Long Island White-tailed Deer Damage Management Demonstration Project Report

Prepared by:
United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services

August 2014

USDA

Wildlife Services

Protecting People | Protecting Agriculture | Protecting Wildlife

APHIS

EXECUTIVE SUMMARY

White-tailed deer (*Odocoileus virginianus*) while being one of the most popular game species across the United States, are a growing problem and a serious concern for New York, especially Long Island. Deer are highly adaptable and can exploit a diversity of habitat types, including agricultural fields, woodlands, marshes, urban areas and suburban tracts. Currently Suffolk County's deer herd is roughly twice the carrying capacity, putting pressure on agricultural production, property, human health and safety, and natural resources.

In the two most recent NASS reports for New York (2000-2001 and 2007-2008) Suffolk County had the highest cash receipts of all counties making it one of New York's most important counties agriculturally. However, a 2004 Cornell Human Dimensions Research Unit study estimated that deer damage to Long Island crops exceeded $1.75 million, and in a more recent 2009 estimation of deer damage, deer cause $5 million per year in agricultural damage to Suffolk County farmers.

White-tailed deer are a vector of several prevalent and serious tick borne diseases on the East End of Long Island, including Lyme disease, ehrlichiosis, Powassan, Southern Tick Associated Rash Illness (STARI), and Babesiosis. Overpopulations of deer over browse and severely impact natural resources such as the understory of forests, preventing new growth from occurring and impacting native flora, small mammals, birds, and insects. This destruction of understory plants prevents regeneration of forests, increases erosion, and changes forest composition.

To assist East End communities with managing the damage caused by white-tailed deer, Wildlife Services acquired access to more than two dozen properties on the East End to conduct a white-tailed deer damage management demonstration project. In all, WS removed 192 individual deer, traveling either alone or in groups, and removed all of them by shooting from stationary locations or mobile units. Throughout this program all the deer were removed in a safe, humane and effective manner with no accidents or property damage, and more than 6,000 pounds of venison were donated to hunger relief organizations.

During this six-week project, many challenges presented themselves, including inclement weather, length of project, direct interference from individuals opposed to this project, and a permitting restraining order placed on NYSDEC. Individually, each of these challenges was manageable; however, due to the short duration of the project, collectively they impacted the total deer removal. Unauthorized human activities near shooting zones and baiting sites had a negative impact on the overall success of the program.

The most effective and long term approach to white-tailed deer damage management caused by an overpopulation of deer is by managing the herd on a regional level with an integrated management approach, through a variety of applicable methods over a period of several years. This project demonstrated that the safe, humane and effective removal of white-tailed deer can be accomplished and should be continued to decrease the damage being caused by white-tailed deer.

TABLE OF CONTENTS

INTRODUCTION

Nationwide, white-tailed deer are among the most popular game animals. Residents of New York State enjoy them for recreational and aesthetic benefits. Although revered, wildlife can have negative implications for humans when conflict causes threats to human health and safety and economic losses to agriculture, natural resources, and property. The wildlife acceptance capacity, or cultural carrying capacity, is the limit of human tolerance for wildlife or the maximum number of a given species that can coexist compatibly with local human populations. This limit may also be a result of a deer population that has access to abundant food resources or that is not impacted by predators. On Long Island, specifically, white-tailed deer cause significant agricultural and property damage, vehicle collisions, and increased tick-borne diseases. When the wildlife acceptance capacity is met or exceeded, it is necessary to implement population or damage management to alleviate damage or threats to human health and safety.

Deer can play a crucial role in shaping ecosystems. Their presence can have positive or negative results on the landscape depending on population size. This biological carrying capacity is the land or habitat's ability to support healthy populations of wildlife without degradation to the species' health or their environment during an extended period of time (Decker and Purdy 1988). Plant communities and the wildlife that depend on them suffer when a deer population becomes overly abundant. The New York State Department of Environmental Conservation (NYSDEC) is the authority on managing the State's wildlife resources, and New York State Environmental Conservation Law (ECL) Section 11-0303 states that the department must manage wildlife to meet requirements for public safety.

In their Management Plan for White-tailed Deer in New York State 2012-2016 NYSDEC has identified, with public input, six goals for deer management in New York: 1) manage deer populations at levels that are appropriate for human and ecological concerns; 2) promote and enhance deer hunting as an important recreational activity, tradition and management tool in New York; 3) reduce the negative impacts caused by deer; 4) foster understanding and communication about deer ecology, management, economic aspects and recreational opportunities while enhancing DEC's understanding of the public's interest; 5) manage deer to promote healthy and sustainable forests and enhance habitat conservation efforts to benefit deer and other species; and 6) ensure that the necessary resources are available to support the proper management of white-tailed deer in New York (NYSDEC 2012). Goal #3 is derived from NYSDEC's belief that the public should not have to suffer from "inordinate" damage caused by state-managed wildlife.

On Long Island, the primary method of managing deer populations has been through regulated bow-hunting seasons. Hunting generally works best over large areas, or when damage is not severe (NYSDEC 2012). In an attempt to increase the annual harvest on Long Island, NYSDEC extended the hunting season and added a shotgun and muzzleloader season. In addition, qualifying landowners can request Deer Management Assistance Program (DMAP) permits when damage to their property or crops is severe. Outside of the normal hunting season, the State issues Deer Damage Permits (DDP) which may allow sharpshooting or capture and removal operations.

USDA, APHIS, Wildlife Services (WS) responded to a request for assistance with white-tailed deer damage by the Long Island Farm Bureau and the Town of Southold on the East End of Long Island. During February, March, and April 2014, WS conducted a deer damage management demonstration project on the East End of Long Island. This project established that white-tailed deer can be safely, humanely and effectively removed from agricultural communities across a wide area and from state land on Long Island. This report outlines the damage that white-tailed deer cause, summarizes Wildlife Services' field activities, and suggests recommendations for future white-tailed deer damage management. Funding for this project was obtained through the Long Island Farm Bureau (LIFB) and the Town of Southold.

Cooperating Agencies and Public Outreach

Wildlife Services staff met with the Long Island Farm Bureau and discussed deer damage management options with NYS Department of Environmental Conservation Bureau of Wildlife Region 1 and Central Office; NYS Office of Parks, Recreation, and Historic Resources; and U.S. Fish and Wildlife Service National Wildlife Refuges on Long Island. In addition, WS addressed meetings held by the towns and villages, as well as met with stakeholders that would be affected by the program. WS also conducted media interviews, both locally and regionally.

IMPACTS

At the time of European settlement the continent held an estimated deer population of 8-20 deer per square mile, which is what can still be found in areas of minimal development in the Northeast (USFWS 2012). Overall, deer populations have increased dramatically across most of their range due to the regrowth of abandoned agricultural lands, forests being clear cut for timber, extirpation of top predators, as well as rigorously enforced hunting laws designed to keep deer numbers high for modern hunters.

The U.S. Forest Service's Northern Research Station conducts studies on deer density and has found that population levels at or below 20 deer per square mile allow damaged forests to recover undergrowth. In some places, deer populations are now so high that they cause long-term negative ecological effects, eating out forest understories of wildflowers, shrubs, and tree seedlings (USFS 2012).

