05 level with an interest in participating in a commercialized harvest and at the 0.01 level with the belief that respondents would benefit from a commercialized harvest (Table 8). The belief that respondents would benefit from a commercialized harvest is also correlated at the 0.01 level with an interested in participating in a commercialized harvest and the fact that respondents would hunt more often if a commercialized harvest were to be established (Table 8). Understanding the relationships between all of these variables is important for exploring the belief structures that hunters have about both axis deer management and the potential axis deer venison industry supplied by a commercialized harvest.

Table 8. Correlation between select hunter variables.

	more deer now	populations should be decreased	aware of over- population problems	do not foresee problems with commercialized hunt	interested in a commercialized hunt	would hunt more often if commercialized hunt
populations should be decreased						
Pearson						
Correlation	0.352*					
Sig. (2-tailed)	0.026					
N	40					
aware of over- population problems						
Pearson						
Correlation	0.196	0.241				
Sig. (2-tailed)	0.225	0.134				
N	40	40				
do not foresee problems with commercialized hunt						
Pearson						
Correlation	0.136	0.474**	0.141			
Sig. (2-tailed)	0.402	0.002	0.384			
N	40	40	40			
interested in a commercialized hunt						
Pearson						
Correlation	-0.103	0.341*	-0.175	0.334*		
Sig. (2-tailed)	0.532	0.033	0.286	0.038		
N	39	39	39	39		
would hunt more often if commercialized hunt						
Pearson						
Correlation	0.089	0.198	0.011	0.249	0.238	
Sig. (2-tailed)	0.585	0.221	0.944	0.121	0.144	
N	40	40	40	40	39	
would benefit from a commercialized hunt						
Pearson						
Correlation	0.062	0.383*	-0.072	0.487**	0.487**	0.698**
Sig. (2-tailed)	0.704	0.015	0.658	0.001	0.002	0.000
N	40	40	40	40	39	40

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

4.3.3 Resident Survey

It is impossible to differentiate which responses were derived from which method of distribution, but it appears that the Facebook post by the *Maui Now* newspaper may have generated the most responses; based on the time-stamp of the response, 101 responses were submitted online within 24 hours of when the Facebook status was posted. Additionally, the post received 31 “likes” (people showing support for the post) and 41 “shares” (people creating a link from the original *Maui Now* post to their own Facebook profiles to share with their friends) within the first 24 hours. People were also able to comment on the Facebook post and many people thanked the newspaper for sharing an outlet where they could voice their views; “Mahalo for including our opinions!”. Others commented on the idea of a commercialized harvest; “This is a no brainer. The deer population is exploding on Maui. We have some of the best quality venison in world. If you could buy fresh, local, healthy venison from a store wouldn't you?? It's a great resource. Let's use it”. Some people also simply commented on the idea of eating deer meat; “Yes, I would love to buy deer meat from the store” and “Yummy”. Of the 1,000 mailed letters seeking survey responses, 169 of them were returned to sender.

Nine responses were labeled as incomplete within the Qualtrics software, so those were discarded from the data set. Additionally, five responses were removed from the data set because the respondent was not currently living in Maui, nor had they lived there in the past two years. As a result, the total data set consisted of 164 responses.

Respondents were allowed to skip questions while taking the survey, so although not

every respondent answered every question; the vast majority of questions were answered by all respondents. All respondents currently live in Maui, or have lived there within the past two years, and all questions regarding axis deer hunting and control methods were specifically noted to be in the context of the island of Maui.

The majority (59.15%) of respondents indicated that they have consecutively lived on the island of Maui for more than 15 years and 70.12% of respondents own land on Maui and 29.88% do not own land on Maui (Figure 20). Of those who own land, 86.09% own fewer than three acres (Figure 21). Of these landowners, 27.19% indicated that they have experienced some kind of damage from deer and 72.81% indicated that they have not experienced some kind of damage from deer. Respondents could select multiple types of damage and, again, landscaping and/or yard damage and agricultural damage were the two most prevalent types (67.74% and 45.16%, respectively) (Figure 22). The “other” types of damage identified by respondents included competition for grass in cattle pastures, fence damage, and damage to native forests and plants.

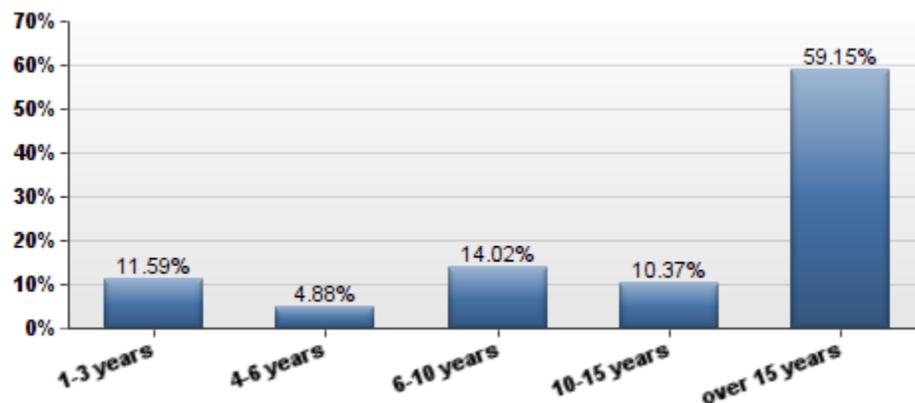


Figure 20. Number of consecutive years residents have lived on the island of Maui.

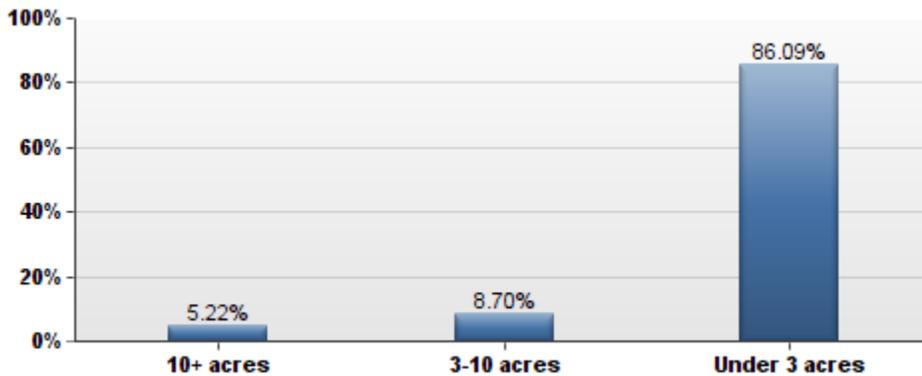


Figure 21. Amount of land owned by residents who own land.

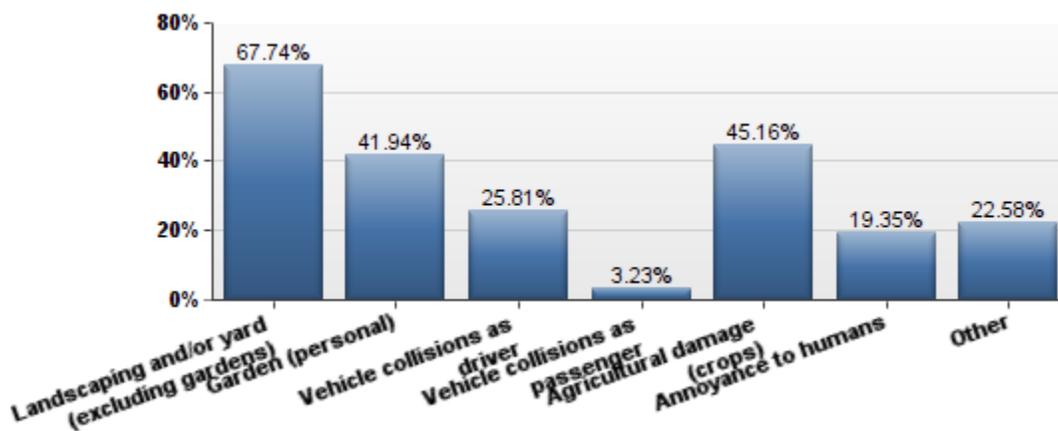


Figure 22. Types of damage recorded by hunter landowners who reported axis deer damage.

Again, the majority of respondents (72.37%) believed that there are a lot more axis deer found on Maui today than compared to five years ago (Figure 23). A combined total of 82.39% residents believe that populations should either be decreased or greatly decreased (Figure 24). Again, respondents generally identify themselves as being very

aware or fairly aware of problems caused by axis deer overpopulation (54.60% and 39.88%, respectively) (Figure 25).

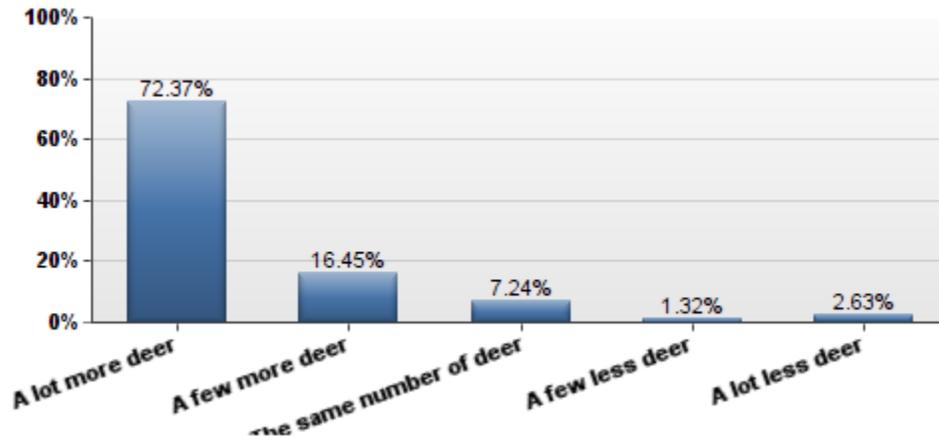


Figure 23. Residents' beliefs about how axis deer populations have changed between five years ago and today.

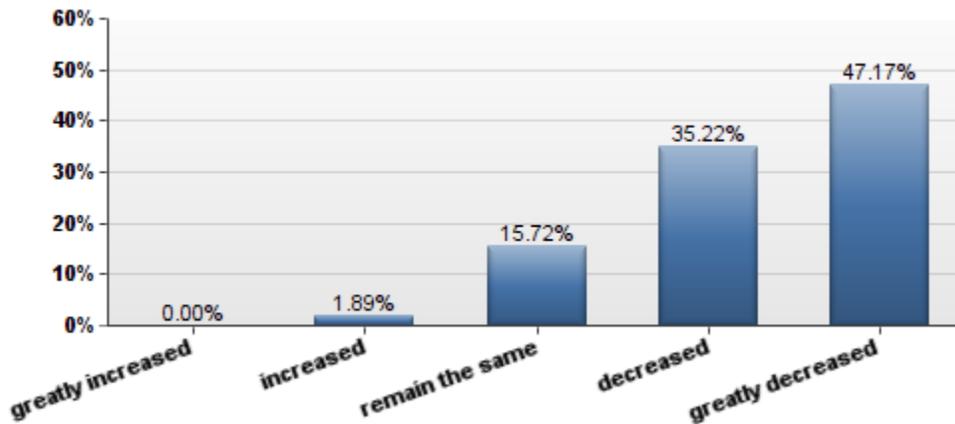


Figure 24. Residents' beliefs about how current axis deer populations should be managed.

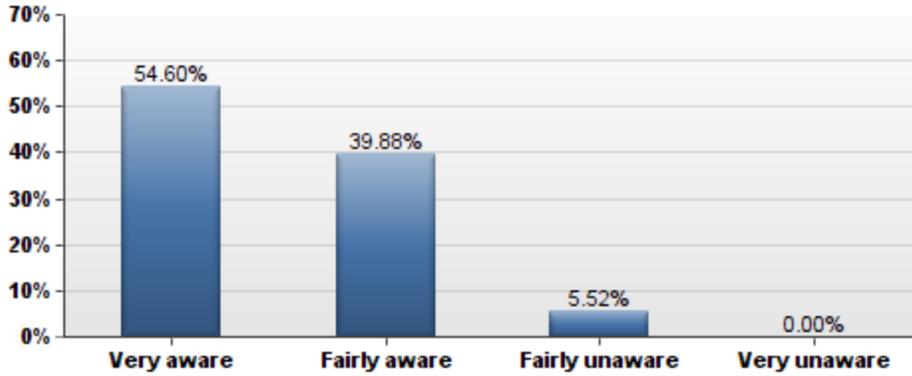


Figure 25. How aware residents believe they are regarding axis deer population problems.

Residents were also asked about the potential problems they foresee with the legalization of the hypothetical commercialized hunt. Overall, fewer residents (16.05%) foresee many and/or serious problems, compared to hunters who felt the same way (26.67%) and more residents do not foresee any problems (36.42%), compared to hunters (31.11%) (Figure 26; Figure 7).

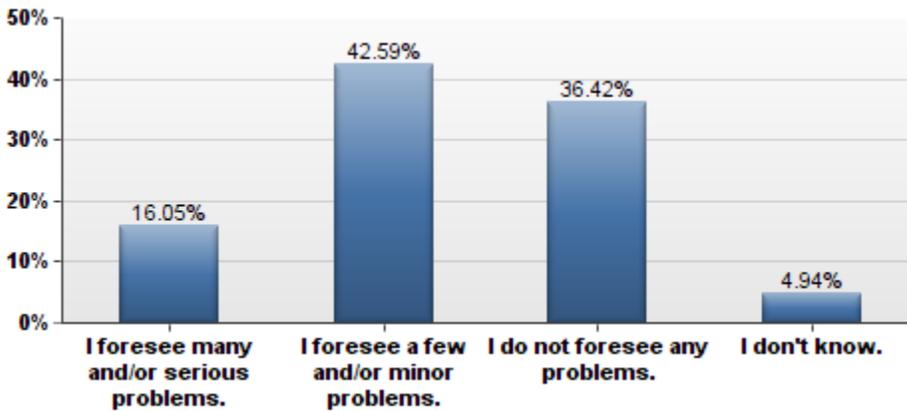


Figure 26. Residents' beliefs about potential problems with a legalized commercialized hunt.

Many people took advantage of the optional comment area and a range of positive and negative comments were provided. A total of 11 comments were focused on health concerns and the necessity of safety regulations, 7 comments were about trespassing and poaching concerns on private land, and 5 comments were regarding the need for hunting regulations for hunters. Others commented on hunting-related issues including safety concerns because inexperienced hunters driven by the economics of a commercialized harvest may act irresponsibly, concerns about people hunting too close to residential areas, and concerns about rifle hunting because the noise can be disturbing to communities (the respondent suggested only allowing bow hunting instead). Some respondents focused on logistical issues including the need for processing facilities, competing land uses between hikers and hunters, and the need for more public hunting land because most deer now are on private land. Some respondents were against the idea of hunting for a profit, some noted they would like to see meat go to shelters first, and others were against hunting as a whole. Others believed that a commercialized harvest should only be available to local hunters, not out of state hunters, and one person noted that they believe “any commerce with the US gov’t is unwelcome”. Finally, some people stated that they do not find the deer to be a problem, while others worried about the potential for accidental eradication.

Seventeen respondents commented on the positive potential of a commercialized hunt. Several people commented on the delicious taste of the meat, as well as the fact that it is local and sustainable; “I believe the majority of people who have lived on Maui for many years or are from here would opt for culling the herd and providing food for anyone

wanted deer meat. This is a great idea!”. Many noted the fact that a commercialized hunt could accomplish several beneficial goals at once; “Great idea. It's a win win! Much better to make game that is here on Maui available especially since the deer are a problem to farmers. Also more sustainable choice for people who eat meat than all the factory farm meat that is shipped here”, although others note that a commercialized harvest may not significantly decrease populations; “I think it’s a great idea, but don’t think it will affect the deer population very much!”. Several respondents commented on their observations of how axis deer have caused “extreme devastation” among native plants. One respondent noted that he plants native Hawaiian trees every day and he has seen years of growth “wiped out” in one night; he adds, “It is not easy to fence off all land where I plant trees. Ecosystems and watersheds locally are damaged and can not return if ungulates continue to over graze. Their population will grow and grow until all plants are gone. I support 100% the sale of local game meats”. Others commented that a commercialized harvest would help enhance the local economy because it is more eco-friendly than “bringing in more tourists”.

Residents were also specifically asked if they were purchase various axis deer products from commercialized harvest efforts. The majority (76.62%) indicated that they would be interested in buying axis deer meat at a store or as a dish in a restaurant; 10.39% of respondents who were not interested in purchasing meat are vegetarians (Figure 27). Respondents commented mostly about the taste of the meat; “I have had the opportunity to eat local axis deer meat, and it is incredible - like no venison I've had anywhere else!”. Some people indicated that they are hunters and would not buy axis

deer in stores because they can hunt it themselves, but other hunters liked the idea of having access to the venison without hunting:

I am a licensed hunter. I don't go very often, but when I do, it is the best tasting local organic meat. I wish I could have access to it more often so I don't have to go through the field dressing and butchering process any time I want to eat venison. It is a lot of work to hunt animals. I would love to support local people who need the work, and feel really good about protecting the health of the land at the same time. It is a win win situation if you ask me.

Again, some people felt that commercially harvested venison should only be available locally and should not be exported to other states or countries:

In Hawaii, there is so much food imported here because all of the better products are exported. This drives up the price of local food so local people can not afford to eat... We need to keep some resources here in Hawaii to uphold the quality of life here and also at the same time stabilize the economy.

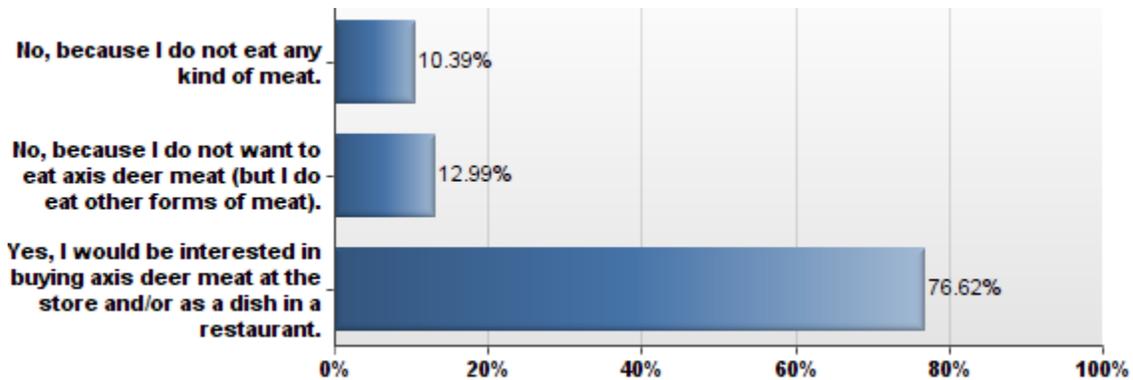


Figure 27. Residents' interest in purchasing axis deer meat to either prepare themselves or at a restaurant.

