Management Plan for Stray Dog (*Canis lupus familiaris*) Populations in Kathmandu, Nepal

May 4, 2019

Iris Li

Dog (*Canis familiaris*) lying at the foot of a temple in Kathmandu, Nepal. Photo taken by Iris Li

A paper submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Fisheries and Wildlife – Wildlife Concentration at Paul Smith's College.

Executive Summary

Dogs (*Canis lupus familiaris*) are the most abundant predators, inhabiting all continents excluding Antarctica. Widely distributed, they are able to adapt to an expansive range of surroundings, maximizing survivability rates throughout the populations. Dogs are able to habituate regardless of rural mountainous terrain or crowded bustling cities. Stray dog populations have been established as a result of the frequent abandonment of pet dogs due to sickness, aggression, estrus behavior, or negligence. The diet of stray dog populations in Poland have been documented consisting of 30% oats, seeds and fruits, 15% small mammals, 12% game species, 7% insects, and 36% organic or inorganic items. The presence of dogs can deter endemic wildlife from utilizing suitable habitats, causing an increase in nest desertions. Dogs have also been known to hybridize with species within the *Canis* genera such as with the endangered Ethiopian wolf (*Canis simensis*), disrupting the genetic integrity of the species. Breeding multiple times within a year, producing anywhere from 1 to 15 pups per litter, there has been an estimate of over 20,000 stray dogs in Kathmandu, Nepal. Exposure to harsh living conditions have resulted in many of these dogs becoming malnourished, increasing susceptibility to parasites and diseases. Decreasing the population of stray dogs in Kathmandu by 50% from 2019 to 2049 will decrease ecological impacts on native wildlife, as well as decrease the transmission of zoonotic diseases. Decreasing food availability for stray dogs will result in a decrease within the stray dog population; if executed gradually, the stray dog population will not disperse to neighboring communities. When food sources suddenly diminish, dogs have been observed dispersing to maximize food availability. Decreasing the fecundity of females ages 1 to 2 will halt the dog population from its current exponential increase. Further educating the public regarding impacts of stray dog populations will decrease opportunities for disease transmission, pet abandonment, as well as discourage the public from sustaining the population. Decreasing the population of stray dogs in Nepal will protect native wildlife by decreasing negative effects on breeding success as well as increasing habitat use by endemic species. Human exposure to zoonotic diseases can also be minimized as a result of decreased interactions with stray dogs.

Table of Contents

Acknowledgements

I would like to thank Dr. Ross Conover and my peers in Fisheries and Wildlife Sciences. I would also like to thank all other professors at Paul Smith's College that have assisted me throughout the process of completing my Bachelor of Science in Fisheries and Wildlife Science. Finally, I would like to thank my family, friends, and would personally like to thank David Haenel for all of the love and support I had received throughout the creation of this management plan, and Rocco Cavalluzzi for keeping me afloat through tough times; I would not have been able to do it without them.

Purpose of the Plan

The purpose of this plan is to create a management plan for stray dogs in Kathmandu, Nepal with intentions of decreasing their population size. Although previous actions have been taken to decrease their populations, prior to this plan, there has been no known existing management plans created for dogs in Nepal. This management plan can be used as a model for future conservation efforts regrading dogs, able to provide additional information in regard to the species' ecology. This management plan will focus on:

Goal: Decrease the stray dog population by 50% in Kathmandu, Nepal from 2019-2049 to protect native wildlife and ecosystems.

Objective 1: Decrease food availability by 25% in fifteen years.

Objective 2: Decrease fecundity of females ages 1-2 by 83% in twenty years.

Objective 3: Increase public education on the ecological, ecological, and sociocultural impacts of stray dog populations by 33% in fifteen years.

Introduction

The global dog (*Canis lupus familiaris*) population has been estimated to exceed 500 million individuals; this number includes both owned as well as stray dogs (Wandeler et al. 1993). With the increase of dog populations follows increasing rates for disease transmission and increasing risks for wildlife conservation (Butler et al. 2018). Dogs are viewed as beloved pets all over the world, preventing the culling of the excessive populations (Young et al. 2011). Contributions to the increase of dog populations include pet abandonment due to sickness, aggression, estrus behavior, or negligence (Acharya and Dhakal 2015). Previous actions taken to manage the dog populations within Kathmandu include administering toxins to individuals, causing contaminated individuals to undergo violent seizures in broad daylight (Kato et al. 2003). Living sympatrically with humans for thousands of years, dogs are often viewed as pets and companions (Konno et al. 2016). Humans often exhibit compassion for charismatic megafauna such as dogs, further complicating conservation efforts regarding the species (Knesl et al. 2017).

Natural History of Dogs

Taxonomy

Morphological evidence has demonstrated that domestic dogs derive from the gray wolf (*Canis lupus*), with genetic evidence suggesting an East Asian origin (Savolainen et al. 2002). Mutual benefits between dog and human (*Homo sapiens*) encouraged the domestication of the species; protection was provided for both parties, dogs were able to provide companionship, provide labor, and are a food source when necessary (Savolainen et al. 2002). It has been found that dogs are capable of comprehending and responding to various human gestures (Miklósi et al. 1998). Studies conducted have determined that dogs are capable of observing and processing gestures such as pointing, nodding, bowing, head-turning, and gazing (Miklósi et al. 1998). Dogs are currently thought to be one of the best models for understanding cognitive skills in cross-species communication (Konno et al. 2016). Comparative studies suggest that an early

divergence from wolves in addition to artificial selection for tameness have led to significant impacts on the modern dog's communication abilities (Konno et al. 2016).

