NANTUCKET TICK-BORNE DISEASE COMMITTEE

Report to the Nantucket Board of Health and Selectmen

November 16, 2009
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1 EXECUTIVE SUMMARY

The high incidence of tick-borne disease on Nantucket Island represents a significant public health problem that warrants intervention. The Centers for Disease Control and Prevention has listed Nantucket among the top three Lyme Disease counties since 1992. Our first priority should be reduce the incidence of human disease and the resulting medical problems but there are also social consequences that result from the high incidence of tick-borne disease including the potential for a negative image of Nantucket.

Blacklegged (or deer) ticks can transmit several tick-borne diseases. Three tick-borne diseases transmitted by the deer tick have been reported on Nantucket. Lyme Disease, human granulocytic anaplasmosis (HGA), and human babesiosis all result from the spillover of pathogens that occur naturally within certain wildlife. The enzootic (wildlife) prevalence and associated incidence of human cases rely on three key animal species: blacklegged tick; white-footed mice; and white-tailed deer.

Nantucket has become an ideal environment for the proliferation of tick-borne disease. The change of the landscape from an open to dense vegetation habitat created an ideal environment. The climate is ideal for ticks. A large part of Nantucket is unbuildable 50 to 67% creating space for mice and deer. There is a large population of white-footed mice and the artificial introduction of the white-tailed deer without natural predators has permitted an unchecked growth in the deer population.

The blacklegged tick transmits the causal agents for all three of the tick-borne diseases over a two year life cycle. Blacklegged tick numbers and distribution are directly linked to deer density, which is directly related to risk. Habitat structure is an important co-factor.

We recommend an integrated long-term and sustainable approach to reduce the incidence of tick-transmitted infections on Nantucket, comprising a program of:

(1) Managed deer reduction to fewer than 10 per square mile;
   - reduction to be accomplished in 5 phases over several years
   - long-term community support must be measured and obtained before starting any reduction program

(2) Island-wide and individual property owner vegetation management directed at limiting human exposure to ticks;

(3) Prudent use of pesticides (acaricides)
   - the strategic use and deployment of Four Poster devices on an experimental basis at appropriate locations such as high risk neighborhoods
   - widespread spaying of acaricides in open areas of Nantucket is not recommended
   - establishment of a program to monitor the level of acaricides in environmentally sensitive areas

(4) Public education programs to include;
   - personal protection instruction in our schools
   - information for property owners on property landscape management
   - information for our island visitors provided on the various modes of transportation to the island and in hotels, inns and rental properties
   - seminars by members of the Tick-borne Disease Committee and experts on the science of tick-borne disease

(5) The development of an improved passive and active surveillance system to better measure the incidence of tick-borne infection on the island to more accurately measure the results of the overall program; and

(6) Continuation of the Nantucket Tick-borne Disease Committee in some form to execute, coordinate and monitor the progress of the recommended activities.

We understand that a deer reduction program will be controversial; however, of the trick-borne disease intervention methods considered feasible for use on Nantucket, we believe that reducing deer herd density to 8-10 deer/sq mile is key to decreasing the enzootic prevalence and human incidence of tick-borne diseases island-wide.

For Nantucket to reach this density threshold, the island-wide herd of approximately 2,500 deer would have to be reduced to 500 or fewer animals. The Massachusetts Division of Fisheries & Wildlife projects that it will take 12-16 years of dedicated effort to design, implement, and conduct the phases of a successful reduction program.

Once the density goal is reached, the deer density will have to be maintained in order to prevent tick-borne disease resurgence. With a properly sustained maintenance program, other intervention methods could be curtailed or discontinued.

Other deer management methods such as relocation or birth control are expensive, not practical, or experimental.

Personal protection measures (protective clothing, repellents, tick checks, and landscape modifications) need to be emphasized within our community and more information about protection needs to be provided to our visitors.

The use of chemicals to reduce the tick density should be considered as complimentary to the overall effort to reduce infection rates but used with caution because of our environmentally sensitive island. The most frequently used agent, permethrin, is known to be toxic to aquatic organisms. Biological control of tick populations is experimental and not recommended at this time for Nantucket.

The Four Poster device consists of a central bin containing whole kernel corn used as bait and two application and feeding stations at either end of the device. When deer feed on the bait, the device forces them to rub their head, neck and ears against permethrin impregnated applicator rollers. The device appears to be effective in reducing tick density but is not without problems and there are considerable expenses in maintaining the device. The device should be complimentary to other tick management efforts.

A widespread organized program directed at artificially reducing the mice population has no supporting data indicating a reduction in tick-borne disease and may in fact alter the ecological predator-prey dynamics of the Island.

Finally, we cannot implement a comprehensive program to reduce the incidence of tick-borne disease unless we can adequately measure our progress. Deer density and tick density can be measured but the only meaningful statistic is the incidence of human infection. The number of tick-borne infections acquired on-island is under reported. Cases are misdiagnosed, some cases are diagnosed clinically without laboratory confirmation and diagnosis is often made after departure from the Island.

In summary, we can reduce the incidence of tick-borne disease on Nantucket with an integrated long-term effort of deer reduction, proper vegetation management, comprehensive personal protection education and the strategic use of Four Poster devices. The program will not be successful unless there is an understanding that this will be a continuing and long-term effort by the entire community. To help in establishing community support, members of the Tick-borne Disease Committee are willing to conduct seminars on the science of tick-borne disease and the Committee's recommendations over the next several months. The Board of Selectmen should consider an Island-wide vote on the question of reducing the deer population and the continuation of the Committee in some form to coordinate the overall program.

2 OBJECTIVE OF THE COMMITTEE

To provide the rationale for developing a sustainable plan to reduce the incidence of tick-borne* infections on Nantucket Island, and in particular, recommend specific actions.