Residents were also asked if they would be interested in purchasing pet food made with axis deer meat or chew toys made from deer parts, such as bones, antlers, and

hooves. A total of 57.60% of respondents indicated that they would be interested in either the pet food or chew toys or both; 19.62% of respondents who were not interested in these products do not have a pet (Figure 28). Most people who commented praised the idea as an innovative way to use as much of the harvest as possible and to minimize waste. Others noted that they would rather see venison used for human consumption first. Some respondents were interested, as long as the pet products are affordable, and a few others indicated concern about feeding pets locally harvested meat.

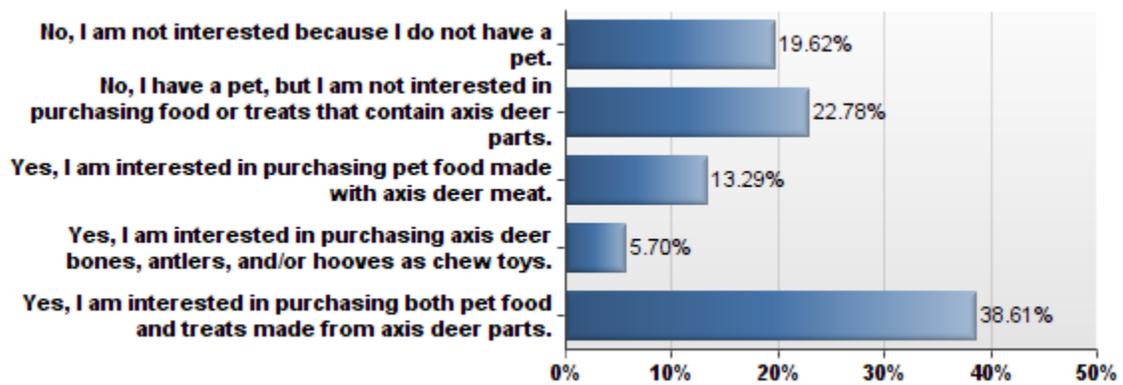


Figure 28. Residents' interest in purchasing pet food made with axis deer meat and/or chew toys made from axis deer parts.

Residents were also asked about their interest in purchasing jewelry made with axis deer antler beads. This type of product received the least amount of interest with only 35.03% indicating interest in such jewelry (Figure 29). In the optional comments, the most discussed theme was that the jewelry should not be labeled as “Hawaiian” because the axis deer are not native, thus jewelry made from these products should not be

considered native jewelry. Others notes that, although they liked the idea of using the whole harvested animal, this kind of jewelry is not their style.

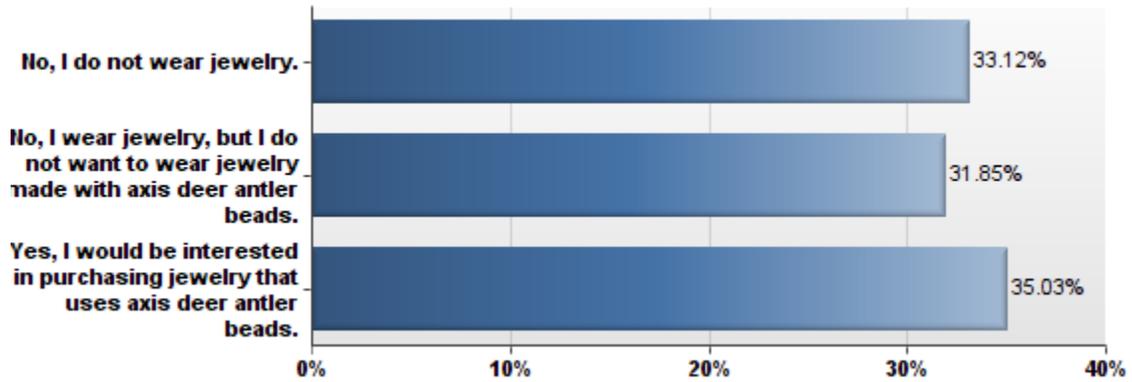


Figure 29. Residents' interest in purchasing jewelry made with axis deer antler beads.

In addition to understanding residents' interest in axis deer products, respondents were also asked if they thought educating other consumers about axis deer overpopulation problems would impact if they purchased axis deer products. A combined total of 78.84% residents indicated that they believe educating consumers would affect if they purchase axis deer products to a large or small degree (Figure 30).

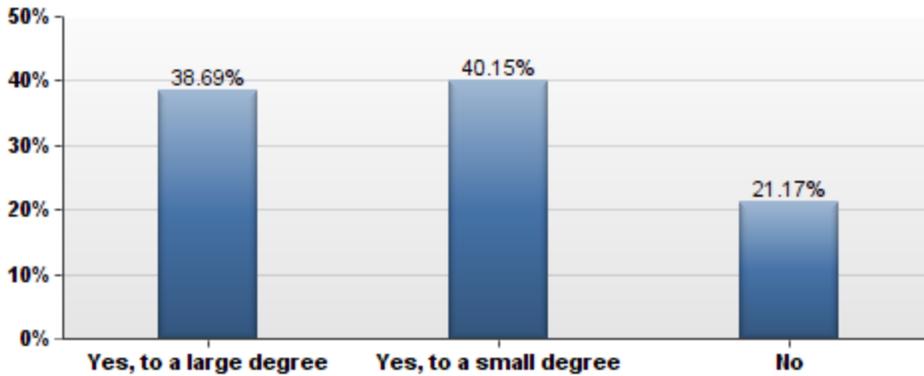


Figure 30. Residents’ opinions regarding if educating other citizens about the problems caused by the overpopulation of axis deer on Maui would affect if they purchase axis deer products.

Residents were also asked about their attitudes towards the seven axis deer population control methods discussed earlier. Residents were asked to indicate their level of support for each method using the scale score (1 for completely support through 5 for do not support at all), as well as using the ranking method. For the scale question, residents most preferred recreational hunting with an average scale score of 1.58, with commercialized harvesting and fencing coming in as the second and third most supported options (average scale scores of 1.99 and 2.09, respectively) (Table 9). Take no action was the least supported with an average scale score of 4.42 (Table 9). It is important to note that all control methods except for take no action were considered “supported” in that they had average scale scores of less than 3 (natural). The ranking question was consistent with the scale question in that recreational hunting was the highest ranked (an average ranking of 2.52) and commercialized harvesting and fencing came in second and

third ranked (average rankings of 3.11 and 3.23, respectively) (Table 10). Again, take no action was ranked the lowest with an average ranking of 6.44 (Table 10).

Table 9. Number of answers per scale score and average scale scores of various control methods by residents.

Method	1 (completely support)	2	3 (neutral)	4	5 (do not support at all)	Mean
Fencing	82	22	27	12	15	2.09
Trap-and-Transfer	55	11	22	16	52	2.99
Contraceptives	59	9	33	14	42	2.82
Recreational Hunting	121	15	5	4	14	1.58
Hired Sharp-shooting	60	19	23	17	39	2.72
Commercial Harvesting	92	25	13	9	20	1.99
Take No Action	9	3	16	11	113	4.42

Table 10. Number of answers per rank and average rank of various control methods by residents.

Method	1 (most supported)	2	3	4	5	6	7 (least supported)	Mean
Fencing	26	31	24	34	19	15	0	3.23
Trap-and-Transfer	3	16	24	34	29	39	4	4.36
Contraceptives	22	15	20	15	39	29	9	4.05
Recreational Hunting	53	34	22	21	11	6	2	2.52
Hired Sharp-shooting	7	18	27	22	36	28	11	4.28
Commercial Harvesting	36	33	26	18	10	20	6	3.11
Take No Action	2	2	6	5	5	12	117	6.44

A total of 18.87% of respondents for the resident survey are currently hunters and 81.13% are not hunters; as mentioned previously, responses from hunters in this resident survey were included in the hunter survey data. Although the gender split was more even in this resident survey with 51.92% male and 48.08% female, the age breakdown was

similar to that of the hunter survey; again, the mode (31.94%) fell into the 55 to 64 age category and no respondents were under 18 years of age (Figure 31). Almost all respondents have at least a high school degree and, again, most respondents had a bachelor's degree or higher (Figure 32). Similar to the hunter survey, the pre-tax annual income mode (25.00%) was the \$50,000 to \$74,999 income range and all given categories of pre-tax 2012 incomes were represented (Figure 33). Again, the vast majority of respondents (92.41%) permanently reside on Maui; approximately 5% of respondents permanently reside on another Hawaiian Island, approximately 3% permanently reside in a different U.S. state, and approximately 1% reside in a different country.

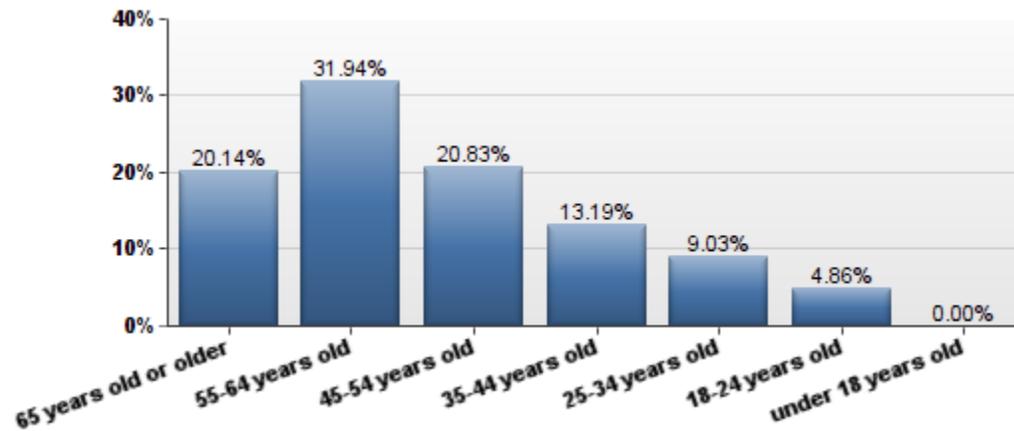


Figure 31. Age breakdown of residents.

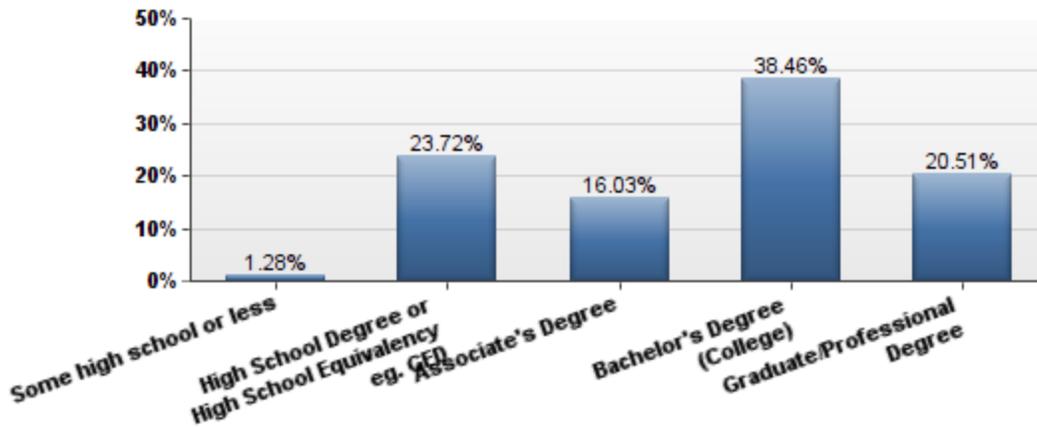


Figure 32. Highest education background of residents.

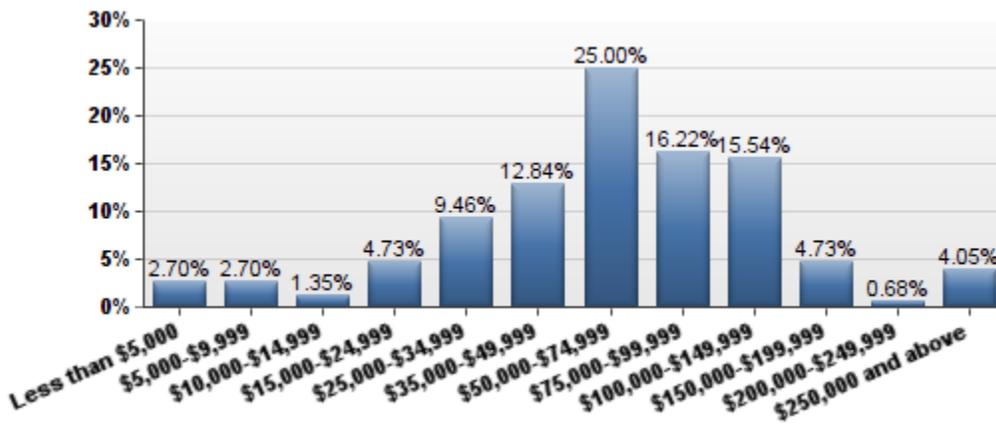


Figure 33. Annual pre-tax 2012 income of residents.

Respondents were asked if they had additional comments at the end of the survey and many people were grateful for the opportunity to share their opinions about axis deer; “I appreciate this survey and hope that Maui County can find a humane solution to our deer concerns”. Others noted the challenges associated with axis deer management; “[Axis deer are] a major problem with catastrophic results if we are unable to stop the

rapid increase in numbers of axis deer. Any and all measures should be taken to reduce and control their numbers. Granted this is difficult to accomplish when so many residents have the "Bambi" view". A few people even indicated that they would prefer eradication over any other type of control.

I used results from this resident survey to create a model to describe the types of residents who would be interested in purchasing axis deer meat at a store or at a restaurant. The model describes residents who would be interested in purchasing deer meat as a function of beliefs about current deer populations, attitudes towards commercialized hunting, and demographic information. For this model, all variables were made into binary variables using results from the survey; the model is a binary logistic model. The model describes that residents *interested in purchasing deer meat* = $B_0 + B_1(\text{hunter}) + B_2(\text{belief that there are more deer now than 5 years ago}) + B_3(\text{belief that deer populations should be decreased}) + B_4(\text{awareness of overpopulation problems}) + B_5(\text{do not foresee problems with legalizing a commercialized harvest}) + B_6(\text{55 years of age or older}) + B_7(\text{male}) + B_8(\text{education of a bachelor's or graduate degree}) + B_9(\text{income of } \$75,000 \text{ or higher}) + u$.

The dependent variable, *interested in purchasing deer meat*, represents residents who would be interested in purchasing axis deer meat from a store or restaurant, as opposed to residents who would not be interested in purchasing axis deer meat or residents who do not eat meat. The independent variables are also all binary variables; the explanations of each independent variable can be found in the previous section. The only

additional variable was the *hunter* variable, which represents residents who own a Maui hunting license, as opposed to residents who do not.

Results of the regression indicate that the independent variable found to be significant was the *belief that deer populations should be decreased* variable; this indicates that the belief that deer populations should be decreased results in an interest in purchasing axis deer meat (Table 11). Although the remaining independent variables were not significant in this model, the signs on the coefficients can still help describe residents interested in purchasing axis deer meat, to some degree. The positive coefficient on the *hunter* variable is logical because hunters often eat deer meat and thus they are probably not against the idea of selling deer meat (Table 11). Additionally, the positive coefficients for the *belief that there are more deer now than 5 years ago* variable and *do not foresee problems with legalizing a commercialized harvest* variables are expected because respondents who believe there are more deer on Maui now than compared to five years ago may be interested in purchasing meat from a commercialized harvest, and would support a commercialized hunt, because they want to see populations decrease (Table 11). The negative coefficient on the *awareness of overpopulation problems* variable is unexpected because respondents who are aware of overpopulation problems should want to see decreased populations, and would thus support products from a commercialized harvest (Table 11).

Table 11. Regression results for respondents who are interested in purchasing axis deer meat.

Independent Variable	Coefficient	Std. Error	P-value
hunter	19.282	7882.485	0.998
belief that there are more deer now than 5 years ago	0.428	0.621	0.491
belief that deer populations should be decreased	1.289	0.649	0.047*
awareness of overpopulation problems	-0.142	0.961	0.882
do not foresee problems with a commercialized harvest	1.088	0.581	0.061
55 years of age or older	-0.157	0.502	0.755
male	0.239	0.496	0.630
education of a bachelor's or graduate degree	-0.336	0.504	0.505
income of \$75,000 or higher	-0.657	0.477	0.168
constant	-0.076	0.984	0.938

**significant at the 1% level

*significant at the 5% level

As with the earlier hunter data-based regression, this model can be helpful for educational planning purposes for wildlife management agencies. However, this model can also help with marketing for axis deer venison and other products resulting from a commercialize harvest. Because axis deer products are essentially a new industry, those looking to make a commercialized harvest profitable and successful must make sure that their consumers are educated about axis deer products. Additionally, this model, and similar models that can be created to expand on this one, can be used to target advertisements. Advertisers can target campaigns to consumers in select, significant demographics to educate consumers about the benefits of axis deer meat, perhaps by educating consumers as to the overpopulation problems associated with axis deer because a combined total of 78.84% residents indicated that they believe educating consumers would affect if they purchase axis deer products to a large or small degree (Figure 30).

4.3.3.1 Only Hunters Filter

To compare and contrast some of the data, I filtered out the responses to select questions by only hunters (hunter residents) and only non-hunters (non-hunter residents); some questions by hunter residents are not included in this section because they are the same as questions outlined and discussed in the hunter survey section.

One particularly important selection of questions for both hunters and non-hunters is their level of interest in axis deer products. Although in the comments section some hunter residents noted that they hunt, so they do not need to purchase axis deer meat in a store, 100% of hunter residents indicated that they would be interested in purchasing deer meat in a store or restaurant in response to the survey question (Figure 34). Despite the fact that the survey question results and comments are obviously not consistent, it can be assumed that hunter residents who commented that they would not need to purchase deer meat because they can hunt it themselves are merely showing support for the idea of selling commercially harvested axis deer venison, even if they have no need for the product. Hunter residents' interest in purchasing axis deer pet products is somewhat greater than the interest of all residents; a combined total of 72.41% of hunter residents were interested in pet food made with axis deer meat, chew toys made from axis deer parts, or both, compared to a combined total of 57.60% % of all residents who were interested in those products (Figure 35; Figure 28). A similar trend was seen for resident hunters' interest in jewelry made with axis deer antler beads; 53.57% of resident hunters indicated interest in this axis deer jewelry, compared to 35.03% of all residents (Figure 36; Figure 29).

