NH DIVISION OF
Public Health Services
Improving health, preventing disease, reducing costs *for all*
Department of Health and Human Services

STATE OF NEW HAMPSHIRE
TICKBORNE DISEASE PREVENTION PLAN

March 31, 2015

New Hampshire Department of Health and Human Services
Division of Public Health Services

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I. INTRODUCTION

A. Purpose

Lyme disease and other tickborne diseases are an important cause of illness in New Hampshire (NH). The incidence of these infections has increased significantly over the last decade prompting the need for a statewide prevention plan to reduce their burden. The purpose of this plan is to outline preventative measures and actions that are recommended for use by the state and local government as well as individuals within NH to prevent tickborne disease. Additionally, this Plan is meant to serve as a resource for all residents of NH interested in the available options to reduce exposure to ticks in their homes and communities. Appendix A: Resources provides the reader with a list of easily accessible sources of additional information about tick control, tickborne disease and other topics related to the prevention of tickborne disease.

This document is meant to be a 'living' document and as such will be reviewed annually and subsequently updated as new information becomes available.

B. Audience

The NH Tickborne Prevention Plan is to be read by and a resource for the general public, parents, community and urban planners, school administrators and anyone seeking more information about how to begin modifying their behavior and physical landscape to reduce the risk of tickborne disease. Given the nature of the large audience addressed in this document, more in-depth research into specific methods for prevention and control may be needed to accomplish the specific goals each reader of this Plan may have.

C. Authors

This plan was created by the NH Department of Health and Human Services (DHHS), Division of Public Health Services (DPHS). Several state and other agencies were consulted and given opportunity to provide input during the development of this Plan, including:

NH Department of Agriculture, Markets and Food
NH Department of Education
NH Department of Environmental Sciences
NH Department of Resources and Economic Development
NH Fish and Game Department
University of New Hampshire Cooperative Extension

D. Scope

Diagnosis and treatment are out of the scope of this document and will not be discussed outside of a prevention framework. As vector and pathogen geographic ranges have the

potential for expansion, it is important to be vigilant for new tick species and monitor for signs of illness after any tick bite. Always contact your health care provider with concerns of illness.

For information regarding symptoms, diagnosis and treatment for tickborne disease, please refer to NH DHHS and the Centers for Disease Control and Prevention (CDC)'s tickborne disease webpages.
NH DHHS: http://www.dhhs.nh.gov/dphs/cdcs/lyme/index.htm
CDC: http://www.cdc.gov/ticks/index.html

E. Contact Information

For questions about this document, please contact:
Bureau of Infectious Disease Control
Division of Public Health Services
NH Department of Health and Human Services
29 Hazen Drive, Concord, NH 03301-6504
Phone: (603) 271-4496
Website: http://www.dhhs.nh.gov/dphs/cdcs/lyme/index.htm

II. DISEASE BACKGROUND

Tickborne Disease in New Hampshire

There are four tickborne diseases that are endemic to NH and are listed here with their causative pathogen: Lyme disease (*Borrelia burgdorferi*), anaplasmosis (*Anaplasma phagocytophilum*), babesiosis (*Babesia microti* and other species) and Powassan virus infection. All four of these diseases are transmitted by the blacklegged tick (*Ixodes scapularis*) and have similar reservoir hosts[1]. The blacklegged tick is the only tick known to transmit tickborne diseases to humans in NH. Because of their shared vectors and reservoirs, all of the diseases endemic to NH are intimately tied to the blacklegged tick's life cycle and survival. There are many points in this life cycle that provide opportunity to influence tick prevalence, infection rates and disease transmission. The possibilities to influence tick survivorship and opportunities to reduce the likelihood of disease transmission to humans is the overarching topic of this Plan.

To our south, other tickborne diseases may be encountered. These include, but are not limited to, tularemia (*Francisella tularensis*), ehrlichiosis (*Ehrlichia chaffeensis*, *E. ewingii*, *E. muris*-like), Rocky Mountain spotted fever (*Rickettsia rickettsii*) and Southern tick-associated rash illness (STARI – unknown pathogen). Tularemia is unique among tickborne diseases in that ticks are just one of many routes of infection. *F. tularemia* may also be transmitted through other means such as infected tissues or body fluids of animals either during the slaughtering process, contact with infected animals, insect bites and contaminated debris. A tickborne pathogen whose significance is still being determined is *Borrelia miyamotoi*, but it likely has a geographic distribution similar to that of *B. burgdorferi*. *B. miyamotoi* has not yet been identified in NH. Cases of these other tickborne diseases reported in NH have been travel associated and will not be discussed in depth in this Plan.

Many of the tickborne pathogens have a complex natural history and as a result, there are many areas of their life history and pathogenicity that remain unknown. As details are learned about tickborne diseases of importance in NH and their control methods, this Plan will be updated accordingly.

Tickborne diseases are known to be underreported so the true incidence of these diseases is likely much higher than is captured by current surveillance methods. The CDC has recently estimated that only 10% of diagnosed Lyme disease cases are reported to public health officials[2]. Irrespective of what the true incidence of these diseases is, tickborne diseases are a serious public health threat in NH.

The identification and removal of any tick as soon as possible is of great importance. Attachment time for transmission from the tick to the host is variable between the pathogens and is related to the amount of time it takes the pathogen to migrate to the salivary glands to be injected into the host as the tick feeds. Because of this, not every person who gets bitten by a tick will be infected even if that tick is carrying a pathogen. Reinfection with Lyme disease,

anaplasmosis and babesiosis is possible. Co-infection is also possible. Co-infection may occur through the bite of a single, co-infected tick (carrying multiple pathogens) or through the bite of multiple ticks infected with single but different pathogens.

Table 1. Tickborne diseases established in NH with their associated pathogen and vector.

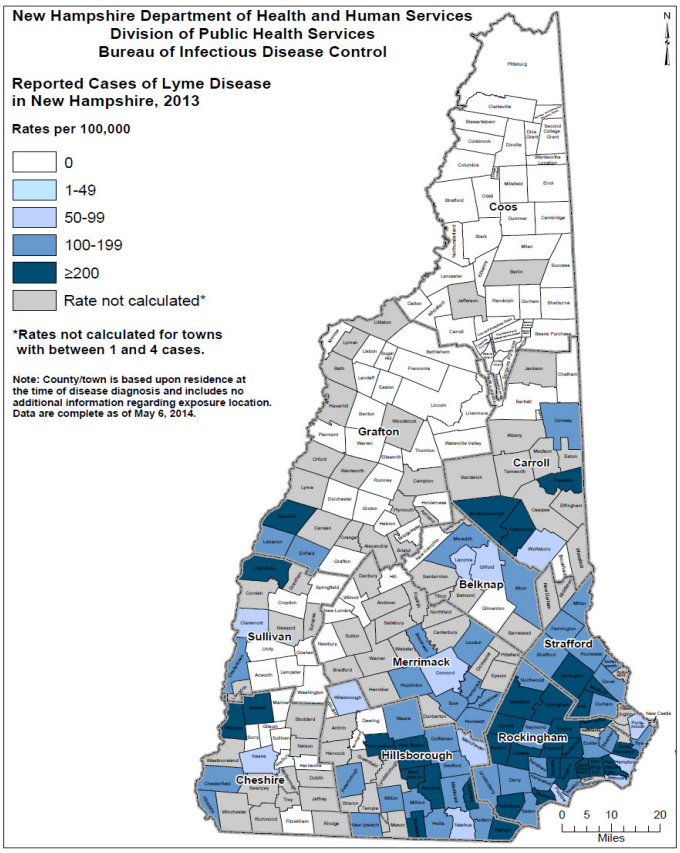
Disease	Pathogen	Vector
Lyme disease	*Borrelia burgdorferi*	Blacklegged tick (*Ixodes scapularis*)
Anaplasmosis	*Anaplasma phagocytophilum*	Blacklegged tick (*Ixodes scapularis*)
Babesiosis	*Babesia* spp	Blacklegged tick (*Ixodes scapularis*)
Powassan virus	Powassan virus	Blacklegged tick (*Ixodes scapularis*)
		Woodchuck tick (*Ixodes cookei*)

Table 2. Reported tickborne disease cases in NH by year, 2009-2013.

Disease	2009	2010	2011	2012	2013
Lyme Disease	1416	1342	1321	1456	1691
Anaplasmosis	18	20	30	52	88
Babesiosis	7	11	14	19	22
Powassan Virus	0	0	0	0	1

A. Lyme Disease

Lyme disease is caused by an extracellular spirochete (a type of bacteria) known as *Borrelia burgdorferi* and was first recognized as a disease in the mid 1970's although it has been shown that *B. burgdorferi* was present in museum specimens from the late 1800's.[3] There are other species of *Borrelia* known to cause Lyme disease in Europe and Asia, but in the United States (US), *B. burgdorferi* is the only organism associated with this disease[4]. About 80% of persons infected with Lyme disease will have an expanding bull's eye rash known as erythema migrans. Other symptoms can include headache, flu-like illnesses, muscle pain, joint pain and swelling, neurological deficits and cardiologic dysfunction.



Map 1. Reported cases of Lyme disease in NH, 2013.