3 DEFINING THE PROBLEM

A. Tick-borne Disease on Nantucket

Blacklegged (or deer) ticks (*Ixodes scapularis [=I. dammini]*) can transmit several tick-borne diseases. Three tick-borne diseases transmitted by the deer tick have been reported on Nantucket:

- Lyme disease (*Borrelia Burgdorferi*);
- Anaplasmosis (*Anaplasma phagocytophilum*) – also known as human granuolocytic anaplasmosis (HGA) or previously as human granulocytic ehrlichiosis (HGE); and
- Babesiosis (*Babesia microti).*

The Lone Star tick *(Amblyomma americanum)* with the capability to transmit anaplasmosis has been increasing in density in the North Eastern US, but has not yet been identified on Nantucket.

The exact incidence of tick-borne disease on Nantucket is difficult to determine at his time. In addition to anecdotal reports by citizens and the experience of Nantucket physicians, data are available to support the conclusion that there is a high incidence of tick-borne disease on the Island that requires intervention.

- The Centers for Disease Control and Prevention has listed Nantucket among the top three Lyme Disease counties since 1992.[1]
- Research performed in the 1990s estimated that the seroprevalence for Lyme Disease in the general Nantucket population is 12-18%.[2]
- Statistics collected capturing emergency room visits and cases confirmed by laboratory diagnosis of tick-borne disease by the Nantucket Cottage Hospital show the following number of cases for 2007 and 2008.

Table 1: Tick-borne Disease on Nantucket 2007 – 2008 [3]

	Lyme	Anaplasmosis (Ehrlichiosis)	Babesiosis	Total
2007	190	15	53	258
2008	325	17	69	411

* The term "tick-borne disease" as used in this document will refer to diseases transmitted by the blacklegged or deer tick that have been reported on Nantucket. The term "tick" or "deer tick" will always refer to the blacklegged tick.

We cannot conclude that there has been an increase in tick-borne disease from 2007 to 2008 because the reporting system was not fully in place until 2008.

- A survey conducted of the voting members of the Tom Nevers Civic Association in December 2008 and January 2009 reported that 60% of households responding had been infected with a tick-borne disease – family members, guests or renters ever having a tick-borne disease reported: 61.3% with Lyme disease; 17.2% with babesisos; and 8.6% with erhrlichiosis. It is important to realize that while the 37% response rate achieved for the survey was good for this type of survey, there was some degree of "response bias" - i.e. those who responded were very likely the ones that had a very good reason to respond. This means that there may be some error in the percentages reported but the overall conclusion of a high incidence of tick-borne disease is correct.

The true incidence of tick-borne disease on the Island is difficult to determine for the following reasons:

- Constant changing nature of our population – unknown and changing "denominator";
- Many cases are acquired on-island but diagnosed off-island;
- Under reporting because of an inadequate reporting system (See Section 6 – 'Measuring Our Results' for a discussion of the reporting system);
- Misdiagnosis; and
- Failure to capture all the cases of Lyme Disease diagnosed clinically without laboratory confirmation.

Committee Conclusion:

Taking all information together, we can conclude that there is a high incidence of tick-borne disease on Nantucket Island and there is true public health problem that warrants intervention.

The medical consequences of tick-borne disease are summarized the next section

B. Medical Aspects of Tick-borne Disease

Lyme Disease: The *Borrelia Burgdorferi* bacterium is inoculated into the skin by the bite of the deer tick. The bacteria replicate locally and then spread throughout the body. A skin rash develops in the majority of people who develop symptomatic disease. This is the finding that leads to diagnosis of acute Lyme Disease in the majority of cases. The organism may localize in joints, heart or nervous system causing symptoms in each of these areas. It also may lead to immunologic reactions that may lead to symptoms of arthritis at later times. Fatality rates are extremely low to nonexistent.

The acute disease is diagnosed primarily by the skin rash, but may also be diagnosed in endemic areas by the presence of the other symptoms, especially when tick exposure has been documented or suspected. Blood tests are not useful in the acute phases of the illness since the antibody responses arise later in the course of the illness (weeks to months). Epidemiologic factors are critical in that the disease is almost always seen only in endemic areas and in persons who have had the opportunity for tick exposure. The disease is much more likely in the months June, July and August, but may be seen year-round, especially if there are pets in the house that may harbor the ticks. Acute Lyme Disease is successfully treated with appropriate antibiotics. A vaccine against Lyme Disease was withdrawn from the market by 2002.

Aaplasmosis (ehrlichiosis): The A*naplasma phagocytophilum* bacterium enters the bloodstream from the bite of a deer tick. The organisms concentrate in circulating granulocytic white blood cells (neutrophils and eosinophils) and travel throughout the body. They cause low white blood cell counts, low platelet counts and elevated liver enzymes. Fever, chills, headache, loss of appetite, nausea, fatigue and muscle pain are the most common symptoms. Fatality rates are extremely low (<1%). Treatment with appropriate antibiotics is virtually always promptly curative and there are no long term sequellae.

Babesiosis: The protozoa *Babesia microti* enter the bloodstream after inoculation from a deer tick bite. They localize and multiply in red blood cells in a manner similar to malaria leading to destruction of infected red blood cells. There may be enlargement of the liver and spleen. Most cases in otherwise healthy individuals are asymptomatic and self limited. The usual symptoms are fever, chills, muscle pain, joint pain, nausea, vomiting and fatigue. Especially in persons who have previously lost their spleens or have underlying immunologic diseases or malignancies, the disease may be severe. In the severe cases failure of multiple organs such as lungs, kidneys or heart may ensue leading to significant mortality rates.

Diagnosis is usually made by finding the organisms in red blood cells on microscopic exam or by other specialized blood tests. Treatment with combinations of appropriate anti-protozoa and antibiotics is usually curative.

Three cases of ruptured spleens occurred on Nantucket in the past year.[4]

C. Health Care and Social Costs Associated with Tick-borne Disease

Medical complications from tick-borne diseases are our greatest concern, but there are social and economic consequences resulting from a high incidence of these diseases that need to be considered.

Negative Public Relations: The negative public relations can be significant. Although it would be difficult to quantify the economic impact on the Island, we must be concerned about potential visitors who might fear to come to Nantucket. As a resort community, we rely on tourism revenue. This summer local brokers heard from those renting in Madaket that because of the mosquito problem, they will "never" return to Madaket. This year many visitors did express the fear that one of their family members might get a tick related disease. Today with social networking on the internet, the word may spread faster. We know from the experience of other resort areas, when a negative public relations news story focuses on an uncontrolled health problem or on a health and welfare issue, tourism revenue falls off.