Suffolk County has an estimated 25,000-36,000 deer according to NYSDEC (J. Stiller, Deer Biologist, NYSDEC Bureau of Wildlife, personal communication). This estimate gives Suffolk County an average density of 27-39 deer per square mile with denser populations in the eastern and northwestern parts of the county. In the Town of East Hampton, the average density of deer for the entire township was estimated to be 51.02 deer per square mile (Verret 2006).

Agricultural Damage

White-tailed deer can cause damage to a wide variety of agricultural resources, including row crops, forage crops, vegetables, fruit trees, nursery stock, ornamentals, and stored hay (Craven and Hygnstrom 1994). In addition to the immediate losses, there may be residual damage in the form of future yield reduction for fruit trees or forage crops, and ornamental trees or nursery stock may be permanently disfigured by deer browsing (Craven and Hygnstrom 1994). Although browsing is the most common type of damage, deer may also damage agricultural crops by trampling or antler rubbing (Dolbeer et al. 1994).

During 2001, field crop losses from wildlife in the United States totaled $619 million and losses of vegetables, fruits, and nuts totaled $146 million. Those losses include destruction of or damage to crops in the field. In 2001, the National Agricultural Statistics Service (NASS) reported that, white-tailed deer accounted for 58% of the total field crop damage and 33% of vegetable, fruit, and nut damage.

In 2013 NYSDEC issued 132 Deer Damage Permits (DDP) to farmers and property owners experiencing deer damage in Region 1 (NYSDEC 2014). These permits were categorized into 6 different categories by NYSDEC (Table 1). Under these permits, 658 deer were taken, whereas a total of 2,873 deer were taken in Suffolk County by hunting licenses/tags (no deer were taken in Nassau County). Together these take numbers represent only 14% of the lower population estimate. Table 2 illustrates the nearly ten-fold difference in number of deer taken in Region 1as compared to the entire state. This dramatic difference speaks to the need for white-tailed deer damage management in Suffolk County.

Table 1. Complaint categories for which NYSDEC Region 1 issued Deer Damage Permits (DDP) during calendar year 2013.[1]

Category	**Region 1**[2]
Airport	5
Agriculture	135
Tree Farm/Orchard	62
Community/Residential	78
Ecological	37
Other	20

[1]Taken from the New York State White-tailed Deer Harvest Summary 2013.
[2]Permits may be issued for more than one category of damage; sum of permit categories may not equal the total. *To maintain the integrity of these data, "Agriculture" and "Tree Farm/Orchard" were not combined even though both interests were protected in this project.*

Table 2. Deer taken in Region 1 and in Regions 1-9 illustrating the difference in number of deer taken for damage purposes as a percentage of total deer taken.[A]

	Deer taken by Deer Damage Permits	Deer taken by licenses/tags	Total deer taken	% of total deer taken that are DDP
Region 1[B]	658	2,873	3,531	19%
Regions 1-9	5,104	243,567	248,671	2%

[A] Taken from the New York State White-tailed Deer Harvest Summary 2013.

[B] No deer were reported as being taken in Nassau County.

In the two most recent NASS reports for New York (2000-2001 and 2007-2008) Suffolk County had the highest cash receipts of all counties making it one of New York's most important counties agriculturally. However, the local deer population impacts the production of this agriculturally important county. A 2004 Cornell Human Dimensions Research Unit (HDRU) study estimated that deer damage to Long Island crops exceeded $1.75 million (Brown et al. 2004), and Suffolk County is included as one of the counties with heaviest deer damage in New York State (Brown et al. 2004). In a more recent 2009 estimation of deer damage, deer cause $5 million per year in agricultural damage to Suffolk County farmers (Frost 2008). Deer, even young fawns, eat vegetables and fruit, from emerging greenery to mature produce. Additionally, when male deer (bucks) rub their antlers on nursery stock, such as young trees, the bucks damage the trees by removing bark and cambium and breaking small branches (Matschke et al. 1984), preventing the trees from being sold.

Property Damage

White-tailed deer can also damage property such as landscaping and ornamental plantings. As development expands into previously rural areas, deer habitat may actually be enhanced because fertilized lawns, gardens, and landscape plants serve as high quality sources of food (Swihart et al. 1995). Furthermore, deer are prolific and adaptable, characteristics which allow them to exploit and prosper in suitable habitats near urban, residential areas (Jones and Witham 1995).

The costs of property damage that deer cause are difficult to obtain. However, we do know that locally, deer impact landscaping and gardens, and East Hampton property damage complaints are increasing to an all-time high and now include urban areas. In 2013 the Town of East Hampton issued a white-tailed deer population management plan. This plan documents that during 2008-2009 the Town of East Hampton's Architectural Review Board issued "a few" permits for deer fence installations; however, from 2010-2012, the Review Board issued a total of 40 deer fence installation permits. Further, in the same plan, an East Hampton Town resident described deer fencing as her "only protection against a deer invasion."

Natural Resource (Ecological) Damage

Natural resources may be described as those assets belonging to the public and often managed and held in trust by government agencies as representatives of the people. Such resources may be plants or animals, including threatened and endangered species; historic properties; or natural habitats in general. Examples of natural resources in New York are historic structures and places; parks and recreation areas; natural areas, including unique habitats or topographic features; threatened and endangered plants or animals; and any plant or animal populations which have been identified by the public as a natural resource.

Deer overabundance can affect native vegetation and natural ecosystems. Numerous studies have shown that overbrowsing by deer decreases plant growth, survivorship, and reproduction (Boerner and Brinkman 1996, Waller and Alverson 1997, Ruhren and Handel 2003) and can affect understory vegetation cover, plant density, or plant diversity (Warren 1991). Forest and savannah sites with over abundant white-tailed deer populations may have lower species diversity of forbs due to preferential feeding (Urbanek et al. 2012). White-tailed deer's preference for eating native species has been associated with the increased success of exotic, or invasive, plant species in eastern hemlock forests. (Eschtruth and Battles 2009). In forest restoration sites, one study showed that herbaceous plants were half as likely to survive in the presence of high numbers of white-tailed deer compared to areas where deer were excluded (Ruhren and Handel 2003). As reported by the North Fork Conservation Council, 92 tracts of land monitored by the Central Pine Barrens Commission showed zero regrowth during the last 10 years due to damage caused by the local deer herds (https://www.youtube.com/watch?v=sSLTrTEhlA0). Indeed, Brookhaven National Laboratories in Suffolk County, New York regularly monitors overbrowsing by deer through the use of fence exclosures.