Between the years 2000 and 2008 Lyme disease incidence increased dramatically in NH, and across the nation. This could be due to a true increase in incidence reflecting spread of the vector and pathogen, increased use of NH's natural areas by NH residents without appropriate personal protective measures, increased awareness among providers, changes in laboratory testing availability and practices, and changes in surveillance methods or increased reporting to the state. Since 2008, incidence has remained high in NH. For the years 2008 and 2012, NH had the highest incidence rate of Lyme disease in the US. Lyme disease remains the most common vectorborne disease in the US. It is predominantly seen in the northeast and upper Midwest but cases have been reported across the country. Additional information about Lyme disease in NH, including data and maps that are updated annually, may be found here:
http://www.dhhs.nh.gov/dphs/cdcs/lyme/index.htm

B. Anaplasmosis

Anaplasma phagocytophilum is the rickettsial organism (intracellular bacteria) that causes anaplasmosis and infects the white blood cells of its host. Anaplasmosis was first recognized in the US in the mid-1990's. Since that time, similar to Lyme disease, there has been a steady increase in cases reported nationally and in NH. A rash is a rare symptom for anaplasmosis and may be indicative of a co-infection with Lyme disease. Symptoms are nonspecific and can include a flu-like syndrome with fever, chills and muscle aches, fever, headache, nausea, fatigue, abdominal pain, cough and confusion. The geographical distribution is similar to that of Lyme disease.

C. Babesiosis

Babesiosis is caused by an infection of red blood cells by protozoan parasites in the genus *Babesia*. The most common parasite causing disease in the US is *Babesia microti*, but there are other species that have been identified in human cases of babesiosis. Babesiosis, first recognized as a public health concern in the US in the 1960's, remains a rare disease, although recent years have seen an increase in incidence in NH and other areas where *Babesia* is endemic. The geographic distribution of this disease is similar to that of Lyme disease and anaplasmosis. While Babesia is predominantly transmitted by the blacklegged tick, blood transfusions are another documented source of babesiosis.

It is possible to be infected with *Babesia* organisms and not have any symptoms of illness, however severe disease is also possible. When symptoms are present, they can include fever, extreme fatigue, dehydration, mental confusion, hemolytic anemia and jaundice.

D. Powassan Virus Infection

Powassan virus is an arbovirus (**ar**thropod-**bo**rne virus) of the *Flavivirus* genus, the same genus as West Nile virus (WNV). It was first identified in Canada in the late 1950's and since then has been identified in New England and the Upper Midwest but remains rare. Like WNV, Powassan

virus infects the central nervous system and can cause inflammation of the brain (encephalitis) and the membranes surrounding the brain and spinal cord (meningitis). Some of those infected may experience mild or no symptoms. For those that do have symptoms, they usually begin with acute onset of fever and may include headache, muscle weakness, nausea, vomiting, stiff neck, fatigue, confusion, paralysis, speech difficulties, and memory loss. It is possible that neurological deficits will persist after the resolution of acute symptoms.

III. TICK AND TICKBORNE DISEASE BACKGROUND

A. New Hampshire Tick Species

There are 15 species of Ixodid (hard) ticks in NH. They include two species in the genus *Dermacentor*: American dog tick (*Dermacentor variabilis*) and winter tick (*Dermacentor albipictus*). Both of these ticks are commonly encountered in NH. The brown dog tick (*Rhipicephalus sanguineus*) is present but uncommon in NH. Additionally, there are two very rare ticks in the genus *Haemaphysalis*. These species do not transmit diseases to humans.

NH has ten species in the genus *Ixodes*. The most important of which, from a disease transmission standpoint, is the blacklegged tick (*Ixodes scapularis*). This abundant species now occurs nearly statewide. The lone star tick (*Amblyomma Americanism*) is not established in NH. The lone star tick is responsible for causing human and veterinary illness in states south of NH. Additional information about the ticks found in NH, including pictures of ticks commonly found, can be found in Dr. Alan Eaton's Biology and Management of Ticks in New Hampshire (http://extension.unh.edu/resources/files/Resource000528_Rep1451.pdf).

B. Blacklegged Tick Life Cycle

Lyme disease is the tickborne disease of greatest importance in NH. However, the same prevention measures will work towards minimizing risk of infection for all four diseases with documented transmission in NH since they share a common vector (the blacklegged tick) and reservoir hosts. Identifying and understanding the blacklegged tick life cycle, the pathogens and reservoir hosts is critical to understanding the retention and transmission of Lyme and other tickborne diseases in NH. The blacklegged tick has a two year life cycle involving multiple reservoir hosts.

A reservoir host is an animal that is capable of sustaining a large enough population of a pathogen in its blood, without displaying significant negative effect, to allow a vector to become infected when it feeds to take a blood meal. Should the animal become ill from the pathogen and either die or be eaten by a predator, it would reduce its ability to function as a host as it would reduce its availability to questing ticks. Similarly, if the pathogen does not reach high enough levels in the host's body, then transmission of the pathogen from the reservoir to the vector will not occur. Understanding the roles that are played by different hosts is an important component in identifying appropriate control methods. The main, and shared, reservoir host for the four tickborne diseases known to be transmitted in NH is the white footed mouse. Chipmunks, shrews, voles and birds, including the American Robin, have also been identified as reservoirs for Lyme disease, although are of lesser importance. Wild rodents have been identified as possible reservoirs for anaplasmosis and babesiosis; woodchucks, squirrels and the white footed mouse are the three known reservoirs for Powassan virus.

Blacklegged ticks hatch from their eggs as larvae in the summer and quest for a host for their first blood meal at that time. This is the first opportunity for the tick to become infected with one or more pathogens. Usually the hosts selected are small mammals or birds, many of which are competent, or suitable, reservoir hosts. After engorging on blood and dropping off, the tick will molt into a nymph and quest for a second blood meal in the late spring to summer. Hosts for this stage of the tick are also small mammals and birds, however humans are possible hosts. The nymph stage of the blacklegged tick is exceedingly small, about the size of a sesame seed, and is easy to miss during routine tick checks. As a result, this is the stage of the tick that is most likely to transmit a pathogen to a human. Should an infected nymph feed on a competent, but naïve (uninfected) reservoir host, disease transmission and the perpetuation of the pathogen in the reservoir host population will occur, and occur just prior to the emergence of the next crop of larval ticks allowing for the infection of a new generation of ticks. Once the nymph has fed, it molts into an adult tick to quest for the next blood meal in the fall or the following spring. See Figure 1.

Adults do not hibernate and will be active and questing for a host during the winter months when the ground is not covered with snow and the temperature is above 41 degrees Fahrenheit. The preferred reproductive host (host which allows them to feed enough to lay eggs) is the white-tailed deer, but other medium and large mammals will also serve as reproductive hosts, but generally not as competent reservoirs. Infection rates of adult ticks are generally higher than those of nymphs since they have had two opportunities to become infected through prior feeding events, however, since nymphs are more likely to go undetected, the nymphs are responsible for more disease transmission and, subsequently, illness.

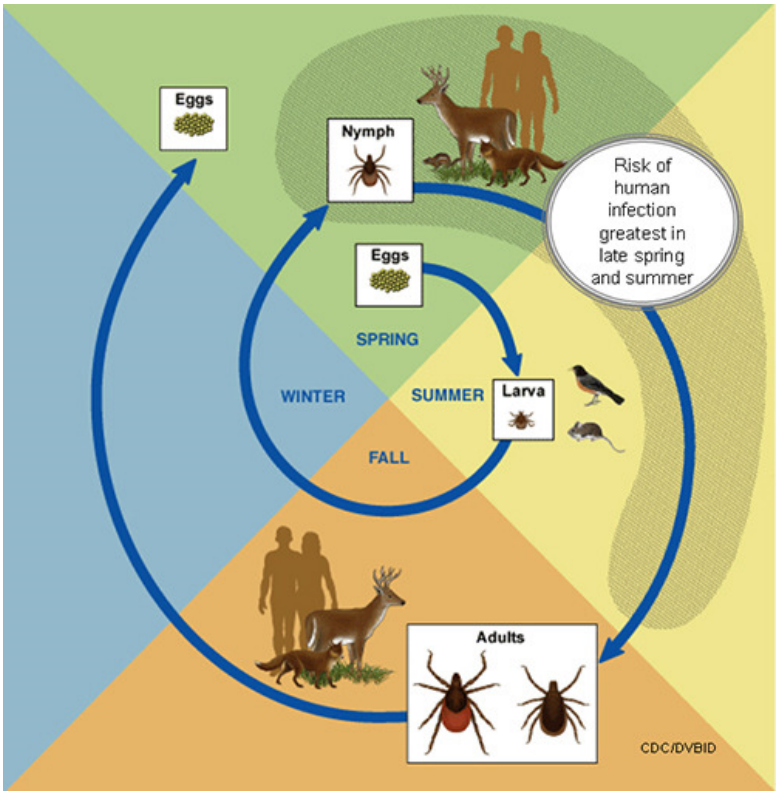
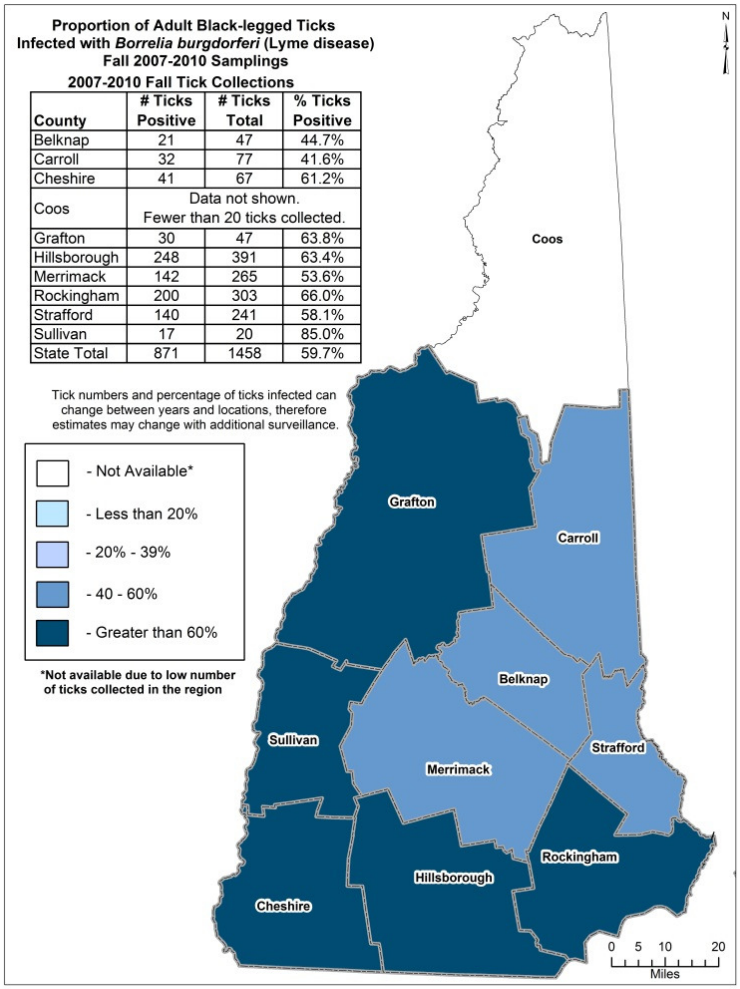