- In the early 1970's, there was a significant tick related disease in the Land Between the Lakes (north central Tennessee and south central Kentucky). This area is a destination area for hikers and campers. There was a Lone Star Tick problem with an outbreak of tick related diseases associated with the lone Star Tick. Traffic fell off to this region.
- In 1993 there was significant breakout of the Hantavirus disease in the Four Corners region (Utah, Colorado, New Mexico and Arizona). With 40 deaths in 17 western states, travelers, hikers and campers reduced their travel to the area.

Medical Costs: Medical costs for physicians, medications, and laboratory costs can be significant. The average cost is unknown, but it can range from $90 to $2,000 for treatment of the various tick-borne diseases without medical complications treated as outpatients.[5] Additional costs are incurred for patients that require treatment of cardiac, neurological and arthritic complications or hospitalization. Medical costs are shared by the individual, as well as the insurance provider.

Lost school and work time: For a child, lost school time can be significant, and it is often difficult for a child to re-establish himself. There are many cases of Nantucket families losing wages because the family wage earner had a tick related disease and could not work. We don't know about visitors who may have contracted a tick related disease on the island, and then are home by the time the disease surfaces and hopefully is diagnosed.

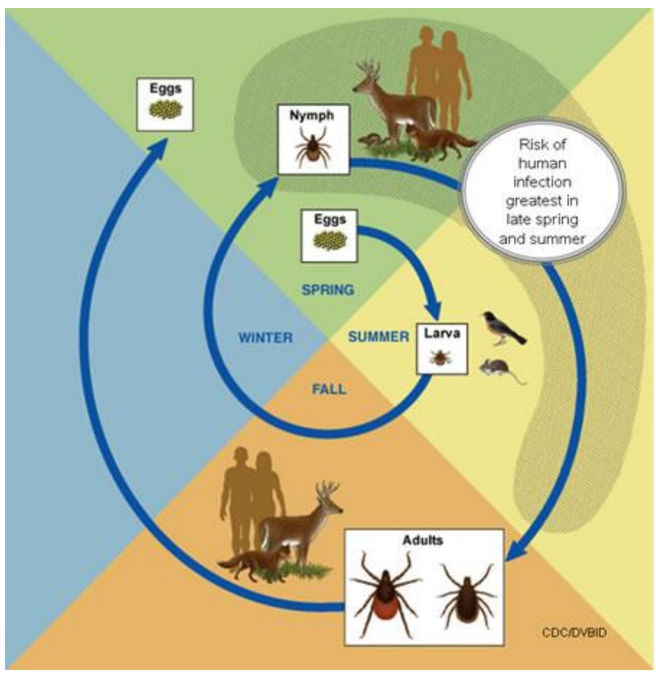
4 EPIDEMIOLOGY OF TICK-BORNE DISEASE

Lyme disease, human granulocytic anaplasmosis (HGA), and human babesiosis all result from the spillover of pathogens that occur naturally within certain wildlife. The enzootic (wildlife) prevalence and associated incidence of human cases rely on three key animal species:

- Blacklegged tick;
- White-footed mice; and
- White-tailed deer.

The blacklegged tick transmits the causal agents for all three of these diseases. Blacklegged ticks have a two-year life cycle that is made up of 4 stages -- eggs, larvae, nymphs, and adults. The life cycle of the blacklegged tick is summarized below in Figure 1.

Figure 1: Life Cycle of Blacklegged Ticks



[Centers for Disease Control and Prevention]

The total population of ticks is made up of two different, but overlapping, year-groups of ticks. Depending on stage, ticks feed on a host for 3-7 days before falling off; each stage feeds one time, on one host. In the first year, eggs laid in May hatch into larva in mid- to late July. After feeding, the larva drop from the host and molt into nymphs that over-winter in the environment. These nymphs emerge the following year in late spring, with peak feeding during May, June, and July.

Both larvae and nymphs feed on a variety of small mammals and birds, but the white-footed mouse is the principle animal carrying the pathogens causing each of these diseases. Following the tick's life cycle, larvae can acquire one or more of these pathogens when feeding on infected white-footed mice. If not acquired as larvae, the resulting nymphs can acquire these pathogens the following spring when feeding on infected mice. The enzootic cycle maintaining these diseases is completed when feeding nymphs, infected as larvae the previous summer, transmit the pathogens to uninfected mice. Once nymphs drop from the host, they molt into adults which appear in fall of the same year.

Adult blacklegged ticks do not hibernate; they can be active on warm winter days and the following spring. White-tailed deer are the primary and preferential host for adult blacklegged ticks,[6] but do not serve as a source of infection to ticks and do not seem to be infected themselves. Adult ticks will feed on other mammals (including rabbits), but these animals do not serve as effective replacement hosts and do not maintain large tick populations. White-tailed deer are the essential key for blacklegged ticks to successfully reproduce, to lay thousands of eggs (approximately 2000), and remain abundant.

Important epidemiologic factors affecting human disease risk:

- Deer density levels, tick abundance, and human disease incidence are directly linked;
- These diseases are transmitted to humans by infected nymphs or adults; larvae are not capable of transmitting these diseases;
- Ticks capable of transmitting disease are present year-round, but seasonal increases in risk are related to high nymph activity during May, June and July due to high adult activity in the fall;
- Nymphs generally transmit more disease than adults due to their smaller size and high nymphal activity that coincides with increased human outdoor activity;
- Each disease requires a minimal amount of tick attachment time in order to be transmitted to people. Lyme disease requires 24-48 hours, about 36 hours for babesiosis, and 12-24 hours for anaplasmosis hours; and
- Risk of human infection is associated with deer and tick numbers, season of the year, outdoor activities, expansion into tick laden areas, and degree of personal protective measures.