In addition to the effects on plants and forest communities, other wildlife can be harmed. Altered and degraded habitat due to overbrowsing by deer can have a detrimental effect on deer herd health and may displace other wildlife communities (e.g., neotropical migrant songbirds and small mammals) that depend upon the understory vegetative habitat destroyed by deer browsing (DeCalesta 1997, VDGIF 1999). For example, deer browsing may affect vegetation that songbirds need for foraging surfaces, escape cover, and nesting (DeCalesta 1997). DeCalesta (1994) found that the species richness and abundance of intermediate canopy nesting songbirds was reduced in areas with higher deer densities. Casey and Hein (1983) reported that 3 species of birds were lost in a research preserve stocked with high densities of ungulates and that the densities of several other species of birds were lower than in an adjacent area with lower deer density. Waller and Alverson (1997) hypothesize that by competing with squirrels and other fruit eating animals for oak mast, deer may further affect many other species of animals and insects. Wheatall et al. (2013) speculates that as high deer densities shift diverse hardwood forests toward black cherry stands, 66% of caterpillar species may lose suitable host plants and therefore be eliminated, which would affect the entire food chain and pollination of certain plant species.

White-tailed deer are documented to reduce the success of new local tree regeneration in East End forests. U.S. Forest Service Biologist, T. Rawinski (2013), reports that local deer have reduced American beech sprouts to knee-high heights. It is a simple matter of too many deer devouring tree seedlings and saplings. Mature trees blown over during storms and dying through natural causes are not being replaced (Rawinski 2013). The same report documents deer negatively impacting understory plants in East End forests. Pink lady's slipper, Canada mayflower, and false Solomon's seal have been reduced to isolated individuals. Wild sarsaparilla is no longer present, and sweet pepperbush stems are also reduced to knee-high levels. Lowbush blueberry has become too stunted to yield fruit.

At the same time invasive species, such as wineberry, mile-a-minute vine, and Japanese barberry are exploiting vacant native plant niches (Rawinski 2013). This destruction of plant life has a direct impact to local animals. The suppression of flowering plants removes vital resources needed by native wildlife. Without pink lady's slipper native insects lose pollen and nectar sources. Fewer native fruits, like lowbush blueberry, will no longer be available to songbirds and small mammals (Rawinski 2013). Further, the elimination of ground plants is thought to contribute to erosion and sediment runoff into local marine estuaries.

In an effort to retard the destruction of natural resources by deer in 2013, 259 New York property owners received Deer Management Assistance Program permits to prevent damage to New York's forests and 13 landowners received the permits for damage to significant natural communities within the state (New York State White-tailed Deer Harvest Summary 2013).

Human Health and Safety

Deer-vehicle Collisions

Deer-vehicle collisions (DVC) are a serious concern nationwide because of losses to property and the potential for human injury and death (Conover et al. 1995, Romin and Bissonette 1996, Conover 1997). The economic costs associated with deer-vehicle collisions include vehicle repairs, human injuries and fatalities, and picking up and disposing of deer (Drake et al. 2005). The Insurance Institute for Highway Safety (2005) estimated that 1.5 million deer-vehicle collisions occur annually in the United States causing approximately 150 fatalities and $1.1 billion in damage to property. Damage costs associated with deer collisions in 2011 were estimated at $3,171 per incident, which was an increase of 2.2% over the 2010 estimate (State Farm Mutual Automobile Insurance Company 2011).

Based on 2011-2012 data, New York is a "High Risk" state for deer-vehicle collisions, and New Yorkers have a 1 in 160 chance of their cars colliding with a deer during the next year, (State Farm Mutual Automobile Insurance Company 2013). In New York State, there were about 35,000 reported deer crashes in 2011 with 4 people killed and 1,311 people injured (Meece 2013). In the Town of East Hampton, reported DVCs have increased from 25 in 2000 to 108 in 2011, an increase of over 400%. Furthermore, it is believed the extensive use of deer exclusion fencing in parts of Suffolk County to reduce crop and ornamental plant damage has resulted in deer spending more time on or near roadways (Civiletti 2011, Verret 2006).

High Fecal Loads

Some threats to human health are related to concern about fecal contamination. The local overpopulation of deer produces unusually high loads of pellet droppings in residential properties, including children's play areas. These deer droppings cause parents to be concerned about the safety of allowing their children to play in these areas. Three residents of Southold reported that the deer fecal loads on their properties rendered their yards unsanitary for their children or grandchildren to play (Southold Public Deer Management Forum, September 26, 2013). Ley et al. (2002) showed that 50% of wild white-tailed deer tested along a Chesapeake Bay tributary contained bovine enterovirus (BEV), and oysters collected from these same waters were contaminated with BEV. This finding is significant as it indicates that deer, especially in high concentrations, can be responsible for non-point source pollution in local water bodies.

Disease Transmission

Zoonoses (zoonotic diseases) are infectious diseases usually transmitted from vertebrate animals to humans either directly or indirectly. Zoonoses that white-tailed deer help spread to humans are usually from ticks that acquired the disease organism from a host such as a white-footed mouse, in the case of Lyme disease, or the deer itself, in the case of ehrlichiosis. Deer help disperse the infected ticks that transmit these diseases to humans. Table 1.3 shows common tick borne illnesses in the northeast that are vectored by white-tailed deer.

Table 3. Tick borne diseases in the Eastern United States that pose potential health risks through transmission to humans. [†]

Disease	**Host**	**Vector**	**Human Exposure**
Anaplasmosis [A]	small mammals and birds	deer tick (*Ixodes scapularis*)	tick bite
Lyme Disease [B]	small mammals, birds, reptiles and amphibians	deer tick (*Ixodes scapularis*)	tick bite
Ehrlichiosis [C]	mammals, birds, reptiles and amphibians	lone star tick (*Amblyomma americanum*)	tick bite
Powassan [D]	small mammals, birds, reptiles and amphibians	deer tick (*Ixodes scapularis*), woodchuck ticks (*Ixodes cookei*), squirrel tick *(Ixodes marxii*)	tick bite
Babesiosis [E]	small mammals, birds, reptiles and amphibians	deer tick *(Ixodes scapularis*)	tick bite

[†] Table 3 is not considered an exhaustive list of tick borne diseases that can be transmitted to humans that are carried by wildlife species. The zoonoses provided are the more common tick borne diseases.
[A] <http://www.cdc.gov/anaplasmosis/>. Accessed 17 July 2014.
[B] <http://www.cdc.gov/lyme/>. Accessed 17 July 2014.
[C] <http://www.cdc.gov/ehrlichiosis/>. Accessed 17 July 2014.
[D] <http://www.cdc.gov/powassan/>. Accessed 17 July 2014.
[E] <http://www.cdc.gov/parasites/babesiosis/>. Accessed 17 July 2014.

<u>Anaplasmosis</u>
Anaplasmosis is transmitted to humans by tick bites primarily from the deer tick, also called blacklegged ticks, (*Ixodes scapularis*) in the northeastern and upper midwestern U.S. Previously known as human granulocytic ehrlichiosis (HGE), Anaplasmosis is caused by the bacterium *Anaplasma phagocytophilia*. In New York State, most cases have been reported on Long Island and in the Hudson Valley (<https://www.health.ny.gov/diseases/communicable/ehrlichiosis/fact_sheet.htm> accessed 17 July 2014). New York is one of six states that represents 90% of all cases reported in the U. S. (CDC 2013*a*).

