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Quantifying the White-Tailed Deer (*Odocoileus virginianus*) Population in the Town of Hamilton, New York

Mabel Baez, Christa Fagliarone, Grace Hilling, Emilyann Keller

Since the early 19th century, deer populations across the nation have increased due to a variety of different anthropogenically driven environmental as well as political circumstances. In many places, these deer populations have exceeded both the ecological as well as social carrying capacity. Exceeding these capacities leads to significant negative effects on the ecosystem as well as the general public leading to overall biodiversity loss and an increase in deer-related diseases among other impacts. In our study, we quantified the local white-tailed deer density in the Town of Hamilton, New York in order to investigate whether local deer populations have reached unsustainable levels. If so, we hope to understand the ecological, medical, social, and economic impact of the overabundant deer population in the town and propose the most suitable and effective deer management strategies for the area. We conducted a roadside survey covering a total of 24 km$^2$ out of 107 km$^2$ (22.38%) of the town for four consecutive days before the start of hunting season during dusk for a total of 63 observation hours. A threshold at which deer become overabundant and were associated with significant, negative ecosystem impacts was chosen based on previous studies done in areas similar to the Town of Hamilton, NY. We predicted that land use changes in the past century as well as restricted hunting availability have led to an unsustainable deer population in the area. As predicted, at an average of 16.4 deer/km$^2$, deer population levels in the area exceed our conservative threshold of 7.7 deer/km$^2$ ($t_{11} = 3.32$, $p = 0.00341$), indicating that the local deer population is overabundant. In addition, we found that Lyme disease is the most significant deer-related disease that afflicts humans in Madison County.

**Introduction**

In the early decades of the twentieth century, strict restriction on deer hunting was followed by regulated hunting designed to increase the health and size of herds throughout the United States (Yarrow 2009, Van Clef et al. 2004). These regulations along with extensive reforestation, the elimination of their natural predators, and the high fecundity of white-tailed deer (*Odocoileus virginianus*) created the perfect environment for unrestrained deer population growth (Yarrow 2009, McShea 2012). Due to this, deer populations have often exceeded the ecological carrying capacity of their habitat, becoming overabundant (Healy et al. 1997, Plata et al. 2011). Under these circumstances high deer densities have detrimental implications on ecosystem functions leading to habitat simplification, stunted forest regeneration, changes in species composition, and altered nutrient cycling (Roseell et al. 2007, Rooney et al. 2004, Stromayer and Warren 1997). Deer overabundance also increases the prevalence of disease within the deer population and can lead to increased transmission to domesticated animals and humans (McShea et al. 2003, Duffy et al. 1994). In order to understand this “deer issue,” a background on deer ecology, deer populations through a historical perspective, as well as the ecosystems impacts and deer-related diseases needs to be examined.

**Ecology**

The white-tailed deer (*O. virginianus*), of the Artiodactyla family and Cervidae order, is a herbivorous mammal native to North and South America and has been introduced to New
Zealand and Finland (Klein 1992, Schwede et al. 1992). The lifespan of a white-tailed deer in the wild usually ranges from 8-12 years in unhunted populations and fewer than 5 years in hunted populations. White-tailed deer become sexually reproductive between 1-1.5 years of age and are the most fecund deer species in the world; a female in an unhunted population can have up to 30 offspring within her lifetime (McShea 2012). Breeding season can start as early as August and goes as late as January with peak breeding happening during November. Gestation takes 190-210 days and fawning occurs between March and July (Yarrow 2009). Before weaning, fawns are completely dependent on their mothers for survival. However, for several months after weaning, fawns, regardless of sex, do not venture far from their mother until they shed their coat and lose their spots (Van Clef et al. 2004). Overall, deer have a small home range of 1 mi² in the summer, and 0.5 mi² in the winter. However, during the rut, bucks expand their range to 1.5 mi² to decrease interbreeding as well as competition among the males. During the winter, deer, regardless of sex, migrate 10-19 mi to their winter yards (Van Clef et al. 2004, Hurst and Porter 2008). Bucks tend to be more solitary, whereas the rest of the population tends to form matrilineal groups of related does and fawns, which are highly territorial (Laubach and Henckel 1992, Matthews 1989, McNulty et al. 1997). Adult males typically range in size from 50-350 pounds, while females range from 50-250 pounds (Burt 1976, Webster et al. 1985). Male bucks have noticeable antlers around 1-1.5 years of age that they shed annually starting in December, after which new antlers immediately begin to grow (Yarrow 2009). Yearling bucks can have up to 10 antler points depending on nutrition. Older animals generally have heavier and more complex antlers than younger animals if nutrition is the same. Though they practically eat all plant species at one time or another, deer are seemingly capable of determining which vegetation is most nourishing, and overall need 5-7 pounds of food per day (Yarrow 2009). Diet varies seasonally and consists of twigs, shrubs, herbs, grass, grains, fruit, and fungi. Grasses dominate their diet in spring, flowering herbs in early summer, leaves of woody plants in late summer, acorns and other fruit in fall, and evergreen woody shrubs and other woody twigs/buds in winter (Van Clef et al. 2004).