[References for Section 4 - 'Epidemiology of Tick-borne Disease': 7,8,9]

5 MODES OF INTERVENTION

The key to reducing the incidence of tick-borne disease is based upon the ability to reduce the exposure and probability of human contact with infected ticks. This can be accomplished at the

- Personal level by
  - the use of appropriate protection and awareness;
  - source reduction around homes by proper habitat and landscape management;
  - the use of host-targeted pesticides (acaricides); and at the
- Community level by
  - habitat and landscape management;
  - host-targeted pesticides (acaricides); and
  - deer reduction.

Education is an important component at both the individual and community level.

A. Personal Protection

Personal protection is the first line of defense against tick-borne disease and includes the wearing appropriate clothing, use of tick repellents, daily bathing and prompt removal of ticks. Individuals can also institute measures to reduce the tick burden around their homes. Actions that homeowners can take are discussed below in Section 5B (2) – 'Habitat Management and Landscaping'. Personal protection information should be part of any comprehensive educational program and will be discussed below in Section 5C – 'Education'.

B. Tick Management

(1) Deer Control

Blacklegged tick numbers and distribution are directly linked to deer density.[10] Deer are the primary host for the adult blacklegged tick; deer feed most adult ticks and are key to the reproductive success of the tick. Other potential hosts are not as important as deer.[11] Islands in Narragansett Bay Rhode Island that lack deer do not sustain deer tick populations even with alternative hosts available.[12]

There is a temporal correlation between the rise in the density of deer in the eastern U.S. and the epidemic curve for Lyme Disease[13,14] High incidences of Lyme Disease have been associated with deer overabundance. Information generated from scientific studies and successful reduction programs indicates that if deer herd density is reduced to or below 8-10 deer/sq mile, tick numbers and the enzootic prevalence of tick-borne disease can be lowered to levels that decrease risk of human disease. Notable examples of successful reduction programs include:

- Monhegan Island, Maine: The entire deer herd was eliminated during 1996–1999. No immature blacklegged ticks were found on rodents by 2004, and by 2007, ticks were very scarce, if not eradicated. Tick-borne disease is now reported as practically non-existent.[15,16]

- Great Island, West Yarmouth, Massachusetts: The deer density was reduced from 30-50/sq mile to fewer than 6 deer/sq mile and tick numbers were significantly reduced. Lyme Disease infection rates were reduced from greater than 3 cases per 100 people to less than 0.2 per 100 people.[17,18]

- Mumford Cove, Connecticut: An immunocontraception project failed and controlled hunts were started in 2000 reducing the deer density by 92% from about 100/sq mile to 10–12/sq mile. Subsequent Lyme Disease incidence decreased from 30 cases/year to 2-3/year within three years.[19]

- The Crane Beach, Ipswich, Massachusetts: Crane Beach is conservation and recreation property without a residential human population. The deer population was reduced over a seven year period from 160/sq mile to 27 deer/sq mile with resulting statistically significant reduction in tick densities on mice.[20]

A deer reduction program in Bernards Township New Jersey did not reduce the incidence of Lyme Disease. After three seasons the deer population was reduced 46.7% from an estimated population of approximately 118/sq. mile to approximately 63/sq mile. There was no apparent effect on the numbers of tick subadults and the Lyme Disease incidence did not vary with declining deer.[21] The deer reduction program failed to lower deer density to the recommended level of less than 10/sq mile in the relatively short time of the three years.

Bernards Township is surrounded by several other towns of similar ecology and human population with few impediments to deer movement. Monhegan Island, Great Island, Mumford Cove, and Crane Beach are geographically isolated without the ability for deer to be repopulated from other areas.

An assessment of Lyme Disease risk (density of tick-infection prevalence of nymphal ticks) using a model comparison approach was conducted using 13 year data on several field plots within Dutchess County New York.[22] The strongest predictors of risk were the prior year's abundance of mice and chipmunks and abundance of acorns 2 years previously. The results showed that deer abundance had no effect on temporal variation in Lyme Disease risk. This was an observational study – the researchers did not manage the experiment and did not perform an intervention such as actively reducing the deer population and the specific deer density used by the investigators is not clearly defined in the report. The management of mice will be discussed below in section 5B (5) – 'Mice Control'.

It is important to understand that tick-borne disease existed in the environment before deer were introduced to Nantucket. Following a successful deer reduction, these diseases would continue to exist at a lower enzootic prevalence in the environment, but human incidence rates would be much less and other intervention methods could be curtailed or discontinued.

Deer were not present on Nantucket and Tuckernuck before the early 1900s. After being artificially introduced, ample food and habitat along with the lack of natural predators have allowed the deer herd to become overabundant. Healthy deer have a tremendous reproductive capacity and can double their population every 2-3 years. On Nantucket, 95% of does deliver 2 fawns annually.

The Massachusetts Division of Fisheries & Wildlife (DFW) currently estimates about 2,500 deer on Nantucket, for a density of 50 deer/sq mile. The DFW estimates deer herd populations using validated models[23] incorporating biological parameters taken from harvested deer presented at check stations during hunting season. These estimates are considered particularly reliable for Nantucket because of the quality of information historically collected. Some groups or individuals subjectively believe the herd is smaller than the DFW estimate, but these figures are above 1500 or 30 deer/sq mile. Considering this and the reliability of the DFW estimates, it is clear that conducting a deer census prior to a reduction program is not necessary.

Notably, the ideal DFW deer management density goals for Nantucket and the tick-borne disease density threshold are essentially the same. From a social carrying capacity perspective, DFW considers Nantucket's deer population to be exceedingly high, with the ideal density goal to be 6-8 deer/sq mile. According to DFW, "these goals are scientifically established to maintain healthy deer populations in balance with their environment (i.e. below the biological carrying capacity), at levels which allow sustainable deer harvest and deer viewing opportunities for hunters and wildlife watchers, and at levels that minimize impacts on public health and safety (i.e. below the cultural carrying capacity)." Additional tangible social values to deer herd reduction include:

- Fewer vehicular-deer accidents;*
- Decreased natural and ornamental habitat destruction;
- Possible reductions of mosquitoes and deerflies that feed on deer;
- Potentially decreased risk of other emerging human diseases (i.e. Powassan related, Jamestown Canyon and Cache Valley viruses) where deer are reservoirs; and
- Decrease of tick-borne disease in dogs and horses.