<u>Lyme Disease</u>
Lyme disease is the most commonly reported vector-borne disease in the US (Yale 2014). It is caused by the bacteria pathogen *Borrelia burgdorferi* and vectored to humans by the deer tick *Ixodes scapularis* in the eastern U.S. (Conover 1997).

Small mammals and birds are reservoirs for Lyme, and blacklegged ticks feed on these animals. Deer are vectors and blood meals for the blacklegged tick nymphs, which are most active in spring and early summer, and deer are immune to Lyme disease. Although deer are implicated in the spread of blacklegged ticks (deer ticks) which vector Lyme disease, researchers have found varying conclusions on the relationship between deer densities and blacklegged tick densities. Local biologists on Long Island's East End surmise that the preponderance of deer on Long Island provides an unusually large food source for the nymphs. Reducing deer densities in isolated environments such as islands and peninsulas has been shown to have a positive effect on reducing the disbursement of blacklegged tick nymphs (Deblinger et al. 1993), and Kilpatrick et al. (2014) showed that reducing deer density in a community has a direct impact on tick abundance and on human cases of Lyme disease.

From 2002-2012, an average of 51 cases/100,000 population with Lyme disease was reported in 56 New York counties (NYS Department of Health, Unpublished Data Dec 2013). This is a notable increase of incidences within New York State. Since 1986, when Lyme disease first became reportable, over 95,000 cases have been confirmed within the state (NYS Department of Health 2013). The number of Lyme disease reports from Suffolk County has fluctuated since 2006 but with a slightly increasing trend during the last 10 years (NYS Department of Health, Unpublished Data). Anecdotally, a local East Hampton medical doctor saw the number of his patients with Lyme disease more than double from 60 in 2010 to 125 in 2011.

Ehrlichiosis

In 1986, another serious tick-borne zoonosis, human ehrlichiosis, was discovered in the United States (McQuiston et al. 1999). Two distinct forms of the illness may affect humans: human monocytic ehrlichiosis (HME) and human granulocytic ehrlichiosis (HGE) (McQuiston et al. 1999, Lockhart et al. 1997). The bacterial agents that cause ehrlichiosis are transmitted to humans by infected ticks that acquire the agents from feeding on infected animal reservoirs (McQuiston et al. 1999). HME is the type of ehrlichiosis predominantly found in the southeastern, south-central, and mid-Atlantic U.S.

White-tailed deer are major hosts for *Amblyomma americanum*, the tick that transmits HME, and deer have been identified as a reservoir for HME (Little et al. 1998, Lockhart et al. 1997). Suffolk County has 44% of the state's cases of Ehrlichiosis (Parpan 2013). Deer contribute to the spread of lone star ticks and blacklegged ticks (deer ticks) vectoring Ehrlichiosis on Long Island. Each year there are 1 to 3.3 cases per million New Yorkers of Ehrlichiosis reported to the CDC (2013*b*). The number of Ehrlichiosis cases has increased, since the disease became reportable, from 200 cases in 2000 to 961 cases in 2008 (CDC 2013*b*).

Powassan

The Powassan virus (POWV) and its variant Deer Tick Virus (DTV) fall within the tick borne encephalitis group of flaviviruses (Grard et al. 2007). POWV was identified in 1958 in Powassan, Canada. There is no specific treatment, but people with severe POWV may need hospital care to reduce swelling of the brain and provide respiratory support (CDC 2013*c*), and doctors have speculated that POWV leads to death in 10%-30% of cases (Neilsen 2013).

Between 2001 and 2012, 13 cases of the Powassan encephalitis were reported in the state of New York (CDC 2013*c*). A majority of these cases were found in the Lower Hudson Valley where Lyme Disease is endemic (Khoury et al. 2013). As deer ticks account for a majority of the tick bites in this area, it is suspected that that the variant DTV is most often being transmitted through deer tick bites (Khoury et al. 2013).

Babesiosis

Caused by the protozoan blood parasite *Babesia microti* that affects red blood cells, Babesiosis is spread by *Ixodes scapularis,* commonly called deer ticks or blacklegged ticks. Babesiosis has been present in the lower Hudson Valley of New York since 2001 (Joseph et al. 2011). Since that time, the number of cases has increased 1.6 fold across the state of New York from 89 cases in 2001 to 142 cases in 2008, and the number of cases within the Lower Hudson Valley have risen 20 fold from 6 per year to 119 per year from 2001 -2008 (Joseph et al. 2011). Suffolk County has 49% of the state's cases of Babesiosis (Parpan 2013). Deer are also implicated in the distribution of blacklegged ticks (deer ticks) vectoring Babesiosis on Long Island. In 2011, there were 1,092 reported cases in 18 states in the U.S. Thirty-two percent (361) were in New York and 5% were in New York City (Herwaldt et. al 2012). The East End of Long Island has had a high and continued incidence of Babesiosis (New York State Department of Health 2012).

Bovine Tuberculosis

Tuberculosis (TB) is a contagious disease of both animals and humans and can be caused by three specific types of the Mycobacterium bacteria. Bovine TB, caused by *Mycobacterium bovis,* primarily affects cattle and other bovine like animals (e.g., bison, deer, and goats) but can be transmitted to humans and other animals.

Bovine TB has affected both animal and human health for years. During the early part of the 20th century the disease affected more U.S. farm animals than did all other infectious diseases combined. The United States Department of Agriculture (USDA) Cooperative State-Federal Tuberculosis Eradication Program, which began in 1917, is chiefly responsible for the near-eradication of the disease from the nation's livestock population.

Pathogenesis of *M. bovis* infection in white-tailed deer begins with either inhalation or ingestion of infectious organisms. Transmission is aided by high deer density and prolonged contact, as occurs at supplemental feeding sites. The most susceptible animals develop disseminated infections throughout their abdominal organs, and can even shed bacilli through their feces or through their milk to their fawns.

In 2008, TB was detected in a captive deer in Columbia County, New York by NYS Department of Agriculture and Markets (DAM). This finding lead to the sampling of road killed and hunter harvested deer to rule out infection of wild deer populations. Sampling of hunter harvest and road killed deer was conducted by NYS DEC BOW, NYS DAM, and USDA WS. No wild deer were diagnosed with TB following this incident (Justin Gansowski, USDA Wildlife Services, personal communication, January 8, 2014). TB has not been documented in free ranging deer populations in New York since the 1930s. The only state with documented, significant levels of Bovine TB in white-tailed deer is Michigan, due to an artificially high density of deer in close association at winter food dumps provided for the deer herds. High deer densities most often occur when the amount of naturally available foods is supplemented, such as in urban or suburban environments or in cases such as Michigan.

Chronic Wasting Disease

Chronic wasting disease (CWD) is a transmissible spongiform encephalopathy (TSE) of deer and elk. To date, this disease has been found only in cervids (members of the deer family) in North America. CWD is typified by chronic weight loss leading to death. Over 400 entities in New York raise nearly 10,000 deer and elk in captivity and have routinely imported captive-bred deer and elk from other states.