Figure 1. The life cycle of the blacklegged tick. Image from the CDC.

C. Infection Prevalence of New Hampshire Ticks

Between 2007 and 2010, a study was conducted in NH looking at the prevalence of infection in adult ticks with *B. burgdorferi*. It was found that approximately 60% of the adult blacklegged ticks in NH are infected with *B. burgdorferi*; the infection rate of nymphs is unknown, but expected to be high. It is also unknown what the infection rate is for *A. phagocytophilum*, *Babesia* spp or Powassan virus in either nymphs or adults, though limited available data from 2007-2010 reflects a much lower prevalence (<5%). A map displaying this information can be seen in Map 2 below. The published article can be found here: http://wwwnc.cdc.gov/eid/article/15/4/08-0940_article

As funding allows, NH DHHS will engage in additional entomological testing, however, there is no current stream of funding identified for such a project at this time. External partners, such as the University of New Hampshire, are also active in identifying funding for this method of surveillance. Wherever possible, collaborations will be formed to maximize the impact of funds received. As data from entomological surveillance becomes available, it will be made public.



Map 2. Proportion of adult blacklegged ticks infected with *Borrelia burgdorferi*, Fall 2007-2010.

IV. CHANGES IN LANDSCAPE, VECTORS AND HOSTS

The emergence of these tickborne diseases as major public health concerns for NH is also tied to the changes that our landscape and wildlife populations have endured and how we interact with the environment we live in.[4] The life cycle of the blacklegged tick and its relationship with the environment is intricate. As the reservoir populations change in response to alterations in predation pressures and food availability, tick populations are also impacted. For example, one study used modeling to estimate the impact on small mammal and tick populations of a transition from foxes, a predator specializing in small mammals and rodents, to the coyote, a generalist predator.[5] The findings suggest that this type of transmission has the capability of increasing the small mammal population (also the reservoir hosts for tickborne disease) and subsequently the tick population. Deer populations have increased in many areas of the state after a period of severe winters and unregulated doe harvest in the late 1970s and 1980s and have likely served to bolster the tick population by readily serving as the reproductive host for these ticks. As these hosts respond to fluctuations in food sources (acorn masts, agricultural crops, bird feeders etc.) so too do the ticks. Over time, edge habitat (the transition area between grass and forest such as around housing developments) has become a major feature of NH's landscape and has served as a contributing factor for increasing tick encounters by humans and wildlife. It is important to understand how the landscape and land usage has changed in NH over time and how that may have contributed to the rise of tickborne diseases in our state, as this will help inform application of mitigation methods.

Significant contributions were made to this section by NH Department of Resources and Economic Development, Division of Forests & Lands, NH Fish and Game Department and University of New Hampshire Cooperative Extension experts.

A. Change in New Hampshire's forests and the impact it has had on hosts and vectors

Population density and geographic range have the potential to change the reproductive capabilities of both ticks and their hosts as a result of environmental pressures. Included in these pressures are changes in habitat and land use patterns. In the Northeast over the past two hundred and fifty years, both landscape and climate have seen many changes. Just over 100 years ago, NH was greater than 80% deforested to allow for agricultural activities and settlement development. Subsequently, the late 1800's and early 1900's New Hampshire experienced a period of farm abandonment, which resulted in the reforestation of the state.

NH is now the second most forested state, with the latest United States Department of Agriculture (USDA) Forest Inventory and Analysis (FIA) data yielding a forest cover estimate of 84%. The data also show that a predominance of NH's forest is now at a mature age, which correlates to the significant production of mast (seeds and nuts, such as acorns). Some studies have shown an association between high mast production and high densities of ticks. These food sources are used by both the reservoir and reproductive host species. Acorn and other seed availability can create epicenters of animal activity, creating possible concentrations of

tick abundance.[6,7] Most tree species, including oaks, begin prolific masting, or seed production, at 50-60 years of age.

Forest understory such as shrubs and regeneration can play a vital role in maintaining a suitable humidity level for all tick life stages. Additionally this understory layer may also provide another viable food source for wildlife use in turn increasing overall animal activity in a particular landscape area. Different species of understory vegetation have different capacities for maintaining favorable food and cover for wildlife use. This may also provide a humid microclimate that is optimal for ticks and their host survival. Some invasive plant species tend to be more adept at this and have been shown to contain more questing and infected ticks. As an example, multiple studies have shown how Japanese Barberry (*Berberis thunbergii*) shrubs create an ideal microclimate for blacklegged ticks and their vertebrate hosts.[8,9]

Research by Ward and Williams in 2010 correlated exotic invasive vegetation to blacklegged ticks and Lyme disease prevalence. This research was conducted in five study areas within Connecticut where Japanese barberry and blacklegged ticks were analyzed for population densities and Lyme infection prevalence. Japanese barberry is an exotic invasive plant species, declared in NH as a prohibitive invasive plant species and it is no longer legal to sell, transport or transplant this species in the state. Ward and Williams' research demonstrated that the conditions that Japanese barberry created were favorable to higher numbers of blacklegged ticks as well as a higher percentage of ticks infected with the Lyme disease pathogen. The Japanese barberry vegetation was shown to create a microclimate where conditions were favorable for all life stages of *I. scapularis* as well as its reservoir hosts. The areas with dense Japanese barberry had slightly more than nine times the density of blacklegged ticks than areas without the plant. Upon the removal of the Japanese barberry, the number of ticks decreased and ticks infected with *B. burgdorferi* dropped by 60% immediately after removal of invasive plants with the expectation of a continued decline over time as the remaining ticks were exposed to more drying conditions. Japanese barberry was also found to have many favorable habitat conditions for white footed mice, including providing ample food sources with extensive cover and protection from predators. It is possible that other shrub species have a similar effect.

During previously mentioned reforestation period, urban development and forest fragmentation (the resultant effect of islands of forests created by development or agricultural use) also increased, most significantly in Rockingham, Hillsborough and Strafford counties. These are the counties where tickborne diseases have been most prevalent. The fragmentation has resulted in an increase of patches of forest less than 100 acres in these same counties.

In NH, the most fragmented landscape is in the southeast portion of the state, which is also the area of highest human population density. The biodiversity and land cover types have changed as urban sprawl has expanded. The amount and the arrangement of land cover types and vegetation age classes influences both wildlife and, subsequently, tick populations. Small scale fragmented habitats of less than 100 acres can affect hosts and disease dynamics. In the south-

southeastern part of NH, both tick numbers and percent of ticks infected with *B. burgdorferi* seem to correlate with the fragmented landscape, and the higher density deer population. It has been documented that habitat fragmentation affects both wildlife movements and the diversity of wildlife found in those smaller landscape patches.

The changing forest landscape and loss of biodiversity undoubtedly play a major role in the complex ecological process of tickborne disease. There are many relationships that have yet to be well understood, of which, long-term landscape change and forest fragmentation only comprise a portion of this changing biological and ecological system. It is well understood that certain conditions and landscape can promote large tick numbers and harbor host species, but more research is needed to fully understand all the interactions between the environmental conditions, host and vector abundance and survival and how those components influence infection prevalence. Managing the urban and suburban landscapes to deter both host species as well as tick suitability should be a priority for homeowners, community planners and municipalities within the endemic zone of blacklegged ticks.

B. Tick Population Change in New Hampshire

Several lines of evidence suggest that two species in particular (American dog tick and blacklegged tick) have significantly increased in numbers and geographic spread in NH over the last 30 years. Many factors could be involved, including increasing deer numbers, increasing human population, and human-driven habitat change. Both of these species are now common in some parts of the state where they were formerly either absent or in very low numbers (parts of Carroll and Grafton counties for example). Blacklegged tick numbers on deer in the fall have significantly increased since 1991 (A. T. Eaton unpublished data).