**History**

In pre-colonial America, white-tailed deer populations maintained a dynamic and sustainable population density across the eastern United States due to habitat restriction associated with vast expanses of old-growth forests, a healthy predator population, and Native American deer management (NYS DEC 2011). Deer were primarily found in meadows, forest edges, and open canopy areas where shrubs, tree saplings, herbs, and grains are primarily found. During the colonial period, unregulated market hunting and extensive deforestation associated with agricultural expansion and rapid settlement led to a drastic decrease in deer populations across the country (Klepeis et al. 2012). Due to this, laws were enacted nationally that restricted deer hunting, restocked areas of low deer densities, and encouraged the hunting of natural predators, which resulted in a rapid increase of deer populations (Yarrow 2009). Aerial imagery of the Town of Hamilton from 1936 to present indicate drastic changes in land use. Klepeis et al. (2012) analyzed land use change from 1936 to 2008 in the adjacent town of Eaton, NY and found a net forest gain associated with the abandonment of agricultural lands and increased interest in suburban development. These findings correspond to the historical land use change in Hamilton throughout this period as well (Ettinger 2008). Interestingly, Klepeis et al. (2012) also found that there was additional reforestation in the area between 1994 and 2008. These changes in local land management provided prime resources for deer, supporting rapid population growth
(Ettinger 2008). Additionally, studies have shown historic winter yards have shifted closer to residential areas, which provide higher food availability. In turn, this has led to a decrease in winter mortality among deer (Hurst and Porter 2008). These residential areas are even more attractive to deer in that they offer protection from hunting due to strict hunting laws near houses and public institutions.

Ecosystem Impacts

The carrying capacity of an ecosystem is based on the type of vegetation present, the feeding habits of the species, and time of the year. It follows that as the population of any particular animal increases, the quantity as well as the quality of the forage available will decrease. When organisms reach their carrying capacity, they are overabundant. Organisms reach their carrying capacity when they reach the maximum number of individuals that would not cause changes in the ecological composition of an ecosystem (Plata et al. 2011). Various studies have shown that when deer densities surpass their carrying capacity, they directly affect forest communities through excessive herbivory leading to limited regeneration of favored woody plants, and outright elimination of favored herbaceous plants that never grow past browsing height (Rooney and Waller 2003). This preferential browsing causes an increase of browse tolerant species that are often high in lignin concentrations and ultimately lead to a higher accumulation of recalcitrant litter with low decomposition rates, negatively affecting site fertility (Rooney and Waller 2003) which studies have shown can create alternate stable states (Stromayer and Warren 1997). These changes ultimately decrease tree and herb species diversity. Indirectly, habitat modification associated with the simplification of the understory feeds back through the trophic levels, decreasing insect and avian species diversity (Rooney and Waller 2003, McShea and Rappole 2000, DeCalesta 1994).

Disease

Deer play direct and indirect roles in the cycles of certain diseases that can infect humans. Humans can contract disease directly from deer through contact with excretions and by eating raw or undercooked venison (CDC 2012a), such as bovine tuberculosis (TB) and brucellosis. Bovine TB is caused by the bacterium *Mycobacterium bovis*, which mainly attacks the lungs and lymph nodes and sometimes the skin, bones, joints, genitourinary system, or meninges as well (The Center for Food Security and Public Health 2009). Antimicrobial drugs can successfully treat bovine TB, but infections that go untreated can be deadly (The Center for Food Security and Public Health 2009). Brucellosis is an infection that causes flu-like symptoms (MedlinePlus 2013) and depending on when the infection is caught, can be cured in as little as a few weeks up to several months, but in less than 2% of cases, death occurs (CDC 2012b). There are three types of bacteria that cause brucellosis in deer: *Brucella abortus, Brucella melitensis,* and *Brucella suis* (Willacy and Knott 2010).