Deer reduction on Nantucket

Hunting is the only practical method for reducing the deer herd on Nantucket. In general, public hunting requires minimal municipal funding and is the most cost effective method to control free-ranging deer populations. Non-hunting methods for reducing deer populations (birth control/sterilization, capture & transport, etc) are currently either experimental or impractical for Nantucket. Presently on Nantucket, public hunting harvests about 500 deer annually (20% of the population), which only maintains deer at current density levels. Clearly, increased annual harvest rates are needed to reduce the density to 8-10 deer/sq mile.

Well managed expanded and/or special public hunting programs and/or professional sharp shooting have been shown to significantly increase harvest rates. Based on DFW modeling, increasing Nantucket's harvest rate to 35% of the population annually over 10-12 years would reach this density goal.[24]

DFW recommends that a reduction program on Nantucket be divided into several hunting stages. The *first hunting stage* would use expanded/special public hunting programs over 5-6 years to reach an interim density goal of 25-30 deer/sq mile. It is unlikely that local hunters would achieve a 35% harvest rate alone; and hence it will be necessary to attract sufficient numbers of off-island hunters that participate in the public hunting programs for this stage to succeed. As the interim goal is reached, the program would need to be evaluated for modifications necessary to sustain the harvest rate during the *second hunting stage* over a subsequent 5-6 year period. As deer numbers continue to decrease, deer would be more difficult to harvest; hunter satisfaction and success will decline. If the needed harvest rate cannot be sustained, additional special hunting and/or professional sharp shooting would likely be necessary to reach the density threshold.

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* MA Department of Transportation reports that there are less number of vehicle crashes on Nantucket than other parts of the state, but Nantucket has double the rate of crashes (3%) attributed to deer compared to the statewide percentage (1.4%).

Hunting laws in Massachusetts are a combination of Fish & Wildlife Board *regulations* and State Legislature *statutes*. Before implementing the first hunting stage, the Board will have to approve changes to existing DFW deer hunting regulations. The Board would likely support Nantucket-specific changes to the deer hunting season calendar and tag limits, but not changes to the legal methods of hunting deer. DFW deer management specialists would provide technical assistance for designing sound hunting programs that would be supported by the Board. The Board would require any changes to be in effect for a minimum number of years (presumably not less than 5 years). If public hunting is determined to be incapable of sustaining adequate annual harvest rates to reach density goals, the Fish & Wildlife Board could consider additional regulatory and/or statutory changes (principally changes that allow for efficient and successful sharp shooting) to be incorporated into the second hunting stage.

New York State has allowed “nuisance” hunters on Shelter Island who can use herd reduction methods including baiting and night shooting. Bernards Township New Jersey uses a small number of local volunteer hunters who are specially trained and certified by the Police Department to hunt in specified areas during an extended season. The Bernards Township deer population has been reduced from approximately 118/sq. mile in 2002 to approximately 25/sq mile in 2009.[25]

Once the threshold density of 8-10 deer/sq mile is reached, continued hunting would have to *maintain* deer density at this level in order to prevent resurgence of tick-borne diseases. Fortunately, maintenance of this population density would be easier than reduction. With 500 deer island-wide, DFW models indicate about 75 deer (or 15% of the population) would have to be harvested annually to maintain density at 10 deer/sq mile. Presumably, public hunting by islanders could provide these harvest rates, but if not successful, additional special hunting or professional sharp shooting would be needed. *Without adequate maintenance, the deer population on Nantucket could return to original levels in as quickly as 10-15 years.*

The science of deer and tick reduction is correct; political, economic, and social factors are the major obstacles to deer reduction. Any proposed deer reduction program can be expected to be controversial, generating strong and emotional opposition from animal rights activists, local hunters, and public members. The special hunt in February 2004 harvested more deer than expected and demonstrated the effectiveness of a special hunting program to increase annual harvest rates, but subsequent public opposition led to the cancellation of future hunts. *Accordingly, these issues will have to be addressed before a reduction program is implemented; DFW deer biologists can assist this process by providing metrics for judging community support for deer management options.* Cooperation from conservation organizations, private individuals, and home-owner associations holding large tracks of land will be needed in order to expand coordinated deer hunting into currently restricted areas. (Note: According to Massachusetts laws, property owners that allow hunting without assessing fees are not liable for any injuries to or by hunters on their property.) Although public hunting programs require little local funding, municipal and/or private funding will be needed for a person(s) to oversee and coordinate the comprehensive elements of a reduction & maintenance program and for professional sharp shooting, if needed. An alternative would be the continuation of the Tick-borne Disease Committee in some form to oversee the deer management program.

Professional sharp shooting costs in other reduction programs have ranged from $200 to $650 per deer. Locally, hunters are accustomed to the success associated with the high deer density on Nantucket, and some are opposed to herd reduction because it will make hunting less productive personally; gaining support from this contingent is critical. (It should be noted that most of the mainland regions of Massachusetts have densities near or below 15 deer/sq mile, and hunter interest and activity has not dissipated.)

Although Nantucket's isolation from the mainland provides the opportunity to consider deer herd elimination rather than reduction and maintenance, elimination is not considered feasible here.

Additionally, DFW does not have any deer herd statistics for Tuckernuck, making it unclear if a reduction program is necessary on that island.

The distribution of venison to people-in-need has been successful in other locations.[26] The method and regulatory requirements need to be evaluated for possible implementation on Nantucket.