History

It has been well researched and established that dogs were the first animals to be domesticated by humans 15,000 years ago (Savolainen et al. 2002). Behavioral as well as morphological data allow for an ancestral correlation to be found between modern dogs and wolves (Savolainen et al. 2002). As a result of these morphological differences, dogs are able to consume and survive on a more diverse range of foods. Dogs have been found to consume foods ranging from large animal carcasses, to human derived waste (Vanak and Gompper 2009).

With a current population of over 22,500 dogs in Kathmandu, Nepal, the population trend can be observed to further increase in the upcoming years (Acharya and Dhakal 2015). Dog populations are dispersed throughout Nepal regardless of rural mountainous terrain, or large crowded cities (Acharya and Dhakal 2015). They are a highly intelligent species, capable of adapting to new environments, maximizing survival rates (Young et al. 2011). Free-ranging dogs can pose risks for not only the ecosystem of which surrounds them but can also affect the health of the citizens of Nepal, as well the country's tourism (Devleesschauwer et al. 2016).

Habitat and Cover

With flexible habitat requirements, when granted the opportunity to persist, dogs can be found alongside human settlements (Fleming et al. 2012). Able to adapt to a variety of climates and terrains, dogs inhabit all continents except for Antarctica (Young et al. 2011). Range and movements of individuals within the population can vary greatly due to estrus behavior, food availability, and adequate shelter (Wandeler et al. 1993). Results from studies conducted in India had concluded that resource availability, shelter from predators, and proximity to humans determine the selection of dens (Majumder et al. 2016). While in the earlier stages of life (<1 age 1), dogs have been observed selecting dens away from human disturbances, often shifting dens to relocate closer to humans as they mature; as a result of domestication (Majumder et al. 2016). Basic denning behaviors include selecting a preferred spot, and digging into the ground, tearing bedding material prior to settling (Majumder et al. 2016). The flexibility regarding species adaptation has increased success of denning across a slew of geographical variations ranging from urban to mountainous terrain (Majumder et al. 2016).

Diet

Dogs are among the most abundant and highly adaptive mammalian predators (Butler et al. 2004). Dogs are opportunistic hunters which have been documented hunting and killing animals ranging from small rodents to hunting larger chiru (*Pantholops hodgsonii*) in Tibet (Young et al. 2011). In urban environments, they can often be observed scavenging for food; foraging for scraps around slaughterhouses, rummaging through refuse (Figure 1), and depending on humans to supply the food source (Wandeler et al. 1993). Studies conducted in Poland discuss the diet composition of the dog populations that are present to find that their diet composed of 30% oats, seeds, and fruits, 15% small mammals, 12% game species, 7% insects, and 36% organic and inorganic items (Krauze-Gryz and Gryz 2014). While studies conducted in remote areas within Zimbabwe have discovered that mammalian remains, maize porridge, and human fecal remains were of the most crucial sources of nutritional value found within the stray dog population that was present (Butler et al. 2018).

Fig 1: Dogs foraging through human derived waste.

Ecological

Stray dog populations cause lasting ecological impacts. Aside from ecological effects caused by dog predation, the presence of dogs can deter endemic wildlife from nesting or may cause nest desertions (Young et al. 2011). Studies conducted in Ethiopia have found dogs breeding with other species within the *Canis* genera such as the Ethiopian wolf (*Canis simensis*), thus creating hybrids (Laurenson et al. 1998). Other studies observed stray dogs transmitting diseases to species outside of the *Canis* genera, affecting then threatened Baikal seals (*Pusa sibirica*) in Lake Baikal, Siberia (Mamaev et al. 1995). In 1988, a study conducted analyzing brown kiwi (*Apteryx mantelli*) reproductive behaviors had found that a single dog had killed 13 of the 23 tagged kiwis. Said dog was estimated to have killed an additional 500 out of the population of 900 brown kiwis present at Waitangi State Forest in New Zealand (Taborsky 1988).

The presence of dogs has been found to deter native species from the use and habitation of the dog occupied areas (Young et al. 2011). Studies conducted found that trails that were

frequently utilized for dog walking lead to a 41% reduction in avian abundance, and a 35% reduction in avian diversity (Banks and Bryant 2007). The recurring presence of dogs trigger anti-predator responses, thus reducing desirable habitat (Banks and Bryant 2007).

Economic and Sociocultural

Dogs are one of the most adaptive species that can be found in Nepal. Recent population studies conducted in 2010 have found that there are currently over 22,500 stray dogs on the streets of Kathmandu, and a total of 1,767 recorded in Pokhara Valley, Nepal (Acharya and Dhakal. 2015). In Nepalese culture, dogs have been known to be celebrated and worshipped as they are believed to be "messengers of the gods" (Devleesschauwer et al. 2016). Tihar is five-day festival that is devoted to celebrating dogs (Figure 2), adorning them with religious ornaments and food (Devleesschauwer et al. 2016). During Tihar, street dogs are provided with an abundance of food; providing stray dogs with food sources diminishes any fear they may have had for humans, increasing human-wildlife conflicts (Devleeschauwer et al. 2016). Lack of fear for humans (Figure 3) has allowed the species to encroach on human activities (Ascota-Jamett et al. 2010).

Fig 2: Dog adorned with religious ornaments during the five-day festival of

Poorly managed slaughter houses as well as the lack of garbage removal has also contributed greatly to sustaining the stray dog population in Nepal (Acharya and Dhakal 2015). Continual presence within vicinity to slaughter houses poses substantial human health risks as dogs may come into contact with meats intended for human consumption, as well as the observation of dogs exhibiting increased aggression regarding food sources (Butler et al. 2018).

Fig 3: Nepali locals feeding stray dogs

Upwards of 150 reported dog bites occur in Kathmandu each day, approximately 200 annual rabies related deaths, with 95% of human rabies cases resulting from stray dog bites (Acharya and Dhakal 2015). It is estimated that there are over 60 zoonotic diseases that can be transmitted from dogs (Acharya and Dhakal 2015).

