Impacts and Management of White-Tailed Deer in Urban Landscapes:

A review

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Introduction

The purpose of this report is to provide a literature review of white-tailed deer (*Odocoileus virginianus*) ecology and management in urban ecosystems. Urban wildlife management was historically not a priority for wildlife managers, but rather it was done out of necessity with emphasis on wildlife nuisance control. However, as rural areas become urbanized, management of white-tailed deer populations in urban landscapes has become common in recent decades (McAninch 1993). As the need for urban deer management increased, research on white-tailed deer ecology and management in urban areas likewise increased. This review summarizes the research on urban white-tailed deer (hereafter, deer) and makes recommendations for future research.

As urban deer populations escalate in much of the United States, natural resource managers increasingly encounter public debate over deer management options (Green et al. 1997). In North America, many urban municipalities have created local management plans to address concerns about increasing wildlife populations (Edelblutte et al. 2021). As human and deer populations rise in urban landscapes so does the likelihood of interactions. These interactions raise questions about ecological impacts, human well-being, the overall habitability of these places for both humans and deer, and when and how to manage deer in urban and suburban areas (Edelblutte et al. 2021). While expansion into urban landscapes leads to loss of habitat for some species, white-tailed deer may thrive in human occupied landscapes. White-tailed deer flourish in urban landscapes where abundant food resources (e.g., landscape ornamentals) facilitate high reproductive rates, and lack of hunting and predators rescues mortality rates (Blanchong et al. 2013).

Methods

Using Google Scholar and the North Carolina State University Library system databases, I reviewed and summarized articles relating to white-tailed deer, white-tailed deer management, and urban landscapes. I included articles identified through citations in previously reviewed literature. Sources include peer-reviewed articles, literature reviews, conference presentations, reports, urban wildlife management plans, and professional and academic websites. Search terms were white-tailed deer, deer, home range, deer management, wildlife management, urbanization, urban landscapes, urban wildlife damage, urban wildlife management, urban wildlife behavior, human-deer, conflict, deer habitat, survival rates, urban wildlife disease, deer-vehicle collisions, urban deer hunting, lethal and nonlethal deer management, and urban white-tailed deer management. I did not include white-tailed deer management in rural landscapes in this review to maintain focus on urban landscapes.

I read each document when identified during searches. I placed each document into a database with keywords related to the subject and key results or salient points. This approach generated 6 thematically related groups of literature: urban deer management, survival and reproduction, urban white-tailed deer habitat, human-deer interactions, urban deer management methods, and disease. I divided urban deer management methods into lethal and non-lethal management methods.

Results

I identified 35 research articles related to white-tailed deer biology or management in urban landscapes. Article publication dates range from 1995 to 2021. Literature came from 16 peer-reviewed publications, two literature reviews, two conference reports, and one book (Table 1). *Wildlife Society Bulletin* was the most common publication.

Table 1: Publication and number of articles in this review

Publication	# of Articles
Wildlife Society Bulletin	11
The Journal of Wildlife Management	8
Urban Deer	3
Human Dimensions of Wildlife	2
Urban Ecosystems	2
Annals of the New York Academy of Sciences	1
American Journal of Agricultural Economics	1
Natural Areas Journal	1
Journal of Clinical Microbiology	1
Mammal Society of Japan	1
The New York Academy of Sciences	1
Joural of Safety Research	1
Ecological Society of America	1
Ecology and Society	1

Urban Deer Management

Recent trends in land use have caused increased residential and commercial development to expand outward from urban centers (Piccolo et al. 2000). Today, managers face the daunting task of deer management in the urban matrix (Decker et al. 1995 and Piccolo et al. 2000). Wildlife residing in urban landscapes poses considerable challenges to local resource managers, because authority over wildlife management often lies with federal or state agencies. Thus, elected officials must work with these agencies to determine and achieve defined objectives (Westerfield et al. 2019). Fortunately, many communities support deer management strategies, but high costs and long wait times until results are observed often decrease support over time (Kilpatrick et al. 1997). However, attitudes and perspectives of residence are not fixed, and communication from managers is the key to successful deer management (Kilpatrick et al. 1997, Urbanek et al. 2011).