Table 3. NH hunter harvested deer check station data for the carriage of the blacklegged tick (BLT), 2013*

Site	Number of Deer Checked with BLTs	Percent of Deer with BLT	Average BLT per Deer
Belknap	6	67	4.33
Carroll	11	100	9.00
Cheshire	23	74	5.13
Grafton	25	52	5.00
Hillsborough	34	74	5.82
Merrimack	9	100	7.80
Rockingham	29	100	6.86
Sullivan	12	50	1.33
Statewide, 2013	**150**	**77**	**5.67**
Statewide, 1991	**525**	**2**	**0.03**

* 2013 data is not included for Coos County (no deer evaluated) and Strafford County (only 1 deer evaluated). Data are from Dr. Alan Eaton, UNH Cooperative Extension.

As mentioned above, approximately 60% of the adult blacklegged tick population in NH is infected with the pathogen responsible for Lyme disease. Data is lacking for infection prevalence of anaplasmosis, babesiosis and Powassan virus in NH's blacklegged tick population.

C. Host Population

The deer population in NH is managed by the NH Fish and Game Department through their NH Big Game Plan, which can be found at:
http://www.wildlife.state.nh.us/Hunting/Hunting_PDFs/NH_Big_Game_Plan_FINAL.pdf

Population goals for the deer herd in NH are made with public input as to the desired size of the herd in the various wildlife management units across the state. Because NH is near the northern limit of white-tailed deer range it is known to have one of the lowest density deer herds in the eastern US. The state's unproductive soils and severe winter weather limit population growth and have resulted in much lower densities than other northeastern states such as New York and Pennsylvania. Deer densities in many areas of NH are also lower than the threshold identified in some studies for targeted reduction to reduce tickborne diseases (5.1 to 7.5 deer/km^2 depending on the study).[10,11] Hunting is the only method of deer control currently in use in NH.

Little is known about the true size of the small rodent populations in NH, however, it is known that they are ubiquitous across the state. No state-wide control efforts or plans for the management of these populations are in place as there are for other species in NH.

V. PREVENTION AND CONTROL

The most effective way to prevent illness from a tickborne disease is to prevent tick bites from happening. NH has a wealth of outdoor recreational areas and a rich natural beauty that should continue to be enjoyed by NH residents and visitors. It is important to be aware of, and utilize, the available prevention methods appropriately and consistently. Personal protection measures are critical in preventing tick bites[18]. Environmental management also has a significant role to play in prevention of tickborne disease.

Important websites for prevention information:
NH DHHS: http://www.dhhs.nh.gov/dphs/cdcs/lyme/index.htm
CDC: http://www.cdc.gov/ticks/

A. Vaccination

There is not currently an approved human vaccine for Lyme disease or any other tickborne disease in the United States. The only Lyme disease vaccine that was available was removed from the market in 2002 based on declining sales and lack of acceptance by the American market.[12] Those persons that received the vaccine when it was available are no longer protected as continued protection required the administration of booster vaccinations. There is a trial underway in Europe that is exploring the safety and efficacy of a new Lyme disease vaccine.[13] The species of *Borrelia* that cause Lyme disease in North America, Europe and Asia are different and this new vaccine will be able to protect against the six species known to cause human disease. While the early trials have been very promising, it is not known when or if the vaccine will be available in the United States. Due to the lack of human vaccine as a possibility for disease control in endemic areas, Lyme and other tickborne diseases must be prevented by other methods.

Action to be taken: Should a vaccine for Lyme or any other tickborne disease become available, each person who is eligible for vaccination should consider if vaccination is the right choice for them and/or their family members. The Lyme vaccine currently under development will not protect against other tickborne diseases, prevent a tick bite or kill a tick that has bitten. Because of this, the following prevention measures should still be considered for the prevention of tickborne disease in NH.

B. Personal Protection Measures

1. Tick checks

The importance of daily, or more frequent, tick checks cannot be over emphasized as part of what an individual can do to reduce their risk of contracting a tickborne disease. If a tick is identified and removed immediately, either before it attaches or after it attaches but before it is able to transmit pathogens (within 24-36 hours after attachment for *Borrelia burgdorferi*),

risk of illness from that tick encounter is absent. The nymph of the blacklegged tick is the stage most likely to transmit a tickborne disease simply because it is easy to miss during a routine tick check. It is helpful to use a mirror or have another person help you check the hard-to-see portions of your body. Child caregivers should always check their children when returning from outdoors as children are not able to perform this task reliably. Adults should always be the ones to perform tick removal for children. Children should be encouraged to go to an adult for this purpose should they find a tick on themselves. After a bite is noted, monitoring for signs of a rash or other symptoms should be done.

A tick can attach to any portion of the body, and the entire body should be checked, however it is wise to spend extra time checking some of the more tick-prone areas:

a. Groin
b. Armpits
c. Hairline/hair
d. Between toes
e. Behind ears
f. Elbows
g. Back of knees
h. Areas of constriction (i.e. waistbands, collar lines)

Action to be taken: Every person that was exposed to potential tick habitat should perform a tick check at least once daily as described above. For children who are not able to perform this activity on their own, parents or guardians should do this for them.

2. Tick removal

Attached ticks should be removed immediately. The head of the tick should be grasped using fine nosed tweezers as close to the skin as possible and removed using a slow, steady retraction motion in the same plane as the tick is attached to minimize the chances of leaving the head behind. Under no circumstances should a tick be burned, submerged in kerosene or other solvents/chemicals or be smothered in a petroleum jelly product or nail polish remover in an effort to kill it prior to removal. These methods actually may increase the likelihood of disease transmission by potentially causing the tick to regurgitate.[14] The feeding apparatus (mouth parts) of ticks, the hypostome, is barbed to ensure that they are able to stay attached to their host to feed to repletion. Because of this, and the cement that they secrete into their host, they cannot detach rapidly. It is important that anyone removing a tick do so carefully and follow guidelines for successful removal. The bite area should be cleaned with soap and water or rubbing alcohol. For later identification purposes, the removed tick may be placed in a crush proof container that has a tight seal to prevent escape. It is also a good idea to mark on a calendar the day and location of any tick bite for later reference should you become ill. If the tick has been attached long enough to feed, it will no longer have the flat body shape of a questing tick. Because of the high proportion of ticks infected with B. burgdorferi in NH, people who have had a tick attached for at least 36 hours should consult their healthcare provider for

possible prophylaxis to prevent the development of Lyme disease. Prophylaxis (a single dose of the antibiotic doxycycline) can only be given to people 8 years of age and older and must be given within 72 hours of tick removal. One study found that if this was done, the prophylactic treatment was 87% effective in preventing early Lyme disease.[15] If any concerns of illness arise after a tick bite, whether or not prophylactic treatment was administered, a healthcare provider should be contacted to discuss whether testing or treatment is needed.

More information about tick bites and removal:
NH DHHS: http://www.dhhs.nh.gov/dphs/cdcs/lyme/documents/tickbites.pdf
CDC: http://www.cdc.gov/ticks/removing_a_tick.html

Action to be taken: All attached ticks should be removed immediately and either kept for identification purposes or disposed of. For any person not able to remove a tick on his or her own, assistance should be sought. A responsible adult should do this for children. Any non-attached ticks should be disposed of to prevent attachment.

3. Repellents

While the State of NH does not endorse any one particular brand of repellent, DEET, which can be found in many repellent products, has been shown to be the most effective tick repellent on the market. DEET should only be applied to exposed skin (not applied to skin and then covered up). A concentration of 20-30% DEET is sufficient to last a few hours and duration of efficacy will be printed on the label of the chosen product. Permethrin, used only on clothing, has also been proven to be extremely effective in decreasing the likelihood of tick attachment and can be used in combination with DEET products applied to skin to great effect. Permethrin infused clothes may be purchased or the permethrin may be applied to clothes you use regularly when outside. Depending on the preparation, the repellency effects of permethrin may last up to 6 weeks. Label information will give details about washability of products and longevity of formulations.

DEET is safe for use on children over two months of age according to the American Academy of Pediatrics. Their guidelines for repellent use in children are found here: http://www.healthychildren.org/English/safety-prevention/at-play/Pages/Insect-Repellents.aspx.

Products that contain both sunscreen and repellent are available for use on children, however they are not recommended as the product will need to be applied more frequently for sun protection than for repellency, which could lead to adverse reactions. Children should never apply repellents; a responsible adult should do this for them. Repellents should also never be applied or sprayed directly onto the face. To apply repellent to the face, or other sensitive area, first apply the repellent to your hands or a cloth and then to the face and/or other sensitive areas. Do not apply repellents on broken or irritated skin, or on wounds. In accordance with federal law, repellents should always be used by following the instructions on the label.

There are a number of repellent options available that are registered with the Environmental Protection Agency. A web-based tool is available to help with the selection of the appropriate product for the desired purpose, length of time and arthropod (insect or tick) to be repelled. That tool can be found here: http://cfpub.epa.gov/oppref/insect/.

UNH Cooperative Extension has also developed a repellent guide that is specific for NH. It can be found here: http://extension.unh.edu/resources/files/Resource000963_Rep1073.pdf

A factsheet developed by the Department of Defense for military personnel is also available and includes information on repellent use and answers to frequently asked questions for their DEET and permethrin system. This factsheet can be found here: http://www.afpmb.org/sites/default/files/pubs/techguides/TG26/files/DODInsectRepellentSystemJustheFacts-June2007.pdf

Action to be taken: All persons above two months of age should either apply or, if a child or in need of assistance, have it applied for them in accordance with the product's label as outline above. Determination of which product or combination of products is appropriate is a personal decision, however a healthcare provider may be able to provide assistance in product selection.