Toxocariasis is a parasitic disease caused by *Toxocara canis*, a roundworm that can be found in the feces of infected canines (Traub et al. 2002). The defecation of infected dogs can greatly increase the spread of toxocariasis to humans that they may come in contact with, by unknowingly ingesting feces contaminated items (Traub et al 2002).

Neighboring India, Nepal can be observed having similar socioeconomic conditions which may provide a reference; roughly 36% of global annual rabies related deaths occur in India (Devleesschauwer et al. 2016). The total number of reported dog bites steadily increased from 15,000 during 2004, to 35,000 during 2013, two of which resulted in the deaths of tourists (Devleesschauwer et al. 2016). Failure to further enforce or improve vaccinations of dogs will allow zoonotic diseases and parasites to persist and increase within the human population, with possibilities of impacting tourism (Amaku et al. 2010).

Legal

Currently, there are laws that allow the eradication of invasive species such as free-roaming dogs (Amaku et al. 2010). Many countries permit the killing of stray dogs, if said dog poses a threat to humans or wildlife (Krauze-Gryz and Gryz, 2014). The culling of stray dogs is heavily frowned upon by animal activists, making it difficult to control feral dog populations (Acharya and Dhakal 2015). The Animal Legal Defense Fund (ALDF) of the United States authorizes the killing of dogs if necessary; dogs may be disposed of if threats are raised towards humans or wildlife (50 CRS § 28.43).

Reproduction

Dogs reach reproductive maturity (Figure 4) at the approximate age of 1 year (Pal 2011). During canine sexual reproduction, a process known as a “copulatory tie” occurs upon penetration of the dog’s penis (Pal 2011). During this time, the penis expands, trapping semen released into the female. The dog (male) and bitch (female) remain attached to one another due to copulatory tying for approximately 5 to 25 minutes (Pal 2011). Gestation occurs for approximately 70 days following copulation (Pal 2011). Litter sizes vary and are determined by the size of the dog. While dogs are able to produce up to 15 pups, an average litter size of 5-6 pups have been observed within domestic dogs (Acharya and Dhakal 2015).

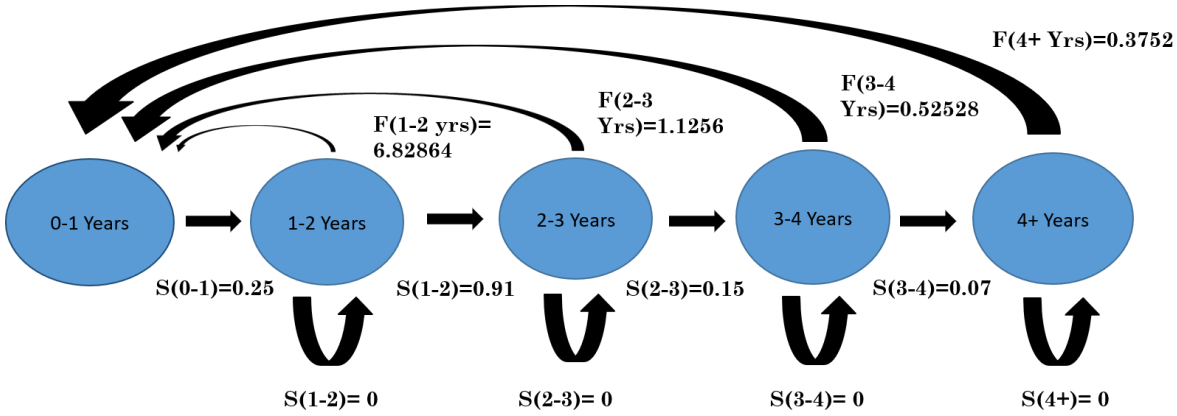

Fig 4: Life stage table created for dogs; this figure shows five stages throughout a dog's life that were input into a population matrix using Microsoft Excel© with values demonstrating survivability(S) and fecundity(F) rates for stages listed above. Figure describes reproductive maturation following the first age class (0-1 Years). Fecundity and survivability rates obtained through studies conducted in Chile (Ascotta-Jamett et al. 2010).

Disease

There are approximately one hundred known zoonotic diseases that could be transferred from dogs to humans (Archarya and Dhakal, 2015). Rabies, echinococcosis, and toxocariasis are some of the major zoonotic diseases that are commonly affecting stray dogs in developing countries (Devleesschauwer et al. 2016). Exposure to harsh living conditions have resulted in many of these dogs becoming malnourished, with the possibility of contracting mange and rabies (Kitala et al. 2001). Dogs have also been observed carrying diseases that are known to affect and can be transmitted to wild carnivores they may encounter (Acosta-Jamett et al. 2010). Rabies is a fatal neurological disease that can be found in infected mammals (Center for Disease Control and Prevention 2011). Approximately 95% of human rabies cases reported in Nepal are a result of contact with a rabid dog (Acharya and Dhakal 2015). Studies conducted have found that 56% of dogs in Kathmandu, Nepal are infected with gastrointestinal nematodes, as well as 67% of dogs in Kathmandu being infected with mites (Acharya and Dhakal 2015). Domestic dogs are responsible for over 99% of human deaths related to rabies (Taylor et al. 2017). All mammals can be infected with the rabies virus (Devleesschauwer et al. 2016). Rabies is transmitted through the saliva of infected individuals. Exposure to a rabid animal may result in a fatal outcome if post-exposure treatments are not provided promptly (Wandeler et al. 1993).

Canine distemper (CDV) is a virus that affects canines as well as many other mammalian organisms. Canine distemper affects the individual's respiratory system, gastrointestinal, as well

as their central nervous system. CDV is transmitted through an infected individual's bodily fluids (Müller et al. 2011).