Survival and Reproduction

White-tailed deer are one of the most fecund deer species in the world, with females in unhunted populations capable of producing 30 offsprings in their lifetime (McShea 2012); therefore, the number of deer on an urban landscape can change quickly. A large amount of natural mortality in white-tailed deer occurs during the first few months of life (Saafeld and Ditchkoff 2007). Additionally, Saafeld and Ditchkoff reported the two-year study showed that overall survival for the first 8 weeks of life was (33.3%) in 2004 and (42.1%) in 2005, and the most common cause of mortality during both years (41.7%) was predation by coyotes. However, patterns of mortality for fawns in urban areas may differ from published studies in rural landscapes. Preliminary unpublished data indicated that coyote predation on neonatal deer in urban areas may exceed what is found in rural areas (Ditchkoff et al. 2006). Deer in urban areas are not normally exposed to hunting pressure, which may lead to greater survival than in rural areas, though, deer-vehicle collisions can be a substantial mortality sources in urban landscapes (Etter et al. 2002).

Urban White-Tailed Deer Habitat

Urbanized landscapes can provide refuge for growing deer populations (Potratz et al. 2019). Despite the fast growth of urban and suburban areas, little research has focused on deer behavior and ecology in these environments (Swihart et al. 1995, Piccolo et al. 2000). Urban areas were historically considered unsuitable for wildlife. However, the mosaic landscape of stream corridors, forest fragments, parks, and other green spaces in many urban areas provide high-quality habitat for deer (Grund et al. 2002). Suburban areas offer cover in green spaces fragmented by dispersed housing and building cover (Kilpatrick et al. 2011, Potratz et al. 2019), and supplemental foods in gardens, less manicured lawns, and ornamental plants. Many new suburban areas are designed with larger lots such that houses are separated by trees and other patches of vegetation. This line-of-sight separation between homes creates deer habitat (e.g., travel corridors, hiding cover, and food) in otherwise unsuitable landscapes (Ditchkoff et al. 2006).

Human-Deer Interactions

People differentially value deer and weigh the acceptability of deer management methods based their social identity, age, gender, area of residence, beliefs about hunting, and personal experiences (Stinchcomb et al. 2022). Humans residing in urban areas are less familiar with wildlife and how to deal with problems posed by wildlife than their rural counterparts (Ditchkoff et al. 2006). Social tolerance of deer varies among residences in urban areas. Some residents have positive views and consider them aesthetically appealing whereas others may view deer as a nuisance: hence, the opposing views can make management difficult. Residents unfamiliar with wildlife often have concerns with some management techniques. Generally, those concerns are with hunters and their behavior, public safety, and animal rights issues. When these concerns are expressed as regulations that prohibit hunting, and firearms discharge they generally result in an increase in deer populations and negative deer-human interactions. Similarly, animal-rights advocates create conflicts by impeding implementation of deer management plans (Girard et al. 1993).

Deer Vehicle Collisions

In 2009, the insurance industry estimated that 2.4 million deer-vehicle collisions (DCVs) had occurred over the previous 24 months, with an estimated cost of over $7 billion and 300 human fatalities (McShea 2012). DVCs occur in urban and suburban areas where both deer and motorists are abundant (Nielsen et al. 2003). DVCs generate the highest amount of monetary damage from wildlife-vehicle collisions, averaging $6,717 per collision (Huijser et al. 2008). Over a 30-year period, human fatalities from collisions involving deer increased more than 100% (Sullivan 2011). Deer in urban areas are not normally exposed to hunting pressure, so their survival tends to be greater; instead, the major cause of urban deer mortality is deer-vehicle collisions. Additionally, deer killed in DVCs results in the loss of recreational hunting opportunities and other intrinsic benefits. In North Carolina more than half of DVCs occurred between October and December, with almost 25% occurring in November. A county-by-county comparison showed that Wake County had the highest number of reported DVCs. Other counties with high DVCs included Pitt, Guilford, Randolph, Union, Columbus, Duplin, Rockingham, and Mecklenburg (Figure 1).