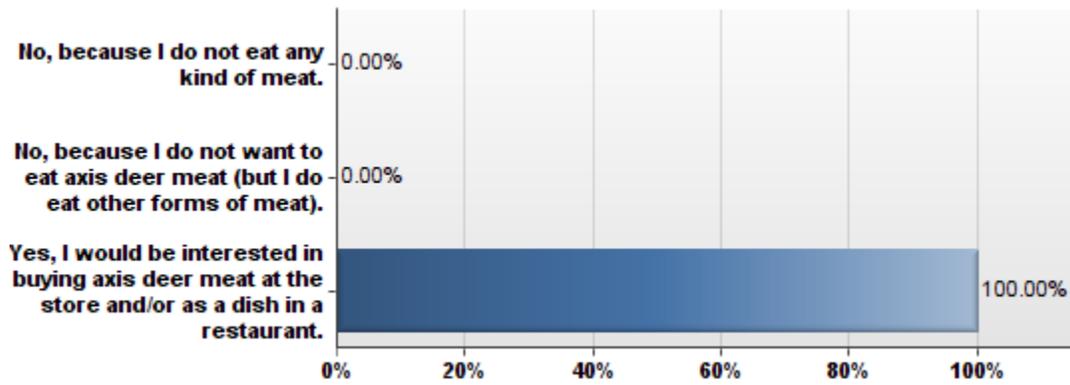


Figure 34. Hunter residents' interest in purchasing axis deer meat to either prepare themselves or at a restaurant.

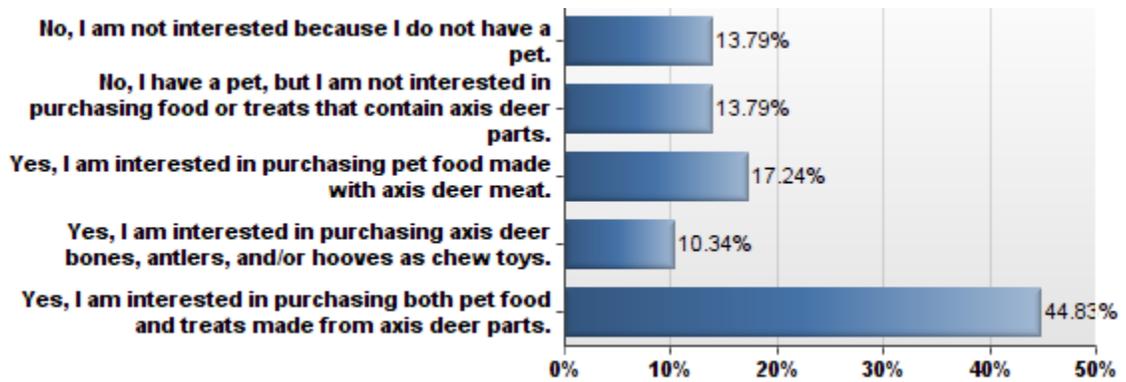


Figure 35. Hunter residents' interest in purchasing pet food made with axis deer meat and/or chew toys made from axis deer parts.

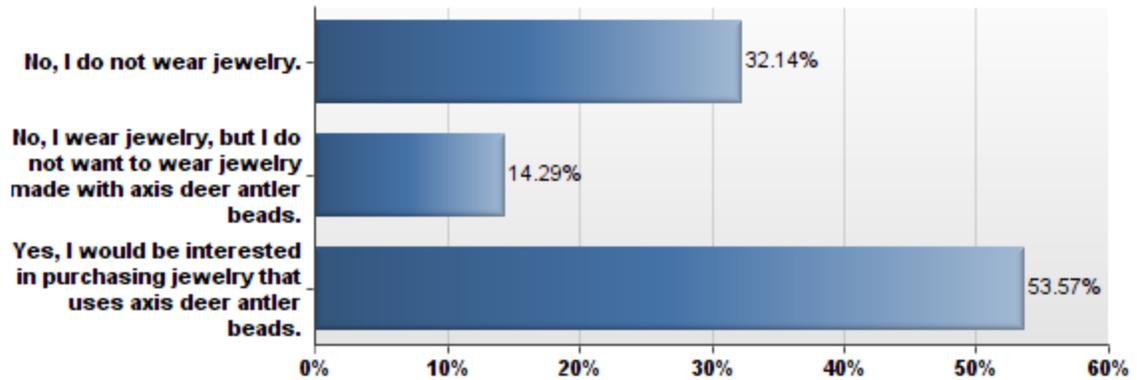


Figure 36. Hunter residents' interest in purchasing jewelry made with axis deer antler beads.

4.3.3.2 Only Non-Hunters Filter

Compared to hunters, more non-hunter residents believe there are a lot more deer present today compared to five years ago; 75.21% of non-hunter residents believe there are a lot more deer present today and 14.53% believe there are a few more (a combined total of 89.74%) (Figure 37). In the hunter survey, 53.33% of hunters indicated that they believe there are a lot more deer and 28.89% indicated that they believe there are a few more deer (a combined total of 82.22%) (Figure 1). In total, there is a less than 8% difference in respondents who think there are “more” deer (meaning a lot more or a few more), but there is 21.88% difference in the number of respondents who believe there are a lot more.

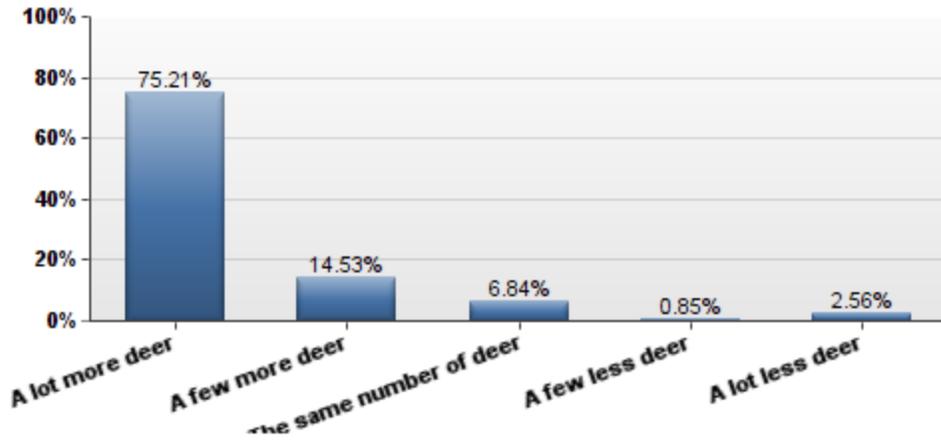


Figure 37. Non-hunter residents' beliefs about how axis deer populations have changed between five years ago and today.

When asked about how populations should be managed, non-hunter residents favored decreasing populations in some way compared to hunters; 49.60% of non-hunter residents believe populations should be greatly decreased and 35.20% believe they should be decreased, for a combined total of 84.80% (Figure 38). There was a combined total of 55.56% of hunters who believed populations should be decreased by some amount (Figure 2). The driving factor between this difference is the fact that only 14.40% of non-hunter residents believe populations should remain at their current levels and 37.78% of hunters want populations to remain the same, as well (Figure 38; Figure 2).

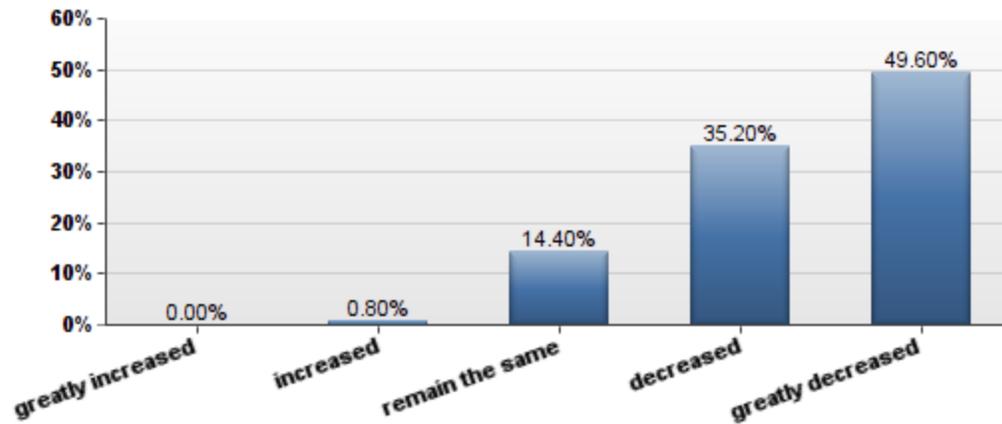


Figure 38. Non-hunter residents' beliefs about how current axis deer populations should be managed.

When asked how aware respondents considered themselves about the problems associated with axis deer overpopulation, 46.88% of non-resident hunters labeled themselves as very aware and 46.88% labeled themselves as fairly aware (Figure 39). This combined total of 93.76% who are considered generally “aware” is very similar to the 95.55% of hunters who consider themselves generally “aware” (Figure 3). However, 82.22% of hunters considered themselves very aware; a 35.34% difference compared to non-hunter residents who also considered themselves very aware (Figure 3 and Figure 39).

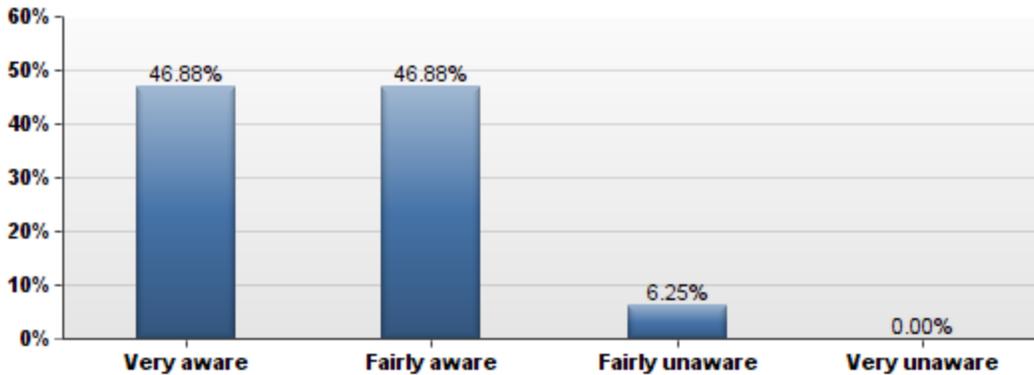


Figure 39. How aware non-hunter residents believe they are regarding axis deer population problems.

Non-hunter residents generally do not have as many concerns with legalizing the hypothetical commercialized harvest as hunters do; this is most likely because hunters better understand the complexities of hunting and processing meat. Only 15.50% of non-hunter residents indicated that they foresee many and/or serious problems with a commercialized hunt, compared to the 26.67% of hunters who indicated foreseeing these problems (Figure 40; Figure 7). Additionally, more non-hunter residents foresee few and/or minor problems (44.19%) or no problems at all (35.66%) compared to hunters (40.00% and 31.11%, respectively) (Figure 40; Figure 7).

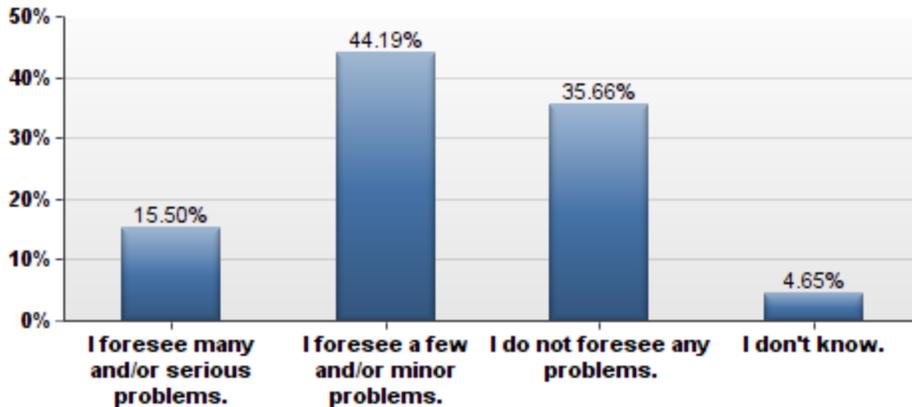


Figure 40. Non-hunter residents' beliefs about potential problems with a legalized commercialized hunt.

Overall, non-hunter residents are less interested in purchasing products resulting from a commercialized harvest, despite the fact that they saw fewer and less serious problems with such a harvest, compared to hunters. There is the most interest in purchasing axis deer meat from a store or restaurant with 71.65% of non-hunter residents showing interest (Figure 41). This is lower than the 100% interest from hunters, although as discussed, that was likely to be hunters showing support for a commercialized hunt rather than an actual measure of interest (Figure 34). The interest in pet products (pet food, chew toys, or both) is again lower for non-hunter residents (53.91%), compared to the interest of hunters (72.41%) (Figure 42; Figure 35). This pattern of approximately 20% less interest is also seen in the differences in interest between non-hunter residents and hunters; 30.47% of non-resident hunters showed an interest in purchasing jewelry, compared to 53.57% of hunters (Figure 43; Figure 36).

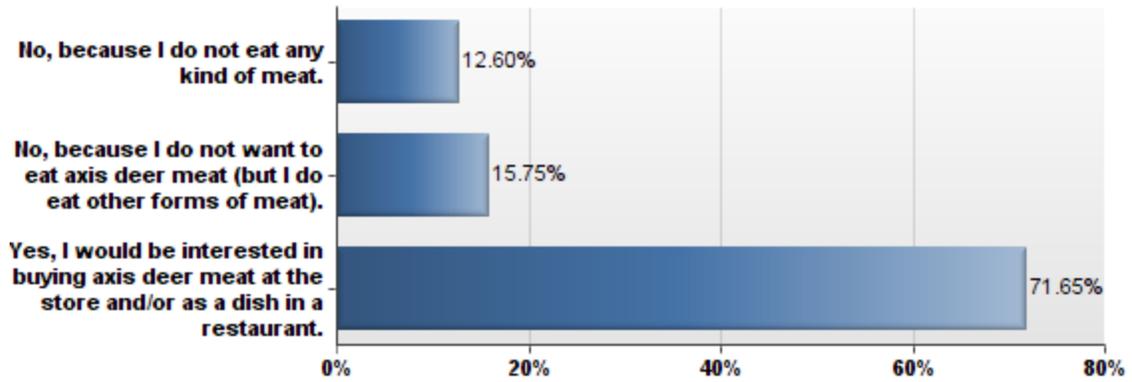


Figure 41. Non-hunter residents' interest in purchasing axis deer meat to either prepare themselves or at a restaurant.

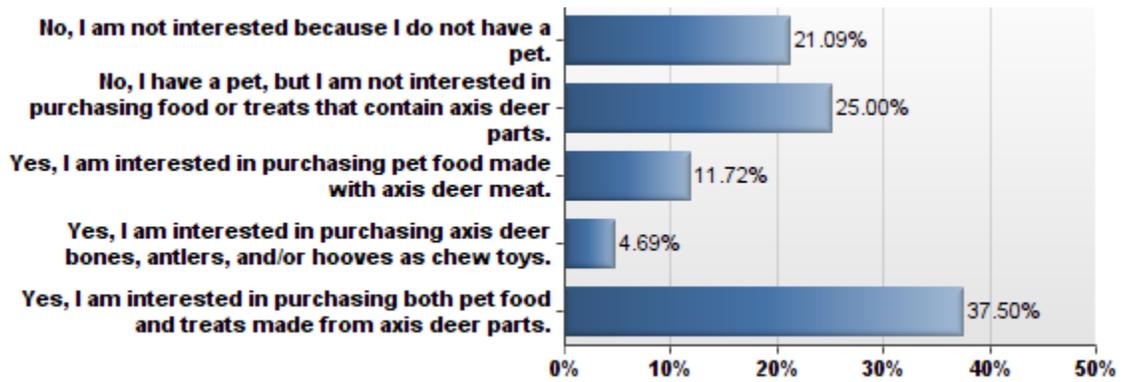


Figure 42. Non-hunter residents' interest in purchasing pet food made with axis deer meat and/or chew toys made from axis deer parts.

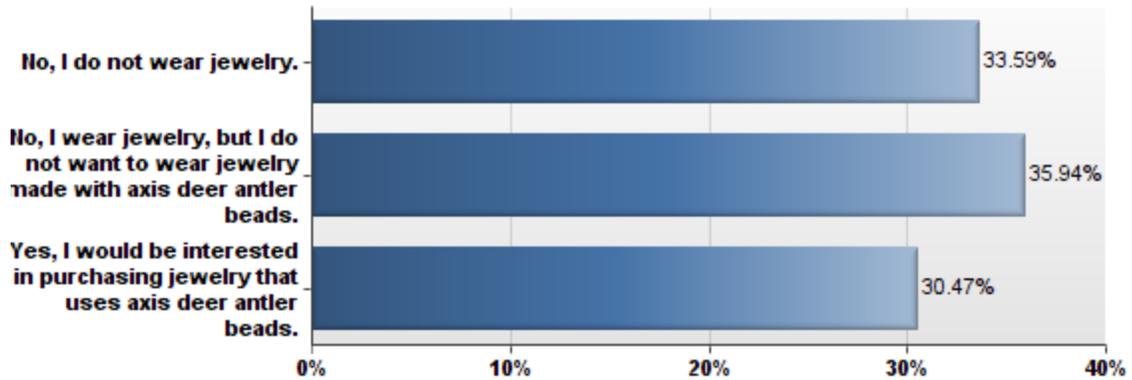


Figure 43. Non-hunter residents' interest in purchasing jewelry made with axis deer antler beads.

Breaking down the scale and rank question to understand the control method preferences of non-hunter residents shows similar results compared to all resident preferences. Again, recreational hunting, then commercial harvesting, then fencing are the top three preferred methods in both the scale question (average scale scores of 1.71, 1.98, and 2.09, respectively) and the rank question (average rankings of 2.70, 3.06, and 3.35, respectively) (Table 12; Table 13). Just as in the combined all resident breakdown, non-hunters generally “support” all control methods except for take no action as they all have average scale scores of less than 3 (neutral) (Table 12). For both the scale and rank question, take no action was the least preferred method with an average scale score of 4.45 and an average ranking of 6.54 (Table 12; Table 13).