4. Pets

People cannot become infected with a tickborne disease from their pet; however, pets can bring ticks into the home and are therefore sources of tick and tickborne disease exposure. Because of this, it is important to check your pets each time they come in from outside and to talk with your veterinarian about tick preventatives for your pet. Similar to humans, ticks may attach anywhere on your pet's body, however some of the more common sites are between the toes, the head and neck, behind ears, the axilla (arm pits) and groin area. There is a very effective canine vaccine available for use and you should discuss with your veterinarian if this would be a good option for your dog in combination with a commercial tick preventative medication.

Action to be taken: Pet owners should consult with a veterinarian about the correct tick prevention regime for their pets. A veterinarian will also be able to discuss tick checks for pets and how to remove any attached ticks.

5. Other important personal protection measures include:

a. Showering when you return inside. This activity will help wash away any crawling or unattached ticks and will help you find ones that have attached.
b. Removing and immediately washing and drying the clothes you wore outside in tick endemic areas. Because ticks are prone to desiccation and dehydration, which are their major mortality risk, they will not be able to survive an hour in a dryer on high

heat. Even if clothes are not washed immediately, placing them in the dryer for 15 minutes will help to kill any remaining ticks on clothing. The wetter the clothes, the longer they will need to be in the dryer for this to be effective.

c. Wear light colored clothing. This will aid in the identification of any ticks that you pick up on the trail or in other tick-prone environments. It is best to wear lightweight long pants and long-sleeved shirts to help in identifying ticks that you have picked up and prevent them from gaining immediate access to your skin.
d. Tuck pants into socks and shirts into pants. This will prevent ticks from being able to find an easy entry point to attach. It is also an option to wear gaiters over shoes and socks. These can also be treated with permethrin to increase their efficacy in repelling ticks.
e. Wearing high rubber boots (16 inch high rubber boots). This will prevent ticks from being able to grab onto legs since the rubber will be too smooth for them to grasp effectively.
f. Review the informative video on tick prevention measures produced by Dr. Alan T. Eaton, a University of New Hampshire extension specialist. It is available here: http://extension.unh.edu/Integrated-Pest-Management/Public-Health-IPM

Action to be taken: Persons exposed to tick habitat should consider making the prevention measures listed above a routine part of their daily routine to further reduce the likelihood of tick attachment and transmission of tickborne disease.

C. Control of the Vector

Some of the prevention methods discussed in this plan will be most effective for one life stage while others will be applicable to all life stages of the blacklegged tick.

An excellent summary resource of available tick control measures was published by the Connecticut Agricultural Experimental Station (CAES). They are currently leading a study looking at integrated control methods with components of deer removal and biological control of ticks[16]. When these results are available, they will be considered for inclusion in this plan.

The summary resource CAES developed is the Tick Management Handbook. It can be found here: http://www.ct.gov/caes/lib/caes/documents/special_features/tickhandbook.pdf. This document is especially useful in modifying landscaping to reduce or eliminate tick and host habitat as well as information about plants that attract hosts and methods to use landscaping to minimize host habitat and food sources. Many of the topics covered below are also discussed in the Tick Management Handbook in more detail. What follows is, in part, an examination of how the recommended actions from this handbook relate to tickborne disease prevention from a NH DHHS perspective. Additional reviews of prevention methods are abundant in the literature and may be useful in considering applications of the methods discussed below.[12,16,17]

Another excellent resource for information about ticks in NH and their control, Biology and Management of Ticks in New Hampshire, is published by Dr. Alan T. Eaton and is available here: http://extension.unh.edu/resources/resource/528/Biology_and_Management_of_Ticks_in_New_Hampshire

Although studies have not proven that the available methods to reduce tick abundance around homes have significantly reduced the incidence of Lyme disease in residential areas, it stands to reason that an integrated approach to minimize tick exposure is beneficial in reducing the number of tick encounters and thereby opportunities for disease transmission. It only takes the bite of one infected tick to contract any of the tickborne diseases, which is why it is difficult to prove in hyperendemic areas (areas with very high incidence rates of disease and/or infection prevalence of infected ticks) that only the use of vector control in residential areas is efficacious or successful in reducing Lyme disease incidence rates.

Various methods exist for controlling ticks around residences, on various types of property or in communities. These methods include chemical and physical/environmental controls:

1. Chemical control. Ticks are not insects. They are more closely related to spiders (arachnids) so require the use of a pesticide called an acaricide to perform chemical control. Treatments can be either liquid or granular in nature and may be applied by a homeowner or a professional pest control company. There are benefits and drawbacks to using this type of control as well as to who applies it. There may be other non-pest species affected by the application of the pesticide, however these pesticides are very effective against ticks and one well timed application of pesticide per year can nearly eliminate the nymphs that are most likely to transmit pathogens. If a home or property owner is not familiar with the use or timing of these products, they may not be applied properly and therefore be of less benefit and more harm to the environment. A commercial pesticide applicator would likely be more expensive than owner-applied pesticide; however, the use of a licensed applicator may result in more effective use of the product.

   Action to be taken: Each home or property owner should consider whether this approach to tick control is right for his or her situation. In NH, pesticide applicators are licensed through the Department of Agriculture, Markets & Food. They may be contacted for a list of licensed applicators throughout the state: http://www.agriculture.nh.gov/divisions/pesticide-control/index.htm

2. Physical/Environmental Control - Residential. Home and property owners have some ability to modify their landscape to minimize tick migration and survivorship.
   a. Creating a three foot boundary between edge or forest habitat and open yard will help prevent ticks migrating into the areas of the yard that see the highest human activity. This will not prevent hosts from traveling between habitats and depositing ticks that could pose a health risk.

b. Since ticks do not tolerate dry conditions, maintaining a mowed yard with sun exposure will aid in keeping ticks from infesting yards and shared areas. Similarly, placing play equipment in sunny areas of the yard or property that are free from brush and debris or in areas that are mulch covered will help minimize tick exposure to children using the equipment.

c. When performing beautification of properties, owners should be aware of the types of plants and landscape arrangements that they use. As mentioned in the Changes in Landscape Use, Hosts and Vectors section above, many non-native and invasive plants are more likely to provide ideal tick and host habitat. These plants should not be used, and if present should be removed. Garden and extension specialists are good resources for developing appealing landscaping using native plants that are deer browse resistant.

Figure 2. Tick-safe zone through landscaping.
Image from: http://www.cdc.gov/lyme/prev/in_the_yard.html.

d. Eliminating hosts and host habitat can reduce the number of ticks encountered. Mice and other rodents can invade homes, woodpiles, stonewalls, garages and

sheds. By controlling both the population of these hosts and the habitat available to them, tick populations will also be controlled. Bird feeders are another food source for rodents that serve as reservoirs and hosts for ticks. While these feeders do not need to necessarily be eliminated, they should be kept away from the house. Consider discontinuing their use during the months of May through August when nymphs are most active and other food sources for birds are plentiful. Keeping woodpiles away from human dwellings and stacking them to minimize rodent friendly habitat will reduce the risk these structures pose. Sealing stonewalls where feasible will also reduce rodent habitat. Excluding hosts from human dwellings or lethal control of rodents will decrease the risk these animals pose for vectorborne and other infectious diseases. Products are available that kill ticks attached to host animals (fipronil bait boxes) or that fall off of the animal hosts into their nests (Damminix tick tubes). Whether the use of these products is appropriate is dependent on the home or property owner.

Action to be taken: All private home or property owners should consider modification to their landscape or property as discussed above to the best of their ability to reduce the risk of being exposed to ticks while enjoying the outdoors. This activity is strongly recommended by the State.

3. Physical/Environmental Control – Municipal and City Planning. Municipalities should consider landscaping of parks, playgrounds, schools and developments to minimize the risk of tickborne disease. Edge habitat (the shrubby area at the edge of a wooden area that is commonly associated with forest fragmentation and urban development) is becoming increasingly common and increases the available habitat for hosts and vectors. Subsequently, this leads to an increase in the prevalence of infected ticks. Measures should be taken by municipalities, commercial or large residential property owners (i.e. housing developments, nursing homes, apartment buildings, residential placement facilities etc.) and city planners to minimize this type of habitat. Many of the same methods as mentioned in the Physical/Environmental Control – Residential section above could be applied to these properties as well, in addition to larger scale landscape alterations to reduce edge and host friendly habitat. Municipalities and other entities responsible for public lands should consider posting signs at trails and entrances to their properties that ticks are present as a reminder that vigilance is required. The CDC has created trail signs for this purpose: http://www.cdc.gov/lyme/toolkit/

   Action to be taken: All persons or organizations that own or are responsible for the maintenance of community or shared outdoor space that could be a source of exposure to ticks have a responsibility to ensure that those using these spaces do so safely and should modify the landscaping of these spaces accordingly. This activity is strongly recommended by the State.