Echinococcosis is a gastrointestinal parasitic tapeworm. *Echinococcosis granulosus* enters the body of the host through the ingestion of fecal matter or through indirect contact with the parasite (Torgerson et al. 2009). The parasites leech nutrients from the host, often resulting in anorexia, malnutrition, and in severe cases, possibly death (Torgerson et al. 2009).

Toxocariasis is a gastrointestinal parasite that is zoonotic to humans. *Toxocara canis* is parsasitic roundworm that causes Toxocariasis. Approximately 50% of pups and 20% of adults are infected with *Toxocara canis*. The larvae of *Toxocara canis* enters the host through ingestion or through indirect contact. *Toxocara* canis can be transferred through infected fecal matter. Unsuspecting individuals consume or come into contact with objects that have been infected with the parasite. Weaning puppies can also contract the parasites through the mother's milk. Ingesting the larvae or the eggs of the parasite will transfer the parasites. Analyzing the fecal matter to detect the presence of parasitic eggs can determine whether the host has been infected. Following the ingestion of the parasite, once in the intestinal region of the host, the parasite penetrates the gut wall, allowing it to travel through the bloodstream of the host. The larvae may travel to the host's lungs, brain, eyes, etc. Once reaching the desired areas, the parasites may cause complications such as fevers, fatigue, rashes, nausea, and may even cause blindness. In pet dogs, a deworming process is often required at young ages to rid the dog of any intestinal parasites that may be present. Frequent practices of proper hygiene may decrease opportunities for *Toxocara canis* to enter the body (Traub et al. 2002).

Statement of Need

The increasing need to manage stray dog populations results from substantial impacts to ecological, economic, sociocultural and legal issues as discussed (Young et al. 2011). With 40% of global rabies cases occurring in the South Asian region, efforts need to be increased to further improve the rabies control in Kathmandu, Nepal (Devleesschauwer et al. 2016). If actions are not taken, the increasing dog populations in Nepal will continue to pose risks to the environment and ecosystems, as well as the people within (Young et al. 2011).

Management Goal and Objectives

Goal: Decrease the stray dog population by 50% in Kathmandu, Nepal from 2019-2049 to protect native wildlife and ecosystems.

Objective 1: Decrease food availability by 25% in fifteen years.

Action 1.1- Establish and deploy an increased amount of garbage removal programs (Raymond et al. 2015). Implement littering fines; if found littering, individuals will be required to pay fines as well as consequently completing community service sessions (Lee et al. 1988). Semiweekly removal of residential as well as commercial waste will be established via sanitation vehicles funded by the city (Baker 1997). Additional garbage removal methods such as community outreach programs including volunteer opportunities to educate and engage the public in litter removal (Baker 1997). Implement recycling incentives such as opportunities to recycle for money; items that can be recycle include but are not limited to bottles and cans, batteries, and scrap metal (Baker 1997).

Action 1.2- Implementation of strictly enforced laws regarding feeding free-roaming dogs will contribute to the management of the overall population (Butler et al. 2018). Feeding of free-roaming dogs will result in a fine (Raymond et al. 2015). Police force patrolling will enforce this action; an anonymous tip-line will be available for those who wish to report feeding occurrences (Lee et al. 1988). Data gathered from the anonymous tip-line will determine areas of higher necessity for patrolling.

- **Rationale:** There are currently no known laws regarding feeding and housing free-roaming dogs in Nepal. Implementation of said laws will discourage and inform the public on the effects of anthropogenic food sources on free-roaming dog populations (Raymond et al. 2015).

Action 1.3- Increase sanitation employment within Kathmandu. Increasing employment within the sanitation field will increase waste management and removal as well as increasing employment opportunities (Butler et al. 2018). Routine waste removal is required to maintain upkeep of the human derived waste (Raymond et al. 2015). Increasing sanitation efforts will not only decrease food availability for stray dogs but will positively benefit human health and living situations (Acharya and Dhakal 2015).

Action 1.4- No action. If no action is taken the population of stray dogs in Kathmandu will continue to scavenge on human waste and garbage, allowing a constant food source to be available, thus allowing the population to continue to exponentially increase (Butler et al. 2018).

Final Course of Action- Actions 1.1, 1.2, and 1.3 will be utilized to indirectly decrease the population of stray dogs in Kathmandu. Implementing a penalty system regarding influencing the dog population has been found to be effective in minimizing the actions of humans.

Assessment Protocol: Objective 1 will be considered complete when laws regarding littering and feeding stray dogs include firm penalties. The implementation of penalties further enforces the severity of the regulation (Lee et al. 1988). The increase of penalty rates will be analyzed through evaluation and observations of repercussions distributed (Raymond et al. 2015). Penalties consist of community service, the payment of fines, and in extreme cases, persons will be incarcerated. Analysis of offence reports will allow for quantitative assessment of the progress. If objective is not met but an overall positive correlation can be observed, actions will persist as efforts have been working in favor of the objective to be achieved.

Objective 2: Decrease fecundity of females ages 1-2 by 83% in twenty years.

Action 2.1- Free or low-cost spaying can be offered to those who apply for circumstantial fee-waivers. Properly sanitized and certified travelling veterinarian posts will be available in select locations throughout Kathmandu; service times, locations and general information will be provided through a website (Acharya and Dhakal 2015). The procedures will be performed on a maximum of 25 animals a day (Devleesschauwer et al. 2016).