The exclusion of deer by fencing has been shown to reduce tick densities and may be considered as part of landscape management.[27] See Section 5B (2) – 'Habitat Modification and Tick Reduction Landscaping' below. Fencing in combination with pesticide usage and vegetation management has also been effective in reducing tick density.[28]

Committee Recommendation:

Initiate a deer reduction and maintenance program in the following phases:

- Phase I (1-2 years): Measure and develop long-term community-based support (including support from land holding organizations and individuals) for a reduction & maintenance program.
- Phase II (1-2 years): Design a sound program and pursue supporting regulatory changes with DFW's guidance.
- Phase III (5-6 years): First stage of expanded or special public hunting programs to reduce density to 25-30 deer/sq mile. Evaluate need for additional reduction measures and supporting regulatory/statutory changes.
- Phase IV (5-6 years): Second stage of public hunting and additional reduction measures (e.g. professional sharp shooting) that assist public hunting in order to achieve the threshold density of 8-10 deer/sq mile.
- Phase V (forever): Ensure hunting programs maintain deer density at necessary levels to prevent tick-borne disease resurgence.

(2) Habitat Modification and Tick Reducing Landscaping

Habitat modification complements other modes of intervention in reducing the risk of acquiring tick-borne disease. Studies have shown that open-grass/sparse-shrub habitats contain fewer immature blacklegged ticks than high shrub areas. Nantucket has undergone a significant change from an open to dense vegetation habitat since the 1970s.

Tick densities are greatest on mice trapped from areas with more shrub cover and woody stem densities.[29] In residential sites,

- 67% of host-seeking ticks that were collected came from woods adjacent to homes;
- 22% from the ecotone (transition area between two adjacent but different plant communities);
- 9% from ornamental vegetation; and
- 2% from lawns proper.[30]

The greatest risk of acquiring a tick-borne disease is therefore closest to homes.

In laboratory and field experiments, deer ticks are very sensitive to desiccation, requiring a microhabitat with >85% relative humidity for extended survival.[31,32] Brushy sites that maintain humid microclimates are more conducive to the survival of ticks and their sessile stages (eggs, engorged subadults) compared to open grassy areas. Excessive watering of grass will increase the humidity and promote a more favorable habitat for ticks. Deer browse, and the "edge" effects of shrub patches provide large areas for browsing. Furthermore, brush allows deer to hide.

<u>Committee Recommendations:</u>

1. Landowners and homeowner associations should be encouraged to reduce brush in yards and common areas as well as keeping grass cut with the minimum usage of water.
2. Conservation organizations should be encouraged to promote more grassland habitats and reduce shrubby scrub oak thickets. Grasslands should be cut as short as possible.
3. Landscaping contractors should be versed in the above methods of property care.

Proper landscaping techniques are also important in reducing tick host mice numbers around homes (see Section 5B (5) – 'Mice Control").

(3) Acaricide usage

Pesticides, acaricides for ticks, are the most effective way to reduce ticks in a local area, particularly when combined with landscaping changes that decrease tick habitat.[33] However, there are risks associated with pesticide usage and they should be used prudently. There are three acceptable methods with adequate usage data for consideration: (1) area application of acaricides; (2) the Four Poster device to apply acaricides to deer; and (3) Damminix® Tick-tubes. "Bait box" systems that are presently available have not been extensively tested.

Area application of acaricides

Area spraying is best applied in May or early June to target nymphal ticks, the stage most likely to transmit tick-borne disease. Adults may be targeted by spraying in the fall (or in the spring if no fall application was made). At least 400 Nantucket families apply the acaricide permethrin to their properties.[34]

Permethrin is a member of the pyrethroid class of pesticides. Pyrethroids are highly toxic to fish and other aquatic organisms, but generally are much less toxic to mammals, birds and other wildlife.[35] We need to be aware of any potential harm to our Nantucket ecosystem.

Committee Conclusions / Recommendations:

1. Widespread spaying of acaricides in open areas of Nantucket is not recommended.
2. Although shown to be effective, the Committee cannot support or condemn local use of acaricides by individual family property owners until sufficient information is available to demonstrate that the use is not detrimental.
3. A program needs to be established to monitor the level of acaricides in environmentally sensitive areas of Nantucket.

The Wannacomet Water Company has agreed to measure permethrin levels as part of their ongoing water quality monitoring at the well sites. Other sites should be tested and the University of Massachusetts Nantucket Field Station has agreed to assist in organizing such testing providing funding is provided.
The estimated cost for this additional testing is about $10,000/ year.

Four Poster device

The Four Poster (4-Poster) device consists of a central bin containing whole kernel corn used as bait and two application and feeding stations at either end of the device.

Figure 2: Four Poster Device

[American Lyme Disease Foundation, Inc]

When deer feed on the bait, the device forces them to rub their head, neck and ears against permethrin (10%) impregnated applicator rollers. The Massachusetts Division of Fisheries and Wildlife consider the 4-Poster device experimental pending more information on safety and efficacy.

Studies have shown the device to be effective in reducing tick density. A study conducted by the U.S. Department of Agriculture in five eastern states concluded that the 4-Poster technology to be an efficacious, safe, and environment-friendly alternative to area-wide spraying of acaricide to control populations of ticks. There was a 71% reduction in nymphal ticks after 5 years in the USDA study [36] Adult, nymphal and larval ticks were reduced by 91-100% from sample plots and nymphal and larval ticks were reduced 70-95% on sampled mice in a study conducted at a NASA facility in Maryland .[37] Other studies have also shown large reductions in tick populations following the use of the 4-Poster device.[38,39,40] There is an ongoing study at several sites on Cape Cod being conducted by the Barnstable County, Cape Cod Cooperative Extension. The Cape Cod study has one study site on Nantucket at the Linda Loring Nature Center and a control site around Almanack Pond. The Four Poster system is also being evaluated by Cornell University on Shelter Island and Fire Island in New York State. There is no hunting on Fire Island and Shelter Island has an expanded hunting season. The long term results from Cape Cod and Shelter Island / Fire Island are not yet available.