A state-wide surveillance program began in 2002 following the detection of CWD in the western US. In April 2005, CWD was confirmed in five white-tailed deer in Oneida County, New York. A containment area was established and deer check points were created to inspect harvested deer. The NYS DEC BOW established an intensive monitoring program, and two additional white-tailed deer within the containment area were confirmed to have had CWD. There have been no reported cases of CWD since that time, and in 2010 the containment area was lifted (NYS DEC 2014*b*). Currently there is no evidence indicating that humans are at risk of acquiring CWD. However, it is recommended that people not consume affected animals and that hunters take precautions when handling suspect deer (NYS Department of Health 2012).

This discussion on zoonoses is intended to address the more common zoonoses associated with white-tailed deer in the United States, but is not intended to be an exhaustive discussion of all potential zoonoses. In summary, the over abundant white-tailed deer population on Long Island has the potential to and in many cases has contributed to increased disease in humans. Suffolk County has reported an increased trend in Lyme disease over the past 10 years; 44% of the State's cases of Ehrlichiosis occur on Long Island, as well as most of the state's cases of Babesiosis. A recent study in Dutchess County, New York indicates that co-infection of Lyme disease with Babesiosis is likely, which is important because co-infections may confound diagnosis and, therefore, treatment (Hersh et al. 2014).

METHODS

In response to local requests, WS initiated a white-tailed deer damage management demonstration project on the East End of Long Island in late February 2014. Management efforts took place on private, agricultural properties where landowners with white-tailed deer damage requested assistance through the LIFB. Wildlife Services also gained access to state land, which was adjacent to one of the agricultural properties that served as a reservoir for deer damaging this property.

Site Selection

WS obtained written permission to conduct deer removal for each property from each land owner. Staff scouted each property and selected safe shooting locations, focusing on those areas where deer were causing the most damage. These shooting zones were baited and camera traps were used to assist in determining deer movements and frequency while minimizing human disturbance at the locations.

Establishment of safe shooting zones (sufficient backstops and appropriate angles) was critical in carrying out a safe deer removal and deer damage management operation.

Removal Techniques

To continue supporting the goals of safety and humaneness, WS used frangible ammunition to eliminate the possibility of a bullet passing intact through a deer and employed equipment such as spotlights and thermal imaging units to locate deer. (Thermal imaging technology allows for the easy detection of non-target species and human presence.) Once the area was determined to be clear and the deer was in a safe shooting zone, the marksman took a humane shot, based on American Veterinary Medical Association guidelines for euthanasia (Leary 2013) and WS sharpshooting procedures for white-tailed deer damage management. All of these factors together provided for safe and humane removal.

WS used two direct control methods throughout the project: stationary and mobile teams. WS marksmen shot from tree stands or ground blinds placed near bait. Tree stands and ground blinds were used in locations where safe shooting zones were limited. Mobile units consisted of three WS personnel: a driver, spotter, and a marksman. A team located deer on participating properties using a thermal imaging unit, positioned the vehicle, and illuminated the deer with a spotlight. These factors together provided for safe and efficient removal.

Carcass Donation

After field dressing, WS transported all deer to a USDA-inspected and NYS DAM-certified meat processor. Some carcasses were delivered whole to Town officials for local needs. Once processed, the meat was delivered to a Long Island food bank for distribution.

RESULTS

Trail cameras monitoring bait sites or travel corridors were instrumental in determining deer presence and visitation schedules. WS field personnel spent 492 hours scouting for deer sign, 392 hours performing lethal removals, and 44 hours consulting landowners and conducting public outreach (Figure 1).

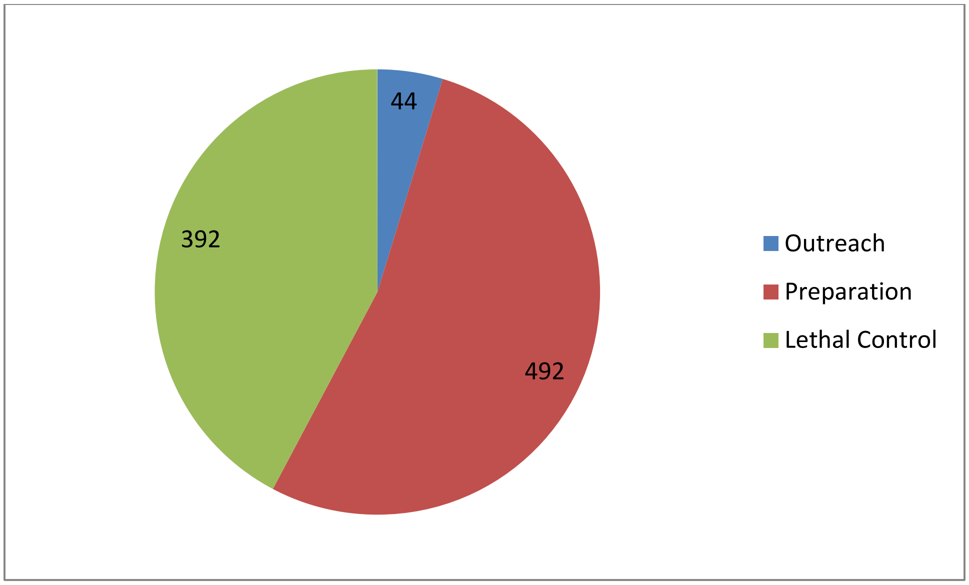

Figure 1. Distribution and average number of hours spent in the field by Wildlife Services personnel during white-tailed deer management in eastern Suffolk County, New York, 2014.

During this demonstration project WS had permission from 16 landowners to perform deer management on over two dozen properties. While monitoring these locations in eastern Suffolk County for deer sign or activity, WS removed deer on 12 properties—the remaining properties either showed no sign of deer activity or did not provide safe shooting zones. During 2014, WS culled a total of 192 deer from stationary locations and by mobile teams.

WS intentionally targeted adult female deer to further reduce the impact of the breeding population. In optimal foraging conditions, 1-year-old juvenile females typically produce one fawn per year whereas adult 2-year-old females will produce twins or triplets (Verme and Ullrey 1984), thus it can be estimated that the local population was reduced an additional 179%. All removals were conducted from the last week in February through the first week of April 2014.

The majority of deer removed were from areas where they would have been impacting agriculture and/or natural resources. Table 4 lists the numbers of deer removed during the project according to the type of property damage.

Table 4. Number of white-tailed deer culled by type of property damage from eastern Suffolk County, New York, 2014.

Property Damage	**Number of Deer Removed**
Agriculture	90
Natural Resources	50
Turf	37
Ornamental	15

North Fork

Wildlife Services routinely monitored properties encompassing 2,035 acres on the North Fork of Long Island. WS personnel performed site visits with landowners to document damage and economic losses. Damage caused by deer on these properties varied. WS removed 132 deer, comprised of 90 (68%) adults and 42 (32%) juveniles from North Fork properties.

South Fork

Wildlife Services routinely monitored properties encompassing 332 acres on the South Fork of Long Island. WS personnel performed site visits with landowners to document damage and economic losses. Damage caused by deer on these properties also varied. WS removed 60 deer, comprised of 48 (80%) adults and 12 (20%) juveniles from South Fork properties.