Property And Ornamental Crop Damage

Property damage may be less obvious than DVCs, but still substantial. Deer, having broad diets, can degrade and restructure ecological communities by over-browsing vegetation in natural areas and residential backyards (DeNicola 2000, Potratz et al. 2019). Deer in urban and suburban settings can become overabundant, reaching densities of 78 deer/km^2 (Magnarelli et al. 1995; Figure 2). In some urban areas, overabundant deer alter landscapes via intensive browsing and indirectly reduce the abundances of other wildlife (Waller and Alverson 1997).

Overabundant deer browse heavily on forest understories creating a browse line free of vegetation within 6 feet off the ground (Adams et al. 2006). This overbrowsing influences the distribution and abundance of wildlife species at multiple trophic levels that depend on those vegetative communities and modifies the relative abundance of species that compete with deer (Waller and Alverson 1997). This type of intensive herbivory is not confined to forests. About 4% of urban and suburban households reported damage from deer herbivory to gardens, yards, and ornamental plants (Conover, 2001). In rare cases deer may be aggressive towards humans, and in 2005 Southern Illinois University-Carbondale reported 13 deer attacks on humans. These attacks were speculated to be female deer protecting fawns; although, these attacks happen, they are generally not a concern due to the rarity of occurrence.

Disease

Deer serves as an intermediate host for several diseases that are transmitted to humans, primarily through ticks; these include Rocky Mountain spotted fever and Lyme disease (McShea 2012). Lyme disease is the most common disease to spread between deer and humans (Adams et al. 2006). Lyme disease is contracted by humans through injection of the bacterium, *Borrelia burgdorferi*, during the bite of a deer tick (Ixodes spp.). White-tailed deer are susceptible to the

SARS-CoV-2 virus. The geographic distribution of white-tailed deer encompasses most of North America and these animals are particularly near urban population centers in the eastern United States (Chandler et al. 2021). The unnatural concentrations and close contact that results from human development and artificial baiting provides ideal conditions for the transmission of bovine TB through inhalation of infectious aerosols and ingestion of contaminated feed (Whipple and Palmer 2000). Viral diseases, such as bluetongue and various hemorrhagic diseases, are episodic, but more prevalent in high density populations of deer, and might reduce populations by 15% in a single year (Davidson and Doster 1997). However, these diseases will not regulate deer density to sustainable levels.

Chronic wasting disease (CWD) is a fatal neurodegenerative disease affecting free-ranging and captive cervids (Samuel and Storm, 2016). CWD prevalence in deer was almost twice as high in developed areas than in undeveloped landscapes (Farnsworth et al. 2005). Urban areas reduce the number of deer harvested by hunters increasing the likelihood of deer reaching the adult age class. Because male deer typically live longer in human areas, they are up to 2.5 times more likely to contract and test positive for CWD in urban landscapes while the difference in CWD prevalence was relatively insignificant for females (Westerfield et al. 2019). To reduce the chance of spreading CWD trapping and relocating deer is not advised. The Southeastern Cooperative Wildlife Disease Study discourages the relocation of wildlife due to the threat of spreading disease. Relocation involves the transport of an entire biological package, including parasites and disease, which could be inadvertently introduced to another population by human efforts (Westerfield et al. 2019).

Deer management methods

The ecology and behavior of urban white-tailed deer are of primary interest regardless of the management strategy under consideration. Governmental agencies often implement deer removal programs to reduce deer densities and alleviate deer-human conflicts (Grund et al. 2002). Aside from the sporadic removal of problem animals by wildlife management agencies, regulated hunting and trapping are the most common form of active management (Rondeau and Conrad 2003). Urban communities often have committees or other groups to represent on the community's behalf; however, these committees may hinder the establishment of a deer management program until there is full support from members of the committee. To gain approval for deer management programs urban wildlife managers use methods such as electronic surveys, paper surveys, or telephone surveys to gage the residents' opinion about which management methods may be best for a community. Urban wildlife managers must make management decisions in environments that are diverse in sociocultural, economic, political, and ecological components. These human dimensions tend to be the prominent drivers of urban wildlife management, and therefore must be well understood and integrated throughout all phases of the management process (McCance et al. 2017).