Although results to date appear promising, some concerns are apparent: (1) The Massachusetts Division of Fisheries and Wildlife prohibits the artificial feeding of deer because of fears of facilitating the transmission of chronic wasting disease, and feeding deer is illegal during hunting season; (2) the potential for ticks to develop a resistance to permethrin and may eventually reduce our limited personal protection arsenal (this also applies to area spraying); and (3) the availability of excess corn may induce an eruption of rodents. The attraction of rodents has been noticed in the Shelter Island experience.[41]

The State of New York Department of Health monitors the deer meat, liver and hides for levels of permethrin from the Shelter Island Four Poster program. Results from the 2008 sampling indicated that permethrin was detected in the meat from two of three deer from the treatment area and no permethrin from one deer from a control area. Permethrin residues were not detected in liver samples from any of these four deer. It is possible that the permethrin residues measured in meat resulted from hide transfer during the dressing process. The amount of permethrin detected in the deer meat from Shelter Island, in this very limited study, is below the tolerance levels established by the US Department of Environmental Protection for cattle, goat and sheep meat.[42] Preliminary test results for 2009 have not demonstrated any residual permethrin levels on a limited number of deer.[43]

The USDA study concluded that 4-Posters need to be deployed at one unit per 21 hectares (52 acres) at a cost of $52 per hectare. The landmass of Nantucket is about 12,380 hectares (30,590 acres or 48 sq. miles). A cost estimates provided by Barnstable County, Cape Cod Cooperative Extension for a single 4-Poster device in the first year is about $2000 per unit. The costs include: (1) the unit; (2) corn; (3) permethrin; (4) labor – maintenance, removal during hunting season; and (5) miscellaneous expenses. Costs will be less during the second year, but it is important to understand that a 4-Poster program would need to be continued for several years, if not forever. Shelter Island maintains 60 Four Poster units spending about $155,000 to $175,000 per year.[44]

There are several actions that would be required to implement a Four Poster system on Nantucket: (1) a license will be required from Massachusetts Division of Fisheries and Wildlife; (2) professional pest control operators with appropriate certification and licensing will be required to maintain the Four Poster stations; (3) an assessment would be required to determine the number and best locations for installing the devices; (4) approval from property owners – private and nonprofit; (5) finding a location for storage of corn and other supplies; (6) review of potential liability issues; and (7) sustained funding of the project.

The Barnstable County, Cape Cod Cooperative Extension has offered to loan Nantucket the devices and assist in establishing a Four Poster program. Yearly maintenance expenses would be the responsibility of Nantucket. The Extension estimates the year cost at about $1500/ unit. Pending available funding, the Extension would measure tick-density in target areas.

Committee Recommendations:

1. Strategic use and deployment of Four Poster devices on an experimental basis at appropriate locations such as high risk neighborhoods and high human traffic areas.
2. Establishment of a collaborated effort with the Barnstable County, Cape Cod Cooperative Extension to determine appropriate locations and installation.

Damminix® Tick-tubes

Damminix tubes are cardboard tubes filled with cotton balls treated with permethrin that mice collect to build their nests. Ticks that feed on nesting mice in the spring and fall are exposed to permethrin.

The effectiveness of Damminix tubes is uncertain. Two studies in Connecticut[45] and New York State[46] failed to show any reduction in the number of infected, host-seeking nymphs when this product was used for a three year period in woodland and residential areas. Lack of control may be due to failure by the mice in some areas to collect the cotton or the presence of alternative tick hosts, such as chipmunks, an important secondary tick host.[47] Reductions in tick numbers were reported in a Massachusetts study.[48]

Committee Conclusion:

The Committee can not substantiate the effectiveness of the Damminix tubes; it is reasonable to assume Damminix tubes are effective to some degree, particularly since Nantucket does not have chipmunks.

Bait Box Systems

A "bait box" system, Maxforce®, which attracts mice and applies an acaricides to their bodies when they enter, has been removed from the market because of low sales of the product. Other bait box systems have not been extensively tested.

Committee Conclusion:

The Committee can not endorse the use or effectiveness of the bait box systems.

(4) Biological Control

Ticks have relatively few natural enemies, but the use of predators, parasites, and pathogens has been examined for tick control including chalcid wasps, fungi, and nematodes. Biological controls with these agents have not been extensively tested and are considered experimental and may interfere with typical predator-prey dynamics.

Committee Recommendations:

1. The use biological controls is not recommended at this time.
2. Continue to follow the research and development of biological control systems.

(5) Mice Control

White-footed mice are a key intermediate host for tick-borne disease. The control of the white-footed mouse is best accomplished by reducing mouse habitat near homes.[49] Dense vegetation and ground cover plants adjacent to homes provide cover for rodents as they forage for food. A widespread organized program directed at artificially reducing the mice population has no supporting data indicating a reduction in tick-borne disease and may in fact alter the ecological predator-prey dynamics of the Island.

Committee Conclusions / Recommendations:

1. Property owners should be encouraged to take action to limit the habitat for mice within their property.
2. Artificial island-wide attempt at reducing the mice population is not recommended.

C. Education

Education should be readily available to the island citizen, property owner, renters and the day visitor. It should emphasize not only the tick and tick-borne diseases, but should stress the personal responsibility of all to avoid ticks:

- daily skin checks for ticks;
- scrubbing daily with a long handle bathing brush;
- protective clothing; and
- repellant use.

Education should extend to the homeowners so they can manage their property to kill or to reduce the tick population.

- maintain grass at 3 inches or less around buildings;
- consider spraying the perimeter of properties contiguous to wild as well as foundation plantings with an acaricide;
- use of pet collars and consider the placement of products such as Damminix®;
- trim perimeter hedges and brush; and
- installing high unobtrusive green metal fencing either electric or non electric to deter deer.

Children must repeatedly receive instruction that provides the basis for risk reduction. Nantucket Schools must be involved in tick and tick-borne disease awareness because information taught in the classroom gets disseminated to the home. A Nantucket slogan and poster campaign can start in the elementary school with a contest to develop a catchy, succinct and visible message for Nantucket Tick Awareness. The Barnstable County School system has been the local leader in tick education and related programs.