In total, more than 6,000 pounds of venison were distributed to citizens on Long Island via local municipalities and hunger relief organizations.

DISCUSSION

Management Challenges

During this six-week project, many challenges presented themselves, including inclement weather, length of project, direct interference from individuals opposed to this project, and a permitting injunction filed against NYSDEC. Individually, each of these challenges was manageable; however, due to the short duration of the project, collectively they impacted the total deer removal.

Field work on three nights was cancelled due to inclement weather, and brutal winter conditions impacted deer movement on other nights. In some cases WS personnel did not work during high winds, strong snow, or periods of heavy rain or fog, because deer decrease movement to conserve energy during inclement weather (Brinkman et al. 2005).

The short period between finalization of the agreement and commencement of operations adversely impacted resource availability (personnel) and preparations, such as site preparations. Unauthorized human activities near shooting zones and baiting sites had a negative impact on the overall success of the program. Indeed, our camera traps documented human disturbances at the baiting sites on twenty occasions. On seven occasions people interfered accidentally or intentionally with deer removal operations. On one occasion local police responded to a call from WS for assistance with an individual obstructing work. This action created a dangerous situation because it involved using one vehicle to block another on a roadway.

On several occasions, opponents made negative allegations about the project through media or online. These allegations were shown to have no basis in truth and were unsubstantiated. Further, some individuals used social media to post specifics of planned activities. These postings created security concern for WS personnel, and substantive changes were made to protocols and locations, which negatively impacted harvest success.

The lack of connecting properties was a challenge for this project. Several properties on the South Fork of Suffolk County were connected, which resulted in a greater number of deer being removed from one larger area which in turn will have a greater reduction on the local damage being caused in that area. The properties on the North Fork were smaller properties spread out over a larger geographical area resulting in less take, and, therefore, less damage reduction for each property.

Finally, the injunction, which was enacted as a result of a law suit, prevented further issuances of permit tags by NYSDEC Bureau of Wildlife. This action directly impacted total deer removal as numerous properties with high deer numbers were prevented from either obtaining additional tags or from being issued a permit and tags.

Future White-tailed Deer Damage Management on Long Island, New York

Through newspaper articles and white-tailed deer damage management presentations, the public is becoming more informed on the damage that deer cause. Continued public outreach on this issue will be important. Pages 2-10 of this report summarize the negative impacts deer have on agricultural, ecological, and economic resources as well as on human health and safety. Recent research by Johnson and Horowitz (2014) indicates that public acceptance of killing of local white-tailed deer can hinge on the public's understanding of the amount of local ecological damage that an overpopulated herd can cause.

The most effective and long-term approach to white-tailed deer damage management caused by an overpopulation of deer is by managing the herd on a regional level with an integrated management approach, through a variety of applicable methods over a period of several years (DeNicola et al. 2000). This project demonstrated that the safe, humane and efficient removal of white-tailed deer can be accomplished and should be continued to decrease the damage being caused by white-tailed deer.

This demonstration project successfully removed deer from agricultural and natural resource areas that were being severely damaged by white-tailed deer. Several of the participating property owners allowed private hunters to remove deer from their properties through NYS DEC-issued Deer Damage Permits and State regulated deer seasons. However, given the size of the deer population and damage in Suffolk County, recreational deer hunting alone under current restraints is not sufficient to accomplish the goal of population reduction to manage damage (Weckel and Rockwell 2013, Williams et al. 2013). This shortcoming is not unusual and can usually be attributed to several factors: most hunters shoot only males (Nixon 1991), the majority of hunters only harvest one antlerless deer per year (Riley et al. 2003, Williams et al. 2013), property access restrictions, and many hunters are not willing to remove deer during the summer months when the majority of the damage is occurring. Other limiting factors have included restrictions to lands suitable for recreational hunting.

Recently however, the setback distance has decreased to 150 feet and state parks have begun to open more land up to hunting. Both of these events may provide more opportunity for diminishing the Suffolk County deer population by hunters. However, even with these opportunities, sharpshooting practices prove to be more efficient than hunting (DeNicola and Williams, 2008).

Recreational hunting is part of an integrated deer damage management plan, when damage management is the focus. A few motivated hunters trained in hunting overpopulated deer for damage management will remove more deer than many untrained, recreational hunters (Williams et al. 2013). These trained and motivated hunters have the willingness and ability to remove deer year round, both of which supplement complementary deer damage management activities. The goals of reducing a population and mitigating the damage by white-tailed deer are met by concentrating on removing the antlerless deer in a deer herd. To stabilize a herd's size, the harvest needs to include 30-40% does (West Virginia Division of Natural Resources 1999). To reduce a herd's size would, therefore, require a greater harvest rate of females than 30-40%. Table 2 demonstrates that Region 1 (including the East End) had a harvest of only 14% through depredation permits and hunting in 2013.

Resource managers throughout the country have established programs to reduce deer populations in localized areas. However, few, if any, have tackled a county-wide reduction. Abundance of a population does not equate to increased hunter harvests; indeed, if it did deer populations would not grow. To best manage populations, managers need to increase availability (or access) and not necessarily abundance (Brinkman et al. 2013). Additionally, it seems necessary in Suffolk County to implement programs that encourage the harvest of antlerless deer. Doing so has multiple benefits including destabilizing a deer herd's growth and increasing the number of larger, more mature bucks (Van Deelen et al. 2010). Further, researchers have even broached discussions on the necessity of regulated commercial harvests to manage white-tailed deer populations (Hygnstrom et al. 2014 and Vercautern et al. 2011) to give management agencies another tool.

This demonstration project was successful in safely removing deer in areas experiencing extensive deer damage in Suffolk County. To improve on the success of this project it is necessary that as many towns, villages, and property owners as possible participate in some form of white-tailed deer damage management. Only through an integrated damage management approach can the damage caused by white-tailed deer and their impacts to residents of Suffolk County, Long Island be diminished.

LITERATURE CITED

Boerner, R. E., and J.A. Brinkman. 1996. Ten years of tree seedling establishment and mortality in an Ohio deciduous forest complex. Bulletin of the Torrey Botanical Club 123:309-317.

Brinkman, T. J., C. S. DePerno, J. A. Jenks, B. S. Haroldson, and R. G. Osborn. 2005. Movement of female white-tailed deer: effects of climate and intensive row-crop agriculture. Journal of Wildlife Management 69(3):1099-1111.

Brinkman, T. J., G. Kofinas, W. D. Hansen, F. S. Chapin, and S. Rupp. 2013. A new framework to manage hunting. The Wildlife Professional 7(3):38-43.

Brown, T. L., D. J. Decker, and P. D. Curtis. 2004. Farmers' estimates of economic damage from white-tailed deer in New York State. Human Dimensions Research Unit, Number 04-3. Cornell University, Ithaca, New York.

Casey, D., and D. Hein. 1983. Effects of heavy browsing on a bird community in deciduous forest. Journal of Wildlife Management 47:829-836.