White-tailed deer are also hosts to ticks and mosquitoes, two vectors that transmit diseases to humans. Several species of mosquitoes from the genus *Aedes* can carry Jamestown Canyon Virus (JCV) (CDC 2011). JCV is a rare and serious infection of the central nervous system that can cause encephalitis and meningitis (NHDHHS 2010). Currently, there is no treatment for this disease other than supportive care (NHDHHS 2010; CDC 2011). In terms of zoonotic vectors of disease in deer, ticks play a much larger role than mosquitoes in the transfer of diseases to humans. The black-legged tick (*Ixodes scapularis*), formerly known as the deer tick, and the lone-star tick (*Amblyomma americanum*) are the biggest culprits. Powassan
encephalitis is transmitted mainly by the black-legged tick, but can also be transmitted to humans by *Ixodes cookeii* as well as *Ixodes marxi* (CDC 2013e). Powassan encephalitis is caused by an RNA virus in the *Flavivirus* genus (CDC 2013e) and causes swelling of the brain and can lead to chronic neurological disorders (The Saratogian 2013). The lone-star tick transmits ehrlichiosis, which includes human ewingii ehrlichiosis, caused by *Ehrlichia ewingii*, and more commonly, human monocytic ehrlichiosis, caused by *Ehrlichia chaffeensis* (CDC 2013c). Ehrlichiosis causes flu-like symptoms and can lead to chronic neurological disorders (The Saratogian 2013). The black-legged tick transmits *Babesia microti*, which causes babesiosis (McShea et al. 2003). About a quarter of people infected with babesiosis do not show symptoms, but if symptoms emerge, they are similar to malaria (American Lyme Disease Foundation 2006b). Babesiosis can also attack the renal system, respiratory system, and heart, and can result in death (American Lyme Disease Foundation 2006b). Lyme disease is by far the most prevalent deer-related disease and is also transmitted by the black-legged tick. Lyme disease causes flu-like symptoms and a rash. If caught early and treated, it is curable, however if left untreated or treated late after the onset of the disease, it can result in chronic ailments related to joints, the heart, and nervous system (CDC 2013d). It is caused by the bacterial spirochete *Borrelia burgdorferi* (McShea et al. 2003).

Chronic Wasting Disease (CWD) is an increasingly prevalent disease that affects deer. Chronic Wasting Disease is caused by prions, which are incorrectly formed proteins that cause emaciation, weakness, salivation, fearlessness, and eventually death (Cambronne 2013).

**Density**

Density is an important parameter that can inform management decisions because many of the impacts of deer on ecosystems and communities are density-dependent (Rooney and Waller 2003, McShea et al. 2003). For example, in their deer and plant survey of temperate coniferous and broad-leaved forests in Central Japan, Suzaki et al. (2012) found that variance in floristic composition across local assemblages was influenced most by deer herbivory. At low deer densities, competitive plant species are dominant, and at high deer densities herbivory-tolerant species are dominant. Species richness is greatest at intermediate deer densities because this is the condition at which species assemblages coexist, and because some species prefer intermediate herbivory intensity (Suzaki et al. 2012). In addition, the relationships between deer density and body weight, and deer density and antler measurements are inverse and linear, even at low population levels (3 deer/km²) (Keyser et al. 2005, Hefley et al. 2013). Thus, at high densities, deer are more likely to be underweight and have slower antler development, indicating poor health. Tilghman (1989) reported that deer starved to death during winter at densities as low as 7.7 deer/km² in northwestern Pennsylvania.