Action 2.2- Trap-Neuter-Release (TNR) programs will be implemented. Stray dogs will be baited using canned dog food, or other pungent foods (Acharya and Dhakal 2015). Oversized Havahart© traps (minimum 42” long, 15” wide) will be utilized to safely and properly enclose the dog (Acharya and Dhakal 2015). Due to the territorial nature of the species, dogs involved with this program must be returned to the original location of capture (Taylor et al. 2017). In settings where large numbers of stray dogs are present, programs that involve the capture, sterilization, vaccination and return of dogs has been found to effectively manage the populations (Taylor et al. 2017).

- **Rationale:** Through conducting sensitivity and elasticity matrices (Appendix A), targeting and trapping bitches ages 1-2 have been found to have the greatest impact on decreasing the overall population of stray dogs present in Kathmandu.

Action 2.3- Permanent and temporary methods of reproductive control will be available. Surgical options require the removal of reproductive organs; spaying of females and the neutering of male individuals (Amaku et al. 2010). Oral contraceptives will also be provided for the individuals within the population. Physical restraints, and injectable contraceptives will also be utilized. Spaying of females utilizing invasive procedures has been found to be the most effective sterilization method (Taylor et al. 2017). Surgical sterilization provides lifelong reproductive control and may reduce problematic behaviors such as aggression and the desire to seek out mates (Acharya and Dhakal 2015). Permanent sterilization is preferable in most settings where rabies infected individuals are abundant (Kitala et al. 2001).

Action 2.4- No action. Stray dogs have been observed having high mortality rates during the post-whelping stage, as well as throughout the ages of 0-1 (Kitala 1995). Dogs have a high fecundity rate to compensate for the high mortality rates present; 1.3 female dogs produced per female per year (Kitala 1995). Thus, over a one-year period, half the population is replaced. If no actions are taken, the stray dog population will continue to exponentially increase, resulting in increased impacts to the environment and the people around them (Kitala 1995).

Final Course of Action- Actions 2.1, and 2.3 will be utilized to allow pet owners and other individuals to admit their pet dogs into the care of a certified veterinarian. This will allow pet owners to be able to properly provide care for their animals at more affordable costs.

Assessment Protocol: Objective 2 will be considered complete when 83% of females within the population of stray dogs in Kathmandu has been spayed (Reece et al. 2008). Studies that have been conducted have found that in order for populations of stray dogs to significantly decrease, 83% of breeding females within the population are to be prevented from breeding (Taylor et al. 2017). Mark-resight survey methods will be utilized to conduct stray dog surveys (Acharya and Dhakal 2015). Dogs that have been spayed during this study have been documented describing distinct features such as gender, coat patterns, ear notches present, etc (Acharya and Dhakal 2015). The survey will be conducted by teams of researchers as well as the Himalayan Animal Rescue Team (HART) (Acharya and Dhakal 2015). The total area of Kathmandu will be divided

into 30 parts, all to be surveyed, documenting any and all dogs sighted to determine the ratio of spayed to unspayed females (Acharya and Dhakal 2015). Dogs will be classified as male or female depending on the observation of genitalia (Acharya and Dhakal 2015). Dogs classified as pups will be determined based on head size, leg length, and body size (Acharya and Dhakal 2015). Catch-Sterilize-Vaccinate-Return otherwise known as Trap-Neuter-Release programs applied to stray dogs have been found to be more effective when larger populations are present (Taylor et al. 2017).

Objective 3: Increase public education on the economical, ecological, and sociocultural impacts of stray dog populations by 33% in fifteen years.

Action 3.1- Abandonment of pet dogs due to estrus behavior, aggression, or lack in ability to care for their dog. have greatly influenced the stray dog populations within Nepal (Acharya and Dhakal 2015). Implement law preventing the abandonment of pet dogs. If found guilty, the individual will be penalized in form of paying hefty fines (Morters et al. 2014).

- **Rationale**- Implementing laws regarding abandonment of pet dogs will bring awareness to the situation at hand (Morters et al. 2014). Implementation of laws will also discourage the public from committing such acts (Morters et al. 2014).

Action 3.2- Free or low-cost wellness care will be provided in properly sanitized and veterinarian certified mobile posts as mentioned in Action 2.1 (Taylor et al. 2017). Circumstantial fee-waivers will be provided on site with proof of gross income. Wellness care such vaccines, microchipping, parasite testing, treatments and prevention methods will be provided, along with the options to spay and neuter being readily available (Taylor et al. 2017). Affordable veterinary services that is available enables the public to become engaged and empowered (Taylor et al. 2017). Vaccinating dogs using inactive tissue culture has been found to be not only affordable, but also effective (Kitala et al. 2001).

- **Rationale:** Being able to offer the public affordable veterinary services allows pet owners to become more involved with the community as well as with their animal (Taylor et al. 2017). Providing affordable veterinary services will indirectly increase public education by empowering pet owners, enabling individuals to

further benefit their pet as well as encourage said individuals to seek optimal living conditions for their pet (Taylor et al. 2017).

Actions 3.3- Rehoming stray dogs are a feat within itself. The dogs may be in critical health conditions, exhibit aggressive behaviors, or may be dismissed by their owners as a result of lack of interest (Acharya and Dhakal 2015). Animal shelters will be built with funding provided by grants provided by the city as well by donations. Shelters that are built will be able to provide adequate care for dogs that have been treated for medical conditions and have been rehabilitated (Turner et al. 2012). Dogs that can no longer be cared for by their owners will be able to be admitted and rehomed if possible (Knesl et al. 2017). Dogs that are not able to be rehomed will be humanely euthanized (Knesl et al. 2017).