State management agencies are faced with the challenges of managing growing deer populations in urban areas (Messmer et al. 19997). Due to hunting restrictions and property access problems these areas often become refuges for deer. Individuals who reside in these locations often have varying beliefs and values regarding how the deer herd should be managed

(Messmer et al. 1997). With such a wide variety of opinions in a localized community, it remains difficult for managers to come to a consensus on how to best manage deer (Stewart 2011). Lethal and nonlethal management techniques are discussed between wildlife managers and stakeholders when proposing and developing a management plan, but there is usually conflict before any agreement.

Lethal Management Methods

Regulated deer hunting remains the preferred method for state agencies to control deer populations but can prove problematic when managing deer herds in urban areas, where hunter access is limited, (Harden et al. 2005). Lethal controls have been shown to be the most effective methods to reduce populations of urban white- tailed deer. Cost-benefits analysis, as well as physiological and biological considerations, make killing deer preferable to trapping and relocation and birth control (Green et al. 1997). A cost benefits analysis from a 5-year study using immunocontraception and culling showed an average cost of $2,078.12/capture compared to culling 30 deer with a total cost of $16,163.63, or $538.79/deer (Walker et al. 2021). The use of regulated public hunting has successfully guided deer management in the modern era (Westerfield et al. 2019). Unlike sharpshooting and euthanasia, regulated hunting allows for the resource to be used as food by hunters, families, and property owners. Venison can be donated to local processors where it is processed and then donated to food assistance programs. However, in urban areas where initial populations exceed 30 deer per/sq mile and when there are restrictions on hunters, it is difficult for hunters to immediately reduce the population. For the best results hunting should be used annually. Of lethal management strategies, homeowners preferred archery, gun, and crossbow hunting over other lethal strategies such as sharpshooting and trap and kill (Kilpatrick et al. 2007).

Sharpshooting is an efficient method of reducing deer populations in urban landscapes and usually produces immediate results (Figures 3 and 4). However, sharpshooting is highly controlled and requires trained personnel to methodically remove deer from the landscape. Sharpshooting can be a costly method to manage a deer herd due to logistics and demand for trained personnel. Harvested deer ideally would be processed for food pantries, but it may be difficult to find a processor that is able to process a deer within the required time frame at high volumes. In 1991, the Minnesota Valley Deer Management Task Force developed a deer management plan for the cities of Bloomington, Burnsville, Eagan and Mendota Heights, Minnesota. Sharpshooter were assigned from the Bloomington police department's Special Operations Unit. Officers were required to pass a shooting test and receive authorization for a non-standard weapon. Additionally, officers were required to take classes on a wide range of topics to include public interaction, safety standards, and shot placement (McAninch 1993). The three-year study concluded with 135 deer killed the first year, 167 deer killed in year 2, and 152 deer killed in year 3 for a total of 454 deer (Stradtmann et al. 1995) with no accidents or injuries. Sharpshooting in urban areas has received little support from homeowners despite having much success at reducing deer populations, the lack of homeowner support for sharpshooting may be attributed to the homeowner's lack of familiarity with the strategy (Drummond, 1995).

Non-Lethal Management Methods

Although lethal deer removal programs have proven effective for many communities, the public may be opposed to lethal methods and favor nonlethal programs such as contraception (Rutberg 1997, Grund et al. 2002). I purposely left out the option of trapping and relocation due stress on wildlife, limited release sites, and the possibility of spreading CWD. There is a myriad of studies investigating the practicality of contraception as an urban deer management alternative (Hobbs et al. 2000). However, contraception has not been demonstrated to be an efficient means of reducing overabundant deer populations because of several limitations (Swihart and DeNicola 1995). Furthermore, the use of fertility control can increase deer longevity, and at least 90% of female deer in a population would need to be treated to be deemed effective (Westerfield et al. 2019). Fertility control only stops or slows reproduction of the existing deer herd and does not account for immigration of other deer. Plus, remaining individuals still pose the risk of DVCs, chances of spreading disease, and likelihood of landscaping damage, culling will likely be necessary to reduce the population (Walker et al. 2021).