Wildlife Management Unit (WMU) 7M, designated by New York State Department of Environmental Conservation (NYS DEC), is 3217 km² and encompasses the Town of Hamilton, NY (NYS DEC 2013b). Blum, Senior Forester at NYS DEC, estimates the deer density in WMU 7M to be 8.5-9.7 deer/km² (A. Blum, pers comm). NYS DEC foresters and biologists perceive this population density as overabundant (A. Blum, pers comm, A. Perry, pers comm, NYS DEC 2013b).
Many different methods are employed to estimate the density of deer, each having advantages and limitations. These include use of infrared-triggered cameras, deer pellet counts and indices, aerial surveys, roadside surveys, reconstruction from harvest data, browse surveys and indices, and statistical models incorporating multiple abundance indices (Curtis et al. 2009, Suzuki et al. 2012, Cobo et al. 2008, Augustine and DeCalesta 2003, Frost et al. 1997, Keyser et al. 2005, Morellet et al. 2001, Iijima et al. 2003). In this study, we determined deer density in The Town of Hamilton using a roadside survey.

**Materials and Methods**

*Study Area*

The study area is the Town of Hamilton, NY, which consists of 107 km$^2$ of predominantly rural landscape (note: 1 km$^2$ $\approx$ 0.386 mi$^2$). The Town of Hamilton, located in Madison County, is contained within WMU 7M. This WMU consists of about 30% farmland and 65% wooded land, and includes an abundance of public land (NYS DEC 2013b). The Town of Hamilton is dominated by cropland/pasture and mixed forestland (U.S. Geological Survey 2013).

*Deer Survey Protocol*

In order to estimate the density of deer in the Town of Hamilton, we used GIS software and a roadside survey. Our protocol is adapted from the methods used by Frost et al. (1997) as advised by Associate Professor McCay (T. McCay, *pers comm*). We used GIS software to generate an imagery map showing the location of wooded forests, open spaces, and roads (ArcGIS Software 2013). A grid demarcating square kilometers was overlaid on the map. Twelve 2 km$^2$ quadrats (1 km x 2 km) accessible by road and with sufficient visibility were chosen for sampling such that no two adjacent quadrats were chosen, although some quadrats met at one corner (Fig. 1). This was done to avoid double counting deer that may travel to adjacent quadrats. We randomly chose the sampling order of the quadrats. Each study night, three groups with three observers each surveyed deer in one 2 km$^2$ quadrat. Deer were surveyed during dusk hours, when they tend to graze in open areas (Alverson et al. 1988), from 5:45-7:30 PM on each night of September 27th-30th, 2013. These surveys were conducted before the start of hunting season, when deer become more cautious. Each group followed the route designed for their assigned quadrat in a vehicle and used binoculars to measure and record the following in that quadrat: number of deer, and presence or absence of antlers when visible. We surveyed 24 km$^2$ of the Town of Hamilton for a total of 63 observation hours.
Figure 1. Map of Town of Hamilton with study quadrats indicated by boxes. Numbers represent the density of each quadrat in deer/km$^2$. Land use is shown, as depicted in the legend.
Overabundance Threshold

We chose our overabundance threshold from studies with comparable habitats to the Town Hamilton, NY, that reported significant ecosystem impacts, especially northwestern Pennsylvania. The U.S. Forest Service Northern Research Station used enclosure studies to determine the carrying capacity of white-tailed deer in northwestern Pennsylvania forests to be 7.7 deer/km² (Fig. 2), above which forest regrowth is inhibited. However, the researchers concluded that this is an overestimate because their experimental conditions consisted of more abundant forage than nearby natural forests (U.S. Forest Service Northern Research Station 2012). Similarly, Cornell biologists in Ithaca, NY recommended a population of fewer than 5.8-7.7 deer/km² in suburban Cayuga Heights (Casler 2013 (Fig. 2). To be conservative, we chose an overabundance threshold of 7.7 deer/km². Reported thresholds of overabundance ranged from 4-10 deer/km², with a mode of 8 deer/km² (Fig. 2). Impacts associated with these densities included the elimination of multiple herbaceous and woody browse species, drastic changes in forest species composition, and severe inhibition of forest regeneration (Cobo et al. 2008, Horsley et al. 2003, Russell et al. 2001, Frost et al. 1997, Alverson et al. 1988, Tilghman 1989, Augustine and DeCalesta 2003). We also identified a biologically acceptable threshold of 4 deer/km². Deer populations at or below this threshold generally produce only minor negative ecosystem impacts (Alverson et al. 1988, Cobo et al. 2008, Tilghman 1989).