Committee Recommendations:

1. Engage civic associations for their organizational, volunteer and fund raising abilities: Civic League and its 23 local groups, Garden Club and Rotary Club and neighborhood associations such as Toms Nevers, Naushop, Nashaquisset, Hedge Row and Underhill.
2. Introduce an education awareness program in the Island schools using the Barnstable program as a model.
3. Work with island schools to develop posters, events and a film on tick and tick-borne disease awareness.
4. Disseminate the posters perhaps designed by the school to the public venues for people carriers: air lines, airports, ferries, ferry terminals, taxis, buses, tour guides, and bicycle shops.
5. Disseminate tick-borne disease information to inns, hotels and rental properties.
6. Communication channels should be engaged. Local media should be approached to publish: newspapers – Independent and Inquirer and Mirror, TV channels – 17 and 22 and realtor trade

organization - NAREB. Service companies that have direct link to home owners: Landscapers, National Grid and Wannacomet Water.

The Education sub-committee of the Tick-borne Disease Committee has had preliminary conversations with several of the groups cited in its recommendations and there has been full support.

6 MEASURING THE RESULTS

The objective endpoint of all the above efforts is only valid if we can accurately measure the before and after incidence of tick-borne diseases. This is dependent upon accurate reporting by the Nantucket Cottage Hospital and the individual private practice physicians. To date it is fair to say that there is significant underreporting of the tick-borne incidence due to several factors:

- Failure to accurately "code" the illness with the correct ICD code.* Every health condition can be assigned to a unique category and given a code. ICD are codes used for billing purposes and to organize the collection of medical statistics. An example of incorrect coding would be to code a case of Lyme Disease coded as a "skin rash.''
- Failure to report timely reports of positive laboratory tests;
- Failure to capture all the cases of Lyme Disease diagnosed clinically without laboratory confirmation;
- Misdiagnosis; and
- Diagnosis after departure from the Island.

<u>Committee Recommendations:</u>

1. Enlist the support of Massachusetts General Hospital Physicians Organization to provide computer lists of appropriate ICD codes for Tick-borne diseases reported on Nantucket. All but one Nantucket physician belong to this organization.
2. Education of seasonal physicians regarding the incidence, signs and symptoms of tick-borne diseases to heighten awareness and improve accuracy of diagnosis.
3. Enlist support of Nantucket Cottage Hospital and the private physicians and emphasize the importance of accurate numbers.
4. The Board of Health should consider introducing a local active reporting system on Nantucket with a part-time employee to collect and collate the data.

* International Statistical Classification of Diseases and Related Health Problems

We have formally requested the information from the Mass General Physicians Organization and are waiting a reply.

In-direct measurement of success determined by entomological surveillance (tick density, tick infection rates) would be helpful, although difficult to apply to a large area such as Nantucket. Repeated testing in target areas and around 4-poster sites would provide useful information. It is possible that the State would require some degree of entomological surveillance in order to obtain licensing for a 4-Poster program. Entomological surveillance should be part of the overall tick-borne disease reduction program. Academic institutions may wish to perform this testing with funding obtained through granting organizations. Estimated costs range from $15,000 to $150,000 / year depending upon the scope of the work.

7 COST ANAYLSIS

The following table lists the estimated costs of the various proposed recommendations. The amounts should be considered as estimations and derived from various sources.

Table 2: **Estimated Costs for Reducing Tick-borne Disease on Nantucket**

	Year 1-5/6	Year 5/6-11+
Hunting	– Minimal local funding ; individual hunters pay licensing fees	– Depends on how well the public hunting has reduce the herd, and the estimated costs can really only be determined in this time frame; sharpshooting cost will range from $200 – 650 per deer based upon 2009 dollars
Acaricide measurements	– Well testing by Wannacomet Water – Additional site testing: $10-15,000/ year depending upon the scope*	– May not be necessary pending outcome of testing – May not be necessary pending outcome of testing
4-Poster	– Up to 25 devices on-loan from Barnstable County Extension – Shipping and transportation costs: TBD – Maintenance: $1500-2900 / year/ device** – Liability insurance: TBD – Entomological surveillance: TBD	– If successful, replacement cost per device ~ $500 / device – Transportation costs for Barnstable County Extension personnel – Maintenance cost continues – Liability cost continues – Entomological surveillance cost continues
Education	– Education posters, handouts etc. $500-600 / year – School education program: TBD	– Education posters, handouts etc. cost continues – School education program cost continues
Measuring results	– Passive and active surveillance to measure human disease: $4-5000/ year – Entomological surveillance: $15,000 - $150,000/ year	– Passive and active surveillance cost continues – Entomological surveillance cost continues

* May not be necessary for the entire 5 year period, pending results
** Shelter Island expenses: $2600-2900. Barnstable County Extension estimation: $1500

In addition to direct local government funding, other options should be considered. The Shelter Island New York tick-borne disease reduction program receives funding from the State and local governments as well as a not-for-profit foundation. The foundation was specifically established to fund the project. A similar non-profit organization should be considered for Nantucket. Homeowner associations may wish to fund 4-Posters devices around their neighborhoods. Fund-raising events may be considered to fund the installation and maintenance of 4-Poster devices.

Academic institutions may be interesting in applying for grant funding from organizations such as the CDC, NSF, NIH and USDA for entomological surveillance. External grant support would most likely not be available to directly support deer reduction but would support collecting the entomological surveillance surrogate endpoint data and possibly the outcome of the entire integrated program.

Worcester Polytechnic Institute is considering providing students to work on the project in September and October 2010. How we would use these interns has not been decided.

8 DEVELOPING COMMUNITY SUPPORT

Tick-borne disease is a problem affecting all members of the community, either directly by acquiring an infection or indirectly by involving friends and relatives or potentially by an impact on the economic wellbeing of the Island through negative publicity. A deer reduction program is always controversial. The special hunt in February 2004 demonstrated the effectiveness of a special hunting program but subsequent public opposition led to the cancellation of future hunts. There was resistance by some members of the Shelter Island New York community to the introduction of a 4-Poster program. We cannot go forward with our recommended program, especially the proposed deer reduction program, without community support.

Committee Recommendations:

1. Members of the Tick-borne Disease Committee and tick-borne disease experts should conduct seminars on the science of tick-borne disease and the Committee’s recommendations over the next several months.
2. The Board of Selectmen should consider an Island-wide vote on the question of reducing the deer population.

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