Two nonlethal deer management techniques currently in use are surgical sterilization and immunocontraception (Warren 2011, Boulanger et al. 2012, Walker et al. 2021). Both are costly and should be coupled with other forms of management to maximize effectiveness. Although, the cost of the contraceptive vaccines is relatively low to produce the labor necessary to apply then to deer populations are costly (Warren 2012). The difference in cost between immunocontraception and culling can be substantial. A study in North Carolina reported that the difference between immunocontraception treatments and culling averaged $1500 per deer for a single dose and $3600 per deer if a second dose was administered (Walker et al. 2021). The city of Town and Country, Missouri funded a sterilization program in conjunction with a culling program for more than two years to reduce the population of deer in the city. Over 130 does underwent the sterilization procedure. The procedure was successful for the treated does but treated deer were placed back out on the landscape resulting with no decline in the population. After two years the sterilization efforts were discontinued due to high cost ($1,300 per treated doe) and the community switched to sharpshooting to maintain a lower deer population (Westerfield et al. 2019). Another study in Ithaca, New York combined archery hunting and sterilization of 77 female deer, which, were surgically sterilized. The sterilization prevented pregnancy but did not stop the does estrus cycle. The continuous estrous cycle attracted bucks from the surrounding area after the normal breeding season had ended. The final results showed that the birth rates initially slowed but after five years the number of deer on the landscape remained the same. In summary, managers must assess two aspects before using sterilization as a management option: (1) whether reducing the population through sterilization is biologically possible, and (2) whether sterilization can be practically implemented (Merrill et al. 2003).

Reducing food and cover for deer limits reproduction, and increases mortality, as food restrictions can increase overwinter mortality and disease susceptibility (McShea2012). Although, no plant may be “deer proof”, there are some plants less attractive to deer. Deer damage to different plant species can vary regionally and by differences in site characteristics (Sayre et al. 1992). List of local deer resistant plants can be identified via web search. Use of native plants in landscaping may be beneficial because these plants have evolved with deer and deer herbivory. Establishment of deer resistant plantings works best when coupled with other

non-lethal management techniques such as fencing, guard dogs, or commercial deer (Westerfield et al. 2019).

Conclusions

The purpose of this literature review was to summarize the research regarding the ecology and management of white-tailed deer in urban landscapes. Deer managers and residents in urban and suburban areas generally agree on the same reasons to decrease deer populations. The disconnect between the two groups is the methods in which deer management is conducted. To bridge this gap, educational material directed at the legal status and effectiveness of these techniques is needed (Urbanek et al. 2011). Coyote predation on neonatal deer in urban landscapes may be an emerging source of deer population management in the eastern US.

Urban residents that support nonlethal methods are often unaware of the costs and relative effectiveness of the methods. Should communities decide to evaluate a nonlethal management program it is important to include the cost over multiple years due to initial start-up cost (Walker et al. 2021). Unlike a hunter harvest management plan, nonlethal methods such as sterilization come with a much higher cost that may be passed on to residents of the community. As the cost of non-lethal management techniques continue to rise for homeowners the desire to wait for results decreases. Long-term community support for contraception as the only management strategy is unlikely based on the cost and time required to reduce the deer population (Walter et al. 2002). Human dimensions will always be a component in urban wildlife management because social, cultural, and political forces are part of the context in which management decisions take place and nowhere is this more important than in situations involving white-tailed deer (Messmer et al. 1997).