Centers for Disease Control and Prevention [CDC]. 2013*a*. CDC webpage Tickborne diseases of the U.S. <http://www. cdc.gov/ticks/diseases/anaplasmosis>. Accessed 17 July 2014.

Centers for Disease Control and Prevention [CDC]. 2013*b*. CDC webpage Tickborne diseases of the U.S. <http://www. cdc.gov/ticks/diseases/ehrlichiosis>. Accessed 17 July 2014.

Centers for Disease Control and Prevention [CDC]. 2013*c*. CDC webpage Tickborne diseases of the U.S. <http://www. cdc.gov/ticks/diseases/powassan>. Accessed 17 July 2014.

Civiletti, D. 2011. Deer mating season means more collisions on local roads. <http://riverheadlocal. com/local-news/deer-mating-season-means-more-collisions-on-local-roads>. Accessed 14 June 2014.

Conover, M. R., W. C. Pitt, K. K. Kessler, T. J. DuBow, and W. A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. Wildlife Society Bulletin 23:407-414.

Conover, M. R. 1997. Monetary and intangible valuation of deer in the United States. Wildlife Society Bulletin 25:298-305.

Craven, S. R., and S. E. Hygnstrom. 1994. Deer. Pages D25-D40 *in* S. E. Hygnstrom, R. M. Timm and G. E. Larson, editors. Prevention and Control of Wildlife Damage. University of Nebraska-Lincoln, Lincoln, Nebraska, USA.

Deblinger, R. D., M. L. Wilson, D. W. Rimmer, and A. Spielman. 1993. Journal of Medical Entomology 30:144-150.

DeCalesta, D. S. 1994. Impact of white-tailed deer on songbirds within managed forests in Pennsylvania. Journal of Wildlife Management 58:711-718.

DeCalesta, D. 1997. Deer and ecosystem management. Pages 267-279 *in* W. J. McShea, H. B. Underwood, and J. H. Rappole, editors. The science of overabundance: deer ecology and population management. Smithsonian Institution Press, Washington, D.C.

Decker, D. J., and K. G. Purdy. 1988. Toward a concept of wildlife acceptance capacity in wildlife management. Wildlife Society Bulletin 16:53-57.

DeNicola, A. J., K. C. VerCauteren, P. D. Curtis, and S. E. Hygnstrom. 2000. Managing white-tailed deer in suburban environments. Cornell Cooperative Extension, Ithaca, New York, USA.

DeNicola, A. J., and S. C. Williams. 2008. Sharpshooting suburban white-tailed deer reduces deer-vehicle collisions. Human-Wildlife Conflicts 2:28–33.

Dolbeer, R. A., N. R. Holler, and D. W. Hawthorne. 1994. Identification and control of wildlife damage. Pages 474-506 *in* T.A. Bookhout, editor. Research and management techniques for wildlife and habitats. The Wildlife Society; Bethesda, Maryland, USA.

Drake, D., J. B. Paulin, P. D. Curtis, D. J. Decker, G. J. San Julian. 2005. Assessment of negative economic impacts from deer in the northeastern United States. Journal of Extension 43(1):1RIB5. < http://www.joe.org/joe/2005february/rb5.php>. Accessed 14 June 2014.

Eschtruth, A. K., and J. J. Battles. 2009. Acceleration of exotic plant invasion in a forested ecosystem by a generalist herbivore. Conservation Biology 23:388-399.

Feder, H. M., D. M. Hoss, L. Zemel, S. R. Telford, F. Dias, and G. P. Wormser. 2011: Southern Tick-Associated Rash Illness (STARI) in the North: STARI following a tick bite in Long Island, New York. Clinical Infectious Diseases 53(10):142–145.

Frost, S. 2008. Suffolk County granted $1 million in state funding for deer fencing. Press Release. County of Suffolk, Riverhead, New York, USA.

Grard, G., G. Moureau, R. N. Charrel, J. J. Lemasson, J. P. Gonzalez, P. Gallian, T. S. Gritsun, E. C. Holmes, E. A. Gould, and X. De Lamballerie. 2007. Genetic characterization of tick-borne flaviviruses: new insights into evolution, pathogenetic determinants and taxonomy. Virology 361:80–92.

Hersh, M. H., R. S. Ostfeld, D. J. McHenry, M. Tibbetts, J. L. Brunner, M. E. Killilea, K. LoGiudice, K. A. Schmidt, and F. Keesing. 2014. Co-infection of blacklegged ticks with *Babesia microti* and *Borrelia burgdorferi* is higher than expected and acquired from small mammal Hosts. PLOS ONE 9(6): e99348 DOI. <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0099348#pone.0099300-Krause3>. Accessed 25 June 2014.

Herwaldt, B. L., S. Montgomery, D. Woodhall, and E. A. Bosserman. 2012. Babesiosis surveillance-18 states, 2011. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report 61(27):505-509.

Hygnstrom, S., D. Drake, T. Van Deelen, and S. Vantassel. 2014. Managing overabundant white-tailed deer: is it time to consider regulated commercial harvest? Outlooks on Pest Management 25(1):11-16.

Insurance Institute for Highway Safety. 2005. Collisions with deer. Status Report 40(1):4-5.

Johnson, B. B. and L. S. Horowitz. 2014. eliefs about Ecological Impacts Predict Deer Acceptance Capacity and Hunting Support, Society & Natural Resources: An International Journal. <http://www.tandfonline.com/doi/pdf/10.1080/08941920.2014.905887>. Accessed 16 July 2014.

Jones, J. M., and J. H. Witham. 1995. Urban deer "problem solving" in northeast Illinois: an overview. Pages 58-65 *in* J. B. McAninch, editor. Urban deer: a manageable resource? Proceedings of the symposium of the 55th Midwest Fish and Wildlife Conference. North Central Section of The Wildlife Society, 12–14 December 1993, St. Louis, Missouri, USA.

Joseph, J. T., S. S. Roy, N. Shams, P. Visintainer, R. B. Nadelman, S. Hosur, J. Nelson, and G. P. Wormser. 2011. Babesiosis in Lower Hudson Valley, New York, USA. Emerging Infectious Diseases 17:843-847.

Khoury, E. L., R. C. Hull, P. W. Bryant, K. L. Escuyer, K. George, and S. J. Wong. 2013. Diagnosis of acute deer tick virus encephalitis. Clinical Infectious Diseases 56(4):e40-47.

Kilpatrick, H. J., A. M. LaBonte, and K. C. Stafford, III. 2014. The relationship between deer density, tick abundance, and human cases of Lyme disease in a residential community. Journal of Medical Entomology 51:777-784.

Leary S., W. Underwood, R. Anthony, S. Cartner, D. Corey, T. Grandin, C. B. Greenacre, S. Gwaltney-Bran, M. A. McCrackin, R. Meyer, D. Miller, J. Shearer, and R. Yanong. 2013. American Veterinary Medical Association guidelines for the euthanasia of animals: 2013 edition. <http://works.bepress.com/cheryl_greenacre/14>. Accessed 4 August 2014.