Density Statistical Analysis

We used a one-sample, one-sided t-test to determine whether the density of white-tailed deer in the Town of Hamilton was greater than our threshold of overabundance, 7.7 deer/km². We recognize our estimate is a minimum as we were limited by visibility from the road. The ratio of antlered to antlerless deer was calculated and analyzed as another important population parameter.

Disease

We investigated the relationship between deer density and human and animal disease prevalence. Due to the lack of information on deer-related diseases in the Town of Hamilton, we expanded our range of disease analysis to encompass Madison County. Data regarding prevalent diseases found in the area were obtained from county reports as well as through consultation with local professionals. We analyzed literature on the subject in order to understand if there is a correlation between local deer density and the occurrence of these diseases.

Results

Density

In the 22.4% of the Town of Hamilton area that we surveyed, we found a mean density of 16.4 deer/km² (± 2.62 SD). The density significantly exceeded our biologically acceptable threshold of 4 deer/km² ($t_{11} = 4.74, p = 0.000303$), as well as our overabundance threshold of 7.7 deer/km² ($t_{11} = 3.32, p = 0.00341$) (Fig. 2). Thus the density of deer in the Town of Hamilton, NY is twice as great as the overabundance threshold, and four times greater than the biologically acceptable threshold, indicating that deer are overabundant in the study area (Fig. 1). Deer densities ranged from 6 to 35 deer/km² throughout the quadrats. We did not find any clear patterns in the spatial distribution of deer, though deer were most abundant in the quadrat consisting of the most residential and suburban land cover. Of the 394 deer that we surveyed, we were able to determine whether or not 383 (97.2%) had antlers. Among these deer, 4.2% had
antlers while 95.8% were antlerless. Thus the ratio of antlered to antlerless deer (bucks:does and fawns) is 22.9:1.

Figure 2. We calculated the density of white-tailed deer in the Town of Hamilton to be 16.4 deer/km², shown above as the red bar. Overabundance thresholds, as reported by studies in areas similar in land use to Hamilton, are shown in grey. The density significantly exceeds our biologically acceptable threshold of 4 deer/km² ($t_{11} = 4.74$, $p = 0.000303$), shown in green, as well as our overabundance threshold of 7.7 deer/km² ($t_{11} = 3.32$, $p = 0.00341$). The local deer population exceeds all reported thresholds and is in fact four times as large as the biologically acceptable threshold and twice as large as the overabundance threshold.

**Disease**

We found a total of ten diseases correlated with deer density in Madison County (Table 1). Lyme disease was the most significant disease out of the ones discussed that affects humans (Fig. 4, Fig. 5) and animals, mainly dogs (Fig. 3). Ehrlichiosis and anaplasmosis also afflict dogs as well, at consistent levels.
<table>
<thead>
<tr>
<th>Disease</th>
<th>Alternate Name</th>
<th>Cause</th>
<th>Vector</th>
<th>Affects Humans?</th>
<th>In NY? Where?</th>
<th>In Madison County?</th>
<th>Correlation between Deer Abundance and Disease Prevalence?</th>
</tr>
</thead>
<tbody>
<tr>
<td>anaplasmosis*</td>
<td>human granulocytic anaplasmosis, HGA formerly HGE</td>
<td>bacteria: <em>Anaplasma phagocytophilum</em></td>
<td>black-legged tick (Ixodes scapularis)</td>
<td>yes</td>
<td>Westchester county, lower Hudson Valley</td>
<td>yes</td>
<td>20 animal cases from 2012-2013 (Fig. 3), no human cases from 2003-2013</td>
</tr>
<tr>
<td>babesiosis</td>
<td>protozoal piroplasm: Babesia microti</td>
<td>black-legged tick (Ixodes scapularis)</td>
<td>yes</td>
<td>no human cases from 2003-2013</td>
<td>Westchester county, Hudson Valley, Long Island</td>
<td>yes</td>
<td>1 case of TB in 2007, 2009, and 2012 each (Fig. 4), but doesn't specify which bacteria was the cause</td>
</tr>
<tr>
<td>brucellosis</td>
<td>bovine TB</td>
<td>bacteria: <em>Brucella abortus</em> (cattle, deer), B. <em>Suis</em> (swine), B. <em>melitensis</em> (goats, deer)</td>
<td>contact w/ excretions or exhaled air, eating venison</td>
<td>yes</td>
<td>36 cases before 2005 in NYC</td>
<td>yes</td>
<td>1 human case in NYC in 2001</td>
</tr>
<tr>
<td>Chronic Wasting Disease</td>
<td>CWD</td>
<td>prion</td>
<td>no</td>
<td>1 human case in NYC in 2001</td>
<td>in 5 captive deer in Oneida county in 2005</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>human enwngii ehrlichiosis*</td>
<td>HEE, ehrlichiosis</td>
<td>bacteria: <em>Ehrlichia equi</em></td>
<td>fiancee (Amblyomma americanum)</td>
<td>26 animal cases from 2012-2013 (Fig. 3), no human cases from 2003-2013</td>
<td>lower Hudson Valley, Long Island, Westchester county, Putnam county, 1-3.3 cases/mil ppl in NY</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>human monocytic ehrlichiosis*</td>
<td>HME, ehrlichiosis</td>
<td>bacteria: <em>Ehrlichia chaffeensis</em></td>
<td>yes</td>
<td>1 mosquito pool tested positive in June '13, no human cases from 2003-2013</td>
<td>1 human case in Clinton county in 2004, southern Saratoga county, northeastern NY</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Jamestown Canyon virus*</td>
<td>JCV</td>
<td>arbovirus</td>
<td>yes</td>
<td>69 human cases from 2003-2013 (Fig. 4), numerous animal cases (Fig. 3)</td>
<td>1 mosquito pool tested positive in June '13, no human cases from 2003-2013</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Powassan encephalitis</td>
<td>Powassan virus</td>
<td>virus from <em>Flavivirus</em> genus</td>
<td>yes</td>
<td>1 encephalitis in Madison but may not be Powassan (not West Nile)</td>
<td>Saratoga county, Poughkeepsie (Dutchess county), Long Island</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Diseases associated with deer density, and their prevalence in Madison County.
* Denotes diseases present in Madison County and whose prevalence can increase with deer density.
Figure 3. Confirmed cases of animal (dog and horse) infection of deer-related disease in Madison County (MCDOH 2012a, MCDOH 2013b).