Graphs and Charts

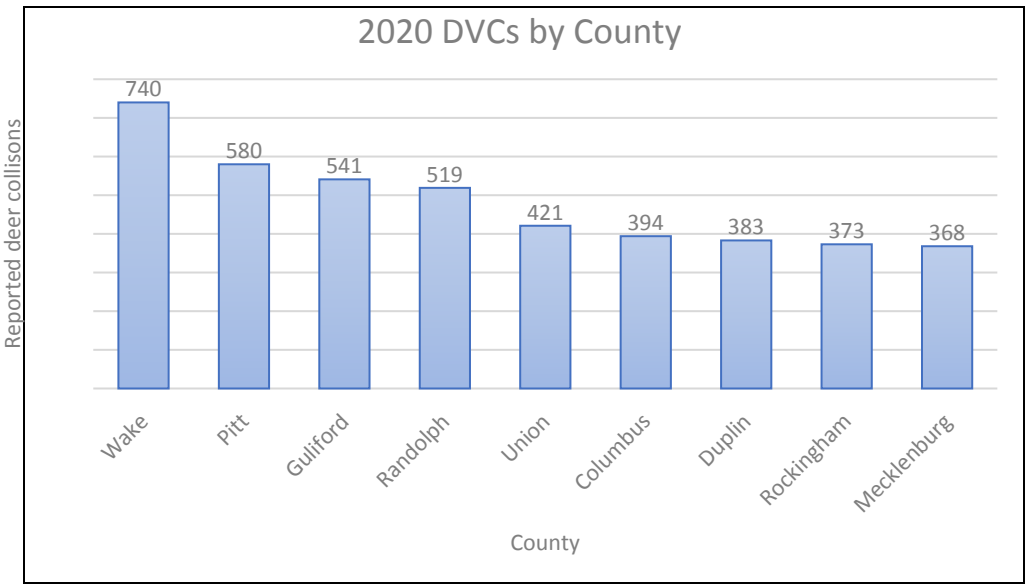

Figure 1. A county-by-county comparison of the data shows that Wake County has the highest number of reported deer-related crashes in 2020. (https://www.hsrc.unc.edu) https://www.hsrc.unc.edu/news/announcements/nc-deer-related-crashes-increase-in-the-fall-2021/

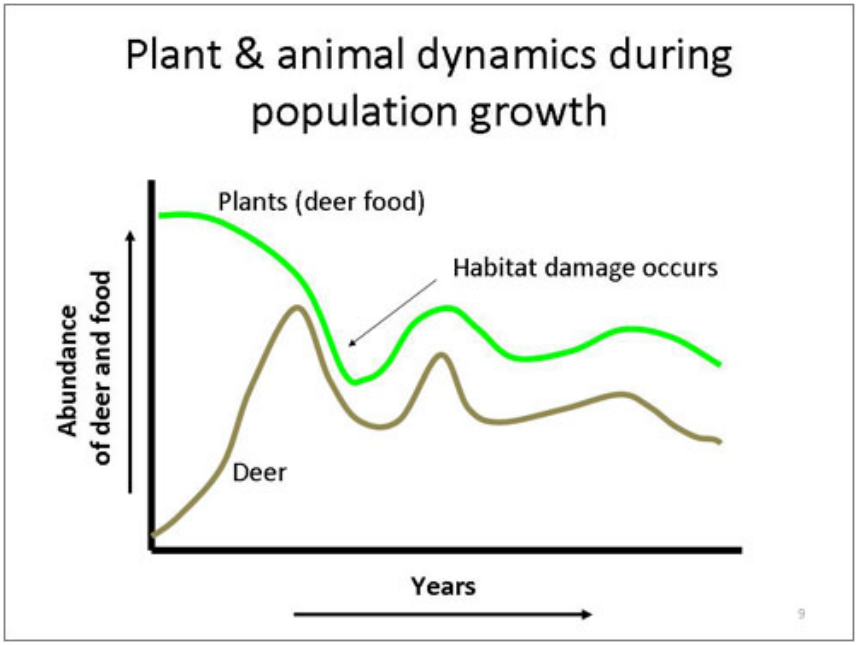

Figure 2. Shows the theoretical relationship between naturally occurring deer food and deer population size over time. When deer populations get too high, they damage the plant-food base that sustains them https://www.msudeer.msstate.edu/deer-habitat-carrying-capacity.php