Action 3.4- Door to door survey (Appendix B) to gather a consensus on the general public's opinion of the current stray dog populations (Devleesschauwer et al. 2016). Dog population management (DPM) will allow researchers to gauge the public's opinion on the current situation at hand as well as provide educational information regarding stray dog impacts on the environment (Taylor et al. 2017). Surveys will be mailed to residential addresses within Kathmandu and will be provided at veterinary offices (Kato et al. 2003). Surveys will also be readily provided at the Kathmandu International Airport, as well as at major hotels such as the Kathmandu Guest House (Kato et al. 2003). A total of 1,000 surveys will be distributed throughout Kathmandu. Surveys will provide researchers with information regarding the knowledge and opinion of individuals within the general public. Surveys are to be completed and submitted anonymously with intentions to be non-biased (Kato et al. 2003).

Action 3.5- Provide educational pamphlets regarding the ecological, economical, and sociocultural impacts that are caused by dogs (Kato et al. 2003). Pamphlets will be available at all locations listed in Action 3.4 as well as in all veterinary offices within Kathmandu. Educational pamphlets provide easy to read material and information (Appendix C).

Action 3.6- No action. If no actions are taken, the public will continue to be uneducated on the impacts of stray dog populations. With the understanding of the impacts of stray dog populations, the public will be able to proceed with caution when confronted with situations involving said dogs. With the knowledge provided, the public will be able to properly care for pet dogs with the knowledge to disassociate and reject stray dogs (Butler et al. 2018).

Final Course of Action- Actions 3.1, 3.2, 3.3, 3.4, and 3.5 will be utilized to effectively educate the public on the impacts of stray dog populations.

Assessment Protocol: Following the distribution of surveys and pamphlets to all registered hotels, residential addresses, and airports within Kathmandu, Objective 3 will be complete upon a minimum return of 500 (50%) surveys. The survey will be relatively short, asking questions such as, "Have you ever owned a dog? Have you ever experienced a dog with rabies?" (Acharya and Dhakal 2015). The survey is intended to be anonymous, dismissing sampling bias (Kato et al. 2003). Questions such as these will allow researchers to gather information regarding the public's knowledge of the stray dog population (Acharya and Dhakal 2015). Surveys can be returned through mail, as well as returned to locations providing such articles (Kato et al. 2003). Pamphlets will include information regarding ecological, economical, and sociocultural impacts caused by the population of stray dogs that is present, as well as provide a list of diseases and parasites that can be transmitted by dogs (Devleesschauwer et al. 2016). If not achieved,

Conclusion

With altitudes ranging from less than 100 meters above sea level to altitudes exceeding 8,000 meters, Nepal's dramatic variation in landscape allows for substantial diversity in wildlife. It is crucial that actions are taken to protect delicate ecosystems that can be found in Nepal. Populations of dogs depend greatly on the relationship they have developed with humans. Anthropogenic food sources have allowed for the populations of dogs to thrive and grow exponentially. This management plan has been designed to decrease the rapidly growing population present in Kathmandu and to reverse the effects that have been caused by dogs. Studies are often overlooked and disregarded, as the species is common and ubiquitous. The goals, objectives, and actions established in this plan are of the first to be created and implemented in Nepal. Furthermore, the compilation of data provided in this management plan, gathered from both literature as well as created models, will allow researchers to proceed with efforts to diminish the stray dog population.

Appendix A

Sensitivity and Elasticity Matrix

Table 1: Sensitivity matrix for age-based population model conducted using Microsoft Excel©. Table contains information regarding population survivability rates.

	Sensitivity matrix				
		F(1-2 yrs)	F(2-3 yrs)	F(3-4 yrs)	F(4+ yrs)
0-1 years	0.1991	0.0860	0.0567	0.0062	0.0003
1-2 years	2.6173	0.4744	0.3130	0.0340	0.0018
2-3 years	0.4075	0.0739	0.0487	0.0053	0.0003
3-4 years	0.1874	0.0340	0.0224	0.0024	0.0001
4+ years	0.1339	0.0243	0.0160	0.0017	0.0001

Table 2: Elasticity matrix for age-based population model conducted using Microsoft Excel©. Table contains information regarding population fecundity rates.

	Elasticity matrix				
	F(0-1 yrs)	F(1-2 yrs)	F(2-3 yrs)	F(3-4 yrs)	F(4+ yrs)
0-1 years	0	0.425657785	0.046288523	0.002349127	8.83552E-05
1-2 years	0.474370632	0	0	0	0
2-3 years	0	0.048725866	0	0	0
3-4 years	0	0	0.002437401	0	0
4+ years	0	0	0	8.83552E-05	3.32321E-06

Appendix B

Information gathered from this survey will contribute to the conservation acts that are to be implemented to manage the stray dog population in Kathmandu, Nepal. Participants will remain anonymous. Please circle the answers that apply, when completed please place the survey into the return envelope provided and return to sender.

1. Have you experienced owning a dog?
   a) Yes b) No

   1a. If yes, do you currently own a dog(s)?

   a) Yes b) No

   1c. If yes, is your dog(s) spayed/neutered?

   a) Yes b) No

   1b. Do you allow your dog(s) to roam unsupervised?

   a) Yes b) No

2. Do you believe in spaying/neutering pet dogs?
   a) Yes b) No

3. Have you ever experienced a dog bite?

   a) Yes b) No

4. Have you ever experienced a dog with rabies?
   a) Yes b) No

5. Do you think it is necessary to wash your hands after petting a dog?
   a) Yes b) No

6. Do you think there is a stray dog problem in Kathmandu?
   a) Yes b) No

   6a. If yes, do you think the stray dog problem is able to be resolved?
   a) Yes b) No

7. What is your current city of residence?

   _____

8. What is your current age?
   a) ≤20 years b) 21-30 yrs c) 31-40 yrs d) ≥41 years

Appendix C

Educational Pamphlet to be available at various locations throughout Kathmandu such as the Kathmandu International Airport, major hotels throughout the city, and at veterinary offices within Kathmandu.

Impacts Caused by Stray Dog Populations

There are currently over 20,000 stray dogs roaming the streets of Kathmandu, Nepal.