4. Four-poster Deer Feeding Stations. These stations were developed to apply acaricides to deer while they eat corn or another grain mix. Some acaricides used in these stations are topical (permethrin) while some are infused into the feed (ivermectin). The topical application seems to be the most effective method to kill the ticks attached to deer, however, four-poster feeding stations have been shown to have variable effect as a result of variation in the environment and methods used to maintain these stations.[10,19,20,21,22,23] Since deer are the main (although not only) reproductive host for the blacklegged tick, this vector control method kills mainly adult ticks, which prevents the deposition of new eggs and the development of a new generation of ticks. While studies have shown these stations to have great efficacy in reducing the tick burden in the environment at a small landscape or island scale, they are extremely expensive to maintain and are not without their limitations.[24] Some studies indicate costs of up to $5,000 to maintain a single device for a season (March-December) due to material, maintenance, and manpower costs multiple units must be deployed over a small area to maintain a moderate degree of efficacy.[25,26] Based on experiences with these devices in Shelter Island, NY the highest efficacy was seen using roughly 5 devices/mi² of land.[24] When efforts were reduced to approximately 2 devices/mi² a possible decrease in efficacy was noted by some residents.[25,26]

   Likely the vast majority of studies on these devices have also been conducted in areas with deer densities far exceeding those of NH. Because NH's deer densities are substantially lower, the use of these devices in the state may not show the same degree of efficacy. More research is also required to see if these devices have the potential to increase small mammal populations by providing supplemental feed. Any associated increase in small mammal populations could lead to increased incidence of Lyme disease in remaining tick populations (as small mammals are the main reservoir host). There are also concerns that these baited stations allow the congregation of wildlife, both deer and non-target species, which may increase the risk of disease transmission and nuisance wildlife issues with possible risk to human health and property.[24] The baits commonly used in these devices are utilized by a number of wildlife species including deer, bear, and raccoons. Increased interactions between other wildlife with common rabies vector species such as raccoons could lead to increased incidence of rabies or rabies exposure events in both wildlife and humans. It should also be noted that special permits from NH Fish and Game Department (see RSA 207:8-c Use of Drugs on Wildlife) are required to use these devices. Additionally, certification from NH Department of Agriculture, Markets & Food, Division of Pesticide Control is also required (see RSA 430:33 Registration Certificates and Permits and Pes 302.01 Categories of Certification).

   Action to be taken: Each community should determine if this method of tick control is appropriate for their residents and will not be performed by the State. Decisions to implement four-poster stations need to be made on a community level as they impact hunting capability, are complicated devices to establish and maintain appropriately and may have undesired or unintended consequences of use.

D. Control of Hosts

Deer

1. Exclusion of deer. The primary method of excluding deer is installation of deer exclusion fences. Generally, these fences, when maintained, are good at keeping deer out of the fenced area. Deer are able to jump more than eight feet from a standstill, but are thought unlikely to jump these fences. Startup and maintenance costs of these fences can be quite high as fences are susceptible to damage by deer, bears, other wildlife and falling trees and need to be regularly examined and repaired to remain effective. It is unknown how these fences contribute to landscape fragmentation or the movement of wildlife if they are used on a large scale. There are also a number of different configurations of electrical fencing that are relatively effective at excluding deer, however, they share some of the same drawbacks as traditional fencing in terms of costs and maintenance and would not be an effective management option at a large scale.[27] Additionally, some studies have shown that there is a minimum area that is required for this method to be useful as small exclusion zones may actually increase the population of ticks.[28,29]

   Action to be taken: NH DHHS would not support a state program to install fences, however, if residents or municipalities are interested in using them, they may choose to further explore this option.

2. Elimination of deer. Elimination, or culling, of deer has been shown to eliminate blacklegged ticks from islands in a time frame similar to the life cycle of the tick (~2 years).[30] However, these island experiments are conducted in much less complex natural systems, and as such this method is less effective on the mainland or in areas that are less isolated because they have a number of other hosts species for ticks to switch to as well as the potential for continual reintroduction of deer from adjacent areas.[31] The CAES does have deer culling in a residential area as part of its current study on integrative management for tick control mentioned above. For culling to be effective long-term in NH, the deer population would need to be drastically reduced and maintained at a density much less than the current density, which is not possible on a statewide level. NH already has one of the lowest density herds of white-tailed deer in the northeast, although the density of deer is not uniform across the state, and it is not advisable or desired to remove this charismatic animal from NH's landscape. Deer are an important part of the ecosystem and cannot be eliminated without the major disruption of other parts of the ecosystem. Learning how to manage the impact of this animal, and not removing it, will better serve the residents of NH and their environment.

   Action to be taken: Elimination or culling of deer is not recommended. The NH Fish and Game Department is heavily invested in maintaining an appropriate density deer herd and provide opportunities for public input into desired herd densities NH's wildlife management

units. For more information about their management strategy see the New Hampshire Big Game Plan referenced above in Section IV C and in Appendix A: Resources.

3. Contraceptives for deer. The application of contraceptives to reduce population size in a free-ranging herd of deer is technically, physically and monetarily challenging. Studies using contraceptive controls on islands and fenced properties have shown only marginal success and no studies exist exhibiting efficacy in open populations. These programs are also extremely expensive to implement and can cost in upwards of $1,000/deer including manpower and materials.[32] In order for a contraceptive program to work nearly all female deer in an area need to be treated on an annual basis. Because of this the same individual deer will need to be identified year after year for contraceptive injections.[33] Since the individuals in any given population of deer are nearly identical in their physical appearance from a distance (particularly females) without some distinguishing feature such as an ear tag, this would be nearly impossible to achieve. There is also a portion of deer that are non-responsive to certain contraceptive controls and will remain reproductive.[33] These non-responsive females along with individuals immigrating from surrounding areas may counteract the effectiveness of contraceptive programs. Deer treated with contraceptives also must be marked as inedible due to human safety concerns.

   Action to be taken: Use of contraceptive management for the NH deer herd is not a viable or recommended option for NH due to the technical, physical and financial burden associated with such programs in addition to the fact that NH already has a low-density herd.

Rodents

1. Exclusion of rodents. As mentioned above, it is advisable for home and property owners to ensure that human dwellings and structures such as garages and sheds are rodent-proofed. This can be accomplished by the owners performing the work themselves or through a pest control company. Since rodents are a major host for immature stages of the blacklegged tick, the elimination of favorable habitat for these animals will decrease the number ticks that a human could be exposed to.

   Action to be taken: All property owners are responsible for ensuring physical structures are rodent-proofed.

2. Elimination of rodents. The lethal control of rodents is an option available for owners or managers of properties and facilities but should not be implemented on a statewide scale. Rodenticide use can have a risk of poisoning non-target wildlife or domestic animals. Some rodenticides have a high risk of secondary poisoning (killing an animal that eats another animal that had fed on the bait), while others have a high risk of killing non-target animals that eat the bait. Rodents serve as an indispensable method of seed dispersion and provide a valuable food source for a number of predators in NH. Studies have theorized that the

changing predator profile may have an impact on the rodent population. In one study, it was determined through mathematical modeling that as the main mid-sized predator switched from foxes to coyotes, mouse populations increased because coyotes do not favor mice and other small rodents as a food source as foxes do.[5] It is worth noting that the fragmentation and loss of biodiversity discussed within this plan is a possible contributing factor to providing favorable rodent habitat. Steps should be taken to reverse this trend by residents and state and local agencies through many of the strategies listed within this plan and the CAES Tick Management Handbook.

Action to be taken: Widespread use of rodenticides is not recommended. The use of poison products needs to be considered very carefully as they can have significant negative consequences. Other lethal control measures (traps) may be considered as well, if used humanely.

3. Vaccination of rodents: There has been some exploration into the possibility of vaccinating the wild rodent population, specifically white-footed mice, against *B. burgdorferi* in an effort to reduce the capacity of these animals to act as reservoirs for the Lyme disease pathogen.[34,35] The most promising method would be an oral vaccination program using treated bait as the mechanism to deliver, however more research needs to be done in this area. At this time, an oral vaccination program targeted at this population is not feasible on a statewide level due to the experimental nature of this product and the resource intensive nature of a program such as this (five consecutive nights a week of bait/trap maintenance for several months of the year).

   Action to be taken: Should a product such as this become commercially available, property owners, community organizations or other entities across the state should determine if this is appropriate for their needs and facilities, bearing in mind that any action that impacts wildlife may have permitting or licensing restrictions.

VI. EDUCATIONAL OUTREACH

Educational outreach will continue to be the main method that NH DHHS will use to address the issue of tickborne disease in NH. The actions to be continued or initiated as funding and resources allow are outlined below. Ancillary methods that are supportive of these efforts by other state agencies are welcome and encouraged, as an integrated approach to addressing the problem of tickborne disease is ideal. For example, some municipalities collaborate with other state agencies to work towards removal of invasive plant species such as Japanese barberry, which will benefit the effort of reducing tickborne disease through removal of problematic tick and rodent habitat.

A. School Based Educational Efforts

NH Lyme disease data show that annual incidence of Lyme disease is highest among the 5-14 year age group, but is high for all primary and secondary aged children. In an effort to reach this age group, NH DHHS will develop age appropriate educational materials and programs including, but not limited to activity booklets and vectorborne curricula targeted to health and science programs. Dissemination of these materials will be targeted to NH school districts as well as after school programs, summer camps and municipal programs. All materials developed will be accessible on the NH DHHS website once completed. Parents are welcome to use these materials at home and discuss with their children the importance of tickborne disease prevention activities. The goal of these outreach measures is to instill from an early age the importance of tick bite avoidance behaviors and thereby provide future generations with a more complete understanding of prevention measures.

Personal protective measures will be the focus of school-based educational efforts, although an effort will be made to adapt available materials to fit within the Common Core State Standards and NH Curriculum Frameworks for science and health. These efforts will allow school districts and teachers to utilize the materials provided by NH DHHS without requiring significant restructuring of the established curricula. As long as resources allow, NH DHHS also plans on engaging students by hosting an annual poster contest specific to Lyme disease or other vectorborne diseases, in which students will design posters with a prevention message to be used in NH DHHS outreach activities for that year or on the NH DHHS website.