Table 12. Number of answers per scale score and average scale scores of various control methods by non-hunter residents.

Method	1 (completely support)	2	3 (neutral)	4	5 (do not support at all)	Mean
Fencing	65	20	21	11	11	2.09
Trap-and-Transfer	44	10	19	13	40	2.96
Contraceptives	55	9	25	12	26	2.57
Recreational Hunting	93	13	5	4	14	1.71
Hired Sharp-shooting	50	15	18	14	31	2.70
Commercial Harvesting	76	20	10	6	17	1.98
Take No Action	6	3	12	10	91	4.45

Table 13. Number of answers per rank and average rank of various control methods by non-hunter residents.

Method	1 (most supported)	2	3	4	5	6	7 (least supported)	Mean
Fencing	21	22	18	28	18	14	0	3.35
Trap-and-Transfer	3	13	20	25	24	34	2	4.36
Contraceptives	22	15	18	11	32	18	5	3.74
Recreational Hunting	35	30	19	20	9	6	2	2.70
Hired Sharp-shooting	7	13	23	20	26	21	11	4.26
Commercial Harvesting	32	26	19	15	8	18	3	3.06
Take No Action	1	2	4	2	4	10	98	6.54

4.3.4 Synthesizing the Hunter and Resident Surveys

In order to generate conclusions about how the people of Maui would like to see their axis deer resources managed, it is important to consider not only broken down sub-populations, but also some general sentiments as a whole. To understand a few basic, general opinions, I have combined the response data from the hunter and resident survey questions that overlapped, leading to a combined sample size of 180 responses. Of these combined responses, 73.71% of respondents are non-hunters and 26.29% are hunters and

71.11% own land on Maui and 28.89% do not own land on Maui. Of respondents who do own land, the majority (83.59%) own less than three acres (Figure 44). Most landowners (70.87%) indicated that they did not experience any kind of damage from axis deer, but 29.13% reported damage. Landscaping and/or yard damage was the most prevalent (67.57%), although agricultural damage to crops (45.95%) and damage to person gardens (37.84%) were also frequently reported (Figure 45).

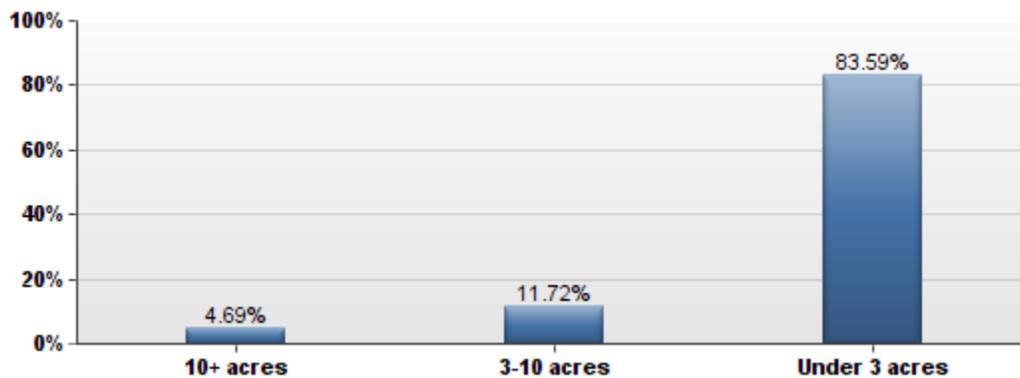


Figure 44. Amount of land owned by all residents and hunters combined who own land.

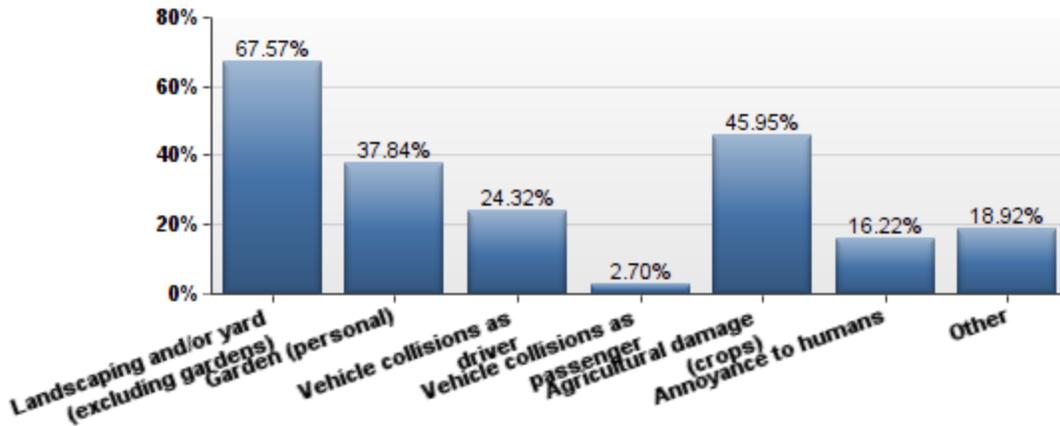


Figure 45. Types of damage recorded by all landowners combined who reported axis deer damage.

In terms of axis deer populations, the majority of combined respondents (69.05%) indicated that they believe there are a lot more deer present on Maui now compared to five years ago (Figure 46). However, due to the combination of resident and hunter response data, management opinions are less extreme; 43.43% of respondents would like to see populations greatly decreased and 33.14% would like to see populations decreased. Approximately a fifth (20.57%) of respondents would like populations to remain the same (Figure 47). Overall, respondents consider themselves aware of problems caused by axis deer overpopulation with 56.42% labeling themselves as very aware and 37.43% labeling themselves as aware (Figure 48). Finally, in terms of foreseeing potential issues with the hypothetical commercialized harvest, 18.54% of respondents foresee many and/or serious problems and 42.70% foresee few and/or minor problems with such a hunt; 34.27% do not foresee any problems at all (Figure 49).

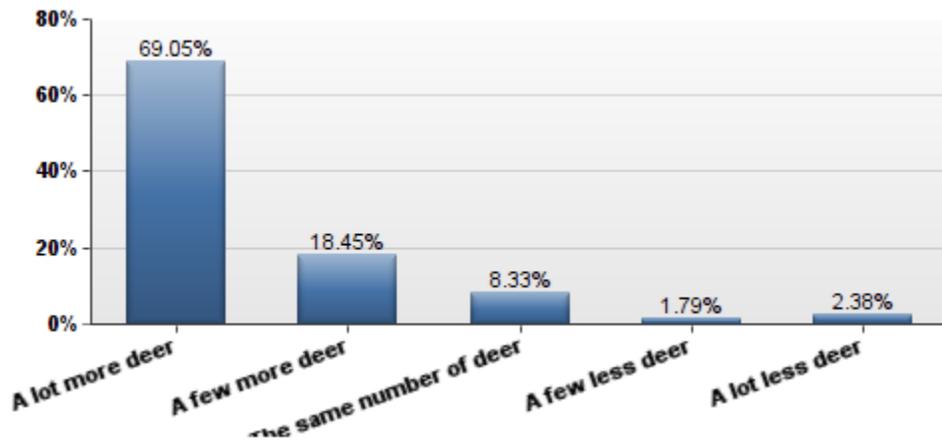


Figure 46. All residents' and hunters' combined beliefs about how axis deer populations have changed between five years ago and today.

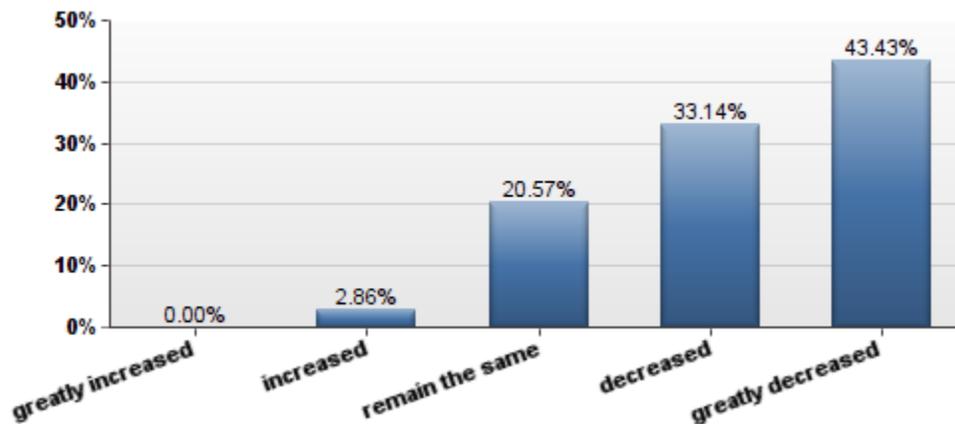


Figure 47. All residents' and hunters' combined beliefs about how current axis deer populations should be managed.

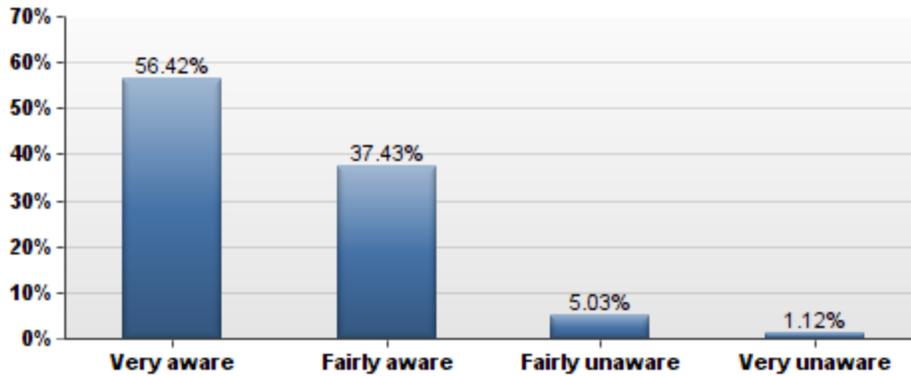


Figure 48. How aware all residents and hunters combined believe they are regarding axis deer population problems.

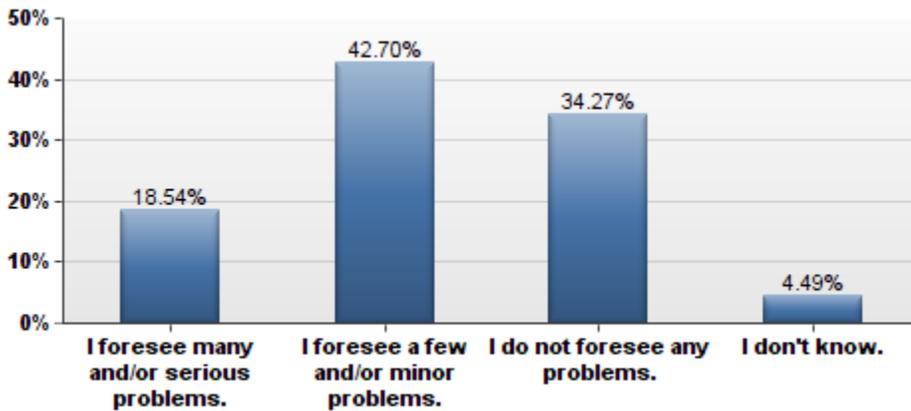


Figure 49. All residents' and hunters' combined beliefs about potential problems with a legalized commercialized hunt.

As was true with all residents and non-hunter residents, all respondents combined favor recreational hunting as the most supported method with an average scale score of 1.59 (Table 14). In this all responses combined data set, however, commercialized harvesting and fencing have much closer average scale scores. Commercialized harvesting (average scale score of 2.10) is still slightly more supported than fencing

(average scale score of 2.13), but these scores are much closer than in the all resident and non-hunter resident data sets due to the fact that hunters actually supported fencing over commercialized harvesting (Table 14; Table 5). Take no action was viewed as the least supported method by all respondents with an average scale score of 4.26 (Table 14). This is consistent with the all resident and non-hunter resident data, but hunters viewed contraceptives as the least supported (Table 5). It is interesting to note that, while all control methods except for take no action were “supported” by the all resident and non-hunter resident data sets in that these methods all had average scale scores of less than 3 (neutral), in this combined data set, trap-and-transfer was not supported with an average scale score of 3.10 (Table 14).

Table 14. Number of answers per scale score and average scale scores of various control methods by all residents and hunters combined.

Method	1 (completely support)	2	3 (neutral)	4	5 (do not support at all)	Mean
Fencing	89	23	31	13	18	2.13
Trap-and-Transfer	56	13	24	16	63	3.10
Contraceptives	60	9	35	14	54	2.96
Recreational Hunting	133	15	8	4	15	1.59
Hired Sharp-shooting	60	19	29	18	47	2.84
Commercial Harvesting	95	28	16	11	25	2.10
Take No Action	13	7	20	11	117	4.26

For the ranking question, the results from this all responses combined data set were more similar to the results from the hunter data set; commercialized harvesting was the highest ranked (average ranking of 2.48), but fencing took the second slot (average ranking of 3.16) and commercialized harvesting the third (average ranking of 3.23)

(Table 15). The all resident and non-hunter resident data sets illustrated that, while recreational hunting was the highest ranked, commercialized harvesting was the second highest and fencing the third (Table 10; Table 13). The results from all of the different data sets, including this all responses combined data set, were consistent across the ranking question in that take no action was the lowest ranked method (Table 15).

Table 15. Number of answers per rank and average rank of various control methods by all residents and hunters combined.

Method	1 (most supported)	2	3	4	5	6	7 (least supported)	Mean
Fencing	32	33	27	36	20	16	0	3.16
Trap-and-Transfer	3	19	25	38	31	43	5	4.37
Contraceptives	23	16	23	16	42	33	11	4.10
Recreational Hunting	59	39	23	24	11	6	2	2.48
Hired Sharp-shooting	7	19	29	24	41	29	15	4.34
Commercial Harvesting	36	35	29	21	13	23	7	3.23
Take No Action	4	3	8	5	6	14	124	6.32

Demographically, 56.40% of combined respondents are male and 43.60% are female. All given age categories were represented, with the mode being between 55 and 64 years of age (Figure 50). Most respondents have a bachelor's degree or higher (a combined total of 59.30%), and all given pre-tax annual income categories were represented, with the mode falling in the \$50,000 to \$74,999 range (Figure 51; Figure 52). The vast majority of all respondents (93.10%) permanently reside on Maui, while approximately 4% reside on other island in Hawaii, approximately 3% live in other state in the U.S., and approximately 1% live in a country besides the United States.

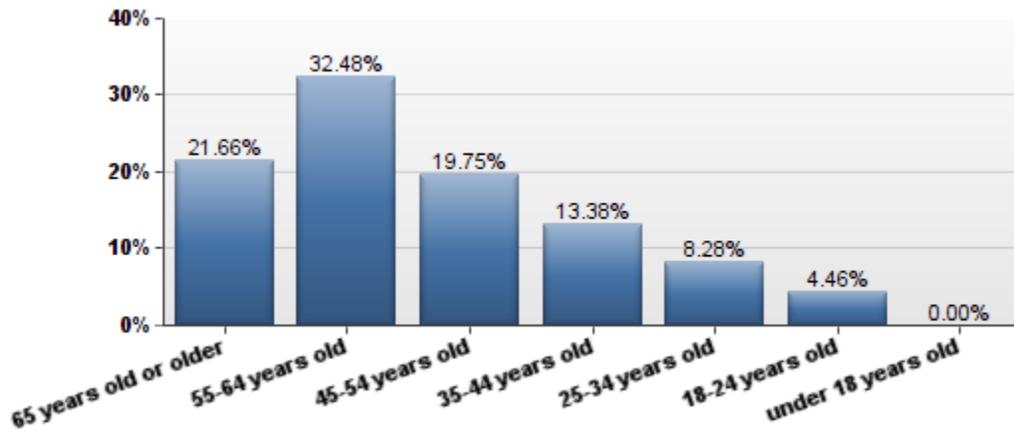


Figure 50. Age breakdown of all residents and hunters combined.

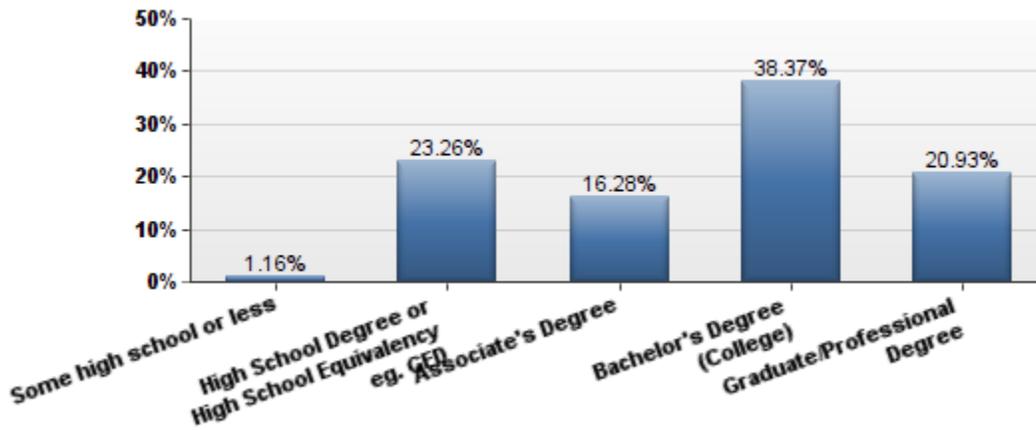


Figure 51. Highest education background of all residents and hunters combined.

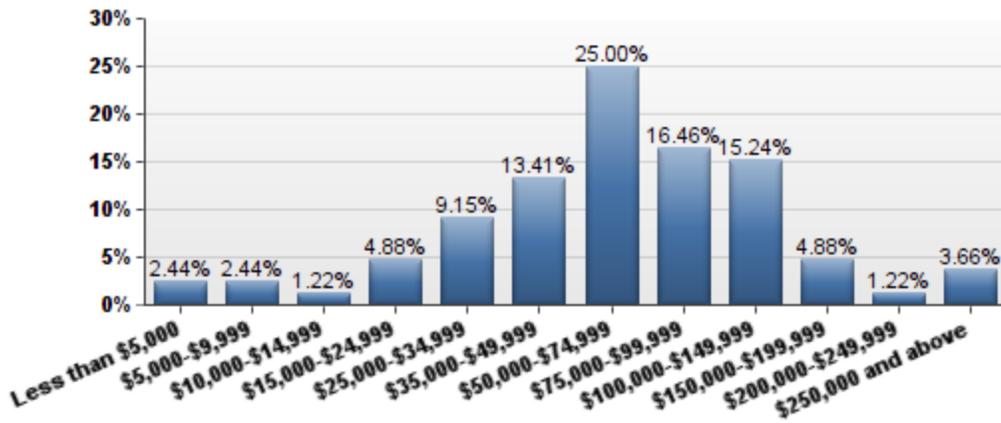


Figure 52. Annual pre-tax 2012 income of all residents and hunters combined.