Stray dog populations have been found to cause lasting impacts on the ecosystems of which they inhabit. Dogs have been found to transmit diseases to not only the wildlife they may come in contact with, but to the people they come in contact with as well.

The presence of dogs has been known to deter native wildlife from utilizing suitable habitat.

The fecal matter of infected dogs has been found transmit gastrointestinal parasites to tea products.

Dogs are the main contributors to the spread of rabies globally.

Stray Dogs in Kathmandu

It is important that one does not approach nor pet dogs if the owner is not present. Approaching a dog without an owner could provoke aggressive behavior.

Petting a stray dog may increase rates of contracting zoonotic diseases and parasites. It is important to practice proper hygiene after coming into contact with dogs.

Dogs may carry diseases such as:

- Rabies
- Ring-worms, Roundworms, & Tapeworms
- Mange
- Canine distemper
- Leptospirosis
- Brucellosis

How can you help?

- Vaccinate your dogs
- Spay/Neuter your dogs
- Avoid littering
- Avoid feeding and housing stray dogs
- Do not allow your dog to roam unsupervised

Stray dog populations are continuing to increase in Kathmandu, causing a variety of safety concerns. Free roaming dogs contribute to sanitation issues, noise pollution, cause traffic incidents, may attack residents, and spread disease.

The population of stray dogs in Kathmandu will continue to increase exponentially if actions are not taken towards managing the populations.

Literature Cited

Acharya, M., and S. Dhakal. 2015. Survey on street dog population in Pokhara Valley in Nepal. Bangladesh Journal of Veterinary Science 13:65-70.

Acosta-Jamett, G., S. Cleaveland, A.A. Cunningham, and B.M. Bronsvoort. 2010. Demography of domestic dogs in rural and urban areas of the Coquimbo region of Chile and implications for disease transmission. Preventative Veterinary Medicine 94:272-281.

Amaku, M., R.A. Dias, and F. Ferreria. 2010. Dynamics and control of stray dog populations. Mathematical Population Studies 17:69-78.

Baker, S. 1997. Community organization and solid waste management in the Kathmandu Valley. Himalaya, The Journal of the Association for Nepal and Himalayan Studies 17:39-48.

Banks, P.B., and J.V. Bryant. 2007. Four-legged friend or foe? Dog walking displaces native birds from natural areas. Biology Letters. 3:611-613.

Belo, V.S., G.L. Werneck, E.S. da Silvia, D.S. Barbosa, and C.J. Struchiner. 2015. Population estimation methods for free-ranging dogs: A systematic review. PLoS One 10:1-15.

Belo, V.S., C.J. Struchiner, G.L. Weneck, R.G.T. Neto, G.B. Tonelli, C.G. de Carvalho Junior, R.A.N. Ribeiro, and E.S. da Silva. 2017. Abundance, survival, recruitment and effectiveness of sterilization of free-roaming dogs: A capture and recapture study in Brazil. PLoS One 12:1-19.

Butler, J.R.A., J.T. du Toit, and J. Bingham. 2004. Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: threats of competition and disease to large wild carnivores. Biological Conservation 115:369-378.

Butler, J.R.A., W.Y. Brown, J.T. and du Toit. 2018. Anthropogenic food subsidy to a commensal carnivore: the value and supply of human faeces in the diet of free-ranging dogs. Animals 8:1-16.

Center for Disease Control and Prevention. 2011. The rabies virus. United States Department of Health and Human Services.

Daniels, T.J., and M. Bekoff. 1989. Population and social biology of free-ranging dogs, *Canis familiaris*. Journal of Mammalogy 70:754-762.

Devleesschauwer B., A. Aryal, B.K. Sharma, A. Ale, A. Declercq, S. Depraz, T.N. Gaire, G. Gongal, S. Karki, B.D. Pandey, S.B. Pun, L. Dachateau, P. Dorny, and N. Speybroeck.

2016. Epidemiology, impact and control of rabies in Nepal: A systematic review. PLoS Neglected Tropical Diseases 10:1-18.

Fleming, P., B. Allen, G. Ballard, and L. Allen. 2012. Wild dog ecology, impacts and management in northern Australian cattle enterprises: A review with recommendations for RD&E investments. Meat & Livestock Australia Limited 1-71.

Kato, M., H. Yamamoto, Y. Inukai, and S. Kira. 2003. Survey of the stray dog population and the health education program on the prevention of dog bites and dog-acquired infections: A comparative study in Nepal and Okayama Prefecture, Japan. Acta Medica Okayama 57:261-266.

Kitala, P.M., and J. McDermott. 1995. Population dynamics of dogs in Machakos District, Kenya. Implications for vaccination strategy. Department of Public Health, Pharmacology and Toxicology, University of Nairobi, Kenya. 9-102.

Kitala, P., J. McDermott, M. Kyule, J. Gathuma, B. Perry, and A. Wandeler. 2001. Dog ecology and demography information to support the planning of rabies control in Machakos District, Kenya. Acta Tropica 78:217-230.

Knesl, O., B.L. Hart, A.H. Fine, L. Cooper, E. Patterson-Kane, K.E. Houlihan, and R. Anthony. 2017. Veterinarians and humane endings: when is it the right time to euthanize a companion animal?. Frontiers in Veterinary Science 4:1-7.

Konno, A., T. Romero, M. Inoue-Murayama, A. Saito, and T. Hasegawa. 2016. Dog breed differences in visual communication with humans. PLoS One 11:1-14.

Krauze-Gryz, D., and J. Gryz. 2014. Free-ranging domestic dogs (Canis familiaris) in central Poland: Density, penetration range and diet composition. Polish Journal of Ecology 62:183-193.