NH DHHS will be working with teachers and school administrators in conjunction with the Department of Education to ensure that the materials developed will be useful, age appropriate and easily incorporated into the classroom. All materials developed by NH DHHS will be freely accessible on the web and a limited number of hard copies will be available for request.

B. Health Care Provider Educational Outreach

NH has been consistently ranked one of the healthiest states in the nation, in part because there is a wealth of outdoor recreational activities that NH residents engage in. Health care

providers are a significant resource for educating NH residents about tickborne disease and prevention methods. It is imperative that they have discussions with their patients about these topics in an effort to increase awareness of tickborne disease and prevention methods so that their patients are better educated about how to experience and enjoy outdoor recreation in NH safely and maintain health doing so. Ideally this would be discussed on a routine basis with their patients. The CDC has recently updated a resource for health care providers that contains information about tickborne diseases as well as basic prevention methods. This reference, Tickborne Disease of the Unites States: A Reference Manual for Health Care Providers, Second Edition, is available at http://www.cdc.gov/lyme/resources/TickborneDiseases.pdf

NH DHHS will continue efforts to educate health care providers about reporting responsibilities in order to obtain and maintain the most accurate data possible to evaluate the burden of Lyme and other tickborne diseases in NH. A pilot Lyme disease provider report card project is underway to provide information back to healthcare providers about their reporting practices and educate providers about reporting requirements. Detailed information about reporting requirements that health care providers must comply with is available in RSA 141-C and He-P 300 and can be found here:
RSA 141-C: http://www.gencourt.state.nh.us/rsa/html/X/141-C/141-C-mrg.htm
He-P 300: http://www.gencourt.state.nh.us/rules/state_agencies/he-p300.html

Each Spring NH DHHS will send out a message through the NH Health Alert Network (HAN) to increase awareness about ticks and tickborne diseases among health care providers as the weather warms and ticks become more active. The message provides prevention information and resources that providers can use to educate their patients. Additionally, HAN messages serve to remind providers about their responsibility to report suspected or confirmed cases of tickborne disease. More information about this network and archived HAN messages can be found here:
http://www.dhhs.nh.gov/dphs/cdcs/alerts/index.htm

Initiatives are underway to survey NH health care providers about their practices relating to tickborne disease and its prevention. As part of this survey, information will be collected about preferred routes of clinician continuing education presentations or material pertaining to tickborne disease. NH DHHS will develop clinician educational programs and materials based on these preferences.

C. Partnerships

Promotion of tickborne disease prevention measures is not solely the responsibility of NH DHHS. Partnerships will be fostered within NH communities and health care settings (as described above) to increase the amount of prevention information available. This will serve to amplify prevention messaging reaching the residents and visitors to NH.

NH DHHS aims to form long lasting partnerships with other state agencies, public health regions, health care providers and facilities, local health departments, community groups, school districts, summer camps and any other organization or entity that is able and willing to provide tickborne disease prevention information and materials to their constituents, clients or members.

C. Website

NH DHHS maintains a Lyme and Other Tickborne Diseases webpage, which can be accessed at: http://www.dhhs.nh.gov/dphs/cdcs/lyme/index.htm. Documentation on this website includes information about the tickborne diseases found in NH, personal protection measures to reduce risk of becoming infected with these diseases, annual data reports, a tickborne disease bulletin and links to other informational websites, including federal and other state agencies.

D. Printed materials

NH DHHS maintains an inventory of cards, brochures and posters with information on how to reduce the risk of tickborne diseases. These materials often include information about mosquito-borne diseases in NH because the prevention and risk messages are similar. Additional copies will be printed and new materials will be designed and made available as funding allows. Digital copies of all available printed materials may be accessed on the NH DHHS Lyme and Other Tickborne Diseases webpage (http://www.dhhs.nh.gov/dphs/cdcs/lyme/publications.htm). Quantities will be provided to NH organizations and residents, upon request, as supplies allow.

In an effort to reach as wide an audience as possible, outreach efforts during the winter and early spring will focus on distributing printed materials to high impact state partners, which may include: NH Department of Resource and Economic Development, NH Fish and Game Department, NH Department of Environmental Services, NH Department of Agriculture, Markets & Food and NH Department of Transportation. By partnering with other wide-reaching state agencies, NH DHHS hopes to reach the largest proportion possible of those working, visiting, and recreating in NH. Targets for distribution of printed materials include: NH Welcome Centers and Rest Areas, NH state parks and campgrounds, NH Fish and Game field offices, and summer camps. As supplies and funding allow, NH DHHS will reach out to external partners, which may include organizations or businesses promoting tourism, conservation and recreational activities such as hiking, camping, and mountain biking. As educational materials are developed for primary and secondary school aged children, priority will be assigned to groups focusing on this segment of the population as well.

E. Other Materials

NH DHHS will, as funding allows, maintain a supply of “tick spoons” designed to aid in the safe removal of attached ticks. NH DHHS tick spoons will be distributed at presentations made by

NH DHHS staff members about vectorborne disease risks in NH and may, as supplies allow, also be available upon request. Tick spoons will be offered as an option for safe tick removal, and will not be presented as a superior alternative to the CDC recommendation of using tweezers for tick removal. Use of tweezers for safe tick removal will continue to be discussed in presentations made by DHHS staff members, and will continue to be included in all printed materials.

NH DHHS will also be investigating the development, printing and distribution of trail signs for posting by municipalities, communities, organizations and residents reminding trail walkers and hikers about the risk for tickborne disease in the area. When these are developed, they will be available for download from the NH DHHS Lyme and Other Tickborne Diseases webpage (http://www.dhhs.nh.gov/dphs/cdcs/lyme/publications.htm) and a limited number of printed signs may be available for request.

F. Presentations

NH DHHS receives frequent requests for presentations on vectorborne, and specifically tickborne, diseases in the state. These requests will continue to be honored as time, staffing and funding allow. Additionally, other state partners may be available through the UNH Cooperative Extension office to provide presentations on ticks, tickborne diseases and prevention messages to appropriate audiences.

G. Training

Due to personnel and funding constraints, DHHS is not able to fulfill all presentation requests received. To better accommodate these groups, a standardized presentation will be developed and taught to interested health and safety partners, including safety officers and OSHA representatives within state agencies, public health region coordinators, interested health officers, representatives from local health departments and other groups with interest in this activity as appropriate. Topics discussed will cover mosquito-borne diseases of concern in NH in addition to tickborne diseases.

The goal of the "train the trainer" program is to increase knowledge and improve practices amongst organizations with employees or stakeholders who are at risk for transmission of vectorborne (tick and mosquito-borne) diseases in order to provide them with accurate and comprehensive information about vectorborne diseases in NH and the personal protective measures effective at reducing risk of becoming infected. This standardized presentation will cover the risks posed by vectorborne diseases in NH, the surveillance efforts of DHHS, and will focus heavily on ways to mitigate personal risk, namely, the avoidance of tick and mosquito bites. The presentation will be accompanied by a list of Frequently Asked Questions (FAQs).

Internal and external partners and organizations in NH interested in utilizing this presentation in their organizations will be required to attend a NH DHHS sponsored training during which NH

DHHS staff will present the information and FAQs, provide background on the vectorborne diseases and surveillance systems in NH and answer any questions from the trainees. To ensure the dissemination of accurate information, the standardized presentation will only be made available to attendees of the trainings.

Each training session will include a pre- and post-test as well as a presentation evaluation as a mechanism to assess for impact and identify areas of improvement in the materials discussed and provided. This program is subject to change both in content and purpose depending on attendance and feedback received from attendees with the goal of providing a useful service to meet the needs of potential participants.

H. Media

In May of every year, NH DHHS will send out a Press Release and promote media interviews as a means to increase awareness throughout the state of the increasing risk of contracting a tickborne disease. If funding becomes available, and as staffing allows, NH DHHS will develop media specific materials such as public service announcements (PSA) for use on NH radio stations and presentations for use on cable access television as well as explore areas where billboard and other mass public messages would be effective for risk communication information. Other media requests will continue to be honored through their usual means in coordination with the NH DHHS Public Information Office. Social media will also be evaluated and utilized as a means to disseminate additional risk and prevention messages at appropriate times of the year. NH DHHS will partner with other state agencies distributing the printed materials listed above to reach as wide an audience as possible in messaging efforts.

VII. SURVEILLANCE

A. Human Disease Surveillance

Lyme disease, anaplasmosis, babesiosis and Powassan virus are reportable conditions in NH. Healthcare providers and laboratories report suspect cases to NH DHHS. NH DHHS collects the data and classifies cases according to the CDC's case definitions. Surveillance data is then analyzed and used to assist in targeting prevention efforts, monitoring disease trends and inform the residents and public health partners of NH about human risk for disease. NH DHHS will continue to monitor incidence of these diseases and work with the public as well as other institutions and state agencies to protect the health and wellbeing of the citizens of NH. Maps and data reports are updated and published annually to allow public access to the changing picture of tickborne disease in NH.