These all responses combined results were used to create a model to describe the types of respondents who believe axis deer populations should be decreased in some way (either greatly decreased or decreased, as per the survey). The model describes respondents who would like to see populations decreased as a function of beliefs about current deer populations and a commercialized harvest, their awareness about deer overpopulation problems, and demographic information. For this model, all variables were made into binary variables using results from the survey; the model is a binary logistic model. The model describes that respondents who *believe populations should be decreased* = $B_0 + B_1(\text{hunter}) + B_2(\text{belief that there are more deer now than 5 years ago}) + B_3(\text{awareness of overpopulation problems}) + B_4(\text{do not foresee problems with legalizing a commercialized harvest}) + B_5(\text{55 years of age or older}) + B_6(\text{male}) + B_7(\text{education of a bachelor's or graduate degree}) + B_8(\text{income of } \$75,000 \text{ or higher}) + u$.

The dependent variable, *belief that populations should be decreased*, represents respondents who believe that deer populations should be either decreased or greatly decreased, as opposed to those who believe populations should remain the same, be increased, or be greatly increased. All of the independent variables are also binary and explanations for the variables can be found in previous sections.

The *hunter* variable was found to be significant at the 1% level and the negative coefficient indicates that hunters do not want to see decreases in axis deer population (Table 16). This is consistent with past research and interviews that have found that hunters prefer high populations of game mammals. The *belief that there are more deer now than 5 years ago*, *awareness of overpopulation problems* variable, and *do not foresee problems with a commercialized hut* variables were also all found to be significant at the 1% level, although all of these variables had positive coefficients (Table 16). This indicates that people who believe that there are more deer currently found on Maui compared to five years ago would like to see populations decrease, which is logical from a management standpoint. Additionally, those who are aware of the problems caused by overpopulation would also like to see decreases in populations. Those who do not foresee problems with a legalizing a hypothetical commercialized hunt want to see populations decreased. This is logically consistent because, considering the reverse scenario, this indicates that those who do not want population decreases do foresee problems with a commercialized harvest. None of the demographic variables were significant, although the signs indicate that males age 55 or older, with an education level below that of a bachelor's degree, who make less than \$75,000 are the types of

respondents who believe axis deer populations should be decreased (Table 16). This model may help wildlife management agencies with understanding the types of people who hold specific opinions about current axis deer populations and their management.

Table 16. Regression results for all resident and hunter respondents combined who believe that deer populations should be either decreased or greatly decreased.

Independent Variable	Coefficient	Std. Error	P-value
hunter	-2.072	0.655	0.002**
belief that there are more deer now than 5 years ago	2.320	0.553	0.000**
awareness of overpopulation problems	2.841	1.097	0.010**
do not foresee problems with a commercialized harvest	1.752	0.654	0.007**
55 years of age or older	0.267	0.513	0.602
male	0.354	0.592	0.550
education of a bachelor's or graduate degree	-0.899	0.533	0.092
income of \$75,000 or higher	-0.252	0.498	0.613
constant	-2.721	1.200	0.023*

**significant at the 1% level

*significant at the 5% level

I also ran a test to explore the correlations between several variables.

Respondents' belief that populations should be decreased was correlated at the 0.01 level with the belief that there are more deer currently present on Maui than compared to five years ago, an awareness of problems caused by deer overpopulation, being a hunter, and not foreseeing problems with legalizing the hypothetical commercialized harvest (Table 17). Additionally, respondents' belief that there are more deer currently present on Maui than compared to five years ago is correlated at the 0.05 level with an awareness of problems caused by overpopulation and not foreseeing problems with legalizing a commercialized harvest (Table 17).

Table 17. Correlation between select all resident and hunter combined variables.

	more deer now	populations should be decreased	aware of over- population problems	hunter
populations should be decreased				
Pearson Correlation	0.414**			
Sig. (2-tailed)	0.000			
N	180			
aware of overpopulation problems				
Pearson Correlation	0.178*	0.222**		
Sig. (2-tailed)	0.017	0.003		
N	179	179		
hunter				
Pearson Correlation	-0.011	-0.282**	-0.036	
Sig. (2-tailed)	0.887	0.000	0.637	
N	175	175	174	
do not foresee problems with commercialized hunt				
Pearson Correlation	0.162*	0.284**	-0.032	-0.048
Sig. (2-tailed)	0.031	0.000	0.677	0.524
N	178	178	177	175

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

I used an unpaired t-test to test the differences of means between males and females using the means from the scale and rank population control questions. There were only significant differences found between all combined resident and hunter males and females for the scale question were for the contraceptive (at the 5% level) and recreational hunting (at the 1% level) methods; males significantly preferred recreational hunting over females and females significantly preferred contraceptives over males (Table 18). Similar significant differences were found between all combined males and females for the rank question; both contraceptive and recreational hunting methods showed a significant difference at the 1% level between males and females; again, males significantly preferred recreational hunting over females and females significantly preferred contraceptives over males (Table 19).

Table 18. Differences between the means of males and females for all respondents of the scale question.

Method	All Female Scale			All Male Scale			p value	t stat	df
	mean	sd	n	mean	sd	n			
Fencing	2.01	1.32	74	2.23	1.44	97	0.3064	1.0259	169
Trap and Transfer	3.00	1.75	73	3.23	1.69	96	0.3894	0.8630	167
Contraceptives	2.58	1.61	73	3.21	1.68	96	0.0150*	2.4586	167
Recreational Hunting	1.92	1.54	75	1.35	0.87	97	0.0025**	3.0682	170
Hired Sharp Shooting	3.03	1.74	74	2.72	1.53	96	0.2191	1.2335	168
Commercialized Harvesting	2.24	1.62	75	2.00	1.37	97	0.2944	1.0518	170
Take No Action	4.34	1.17	71	4.20	1.36	94	0.4883	0.6946	163

**significant at the 1% level
*significant at the 5% level

Table 19. Differences between the means of males and females for all respondents of the rank question.

Method	All Female Rank			All Male Rank			p value	t stat	df
	mean	sd	n	mean	sd	n			
Fencing	2.99	1.54	71	3.32	1.65	90	0.1964	1.2973	159
Trap and Transfer	4.15	1.48	71	4.49	1.46	90	0.1467	1.4567	159
Contraceptives	3.62	1.97	71	4.43	1.70	90	0.0058**	2.7980	159
Recreational Hunting	2.86	1.74	71	2.21	1.30	90	0.0074**	2.7126	159
Hired Sharp Shooting	4.58	1.63	71	4.22	1.62	90	0.1646	1.3962	159
Commercialized Harvesting	3.46	1.90	71	3.03	1.84	90	0.1487	1.4513	159
Take No Action	6.34	1.39	71	6.29	1.59	90	0.8326	0.2118	159

**significant at the 1% level
*significant at the 5% level

The same unpaired t-test was used to test the differences of means between hunters and non-hunters using the means from the scale and rank population control questions. For the scale question, contraceptives were significantly preferred at the 1% level by non-hunters over hunters (Table 20). Non-hunters also significantly supported hired sharp shooting and commercialized harvesting over hunters at the 5% level. Hunters significantly supported recreational hunting over non-hunters at the 5% level and

they significantly supported taking no action over non-hunters at the 1% level (Table 20). For the rank question, fencing was significantly preferred by hunters compared to by non-hunters at the 5% level (Table 21). Non-hunters significantly preferred contraceptives over hunters at the 1% level. Hunters also significantly preferred recreational hunting and taking no action over non-hunters at the 1% level (Table 21).

Table 20. Differences between the means of hunters and non-hunters for the scale question.

Method	Hunters Scale			Non-Hunters Scale			p value	t stat	df
	mean	sd	n	mean	sd	n			
Fencing	2.27	1.51	45	2.09	1.34	128	0.4546	0.7495	171
Trap and Transfer	3.53	1.71	45	2.96	1.69	126	0.0545	1.9362	169
Contraceptives	4.05	1.38	44	2.57	1.60	127	0.0001**	5.4689	169
Recreational Hunting	1.27	0.78	45	1.71	1.34	129	0.0386*	2.0807	172
Hired Sharp Shooting	3.27	1.59	44	2.70	1.64	128	0.0466*	2.0041	170
Commercialized Harvesting	2.49	1.55	45	1.98	1.43	129	0.0454*	2.0154	172
Take No Action	3.82	1.53	45	4.45	1.09	122	0.0036**	2.9537	165

**significant at the 1% level
*significant at the 5% level

Table 21. Differences between the means of hunters and non-hunters for the rank question.

Method	Hunters Rank			Non-Hunters Rank			p value	t stat	df
	mean	sd	n	mean	sd	n			
Fencing	2.69	1.41	42	3.35	1.63	121	0.0207*	2.3370	161
Trap and Transfer	4.45	1.45	42	4.36	1.48	121	0.7333	0.3413	161
Contraceptives	5.07	1.44	42	3.74	1.86	121	0.0001**	4.2134	161
Recreational Hunting	1.83	1.21	42	2.70	1.58	121	0.0014**	3.2505	161
Hired Sharp Shooting	4.55	1.53	42	4.26	1.68	121	0.3259	0.9855	161
Commercialized Harvesting	3.67	1.83	42	3.06	1.85	121	0.0667	1.8462	161
Take No Action	5.74	1.98	42	6.54	1.18	121	0.0021**	3.1304	161

**significant at the 1% level
*significant at the 5% level

It is interesting to consider why hunters significantly prefer recreational hunting compared to non-hunters, yet they significantly do not prefer other lethal methods, such as hired sharp shooting and commercialized harvesting, compared to non-hunters; especially when one may expect that non-hunters might prefer non-lethal methods and hunters might prefer lethal methods. Hunters may not prefer commercialized hunting for two reasons. The first may be because they have value structures very similar to those found in the North American Model for Wildlife Conservation and thus they are wary of market hunting due to their conservation values and history of such a commercialized wildlife market. However, the more plausible explanation is that hunters may not like the idea of competing with others for their game animals; commercialized hunting may increase competition between hunters by increasing the frequency of hunting or the total number of hunters. This explanation is backed by the fact that hunters significantly do not prefer hired sharp shooting compared to non-hunters; hired sharp shooters are not related to market hunting or the North American Model for Wildlife Conservation, yet they could be considered to provide a source of competition for hunters. As a result, it can be concluded that hunters would generally not favor any lethal axis deer population control method—they appear to feel that they are lethally managing populations themselves and do not want others competing for their game resource.

Understanding these relationships between preferred management methods and sub-populations of the types of people who live on Maui can help aid wildlife management agencies in their educational outreach, as well as help with identifying different stakeholder groups to include in their management plans.

Chapter 5

**MANAGEMENT IMPLICATIONS: POPULATION CONTROL AND A
VENISON INDUSTRY**

Management implications from this survey fall into two components: the first relating to the public's preferred axis deer population control techniques, and the second relating to the market demand for axis deer venison. The two are clearly separate, yet connected; it can be assumed that those who do not support the commercialized harvest of axis deer as a control method would not be interested in the establishment of a venison industry. It should be noted that while farm-raised axis deer could potentially be available to supply the venison, the survey explicitly stated that venison or other axis deer products mentioned in the survey would be the result of a commercialized harvest.

Different communities and areas will likely require different management methods based on a variety of factors, not limited to the terrain, population number objectives, and how residential the area is. However, it can generally be asserted that the people of Maui believe that some form of population control is necessary. The vast majority (82.39%) of residents surveyed want to see axis deer populations decreased or greatly decreased (Figure 24). Even the majority of hunters (55.56%)—a subpopulation that historically prefers high game populations-- think that populations should either be

decreased or greatly decreased, and 37.78% think populations should remain the same, with low percentages pushing for increases in axis deer numbers (Figure 2).

For hunters, fencing, recreational hunting, and commercialized harvesting were all methods that were, on average, considered “supported” (meaning they scored higher than “neutral” in the scale question) (Table 5). The same three methods were the highest ranked in the hunters’ ranking question (Table 6). The general public was generally more supportive of all control methods, where all six techniques were “supported”, and only take no action was “not supported” in their scale question (Table 9). However, fencing, recreational hunting, and commercialized harvesting, again, were the top three most supported, on average, for both the scale and ranking questions for residents (Table 9 and Table 10).

Results from the resident survey regarding interest in products from a commercialized axis deer harvest corroborate the findings that the idea of a commercialized harvest is generally supported on Maui. The resident survey attempted to shed light onto the market demand for products resulting from a commercialized deer harvest, including venison, pet food and chew treats, and jewelry made with beads from axis deer antlers. Results indicate that 76.62% of respondents would be interested in purchasing axis deer venison, 57.60% were interested in either dog food with axis deer meat, chew treats made from axis deer parts, or both products for pets, and 35.03% were interested in axis deer jewelry (Figure 27; Figure 28; Figure 29). Additionally, 15 out of 18 businesses surveyed indicated that they would be interested in offering axis deer products; this included venison for grocery stores, meat markets/delis, restaurants/cafes,

chefs, and meat suppliers, meat and other axis deer parts for pet food companies and zoos, and axis deer antler beads for jewelry makers and bead sellers/manufacturers. Overall, there appears to be a healthy demand for axis deer products, indicating that a commercialized axis deer harvest could fulfill this niche of the market that is currently available. Furthermore, because of the range of products that could result from a commercialized axis deer harvest, this industry has the potential to be a virtually “zero waste” industry, meaning that all parts of the animal could be sold and used for some purpose—adhering to the traditional Hawaiian idea of sustainability and avoiding waste.

A combination of control mechanisms should be used throughout Maui to decrease the number of axis deer, hopefully resulting in ecosystem restoration and decreases in deer-vehicle collisions. Incentive structures should be used to encourage recreational hunting and commercial harvesting, as these methods are preferred by hunters and general residents, alike. There is ample market demand, by both consumers and retailers, for products resulting from a commercialized harvest so, once U.S.D.A. regulations are addressed to make a commercialized harvest a cost-effective option for everyone interested, such a harvest would be beneficial to hunters, the general public, and the ecosystem.

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Appendix A

BUSINESS SURVEY

University of Delaware- Informed Consent Form

Title of Project: Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- business survey

Principal Investigator (s): Elena Rubino

Other Investigators: Dr. Chris Williams

You are being asked to participate in a research study. This form tells you about the study including its purpose, what you will do if you decide to participate, and any risks and benefits of being in the study. Please read the information below and ask the research team questions about anything we have not made clear before you decide whether to participate. Your participation is voluntary and you can refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you will be asked to sign this form and a copy will be given to you to keep for your reference.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to help determine how the potential commercial harvest of axis deer as a population control method would benefit local Hawaiian businesses. This study is to be used as part of Elena Rubino's master's thesis. You are being asked to take part in this study because you have a local business in Hawaii that may be able to utilize parts of a commercially harvested axis deer. All subjects will be specifically recruited and thus would not be excluded from volunteering. Approximately 300 participants will be interviewed for this study.

WHAT WILL YOU BE ASKED TO DO?

You will be asked to answer a series of survey questions about your local business and your demographic information. Questions will be in multiple choice, ranking/listing, and short answer form. The survey will take between 10 minutes and 30 minutes to complete, depending on your business type.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS? Survey procedures involve using your computer for between 10 minutes and 30 minutes so there is the

potential for slight eye discomfort. There are no other foreseeable risks from participating in this survey.

WHAT ARE THE POTENTIAL BENEFITS?

You will not benefit directly from taking part in this research. However, this survey will help determine if there is support from the local business community for a new system of axis deer management involving the commercialization of deer meat. This could result in major policy changes which would reform how states manage overabundant wildlife. Policy changes could potentially benefit the ecosystem, human safety (reducing deer-related automobile accidents), and the economy (providing a natural, local source of meat).

HOW WILL CONFIDENTIALITY BE MAINTAINED?

We will make every effort to keep all research records that could identify you confidential to the extent permitted by law. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Data will be kept on a secure computer and data will be coded so confidentiality will be maintained. Code numbers will be kept in a different location than survey data. Data may be stored indefinitely.

Your research records may be viewed by the University of Delaware Institutional Review Board, but the confidentiality of your records will be protected to the extent permitted by law. De-identified data may be shared with the Maui Axis Deer Working Group and other governmental groups related to axis deer population control.

WILL THERE BE ANY COSTS RELATED TO THE RESEARCH?

There are no costs related to participating in this research.

WILL THERE BE ANY COMPENSATION FOR PARTICIPATION?

There will be no monetary compensation for participation.

DO YOU HAVE TO TAKE PART IN THIS STUDY?

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time and to choose which questions in this survey you want to answer. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware or the Maui Axis Deer Working Group. Subject participation will not be terminated by the investigator.

WHO SHOULD YOU CALL IF YOU HAVE QUESTIONS OR CONCERNS?

If you have any questions about this study, please contact the Principal Investigator, Elena Rubino at 908-451-7228 or rubi@udel.edu. If you have any questions or concerns about your rights as a research participant, you may contact the University of

By checking below, you indicate that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You may copy and paste this consent form as a record. By checking this box, you indicate that you voluntarily agree to participate in this study and that you are at least 18 years old.

I agree (1)

Q1 Axis deer are non-native to Hawaii and the populations of deer on the Island of Maui have reached a critical threshold, but are still growing. These increased populations have been linked to the degradation of the natural ecosystem and cause of human-wildlife conflicts, including increased deer-automobile collisions and damage to agricultural operations. A commercial harvest of axis deer is being considered in order to control their populations. We are reaching out to companies throughout Hawaii to determine how the potential commercial harvest of axis deer as a population control method would benefit the economy. Axis deer would be harvested by hunters, who could then sell the whole deer or parts of the deer for a profit. We seek to determine how every part of the harvested deer could be used to create products ranging from food to jewelry beads. We ask that you try to answer these questions about your business as honestly as possible to give us the most accurate picture of how an axis deer harvest could impact the local economy. Please remember that your responses are very helpful to our data collection whether you are interested in utilizing axis deer products or not.

Q2 How would you describe your type of business? Please check all that apply.

- Hunting Guide (1)
- Meat processor (who may or may not also act as a meat supplier) (2)
- Grocery store (3)
- Meat market/deli (4)
- Restaurant/cafe (5)
- Chef (6)
- Zoo/animal sanctuary (7)
- Pet food company (8)
- Leather smith/tanner (9)
- Meat supplier (who does NOT act as a meat processor) (10)
- Jewelry maker (11)
- Bead seller/manufacturer (12)

Q3 What is the name of your business?