Little, S. E., D. E. Stallkneck, J. M. Lockhart, J. E. Dawson, and W. R. Davidson. 1998. Natural coinfection of a white-tailed deer (*Odocoileus virginianus*) population with three *Ehrlichia* spp. Journal of Parasitology 84:897-901.

Lockhart, J. M., W. R. Davidson, D. E. Stallknecht, J. E. Dawson, and S. E. Little. 1997. Natural history of Ehrlichia Chaffeensis (Rickettsiales: Ehrlichieae) in the piedmont physiographic province of Georgia. Journal of Parasitology 83:887-894.

Matschke, G. H., D. S. DeCalesta, and J. D. Harder. 1984. Crop damage and control. Pages 647-654 *in* L. K. Halls, editor. White-tailed deer ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

McQuiston, J. H., C. D. Paddock, R. C. Holman, and J. E. Childs. 1999. The human ehrlichioses in the United States. Emerging Infectious Diseases 5:635-642.

Meece, M. 2013. Deer mating season: drivers beware. The New York Times, November 1, 2013. <http://www.nytimes.com/2013/11/03/automobiles/deer-mating-season-drivers-beware.html?_r=0>. Accessed 14 June 2014.

National Agricultural Statistics Service. 2002. U.S. Wildlife Damage. U.S. Department of Agriculture, Washington, D.C., USA.

New York State Department of Environmental Conservation. 2011. Management Plan for White-tailed Deer in New York State 2012-2016. < http://www.dec.ny.gov/docs/wildlife_pdf/ deerplan2012.pdf>. Accessed 14 July 2014.

New York State Department of Environmental Conservation. 2014. New York State white-tailed deer harvest summary 2013. <http://www.dec.ny.gov/docs/wildlife_pdf/2013deerrpt.pdf>. Accessed 3 July 2014.

New York State Department of Health. 2012. Babesiosis, human ehrlichiosis and human anaplasmosis: potential transfusion complications. Third edition. New York State Council on Human Blood and Transfusion Services, Wadsworth Center. Albany, New York, USA.

New York State Department of Health [NYSDOH]. 2013. NYSDOH webpage. Ticks and Lyme disease. <http://www.health.ny.gov/diseases/communicable/lyme/>. Accessed 14 June 2014.

Parpan, G. 2013. Southold: clear out so we can better hunt deer. Suffolk Times. September 27, 2013.

Rawinski, T. J. 2013. Reconnaissance assessment of white-tailed deer impacts in the forests of Southold, New York. Trip Report for the U.S. Forest Service. Durham, New Hampshire, USA.

Riley, S. J., D. J. Decker, J. W. Enck, P. D. Curtis, T. B. Lauber, and T. L. Brown. 2003. Deer populations up, hunter populations down: implications of interdependence of deer and hunter population dynamics on management. Ecoscience 10:455-61.

Romin, L. A., and J. A. Bissonette. 1996. Deer-vehicle collisions: status of state monitoring activities and mitigation efforts. Wildlife Society Bulletin 24:276-283.

Ruhren, S., and S. N. Handel. 2003. Herbivory constrains survival, reproduction and mutualisms when restoring nine temperate forest herbs. Journal of the Torrey Botanical Society 130(1):34-42.

State Farm Mutual Automobile Insurance Company. 2011. U.S. deer-vehicle collisions fall 7 percent—mishaps most likely in November and in West Virginia. <http://learningcenter.statefarm.com/ auto/us-deer-vehicle-collisions-fall-7-percent/>. Accessed 14 June 2014.

State Farm Mutual Automobile Insurance Company. 2013. U.S. deer-vehicle collisions decline—trend more pronounced in nations's mid-section. <http://www.multivu.com/mnr/56800-state-farm-survey-show-u-s-deer-vehicle-collisions-decline>. Accessed 14 June 2014.

Swihart, R. K., P. M. Picone, A. J. DeNicola, and L. Cornicelli. 1995. Ecology of urban and suburban white-tailed deer. Pages 35-44 *in* J. B. McAninch, editor. Urban deer—a manageable resource? Proceedings of the symposium of the 55th Midwest Fish and Wildlife Conference. North Central Section of The Wildlife Society, 12–14 December 1993, St. Louis, Missouri, USA.

United States Forest Service. 2012. Deer can be too many, too few or just enough for healthy forests. US Forest Service Northern Research Station. Research Review, Number 16.

Urbanek, R. E., C. K. Nielsen, G. A. Glowacki and T. S. Preuss. 2012. Effects of white-tailed deer (*Odocoileus virginianus*) herbivory in herbaceous plant communities in northeastern Illinois. Natural Areas Journal 32(1):6-14.

Van Deelen, T. R., B. J. Dhuey, C. N. Jacques, K. R. McCaffery, R. E. Rolley, and K. Warnke. 2010. Effects of earn-a-buck and special antlerless-only seasons on Wisconsin's deer harvests. Journal of Wildlife Management 74:1693–1700.

Vercauteren, K. C., C. W. Anderson, T. R. Van Deelen, D. Drake, W. D. Walter, S. Vantassel, and S. Hygnstrom. 2011. Regulated commercial harvest to manage overabundant white-tailed deer: an idea to consider? Wildlife Society Bulletin 35(3):185-194.

Verme, L. J., and D. E. Ullrey. 1984. Physiology and nutrition. Pages 91-118 *in* White-tailed deer ecology and management, L.K. Halls, editor. Stackpole Books, Harrisburg, Pennsylvania.

Verret, F. 2006. White-tailed deer population estimates in the Town of East Hampton, New York. Wildlife Biometrics Report. Berkshire, New York, USA.

Virginia Department of Game and Inland Fisheries [VDGIF]. 1999. Virginia deer management plan. VDGIF, Wildlife Division, Wildlife Information Publication Number 99-1. Richmond, Virginia, USA.

Waller, D. M., and W. S. Alverson. 1997. The white-tailed deer: a keystone herbivore. Wildlife Society Bulletin 25:217-226.

Warren, R. J. 1991. Ecological justification for controlling deer populations in eastern National parks. Transactions of the North American Wildlife and Natural Resources Conference 56:56-66.

Weckel, M., and R. F. Rockwell. 2013. Can controlled bow hunts reduce overabundant white-tailed deer populations in suburban ecosystems? Ecological Modelling 250:143-154.

West Virginia Division of Natural Resources. 1999. Fundamentals of deer harvest management. Cooperative Extension Service, West Virginia University, Number 806. Morgantown, West Virginia, USA.

Wheatall, L., T. I. M. Nuttle, and E. Yerger. 2013. Indirect effects of pandemic deer overabundance inferred from caterpillar-host relations. Conservation Biology 27:1107–1116.

Williams, S.C., A. J. DeNicola, T. Almendinger, and J. Maddock. 2013. Evaluation of organized hunting as a management technique for overabundant white-tailed deer in suburban landscapes. Wildlife Society Bulletin, 37(1), 137-145.

Yale School of Public Health. 2014. Tick-borne diseases. Yale School of Medicine <http://public health.yale.edu/emd/research/zoonosis/projects/tick.aspx>. Accessed June 16, 2014.