Published documents can be found at:
http://www.dhhs.nh.gov/dphs/cdcs/lyme/publications.htm
http://www.dhhs.nh.gov/dphs/cdcs/documents/monthly.pdf

CDC case definitions can be found here:
http://wwwn.cdc.gov/nndss/script/casedefDefault.aspx

B. Entomological Surveillance

Entomological surveillance is most commonly performed by collecting ticks throughout the state in their natural habitat and testing them for the presence of pathogens. It is not recommended to wait for or determine the need for treatment based solely on testing a tick that was attached and feeding on either humans or animals. Continued surveillance of pathogen prevalence in the tick population will provide valuable information about how the vectors are dispersing throughout the landscape and what expansion, if any, is seen in the pathogen population as well. This information can be combined with already known incidence rates and land use patterns for a more accurate assessment of tickborne disease risk to the residents of NH. At this time, NH DHHS does not have funding to support further entomological surveillance. As long as grant funding allows, UNH Cooperative Extension will continue to monitor blacklegged tick abundance and geographic spread in NH. Information about this for public use is posted at:
http://extension.unh.edu/Integrated-Pest-Management/Public-Health-IPM

C. Geographical Information Systems

It is important to understand both human disease occurrence and vector infection prevalence in the context of land use, habitat factors such as soil type, forest cover, and edge habitat, and maximum likelihood of exposure. The state will be exploring these connections through

extensive use of Geographical Information Systems (GIS) in a project aimed at providing a detailed Lyme disease risk map for the entire state that will be able to serve as a tool to aid in targeted interventions for tickborne disease prevention. This interactive map will also be a model for other states interested in more fully describing hot spot areas of tickborne disease risk and performing similar interventions.

VIII. TICKBORNE DISEASE PREVENTION FUNDING PROPOSALS

Currently no state funds are provided for tickborne disease surveillance or prevention. The only funds dedicated to this disease are Centers for Disease Control and Prevention (CDC) funds in the amount of approximately $40,000 per year. These funds are used to support one part-time position for human case surveillance for Lyme disease only, and some limited funds for the purchase and development of educational materials. Additional funds have been requested, but not granted by CDC. In consideration of the new NH Tickborne Disease Prevention Plan, should additional State or Other funds become available, the Bureau of Infectious Disease Control would recommend initiating the following activities.

A. Tick Testing for Tickborne Disease Pathogens

Cost: $60,000 for two year study to include lab testing supplies and a tick collection contract

Background: Between 2007-2010, NH participated in an entomological study where the rate of pathogen carriage was examined for Lyme disease, Anaplasmosis and Babesiosis. This study found a high prevalence of Borrelia burgdorferi in the NH black-legged tick population such that approximately 60% of adult ticks across the state of NH carry this pathogen. Sporadic identifications of Anaplasma phagocytophilum or Babesia spp. were noted in 2007 and 2008, the only years ticks were tested for these pathogens. Prior to the loss of other CDC funding, the NH Public Health Laboratory (PHL) was in the process of developing a multiplex test to perform more robust surveillance for these three pathogens in their vector. Although rare, Powassan virus is known to be circulating in NH and surrounding states. Testing for this pathogen has not yet been established at the PHL. A standalone test for this pathogen was to be included in the battery of tests under development for an entomological surveillance program. This portion of development has also been postponed due to lack of funds.

The goal of establishing an entomological testing program is to determine the extent of carriage of these organisms in the NH tick population as a means to more fully explain disease transmission risk in NH. Any information gained through these efforts will be graphically displayed with maps for public access and will be routinely updated in publications relating to tickborne and /or vectorborne diseases including annual summary reports and the Tickborne Disease Prevention Plan that is being developed.

Justification: It has been five years since the last tick assessment has conducted. During this time, NH has seen significant increases in Babesiosis an Anaplasmosis, and expansion of Lyme disease. This study would offer a snapshot of changes in the prevalence of these pathogens in the NH tick population that could be used in prevention education initiatives.

B. Educational Outreach Initiative

1. Billboard Educational Campaign

Cost: $20,000
Justification: Spring, summer and fall are considered the highest risk time periods for the transmission of vectorborne disease in NH, not just for our residents but also for tourists enjoying NH's natural heritage. The placement of billboards emphasizing the importance of personal protective measures in an area that is accessed by thousands of people traveling within NH will serve as an important reminder of the risks and appropriate measures necessary to prevent transmission of these diseases.

2. Public Knowledge, Attitudes and Practices (KAP) Survey

Cost: $25,000
Justification: Performing a KAP survey of NH residents will serve to help target prevention messaging to the groups that are most at risk of tickborne diseases about general disease background, the vectors and methods to reduce the risk of transmission. Since many of the prevention measures are similar for preventing the transmission of tick and mosquito-borne diseases, the information gathered will provide a good evaluation of vectorborne disease prevention practices overall in NH.

3. Public Service Announcements (PSA) on Radio and Television

Cost: $50,000
Justification: PSAs will provide reliable information about vectorborne diseases and prevention methods through a platform that will reach potentially hundreds of thousands of NH residents prior to and during peak transmission seasons. Outreach such as this will give residents the tools and knowledge they need to educate themselves about the risks of NH's vectors and how best to protect themselves as they live and recreate in NH.

4. Development and Distribution of Comprehensive Educational Materials for Primary and Secondary School-aged Children in NH

Cost: $30,000
Justification: Development of educational materials is underway with support from CDC funds, however, the development and deployment of educational materials for children K-12 would be completed much more quickly with additional funding or resource support from the state. This funding could also be used to partially fund an expert in the Department of Education to assist DHHS in the development of educational materials that meet Common Core State Standards curriculum guidelines for more uniform adoption of prevention messaging for this most at risk group of NH residents that will benefit both educators and students across NH.

The costs described for the activities listed above are one-time expenses, although they may cover more than one year of effort. Continuation of these projects would need additional funds supplied on a regular schedule.

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Appendix A: Resources

University of New Hampshire Cooperative Extension

1. Biology and Management of Ticks in New Hampshire: http://extension.unh.edu/resources/files/Resource000528_Rep1451.pdf
2. Public Health and Integrated Pest Management: http://extension.unh.edu/Integrated-Pest-Management/Public-Health-IPM
3. Map of Blacklegged Tick Records in New Hampshire: http://extension.unh.edu/Blacklegged-Ticks-New-Hampshire

Centers for Disease Control and Prevention

1. Work place safety: http://www.cdc.gov/niosh/topics/tick-borne/
2. Lyme disease toolkit: http://www.cdc.gov/lyme/toolkit/index.html
3. Publication ordering information: http://wwwn.cdc.gov/pubs/CDCInfoOnDemand.aspx?ProgramID=148
4. Tickborne Disease: http://www.cdc.gov/ticks/index.html
5. Physician Reference:
    a. Tickborne Disease of the United States: A Reference Manual for Health Care Providers, Second Edition. http://www.cdc.gov/lyme/resources/TickborneDiseases.pdf

New Hampshire Department of Health and Human Services

1. Lyme and Other Tickborne Diseases: http://www.dhhs.nh.gov/dphs/cdcs/lyme/index.htm
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New Hampshire Fish & Game

1. New Hampshire Big Game Plan: Species Management Goals and Objectives 2006-2015. (This document is currently in the process of being updated for the 2016-2025 period.) http://www.wildlife.state.nh.us/Hunting/Hunting_PDFs/NH_Big_Game_Plan_FINAL.pdf
2. NH White-tailed Deer Assessment 2015. http://www.wildlife.state.nh.us/Hunting/species-assessments/nh-deer-assessment-2015.pdf

New Hampshire Department of Agriculture, Markets & Food

1. For additional information about certification and licensing for pesticide application see the Division of Pesticide Control: http://www.agriculture.nh.gov/divisions/pesticide-control/index.htm

Tick Identification Resources

1. State Entomologist (No fee associate with this service): http://agriculture.nh.gov/publications-forms/documents/tick-submission-form.pdf

2. UNH Cooperative Extension Arthropod Identification Center (There is a $5 fee per specimen.): http://extension.unh.edu/Problem-Diagnosis-and-Testing-Services/Insect-Identification-Service

Connecticut Agricultural Experimental Station

1. CAES Tick Management Handbook: http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1010.pdf
2. Managing Exposure to Ticks on your Property: http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/entomology/tick_control_fs.pdf
3. Tick Related Information: http://www.ct.gov/caes/cwp/view.asp?Q=378212&A=2837
4. An Integrated and Individual Tick Management Program to Reduce Risk of Lyme Disease in a Residential Endemic Area: http://www.ct.gov/caes/lib/caes/documents/publications/ticks/an_integrated_and_individual_tick_management_program_redding_ct.pdf
5. Managing Urban Deer in Connecticut: http://www.ct.gov/deep/lib/deep/wildlife/pdf_files/game/urbandeer07.pdf

Integrated Pest Management

1. United States Environmental Protection Agency. Tick Safety in Schools: Integrated Pest Management for Protecting Children from Tick-Borne Diseases. http://www3.epa.gov/pestwise/ticks/tick-safety-in-schools.pdf
2. United States Environmental Protection Agency. Federal Initiative: Tick-Borne Disease Integrated Pest Management White Paper. http://www3.epa.gov/pestwise/ticks/tick-ipm-whitepaper.pdf
3. Cornell University: http://idl.entomology.cornell.edu/files/2013/11/Deer-Tick-1q9srf1.pdf

Studies Performed, or Resources from, Neighboring States

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3. University of Rhode Island. http://www.tickencounter.org/
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Local Health Department Resources

1. Nashua Health Department's Lyme Disease Toolkit: http://www.nashuanh.gov/CityGovernment/Departments/PublicHealthCommunityServices/CommunityServicesDepartment/HealthEducationandPreventionServices/LymeDiseaseToolkit/tabid/1176/Default.aspx

Additional Prevention and Tickborne Disease Articles of Interest

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