Q4 Approximately how many total customers do you serve each year?

Q5 Approximately what percentage of customers are Hawaiian citizens?

- over 90% (1)
- 80-90% (2)
- 70-80% (3)
- 60-70% (4)
- 50-60% (5)
- 40-50% (6)
- 30-40% (7)
- Under 30% (8)

Q6 What percentage of your customers are citizens of other US states besides Hawaii?

- over 80% (1)
- 70-80% (2)
- 60-70% (3)
- 50-60% (4)
- 40-50% (5)
- 30-40% (6)
- 20-30% (7)
- 10-20% (8)
- Under 10% (9)

Q7 What percentage of your customers are citizens of a country besides the US?

- over 80% (1)
- 70-80% (2)
- 60-70% (3)
- 50-60% (4)
- 40-50% (5)
- 30-40% (6)
- 20-30% (7)
- 10-20% (8)
- Under 10% (9)

Q8 From which non-US countries are your customers? Please include rough percentages if you can.

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q9 How long have you been a hunting guide?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q10 What types of species do your customers hunt?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q11 Do you frequently see axis deer? If yes, approximately how often and how many?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q12 In this last season, approximately how many customers did you have that hunted for axis deer?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q13 How many axis deer do you think your customers have hunted per month on average while on hunts with you?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q14 How much do you charge for axis deer hunts?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q15 How much revenue do you earn per year based on axis deer hunt guiding?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q16 If hunters you guide could sell the axis deer they hunted for a profit, how do you think your current customers would react?

- Current customers would hunt much more often (1)
- Current customers would hunt a little more often (2)
- Current customers would not change their behavior (3)
- Current customers would hunt a little less often (4)
- Current customers would hunt much less often (5)
- Don't know (6)

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q17 If hunters you guide could sell the axis deer they hunted for a profit, how do you think new customers would react? "New" meaning customers who have never hunted with a guide before.

- There would be a large increase in new customers (1)
- There would be a small increase in new customers (2)
- It would not impact the number of new customers at all (3)
- There would be a small decrease in new customers (4)
- There would be a large decrease in new customers (5)
- Don't know (6)

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q18 Currently, it is illegal to sell meat and other products from wildlife, however, if commercial harvest became legalized for axis deer, the sale of these items would be permitted. Licenses would be issued to hunters to commercially harvest axis deer and the hunters could then sell the carcasses to processors. Do you foresee any problems with legalizing the commercial harvest of axis deer?

- I foresee many and/or serious problems. (1)
- I foresee a few and/or minor problems. (2)
- I do not foresee any problems. (3)
- I don't know. (4)

Answer If How would you describe your type of business? Hunting Guide Is Selected
Q19 Do you have any comments in regards to the previous question?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q20 Please respond to the statement "My business would benefit from customers being able to sell their harvest for a profit."

- Strongly Agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Disagree (4)
- Strongly Disagree (5)
- I don't know (6)

Answer If How would you describe your type of business? Hunting Guide Is Selected
Q21 Do you have any comments in regards to the previous question?

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q22 As a hunting guide, how do you feel about the current population of axis deer on Maui Island?

- There are way too many axis deer (1)
- There are too many axis deer (2)
- There are the right amount of axis deer (3)
- There are too few axis deer (4)
- There are way too few axis deer (5)
- Don't know (6)

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q23 Please respond to the statement "As a hunting guide, I believe axis deer populations should be controlled." (This does not include hunting simply for recreation, but includes recreational hunting as a form of population control.)

- Strongly agree (1)
- Agree (2)
- Neither Agree nor Disagree (3)
- Disagree (4)
- Strongly Disagree (5)
- Don't know (6)

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q24 How aware are most of your customers of the problems caused by the overpopulation of axis deer on Maui Island?

- Most are very aware (1)
- Most are fairly aware (2)
- Most are fairly unaware (3)
- Most are very unaware (4)
- Don't know (5)

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q25 Do you think that educating your customers about the problems caused by the overpopulation of axis deer on Maui Island would affect how they hunt axis deer?

- Yes, to a large degree (1)
- Yes, to a small degree (2)
- No (3)
- Don't know (4)

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q26 There are many control methods being considered for axis deer. On a scale from 1-5, with 1 representing that you completely support, 3 being neutral, and 5 being you do not support at all, please mark how you feel about each method:

	1 (Completely Support) (1)	2 (2)	3 (Neutral) (3)	4 (4)	5 (Do Not Support At All) (5)
Fencing (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trap-and-Transfer (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contraceptives (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recreational Hunting (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hired Sharp-shooting (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial Harvesting (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Take No Action- Axis deer population numbers should remain unchanged (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Answer If How would you describe your type of business? Hunting Guide Is Selected

Q27 Please rank the control methods in the order in which you support them. 1 being the most supported, 7 being the least supported.

- _____ Fencing (1)
- _____ Trap-and-Transfer (2)
- _____ Contraceptives (3)
- _____ Recreational Hunting (4)
- _____ Hired Sharp-shooting (5)
- _____ Commercial Harvesting (6)
- _____ Take No Action- Axis deer population numbers should remain unchanged (7)

Answer If How would you describe your type of business? Meat processor Is Selected

Q28 Are you a USDA certified meat processor?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Meat processor Is Selected

Q29 What species does your business process? Please include percentages if possible- ie, 40% beef, 60% pork.

Answer If How would you describe your type of business? Meat processor Is Selected

Q30 How much to you currently pay producers for their animals? Please list cost per pound per species.

Answer If How would you describe your type of business? Meat processor Is Selected

Q31 How much to you currently sell for cuts of meat? Please list cost per species per cut per pound.

Answer If How would you describe your type of business? Meat processor Is Selected

Q32 Do you process wild game meat?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Meat processor Is Selected
And Do you process wild game meat? Yes Is Selected

Q33 How much do you charge for your game processing fees? To save you time, if you have all of your prices on a pricing sheet, you may email that sheet to rubiel@udel.edu.

Answer If How would you describe your type of business? Meat processor Is Selected

Q34 Have you processed axis deer?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Meat processor Is Selected

Q35 To whom do you supply your processed meats? Please check all that apply.

- Restaurants/cafes (1)
- Chefs (2)
- Grocery stores (3)
- Meat markets/delis (4)
- Individuals/families (5)
- Other, please list (6) _____

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected Or How would you describe your type of business? Meat supplier Is Selected

Q36 Would you describe your business as catering to customers who prefer to buy local products?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected Or How would you describe your type of business? Meat supplier Is Selected

Q37 Would you describe your business as catering to customers who prefer to buy organic products?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Restaurant/cafe Is Selected

Q38 What is the average price of a dinner meal at your restaurant/cafe?

Answer If How would you describe your type of business? Chef Is Selected

Q39 Please check all that apply to your work as a chef.

- I work at a restaurant/cafe (1)
- I work for individuals/families (2)
- I work elsewhere: (3) _____

Answer If How would you describe your type of business? Chef Is Selected

Q40 What is the average price of a dinner meal you prepare as a chef?

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected

Q41 Do you currently sell any kind of venison or venison dishes to your customers?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Grocery store Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Meat market/deli Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Chef Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected

Q42 Is venison a seasonal item?

- Yes, during the following seasons: (1) _____
- No (2)

Answer If How would you describe your type of business? Grocery store Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected

Or How would you describe your type of business? Meat market/deli Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Chef Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected

Q43 Approximately how much venison or how many venison dishes do you sell per year? (In terms of weight and revenue)

Answer If How would you describe your type of business? Grocery store Is Selected And Do you currently sell any kind of venison to your customers? Yes Is Selected Or How would you describe your type of business? Meat market/deli Is Selected And Do you currently sell any kind of venison to your customers? Yes Is Selected

Q44 What preparations of venison have you sold in your store in the last 3 years and what is the average price per pound? Please check all that apply.

- Loin. Price per lb: (1) _____
- Rump. Price per lb: (2) _____
- Ribs. Price per lb: (3) _____
- Shoulder. Price per lb: (4) _____
- Flank. Price per lb: (5) _____
- Ground meat. Price per lb: (6) _____

Answer If How would you describe your type of business? Grocery store Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Meat market/deli Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected Or How would you describe your type of business? Chef Is Selected And Do you currently sell any kind of venison or venison dish... Yes Is Selected

Q45 What population segment of customers buys the most venison?

- Hawaiian customers (1)
- US customers from states other than Hawaii (2)
- Customers from countries other than the US (3)

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected

Q46 Were you previously aware of the problems associated with the overpopulation of axis deer on Maui Island?

- Very aware (1)
- Somewhat aware (2)
- Somewhat unaware (3)
- Very unaware (4)

Answer If How would you describe your type of business? Please chec... Grocery store Is Selected Or How would you describe your type of business? Please chec... Meat market/deli Is Selected

Q47 Would you be interested in selling axis deer meat to your customers at your store?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Please chec... Grocery store Is Selected Or How would you describe your type of business? Please chec... Meat market/deli Is Selected

Q48 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Please chec... Grocery store Is Selected And Would you be interested in selling axis deer meat to your... Yes Is Selected Or How would you describe your type of business? Please chec... Meat market/deli Is Selected And Would you be interested in selling axis deer meat to your... Yes Is Selected

Q49 Please mark which cuts of meat you would be interested in purchasing to sell in your store. Please include the price per pound that you would be willing to pay.

- Loin. Price per pound: (1) _____
- Rump. Price per pound: (2) _____
- Ribs. Price per pound: (3) _____
- Shoulder. Price per pound: (4) _____
- Flank. Price per pound: (5) _____
- Ground meat. Price per pound: (6) _____

Answer If How would you describe your type of business? Please chec... Grocery store Is Selected And Would you be interested in selling axis deer meat to your... Yes Is Selected Or How would you describe your type of business? Please chec... Meat market/deli Is Selected And Would you be interested in selling axis deer meat to your... Yes Is Selected

Q50 Based on your answer to the previous question, please mark which cuts of meats you would be interested in selling in your store and how much you would charge to the customers per pound.

- Loin. Price per pound: (1) _____
- Rump. Price per pound: (2) _____
- Ribs. Price per pound: (3) _____
- Shoulder. Price per pound: (4) _____
- Flank. Price per pound: (5) _____
- Ground meat. Price per pound: (6) _____

Answer If How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected

Q51 Would you be interested in including axis deer meat in your dishes?

- Yes, especially after hearing about axis deer overpopulation (1)
- Yes, although my answer is unrelated to the overpopulation problem (2)
- No (3)

Answer If How would you describe your type of business? Please chec... Restaurant/cafe Is Selected Or How would you describe your type of business? Please chec... Chef Is Selected

Q52 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Please chec... Grocery store Is Selected Or How would you describe your type of business? Please chec... Meat market/deli Is Selected

Q53 Do you think your customers would be interested in buying axis deer meat at your store as a local and organic source of protein?

- Yes (1)
- Maybe (2)
- I don't know (3)

Answer If How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected

Q54 Do you think your customers would be interested in buying an axis deer meat dish as a local and organic source of protein?

- Yes (1)
- No (2)
- I don't know (3)

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected Or How would you describe your type of business? Restaurant/cafe Is Selected Or How would you describe your type of business? Chef Is Selected

Q55 Do you think most of your customers are aware of the problems associated with the overpopulation of axis deer on Maui Island?

- Most are very aware (1)
- Most are fairly aware (2)
- Most are fairly unaware (3)
- Most are very unaware (4)
- Don't know (5)

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected

Q56 Do you think that if your customers were educated about the problems associated with the overpopulation of axis deer on Maui Island they would be interested in buying axis deer meat at your store?

- Yes (1)
- Maybe (2)
- I don't know (3)

Answer If How would you describe your type of business? Restaurant/caf  Is Selected Or How would you describe your type of business? Chef Is Selected

Q57 Do you think that if your customers were educated about the problems associated with the overpopulation of axis deer on Maui Island they would be interested in buying an axis deer meat dish?

- Yes (1)
- No (2)
- I don't know (3)

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected

Q58 Would you be interested in holding an informational seminar about axis deer and axis deer meat at your store for customers to learn about axis deer, the problems they cause, and commercialized hunting/other control methods?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Restaurant/caf  Is Selected

Q59 Would you be interested in holding an informational seminar about axis deer and axis deer meat at your restaurant/caf  for customers to learn about axis deer, the problems they cause, and commercialized hunting/other control methods?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Grocery store Is Selected Or How would you describe your type of business? Meat market/deli Is Selected

Q60 Would you be interested in having pamphlets available at your store for customers to learn about axis deer, the problems they cause, and commercialized hunting/other control methods?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Please chec... Chef Is Selected
Or How would you describe your type of business? Please chec... Restaurant/cafe Is Selected

Q61 Would you be interested in having pamphlets available for customers to learn about axis deer, the problems they cause, and commercialized hunting/other control methods?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected

Q62 How many total animals do you keep?

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected

Q63 Which species do you keep that eat frozen animals? Please include the number of animals of each species.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected

Q64 How many pounds of frozen animal do you purchase per year for carnivore consumption or enrichment?

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected

Q65 How much do you spend on frozen animal carcasses/meat per year for carnivore consumption or enrichment?

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected

Q66 What types of frozen animals do you purchase for consumption? Please include the prices you currently pay.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected

Q67 Would your zoo or animal sanctuary be interested in purchasing axis deer (whole carcass, meat, antlers, meaty bones, etc) for carnivore consumption or enrichment?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Please chec... Zoo/animal sanctuary Is Selected

Q68 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected And Would your zoo or animal sanctuary be interested in purch... Yes Is Selected

Q69 Would your zoo or animal sanctuary be interested in purchasing whole axis deer carcasses for carnivore consumption or enrichment? If yes, please include how much you would be willing to pay per carcass, how many carcasses you would be willing to buy, and for how many/which species of animals would this provide.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected And Would your zoo or animal sanctuary be interested in purch... Yes Is Selected

Q70 Would your zoo or animal sanctuary be interested in purchasing axis deer meat for carnivore consumption or enrichment? If yes, please include how much you would be willing to pay per pound, how many pounds you would be willing to buy, and for how many/which species of animals would this provide.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected And Would your zoo or animal sanctuary be interested in purch... Yes Is Selected

Q71 Would your zoo or animal sanctuary be interested in purchasing meaty axis deer bones for carnivore consumption or enrichment? If yes, please include how much you would be willing to pay per pound, how many pounds you would be willing to buy, and for how many/which species of animals would this provide.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected And Would your zoo or animal sanctuary be interested in purch... Yes Is Selected

Q72 Would your zoo or animal sanctuary be interested in purchasing axis deer bones (stripped of meat) for carnivore consumption or enrichment? If yes, please include how much you would be willing to pay per pound, how many pounds you would be willing to buy, and for how many/which species of animals would this provide.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected And Would your zoo or animal sanctuary be interested in purch... Yes Is Selected

Q73 Would your zoo or animal sanctuary be interested in purchasing axis deer antlers for carnivore consumption or enrichment? If yes, please include how much you would be willing to pay per pound, how many pounds you would be willing to buy, and for how many/which species of animals would this provide.

Answer If How would you describe your type of business? Zoo/animal sanctuary Is Selected And Would your zoo or animal sanctuary be interested in purch... Yes Is Selected

Q74 Would your zoo or animal sanctuary be interested in purchasing other axis deer parts (for example, hooves) for carnivore consumption or enrichment? If yes, please include what deer part, how much you would be willing to pay per pound, how many pounds you would be willing to buy, and for how many/which species of animals would this provide.

Answer If How would you describe your type of business? Pet food company Is Selected

Q75 Do you cater to pet owners looking for organic pet food?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Pet food company Is Selected

Q76 Do you cater to pet owners looking for local pet food?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Pet food company Is Selected

Q77 What kind of pet food do you sell? Please check all that apply.

- Dry food (1)
- Wet food (2)
- Bones (3)
- Raw meat (4)
- Treats (5)
- Other (6) _____

Answer If How would you describe your type of business? Pet food company Is Selected

Q78 For what species do you sell food? Please check all that apply.

- Dogs (1)
- Cats (2)
- Other (3) _____

Answer If How would you describe your type of business? Pet food company Is Selected

Q79 Would you be interested in buying commercially harvested axis deer meat or parts to include in your pet food?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Please chec... Pet food company Is Selected

Q80 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Pet food company Is Selected And Would you be interested in buying commercially harvested ... Yes Is Selected

Q81 Would your pet food company be interested in purchasing processed axis deer meat? If yes, please include how much you would be willing to pay per pound.

Answer If How would you describe your type of business? Pet food company Is Selected And Would you be interested in buying commercially harvested ... Yes Is Selected

Q82 Would your pet food company be interested in purchasing meaty axis deer bones? If yes, please include how much you would be willing to pay per pound.

Answer If How would you describe your type of business? Pet food company Is Selected And Would you be interested in buying commercially harvested ... Yes Is Selected

Q83 Would your pet food company be interested in purchasing axis deer bones (stripped of meat)? If yes, please include how much you would be willing to pay per pound.

Answer If How would you describe your type of business? Pet food company Is Selected And Would you be interested in buying commercially harvested ... Yes Is Selected

Q84 Would your pet food company be interested in purchasing axis deer antlers? If yes, please include how much you would be willing to pay per pound.

Answer If How would you describe your type of business? Pet food company Is Selected And Would you be interested in buying commercially harvested ... Yes Is Selected

Q85 Would your pet food company be interested in purchasing some other axis deer part (for example, hooves)? If yes, please state which deer part and include how much you would be willing to pay per pound.

Answer If How would you describe your type of business? Leather smith/tanner Is Selected

Q86 What leather do you currently use in your leather products?

Answer If How would you describe your type of business? Leather smith/tanner Is Selected

Q87 How much do you pay per pelt for your leather products? Please specify the pelt species.

Answer If How would you describe your type of business? Leather smith/tanner Is Selected

Q88 What types of leather products do you make?

Answer If How would you describe your type of business? Leather smith/tanner Is Selected

Q89 Would you be interested in purchasing commercially harvested axis deer pelts for your products, why or why not? If yes, how much would you be willing to pay per pelt?

Answer If How would you describe your type of business? Leather smith/tanner Is Selected

Q90 For how much would you sell axis deer leather products? Please specify the type of product and the price.

Answer If How would you describe your type of business? Meat supplier Is Selected

Q91 To whom to you supply meat? Please check all that apply.