Figure 4. Number of confirmed cases of human infection of four deer-related diseases in Madison County (MCDOH 2012b, MCDOH 2008).
Discussion

Deer are overabundant in the Town of Hamilton, NY and this will have a negative feedback on ecosystem function and possibly impact human and animal disease prevalence. We found that the deer density in the Town of Hamilton, 16.4 deer/km², is significantly greater than both the biologically acceptable and overabundance thresholds of 4 deer/km² and 7.7 deer/km² respectively. Thus, the data clearly show that the deer population in the Town of Hamilton is overabundant. Based on scientific knowledge of the effects of overabundant deer on ecosystems, we can conclude that the local deer population is indeed causing strong negative ecosystem effects, including the elimination of multiple herbaceous and woody browse species, drastic changes in forest species composition, severe inhibition of forest regeneration, and a reduction in biodiversity. In the Hamilton area, the deer population is removing red maple, sugar maple, white ash, black cherry, and red oak tree saplings from the forest understory. Beech, eastern hophornbeam, and American hophornbeam are becoming more dominant as a result (A. Blum, *pers comm*). Deer are also affecting the ground nesting birds of Hamilton, including the hooded warbler and brown thrasher (J. Pumilio, *pers comm*). This loss of biodiversity threatens ecosystem services. Ecosystem services are benefits that humans acquire from ecosystems. These benefits may be in the form of regulating services, provisions, cultural services, and supporting services, such as photosynthesis. Not only are these services essential for human survival, but they are also crucial for the economic advantage of a community. Studies have shown that overall there is a correlation between increased species richness and ecosystem function (Aerts and Honnary 2011). Therefore it is of the utmost interest for the Hamilton
community to promote the health of the local ecosystem by reducing deer density populations to a sustainable level.

Deer density is also correlated with the prevalence of certain diseases and therefore we also looked at the relationship between deer and disease in Madison County. We found that Lyme disease is the most significant deer-related disease that afflicts humans in Madison County, although the number of infected humans is still low in the area (Fig. 4, Fig. 5). Overabundant deer populations, like the one in the Town of Hamilton, can maintain the prevalence of this serious disease.
Works Cited


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Abbreviations

CDC Center for Disease Control
MCDOH Madison County Department of Health
NHDHHS New Hampshire Department of Health and Human Services