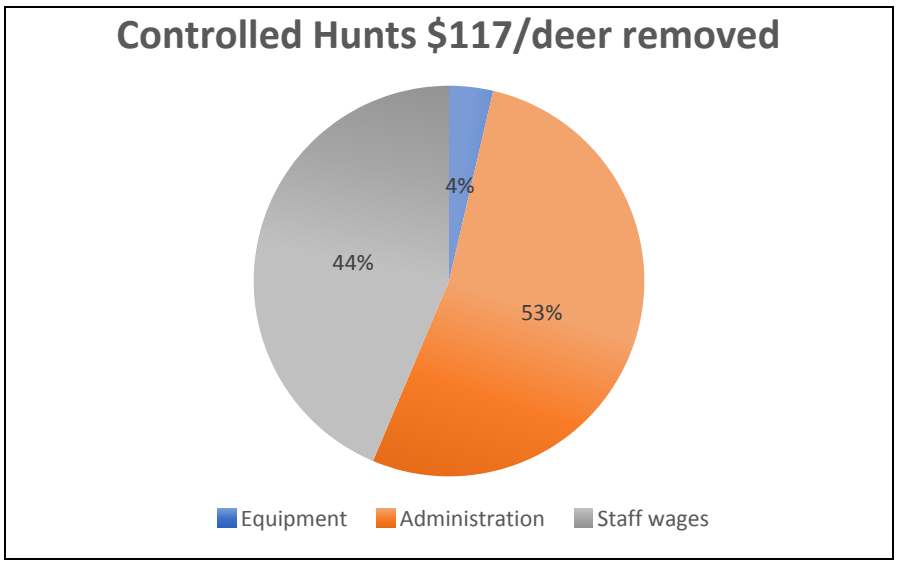

Figure 3. Figures 3 and 4 show a cost comparison between controlled hunting and sharpshooting to reduce white-tailed deer on urban landscapes in Bloomington, Minnesota (Doerr et al. 2001).

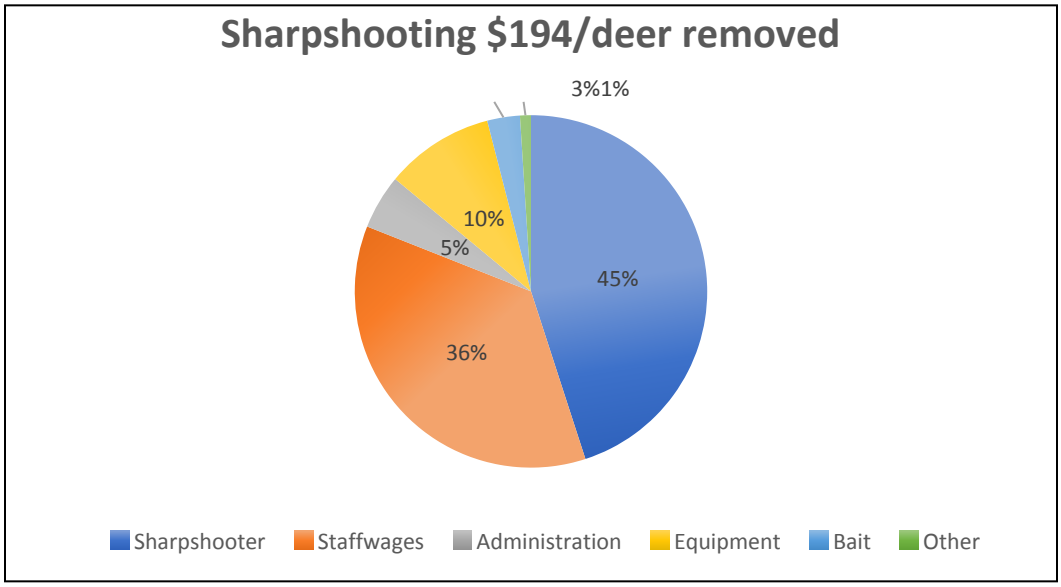

Figure 4.

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