- Restaurants/cafes (1)
- Meat markets/delis (2)
- Grocery stores (3)
- Chefs (4)
- Individuals/families (5)
- Other: (6) _____

Answer If How would you describe your type of business? Meat supplier Is Selected

Q92 What types of meat and what preparations do you currently offer? Please include percentages where possible—for example, ground beef is 60% of total sales.

Answer If How would you describe your type of business? Meat supplier Is Selected

Q93 How much do you pay for type of meat and preparation per pound and how much do you sell each per pound?

Answer If How would you describe your type of business? Meat supplier Is Selected

Q94 Do you currently supply any preparation of venison?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Meat supplier Is Selected And Do you currently supply any preparation of venison? Yes Is Selected

Q95 Approximately how much venison do you sell per year? (In terms of weight and revenue)

Answer If How would you describe your type of business? Please chec... Meat supplier Is Selected

Q96 Are interested in buying axis deer meat from a processor to resell?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Please chec... Meat supplier Is Selected

Q97 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Please chec... Meat supplier Is Selected And Are interested in buying axis deer meat from a processor ... Yes Is Selected

Q98 If you are interested in buying axis deer meat to sell, please mark which cuts of meat you would be interested in purchasing to resell. Please include the price per pound that you would be willing to pay.

- Loin. Price per pound: (1) _____
- Rump. Price per pound: (2) _____
- Ribs. Price per pound: (3) _____
- Shoulder. Price per pound: (4) _____
- Flank. Price per pound: (5) _____
- Ground meat. Price per pound: (6) _____

Answer If How would you describe your type of business? Please chec... Meat supplier Is Selected And Are interested in buying axis deer meat from a processor ... Yes Is Selected

Q99 Based on your answer to the previous question, please mark which cuts of meats you would be interested in reselling and how much you would charge to customers per pound.

- Loin. Price per pound: (1) _____
- Rump. Price per pound: (2) _____
- Ribs. Price per pound: (3) _____
- Shoulder. Price per pound: (4) _____
- Flank. Price per pound: (5) _____
- Ground meat. Price per pound: (6) _____

Answer If How would you describe your type of business? Jewelry maker Is Selected

Q100 What types of jewelry do you make and what is the average price of each type of piece? Please check all that apply.

- Rings. Average price: (1) _____
- Earrings. Average price: (2) _____
- Necklaces. Average price: (3) _____
- Bracelets. Average price: (4) _____
- Anklets. Average price: (5) _____
- Other, please explain. Average price: (6) _____

Answer If How would you describe your type of business? Jewelry maker Is Selected

Q101 How often do you use beads in your jewelry?

- Very often (1)
- Often (2)
- Not often (3)
- Never (4)

Answer If How would you describe your type of business? Please chec... Jewelry maker Is Selected And How often do you use beads in your jewelry? Never Is Not Selected Or How would you describe your type of business? Please chec... Bead seller/manufacturer Is Selected

Q102 Approximately how much do you spend on a 1lb package of beads (whether to use or resell)? (Please specify weight of package if you use a weight other than 1lb packages)

Answer If How would you describe your type of business? Jewelry maker Is Selected

Q103 Would you be interested in including beads made from commercially harvested axis deer antlers in your jewelry?

- Yes (1)
- No (2)

Answer If How would you describe your type of business? Please chec... Jewelry maker Is Selected

Q104 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Jewelry maker Is Selected

Q105 Do you think customers would be interested in jewelry made with axis deer antler beads?

- Yes (1)
- No (2)
- I don't know (3)

Answer If How would you describe your type of business? Please chec... Jewelry maker Is Selected

Q106 Do you have any comments in regards to the previous question?

Answer If How would you describe your type of business? Bead seller/manufacturer Is Selected

Q107 Would you be interested in making or selling beads that use commercially harvested axis deer antlers? Please check all that apply.

- Yes, I would be interested in making beads if given the antlers (1)
- Yes, I would be interested in selling pre-made beads made out of antlers (2)
- No, I am not interested in including axis deer antler beads in my selection of beads (3)

Answer If How would you describe your type of business? Please chec... Bead seller/manufacturer Is Selected

Q108 Can you please explain the reasoning behind your answer to the previous question.

Answer If How would you describe your type of business? Bead seller/manufacturer Is Selected And Would you be interested in making or selling beads that u... Yes, I would be interested in making beads if given the antlers Is Selected

Q109 How much would you be willing to spend on a rack (pair) of antlers to make into beads?

Answer If How would you describe your type of business? Please chec... Jewelry maker Is Selected And Would you be interested in including beads made from comm... Yes Is Selected Or How would you describe your type of business? Please chec... Bead seller/manufacturer Is Selected And Would you be interested in making or selling beads that u... Yes, I would be interested in selling pre-made beads made out of antlers Is Selected

Q110 How much would you be willing to pay for a 1lb package of axis deer antler beads?

Answer If How would you describe your type of business? Bead seller/manufacturer Is Selected And Would you be interested in making or selling beads that u... Yes, I would be interested in making beads if given the antlers Is Selected Or How would you describe your type of business? Bead seller/manufacturer Is Selected And Would you be interested in making or selling beads that u... Yes, I would be interested in selling pre-made beads made out of antlers Is Selected

Q111 For how much would you sell a 1lb package of axis deer antler beads to a jewelry maker or arts and crafts store?

Answer If How would you describe your type of business? Jewelry maker Is Selected Or How would you describe your type of business? Bead seller/manufacturer Is Selected

Q112 Do you offer online orders off of a website? If yes, what percentage of your sales is online?

- Yes (1) _____
- No (2)

Q113 What is your year of birth?

Q114 Are you male or female?

- Male (1)
- Female (2)

Q115 What is your highest level of education?

- Some high school or less (1)
- High School Degree or High School Equivalency eg. GED (2)
- Associate's Degree (3)
- Bachelor's Degree (College) (4)
- Graduate/Professional Degree (5)

Q116 Which category best describes your business' income (before taxes) in 2012?

- Less than \$5,000 (1)
- \$5,000-\$9,999 (2)
- \$10,000-\$14,999 (3)
- \$15,000-\$24,999 (4)
- \$25,000-\$34,999 (5)
- \$35,000-\$49,999 (6)
- \$50,000-\$74,999 (7)
- \$75,000-\$99,999 (8)
- \$100,000-\$149,999 (9)
- \$150,000-\$199,999 (10)
- \$200,000-\$249,999 (11)
- \$250,000 and above (12)

Q117 On which island is your business located? Please check all that apply if you have multiple locations.

- Hawai'i (1)
- Maui (2)
- O'ahu (3)
- Kaua'i (4)
- Moloka'i (5)
- Lāna'i (6)
- Ni'ihau (7)
- I don't have a physical location, my business is only online (8)
- Other: (9) _____

Q118 What is your permanent residence?

- The state of Hawaii. (1)
- US state other than Hawaii. Which state? (2) _____
- Country other than United States. Which country? (3) _____

Answer If What is your permanent residence? The state of Hawaii. Is Selected

Q119 Which island is your permanent residence?

- Hawai'i (1)
- Maui (2)
- O'ahu (3)
- Kaua'i (4)
- Moloka'i (5)
- Lāna'i (6)
- Ni'ihau (7)

Q120 Thank you for your participation in the survey! We very much appreciate your taking the time! Use the space below if you have any comments for us.

Appendix B

HUNTER SURVEY

University of Delaware Informed Consent Form

Title of Project: Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- hunter survey

Principal Investigator (s): Elena Rubino

Other Investigators: Dr. Chris Williams

You are being asked to participate in a research study. This form tells you about the study including its purpose, what you will do if you decide to participate, and any risks and benefits of being in the study. Please read the information below and ask the research team questions about anything we have not made clear before you decide whether to participate. Your participation is voluntary and you can refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you will be asked to sign this form and a copy will be given to you to keep for your reference.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to help determine how the potential commercial harvest of axis deer as a population control method would benefit local Hawaiian hunters. This study is to be used as part of Elena Rubino's master's thesis. You are being asked to take part in this study because you are registered as a licensed hunter for Maui Island. All subjects will be specifically recruited and thus would not be excluded from volunteering. Approximately 200 participants will be surveyed for this study.

WHAT WILL YOU BE ASKED TO DO?

You will be asked to answer a series of survey questions about your hunting experiences, opinions about axis deer population control, and your demographic information. Questions will be in multiple choice, ranking/listing, and short answer form. The survey will take between 10 minutes and 30 minutes to complete.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

Survey procedures involve using your computer for between 10 minutes and 30 minutes so there is the potential for slight eye discomfort. There are no other foreseeable risks from participating in this survey.

WHAT ARE THE POTENTIAL BENEFITS?

You will not benefit directly from taking part in this research. However, this survey will help determine if there is support from the local hunting community for a new system of axis deer management involving the commercialization of deer meat. This could result in major policy changes which would reform how states manage overabundant wildlife. Policy changes could potentially benefit the ecosystem, human safety (reducing deer-related automobile accidents), and the economy (providing a natural, local source of meat).

HOW WILL CONFIDENTIALITY BE MAINTAINED?

We will make every effort to keep all research records that could identify you confidential to the extent permitted by law. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Data will be kept on a secure computer and data will be coded so confidentiality will be maintained. Code numbers will be kept in a different location than survey data. Data may be stored indefinitely. Your research records may be viewed by the University of Delaware Institutional Review Board, but the confidentiality of your records will be protected to the extent permitted by law. De-identified data may be shared with the Maui Axis Deer Working Group and other governmental groups related to axis deer population control.

WILL THERE BE ANY COSTS RELATED TO THE RESEARCH?

There are no costs related to participating in this research.

WILL THERE BE ANY COMPENSATION FOR PARTICIPATION?

There will be no monetary compensation for participation.

DO YOU HAVE TO TAKE PART IN THIS STUDY?

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time and to choose which questions in this survey you want to answer. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware or the Maui Axis Deer Working Group.

Subject participation will not be terminated by the investigator.

WHO SHOULD YOU CALL IF YOU HAVE QUESTIONS OR CONCERNS?

If you have any questions about this study, please contact the Principal Investigator, Elena Rubino at 908-451-7228 or rubi@udel.edu.

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

By checking below, you indicate that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You may copy and paste this consent form as a record. By checking this box, you indicate that you voluntarily agree to participate in this study and that you are at least 18 years old.

I agree (1)

Q1 On the island of Maui, do you think there are more axis deer, fewer axis deer, or the same amount of axis deer as compared to 5 years ago?

- A lot more deer (1)
- A few more deer (2)
- The same number of deer (3)
- A few less deer (4)
- A lot less deer (5)
- I don't know (6)

Q2 Please fill in the blank: "I believe axis deer populations on Maui should be _____".

- greatly increased (1)
- increased (2)
- remain the same (3)
- decreased (4)
- greatly decreased (5)
- I don't know (6)

Q3 How aware are you of the problems caused by the overpopulation of axis deer on Maui?

- Very aware (1)
- Fairly aware (2)
- Fairly unaware (3)
- Very unaware (4)

Q4 Axis deer are non-native to Hawaii and the populations of deer on the island of Maui have reached a critical threshold, but are still growing. These increased populations have been linked to the degradation of the natural ecosystem and cause of human-wildlife conflicts, including increased deer-automobile collisions and damage to agricultural

operations. A commercial harvest of axis deer is being considered in order to control their populations. We are reaching out to hunters throughout Maui to determine how the potential commercial harvest of axis deer as a population control method would benefit hunters. Axis deer would be harvested by hunters, who could then sell the whole axis deer or parts of the deer for a profit. We ask that you try to answer these questions about your attitudes and opinions as honestly as possible to give us the most accurate picture of how an axis deer harvest could impact hunters. Please remember that your responses are very helpful to our data collection regardless of your opinions about a commercialized hunt. We seek your honest opinions.

Q5 Are you currently a licensed hunter in Maui?

- Yes (1)
- No (2)

Answer If Are you currently a licensed hunter in Maui? No Is Selected

Q6 Have you been a licensed hunter in Maui in the past 2 years?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Block

Q7 When you go out hunting on Maui, approximately how many axis deer do you see per month on average?

Q8 Describing your hunting patterns within the past 2 years: Do you hunt axis deer on the island of Maui?

- Yes, I only hunt axis deer (1)
- Yes, I primarily hunt axis deer, but I hunt a few other species (2)
- Yes, I occasionally hunt axis deer, but I focus mainly on other species (3)
- No, I never hunt axis deer (4)

If No, I never hunt axis deer Is Selected, Then Skip To End of Block

Q9 How many days did you hunt axis deer in the past 2 years on Maui on any type of land, public or private (total of both years)?

- more than 30 days (1)
- 26-30 days (2)
- 21-25 days (3)
- 16-20 days (4)
- 11-15 days (5)
- 6-10 days (6)
- 1-5 days (7)
- I don't know (8)

Q10 In the past 2 years, how many axis deer have you hunted per month on average on the island of Maui?

Q11 With what sporting devices did you hunt axis deer on Maui in the past 2 years?

- shotgun (1)
- rifle (2)
- bow and arrow (excluding crossbow) (3)
- crossbow (4)
- dogs (5)
- other (6)

Q12 Currently, it is illegal to sell meat and other products from wildlife; however, if commercial harvest became legalized for axis deer, the sale of these items would be permitted. Licenses would be issued to hunters to commercially harvest axis deer and the hunters could then sell the carcasses to processors. Do you foresee any problems with legalizing the commercial harvest of axis deer?

- I foresee many and/or serious problems. (1)
- I foresee a few and/or minor problems. (2)
- I do not foresee any problems. (3)
- I don't know. (4)

Q13 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q14 If a commercial harvest were legalized for axis deer, would you be interested in participating?

- Yes (1)
- Maybe (2)
- No (3)

Q15 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q16 If axis deer carcasses for an average sized deer sold for \$5 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q17 If axis deer carcasses for an average sized deer sold for \$10 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q18 If axis deer carcasses for an average sized deer sold for \$20 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q19 If axis deer carcasses for an average sized deer sold for \$30 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q20 If axis deer carcasses for an average sized deer sold for \$50 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q21 If axis deer carcasses for an average sized deer sold for \$60 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q22 If axis deer carcasses for an average sized deer sold for \$80 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q23 If axis deer carcasses for an average sized deer sold for \$100 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q24 If axis deer carcasses for an average sized deer sold for \$200 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q25 If axis deer carcasses for an average sized deer sold for \$250 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q26 How certain are you of your response? (Where 1 is extremely uncertain and 10 is extremely certain.)

_____ Where do you fall on the scale? (1)

Q27 At this price per carcass, how many deer carcasses are you likely to sell in one year?

- 1-3 (1)
- 4-6 (2)
- 7-10 (3)
- 11-15 (4)
- over 15 (5)

Answer If Describing your hunting patterns within the past 2 years: Do you hunt axis deer on Maui Island? No, I never hunt axis deer Is Not Selected

Q28 If you could sell the axis deer you hunted on Maui for a profit, how would your hunting behavior change?

- I would hunt much more often (1)
- I would hunt a little more often (2)
- I would not change my behavior (3)
- I would hunt a little less often (4)
- I would hunt much less often (5)
- Don't know (6)

Answer If Describing your hunting patterns within the past 2 years: Do you hunt axis deer on Maui Island? No, I never hunt axis deer Is Not Selected

Q29 Please respond to this statement: "I would benefit from being able to sell my axis deer harvest for a profit."

- Strongly Agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Disagree (4)
- Strongly Disagree (5)
- I don't know (6)

Answer If Describing your hunting patterns within the past 2 years: Do you hunt axis deer on Maui Island? No, I never hunt axis deer Is Not Selected

Q30 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Answer If Describing your hunting patterns within the past 2 years: Do you hunt axis deer? No, I never hunt axis deer Is Not Selected

Q31 Do you often utilize the services of a hunting guide when you hunt axis deer on the island of Maui?

- Always (1)
- Most of the time (2)
- Rarely (3)
- Never (4)

Answer If Describing your hunting patterns within the past 2 years: Do you hunt axis deer on Maui Island? No, I never hunt axis deer Is Not Selected

Q32 Which of the following was your single most important reason for hunting axis deer on Maui in the past 2 years?

- For the meat (1)
- For the sport and recreation (2)
- To be with family and friends (3)
- For relaxation (4)
- To be close to nature (5)
- For a trophy (6)

Answer If Describing your hunting patterns within the past 2 years: Do you hunt axis deer on Maui Island? No, I never hunt axis deer Is Not Selected

Q33 In the past 2 years, did you hunt axis deer primarily on private land or public land on the island of Maui?

- Private land (1)
- Public land (2)
- Both about equally (3)

Q34 Do you think that educating other hunters about the problems caused by the overpopulation of axis deer on the island of Maui would affect how they hunt axis deer?

- Yes, to a large degree (1)
- Yes, to a small degree (2)
- No (3)
- Don't know (4)

Q35 There are many control methods being considered for axis deer on Maui. On a scale from 1-5, with 1 representing that you completely support, 3 being neutral, and 5 being you do not support at all, please mark how you feel about each method:

Definitions—

Fencing: Fences are placed around property to keep axis deer inside or outside of a given area

Trap-and-Transfer: Some axis deer are trapped and relocated to be released in a different area

Contraceptives: Some axis deer are given contraceptives so that they cannot reproduce

Recreational Hunting: Hunters hunt deer as a form of recreation and keep the meat/trophy for themselves

Commercial Harvesting: Hunters are paid for their harvested deer by processors, who then inspect and sell the meat

Take No Action: Axis deer population numbers should remain unchanged

	1 (Completely Support) (1)	2 (2)	3 (Neutral) (3)	4 (4)	5 (Do Not Support At All) (5)
Fencing (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trap-and-Transfer (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contraceptives (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recreational Hunting (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hired Sharp-shooting (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial Harvesting (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Take No Action- Axis deer population numbers should remain unchanged (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q36 Please rank the control methods in the order in which you support them. 1 being the most supported, 7 being the least supported. (Click and drag into appropriate order)

- _____ Fencing (1)
- _____ Trap-and-Transfer (2)
- _____ Contraceptives (3)
- _____ Recreational Hunting (4)
- _____ Hired Sharp-shooting (5)
- _____ Commercial Harvesting (6)
- _____ Take No Action- Axis deer population numbers should remain unchanged (7)

Q37 Do you own land on the island of Maui?

- Yes (1)
- No (2)

Answer If Do you own land on Maui Island? Yes Is Selected

Q38 How much land do you own?

- 10+ acres (1)
- 3-10 acres (2)
- Under 3 acres (3)

Answer If Do you own land on Maui Island? Yes Is Selected

Q39 Have you ever experienced any kind of damage from axis deer?