Laurenson, K., C. Sillero, H. Thompson, F. Shiferaw, S. Thirgood, and J. Malcolm. 1998. Disease as a threat to endangered species: Ethiopian wolves, domestic dogs and canine pathogens. Animal Conservation 1:273-280.

Lee, D.R., P.E. Graves, and R.L. Sexton. 1988. On mandatory deposits, fines, and the control of litter. Natural Resources Journal 28:838-847.

Majumder, S.S., M. Paul, S. Sau, and A. Bhadra. 2016. Denning habits of free-ranging dogs reveal preference for human proximity. Scientific Reports 6:1-8.

Makenov, M.T., and S.K. Bekova. 2016. Demography of domestic dog population and its implications for stray dog abundance: a case study for Omsk, Russia. Urban Ecosyst 19:1405-1418.

Mamaev, L.V., J.K. Visser, S.I. Belikov, N.N. Denikina, T. Harder, L. Goatley, B. Rima, B. Edington, A.D.M.E. Osterhaus, and T. Barrett. 1996. Canine distemper virus in Lake Baikal seals (Phoca sibirica). The Veterinary Record 437-439.

Miklósi, A., R, Polgárdi, J. Topál, and V. Csányi. 1998. Use of experimenter-given cues in dogs. Animal Cognition 1:113-121.

Morters, M.K., T. J. McKinley, O. Restif, A.J.K. Conlan, S. Cleaveland, K. Hampson, H.R. Whay, I.M. Damriyasa, and J.L.N. Wood. 2014. The demography of free-roaming dog populations and applications to disease and population control. Journal of Applied Ecology 51:1096-1106.

Müller, A., E. Silva, N. Santos, and G. Thompson. 2011. Domestic dog origin of canine distemper virus in free-ranging wolves in Portugal as revealed by Hamagglutinin gene characterization. Journal of Wildlife Diseases 47:725-729.

Pal, S.K. 2001. Population ecology of free-ranging urban dogs in West Bengal, India. Acta Theriologica 46:69-78.

Pal, S.K. 2005. Parental care in free-ranging dogs, *Canis familiaris*. Applied Animal Behaviour Science 90:31-47.

Pal, S.K. 2011. Mating systems of free-ranging dogs (*Canis familiaris*). International Journal of Zoology 2011:1-8

Raymond, T.N., M.E. Roland, K.M.M. Francoise, Z. Francis, E.F. Livo, and S.T.H. Clovis. 2015. Do open garbage dumps play a role in canine rabies transmission in Biyem-Assi health district in Cameroon?. Infection Ecology and Epidemiology 5:1-7.

Reece, J.F., S.K. Chawla, E.F. Hiby, and L.R. Hiby. 2008. Fecundity and longevity of roaming dogs in Jaipur, India. BMC Veterinary Research 4:1-7.

Savolainen, P., Y. Zhang, J. Luo, J. Lundeberg, and T. Leitner. 2002. Genetic evidence for an East Asian origin of Domestic dogs. Science 298:1610-1613.

Taborsky, M. 1988. Kiwis and dog predation: Observations in Waitangi State Forest. Notornis 35:197-202.

Taylor, L.H., R.M. Wallace, D. Balaram, J.M. Lindenmayer, D.C. Eckery, B. Mutonono-Watkiss, E. Parravani, and L.H. Nel. 2017. The role of dog population management in rabies elimination-a review of current approaches and future opportunities. Frontiers in Veterinary Science 4:1-15.

Tenzin, T., R. Ahmed, N.C. Debnath, G. Ahmed, and M. Yamage. 2015. Free-roaming dog population estimation and status of the dog population management and rabies control program, in Dhaka City, Bengladesh. PLoS Neglected Tropical Diseases 9:1-9.

Tischler, J. 2007. Table of state and federal laws concerning dogs chasing wildlife. Animal Legal Defence Fund, Michigan State University College of Law. 17 November 2010; (www.animallaw.info/articles/arusdogschasewildlifetable.htm).

Torgerson, R.P., K. Rosenheim, I. Tanner, I. Ziadinov, F. Grimm, M. Brunner, S. Shaiken, B. Shaikenov, A. Rysmukhambetova, and P. Deplazes. 2009. Echinococcosis, toxocariasis and toxoplasmosis screening in a rural community in Eastern Kazakhstan. Tropical Medicine and International Health 14:341-348.

Torres, P.C., and P.I. Prado. 2010. Domestic dogs in a fragmented landscape in the Brazilian Atlantic Forest: abundance, habitat use and caring by owners. Brazilian Journal of Biology 70: 987-994.

Traub, R.J., I.D. Robertson, P. Irwin, N. Mencke, and R.C. Andrew-Thompson. 2002. The role of dogs in transmission of gastrointestinal parasites in a remote tea-growing community in Northeastern India. The American Society of Tropical Medicine and Hygiene 67:539-545.

Turner, P., J. Berry, and S. MacDonald. 2012. Animal shelters and animal welfare: raising the bar. Canadian Veterinary Journal 53:893-896.

Vanak, A.T., and M.E. Gompper. 2009. Dogs Canis familiaris as carnivores: their role and function in intraguild competition. Mammal Review 39:265-283.

Van't Woudt, B.D. 1990. Roaming, stray, and feral domestic cats and dogs as wildlife problems. Proceedings of the Fourteenth Vertebrate Pest Conference 1990. 78:291-295.

Wandeler, A.I., H.C. Matter, A. Kappeler, and A. Budde. 1993. The ecology of dogs and canine rabies: a selective review. Revue Scientifique Et Technique International Office of Epizootics 12:51-71.

Young, J.K., K.A. Olson, R.P. Reading, S. Amgalanbaatar, and J. Berger. 2011. Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. BioScience 61:125-132.