- Yes (1)
- No (2)

Answer If Do you own land on Maui Island? Yes Is Selected And As a landowner, have you ever experienced damage from axis deer? Yes Is Selected

Q40 What type of damage caused by axis deer have you had?

- Landscaping and/or yard (excluding gardens) (1)
- Garden (personal) (2)
- Vehicle collisions as driver (3)
- Vehicle collisions as passenger (4)
- Agricultural damage (crops) (5)
- Annoyance to humans (6)
- Other (7) _____

Q41 What is your year of birth?

Q42 Are you male or female?

- Male (1)
- Female (2)

Q43 What is your highest level of education?

- Some high school or less (1)
- High School Degree or High School Equivalency eg. GED (2)
- Associate's Degree (3)
- Bachelor's Degree (College) (4)
- Graduate/Professional Degree (5)

Q44 Which category best describes your income (before taxes) in 2012?

- Less than \$5,000 (1)
- \$5,000-\$9,999 (2)
- \$10,000-\$14,999 (3)
- \$15,000-\$24,999 (4)
- \$25,000-\$34,999 (5)
- \$35,000-\$49,999 (6)
- \$50,000-\$74,999 (7)
- \$75,000-\$99,999 (8)
- \$100,000-\$149,999 (9)
- \$150,000-\$199,999 (10)
- \$200,000-\$249,999 (11)
- \$250,000 and above (12)

Q45 Where is your permanent residence?

- Hawai'i (1)
- Maui (2)
- O'ahu (3)
- Kaua'i (4)
- Moloka'i (5)
- Lāna'i (6)
- Ni'ihau (7)
- A US state other than Hawaii. Which state? (8) _____
- Country other than the United States. Which country? (9) _____

Q46 Thank you for your participation in the survey! We very much appreciate your taking the time! Use the space below if you have any comments for us.

Appendix C

RESIDENT SURVEY

University of Delaware- Informed Consent Form

Title of Project: Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- citizen survey

Principal Investigator (s): Elena Rubino

Other Investigators: Dr. Chris Williams

You are being asked to participate in a research study. This form tells you about the study including its purpose, what you will do if you decide to participate, and any risks and benefits of being in the study. Please read the information below and ask the research team questions about anything we have not made clear before you decide whether to participate. Your participation is voluntary and you can refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you will be asked to sign this form and a copy will be given to you to keep for your reference.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to help determine how the potential commercial harvest of axis deer as a population control method would impact Hawaiian citizens. This study is to be used as part of Elena Rubino's master's thesis. You are being asked to take part in this study because you are a citizen of the island of Maui. All subjects will be specifically recruited and thus would not be excluded from volunteering. Approximately 200 participants will be surveyed for this study.

WHAT WILL YOU BE ASKED TO DO?

You will be asked to answer a series of survey questions about your opinions about axis deer population control, consumer choices about axis deer products, and your demographic information. Questions will be in multiple choice, ranking/listing, and short answer form. The survey will take between 10 minutes and 20 minutes to complete.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

Survey procedures involve using your computer for between 10 minutes and 20 minutes so there is the potential for slight eye discomfort. There are no other foreseeable risks from participating in this survey.

WHAT ARE THE POTENTIAL BENEFITS?

You will not benefit directly from taking part in this research. However, this survey will help determine if there is support from the local community for a new system of axis deer management involving the commercialization of deer meat. This could result in major policy changes which would reform how states manage overabundant wildlife. Policy changes could potentially benefit the ecosystem, human safety (reducing deer-related automobile accidents), and the economy (providing a natural, local source of meat).

HOW WILL CONFIDENTIALITY BE MAINTAINED?

We will make every effort to keep all research records that could identify you confidential to the extent permitted by law and we are not collecting any personally identifiable information. Data will be kept on a secure computer and data may be stored indefinitely. Your research records may be viewed by the University of Delaware Institutional Review Board, but the confidentiality of your records will be protected to the extent permitted by law. Data may be shared with the Maui Axis Deer Working Group and other governmental groups related to axis deer population control.

WILL THERE BE ANY COSTS RELATED TO THE RESEARCH?

There are no costs related to participating in this research.

WILL THERE BE ANY COMPENSATION FOR PARTICIPATION?

There will be no monetary compensation for participation.

DO YOU HAVE TO TAKE PART IN THIS STUDY?

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time and to choose which questions in this survey you want to answer. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware or the Maui Axis Deer Working Group.

Subject participation will not be terminated by the investigator.

WHO SHOULD YOU CALL IF YOU HAVE QUESTIONS OR CONCERNS?

If you have any questions about this study, please contact the Principal Investigator, Elena Rubino at 908-451-7228 or rubi@udel.edu.

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

By checking below, you indicate that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and

those questions have been answered. You may copy and paste this consent form as a record. By checking this box, you indicate that you voluntarily agree to participate in this study and that you are at least 18 years old.

I agree (1)

Q1 Do you currently live on the island of Maui?

- Yes (1)
- No (2)

Answer If Do you currently live on the island of Maui? No Is Selected

Q2 Have you lived on the island of Maui in the past 2 years?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Survey

Q3 How many consecutive years have you lived on the island of Maui?

- 1-3 years (1)
- 4-6 years (2)
- 6-10 years (3)
- 10-15 years (4)
- over 15 years (5)

Q4 Do you own land on Maui Island?

- Yes (1)
- No (2)

Answer If Do you own land on Maui Island? Yes Is Selected

Q5 How much land do you own?

- 10+ acres (1)
- 3-10 acres (2)
- Under 3 acres (3)

Answer If Do you own land on Maui Island? Yes Is Selected

Q6 Have you ever experienced any kind of damage from axis deer?

- Yes (1)
- No (2)

Answer If Do you own land on Maui Island? Yes Is Selected And As a landowner, have you ever experienced damage from axis deer? Yes Is Selected

Q7 What type of damage caused by axis deer have you had?

- Landscaping and/or yard (excluding gardens) (1)
- Garden (personal) (2)
- Vehicle collisions as driver (3)
- Vehicle collisions as passenger (4)
- Agricultural damage (crops) (5)
- Annoyance to humans (6)
- Other (7) _____

Q8 On Maui Island, do you think there are more axis deer, fewer axis deer, or the same amount of axis deer as compared to 5 years ago?

- A lot more deer (1)
- A few more deer (2)
- The same number of deer (3)
- A few less deer (4)
- A lot less deer (5)
- I don't know (6)

Q9 Please fill in the blank: "I believe axis deer populations on Maui Island should be _____".

- greatly increased (1)
- increased (2)
- remain the same (3)
- decreased (4)
- greatly decreased (5)
- I don't know (6)

Q10 How aware are you of the problems caused by the overpopulation of axis deer on Maui Island?

- Very aware (1)
- Fairly aware (2)
- Fairly unaware (3)
- Very unaware (4)

Q11 Axis deer are non-native to Hawaii and the populations of deer on the island of Maui have reached a critical threshold, but are still growing. These increased populations have been linked to the degradation of the natural ecosystem and cause of human-wildlife conflicts, including increased deer-automobile collisions and damage to agricultural operations. A commercial harvest of axis deer is being considered in order to control their populations. We are reaching out to citizens throughout Maui to determine how the potential commercial harvest of axis deer as a population control method would benefit the general population. Axis deer would be harvested by hunters, who could then sell the whole axis deer or parts of the deer for a profit to processors, who would then sell the meat and/or parts to various companies including grocery stores and restaurants. We ask that you try to answer these questions about your attitudes and opinions as honestly as possible to give us the most accurate picture of how an axis deer harvest could impact the community. Please remember that your responses are very helpful to our data collection regardless of your opinions about a commercialized hunt. We seek your honest opinions.

Q12 Currently, it is illegal to sell meat and other products from wildlife; however, if commercial harvest became legalized for axis deer, the sale of these items would be permitted. Licenses would be issued to hunters to commercially harvest axis deer and the hunters could then sell the carcasses to processors who would then sell the meat to grocery stores, delis, and restaurants. Do you foresee any problems with legalizing the commercial harvest of axis deer?

- I foresee many and/or serious problems. (1)
- I foresee a few and/or minor problems. (2)
- I do not foresee any problems. (3)
- I don't know. (4)

Q13 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q14 A possible use of axis deer as a result of a commercialized harvest is the selling of axis deer meat in grocery stores and delis, as well as the selling of axis deer meat dishes

in restaurants. Would you be interested in purchasing axis deer meat (for example, steaks or ground meat) either to prepare yourself or at a restaurant?

- No, because I do not eat any kind of meat. (1)
- No, because I do not want to eat axis deer meat (but I do eat other forms of meat). (2)
- Yes, I would be interested in buying axis deer meat at the store and/or as a dish in a restaurant. (3)

Q15 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q16 Another possible use of axis deer as a result of a commercialized harvest is including meat and other deer parts in pet food and treats. Would you be interested in purchasing pet food (made with axis deer meat) or treats (such as axis deer bones, antlers, and hooves as dog chew toys)?

- No, I am not interested because I do not have a pet. (1)
- No, I have a pet, but I am not interested in purchasing food or treats that contain axis deer parts. (2)
- Yes, I am interested in purchasing pet food made with axis deer meat. (3)
- Yes, I am interested in purchasing axis deer bones, antlers, and/or hooves as chew toys. (4)
- Yes, I am interested in purchasing both pet food and treats made from axis deer parts. (5)

Q17 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q18 Another possible use of axis deer as a result of a commercialized harvest is using axis deer antler beads in Hawaiian jewelry. Would you be interested in purchasing jewelry made with axis deer antler beads?

- No, I do not wear jewelry. (1)
- No, I wear jewelry, but I do not want to wear jewelry made with axis deer antler beads. (2)
- Yes, I would be interested in purchasing jewelry that uses axis deer antler beads. (3)

Q19 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q20 Do you think that educating citizens about the problems caused by the overpopulation of axis deer on Maui Island would affect if they purchase axis deer products?

- Yes, to a large degree (1)
- Yes, to a small degree (2)
- No (3)
- Don't know (4)

Q21 There are many control methods being considered for axis deer on Maui Island. On a scale from 1-5, with 1 representing that you completely support, 3 being neutral, and 5 being you do not support at all, please mark how you feel about each method:

Definitions--Fencing: Fences are placed around property to keep axis deer inside or outside of a given area

Trap-and-Transfer: Some axis deer are trapped and relocated to be released in a different area

Contraceptives: Some axis deer are given contraceptives so that they cannot reproduce

Recreational Hunting: Hunters hunt deer as a form of recreation and keep the meat/trophy for themselves

Commercial Harvesting: Hunters are paid for their harvested deer by processors, who then inspect and sell the meat

Take No Action: Axis deer population numbers should remain unchanged

	1 (Completely Support) (1)	2 (2)	3 (Neutral) (3)	4 (4)	5 (Do Not Support At All) (5)
Fencing (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trap-and-Transfer (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contraceptives (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recreational Hunting (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hired Sharpshooting (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial Harvesting (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Take No Action: Axis deer population	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

numbers should remain unchanged (7)					
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Q22 Please rank the control methods in the order in which you support them. 1 being the most supported, 7 being the least supported. (Click and drag into appropriate order)

- _____ Fencing (1)
- _____ Trap-and-Transfer (2)
- _____ Contraceptives (3)
- _____ Recreational Hunting (4)
- _____ Hired Sharp-shooting (5)
- _____ Commercial Harvesting (6)
- _____ Take No Action- Axis deer population numbers should remain unchanged (7)

Q23 Are you currently a licensed hunter in Maui?

- Yes (1)
- No (2)

Answer If Are you currently a licensed hunter in Maui? No Is Selected

Q24 Have you been a licensed hunter in Maui in the past 2 years?

- Yes (1)
- No (2)

If No Is Selected, Then Skip To End of Block

Q25 Have you previously been asked to take an online survey about hunting axis deer for a commercialized harvest?

- Yes (1)
- No (2)

If Yes Is Selected, Then Skip To End of Block

Q26 When you go out hunting on Maui Island, approximately how many axis deer do you see per month on average?

Q27 Describing your hunting patterns within the past 2 years: Do you hunt axis deer on Maui Island?

- Yes, I only hunt axis deer (1)
- Yes, I primarily hunt axis deer, but I hunt a few other species (2)
- Yes, I occasionally hunt axis deer, but I focus mainly on other species (3)
- No, I never hunt axis deer (4)

If No, I never hunt axis deer Is Selected, Then Skip To End of Block

Q28 How many days did you hunt axis deer in the past 2 years on Maui Island on any type of land, public or private (total of both years)?

- more than 30 days (1)
- 26-30 days (2)
- 21-25 days (3)
- 16-20 days days (4)
- 11-15 days (5)
- 6-10 days (6)
- 1-5 days (7)
- I don't know (8)

Q29 With what sporting devices did you hunt axis deer on Maui Island in the past 2 years?

- shotgun (1)
- rifle (2)
- bow and arrow (excluding crossbow) (3)
- crossbow (4)
- dogs (5)
- other (6)

Q30 In the past 2 years, how many axis deer have you hunted per month on average on Maui Island?

Q31 If a commercial harvest were legalized for axis deer, would you be interested in participating?

- Yes (1)
- Maybe (2)
- No (3)

Q32 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q33 If axis deer carcasses for an average sized deer sold for \$5 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q34 If axis deer carcasses for an average sized deer sold for \$10 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q35 If axis deer carcasses for an average sized deer sold for \$20 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q36 If axis deer carcasses for an average sized deer sold for \$30 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q37 If axis deer carcasses for an average sized deer sold for \$50 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q38 If axis deer carcasses for an average sized deer sold for \$60 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q39 If axis deer carcasses for an average sized deer sold for \$80 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q40 If axis deer carcasses for an average sized deer sold for \$100 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q41 If axis deer carcasses for an average sized deer sold for \$200 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q42 If axis deer carcasses for an average sized deer sold for \$250 per carcass, would you participate in a commercialized hunt?

- Yes (1)
- No (2)

Q43 How certain are you of your response? (Where 1 is extremely uncertain and 10 is extremely certain.)

_____ Where do you fall on the scale? (1)

Q44 At this price per carcass, how many deer carcasses are you likely to sell in one year?

- 1-3 (1)
- 4-6 (2)
- 7-10 (3)
- 11-15 (4)
- over 15 (5)

Q45 If you could sell the axis deer you hunted on Maui Island for a profit, how would your hunting behavior change?

- I would hunt much more often (1)
- I would hunt a little more often (2)
- I would not change my behavior (3)
- I would hunt a little less often (4)
- I would hunt much less often (5)
- Don't know (6)

Q46 Please respond to this statement: "I would benefit from being able to sell my axis deer harvest for a profit."

- Strongly Agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Disagree (4)
- Strongly Disagree (5)
- I don't know (6)

Q47 Do you have any comments in regards to the previous question? If not, please move onto the next question.

Q48 Do you think that educating other hunters about the problems caused by the overpopulation of axis deer on Maui Island would affect how they hunt axis deer?

- Yes, to a large degree (1)
- Yes, to a small degree (2)
- No (3)
- I don't know (4)

Q49 Do you often utilize the services of a hunting guide when you hunt axis deer on Maui Island?

- Always (1)
- Most of the time (2)
- Rarely (3)
- Never (4)

Q50 Which of the following was your single most important reason for hunting axis deer on Maui Island in the past 2 years?

- For the meat (1)
- For the sport and recreation (2)
- To be with family and friends (3)
- For relaxation (4)
- To be close to nature (5)
- For a trophy (6)

Q51 In the past 2 years, did you hunt axis deer primarily on private land or public land on Maui Island?

- Private land (1)
- Public land (2)
- Both about equally (3)

Q52 What is your year of birth?

Q53 Are you male or female?

- Male (1)
- Female (2)

Q54 What is your highest level of education?

- Some high school or less (1)
- High School Degree or High School Equivalency eg. GED (2)
- Associate's Degree (3)
- Bachelor's Degree (College) (4)
- Graduate/Professional Degree (5)

Q55 Which category best describes your income (before taxes) in 2012?

- Less than \$5,000 (1)
- \$5,000-\$9,999 (2)
- \$10,000-\$14,999 (3)
- \$15,000-\$24,999 (4)
- \$25,000-\$34,999 (5)
- \$35,000-\$49,999 (6)
- \$50,000-\$74,999 (7)
- \$75,000-\$99,999 (8)
- \$100,000-\$149,999 (9)
- \$150,000-\$199,999 (10)
- \$200,000-\$249,999 (11)
- \$250,000 and above (12)

Q56 Where is your permanent residence?

- Hawai'i (1)
- Maui (2)
- O'ahu (3)
- Kaua'i (4)
- Moloka'i (5)
- Lāna'i (6)
- Ni'ihau (7)
- A US state other than Hawaii. Which state? (8) _____
- Country other than the United States. Which country? (9) _____

Q57 Thank you for your participation in the survey! We very much appreciate your taking the time! Use the space below if you have any comments for us.

Appendix D
IRB APPROVAL LETTERS



RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: September 23, 2013

TO: Elena Rubino
FROM: University of Delaware IRB

STUDY TITLE: [514545-1] Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- business survey

SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: September 23, 2013

REVIEW CATEGORY: Exemption category # 2

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Maria Palazuelos at (302) 831-8619 or mariapj@udel.edu. Please include your study title and reference number in all correspondence with this office.



RESEARCH OFFICE

210 Hullahen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: December 6, 2013

TO: Elena Rubino
FROM: University of Delaware IRB

STUDY TITLE: [544584-1] Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- hunter survey

SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: December 6, 2013

REVIEW CATEGORY: Exemption category # 2

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.



RESEARCH OFFICE

210 HULLIHEN HALL
UNIVERSITY OF DELAWARE
NEWARK, DELAWARE 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: December 17, 2013

TO: Elena Rubino
FROM: University of Delaware IRB

STUDY TITLE: [544885-1] Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- interview phase

SUBMISSION TYPE: New Project

ACTION: APPROVED
APPROVAL DATE: December 17, 2013
EXPIRATION DATE: December 16, 2014
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # 6,7

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.



RESEARCH OFFICE

210 HULLIHEN HALL
UNIVERSITY OF DELAWARE
NEWARK, DELAWARE 19716-1551
PH: 302/831-2136
FAX: 302/831-2828

DATE: December 18, 2013

TO: Elena Rubino
FROM: University of Delaware IRB

STUDY TITLE: [550888-1] Methods for Population Control: A Case Study on the Axis Deer of Maui Island, HI- citizen survey

SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: December 18, 2013

REVIEW CATEGORY: Exemption category # 2

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.