Raising Tourist Awareness of Lyme Disease on Nantucket Island

An Interactive Qualifying Project

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By

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Abstract

Lyme disease is the most prominent tick-borne disease in the United States. Island systems, like Nantucket contain isolated populations of reservoir and reproductive hosts that aid in the spread of disease. Tourists that come to Nantucket generally lack knowledge of the risk of contracting Lyme disease because they are not from areas that are at risk. The objective of this project is to educate tourists about Lyme disease. To achieve our objectives we created an online survey to assess tourist knowledge of Lyme disease and a poster to provide tourists with a way to access the survey. These tools will serve as an excellent foundation for future intensive research and intervention relating to Lyme disease on Nantucket Island.

Executive Summary

Lyme disease, a debilitating disease caused by the bacterium *Borrelia burgdorferi*, is the most commonly reported vector-borne illness in the United States. According to the Centers for Disease Control and Prevention of Bacterial Diseases, in 2013 95% of confirmed Lyme disease cases were reported from 14 states: Connecticut, New Jersey, Delaware, New York, Maine, Pennsylvania, Maryland, Rhode Island, Massachusetts, Vermont, Minnesota, Virginia, New Hampshire, and Wisconsin (Cdc.gov 2013).

White-tailed deer serve as the primary host for the adult blacklegged tick and as a result there is a strong correlation between deer density and Lyme disease incidence (Tickencounter.org 2014). Many notable studies have been completed in order to examine and analyze this correlation. One such study was performed in the Mumford Cove community located in Groton, Connecticut over a 13-year period. By reducing deer density from 39.8-54.5 deer per square kilometer to an average 5.1 deer per square kilometer, there was a 76% reduction in tick abundance, a 70% reduction in the entomological risk index, and an 80% reduction in resident-reported cases of Lyme disease (Kilpatrick, Labonte and Stafford III 2014).

While deer act as reproductive hosts in the spread of Lyme disease, small rodents, especially mice and chipmunks, are key reservoir hosts. Immature ticks feeding on infected mice become infected and later pass that infection on to a larger host when they engage in a blood feeding (Tickencounter.org 2014). The study of mice in relation to Lyme disease is especially relevant when studying incidence of Lyme disease amongst humans who live near fragmented forests. According to the National Science Foundation fragmented forests have a lower biodiversity, and therefore are home to fewer predators (Nsf.gov 2014). In such an environment, mice reproduce heavily, and in turn both ticks and Lyme disease thrive.

Symptoms of Lyme disease begin to manifest in humans over three stages. One of the biggest signs of transmission is erythema migrans (EM) or the “bulls-eye” rash. This rash appears at the site of the tick bite approximately 7 days after the host is bitten, and occurs in approximately 70-80% of infected

persons. The rash gradually expands over several days and in some cases can reach up to 12 inches in diameter. Parts of the rash have a tendency to clear as it enlarges, resembling a bulls-eye.

Past studies of Lyme disease incidence have isolated islands as an ideal ecosystem for the spread and transmission of the disease. Islands as ecosystems tend to lack species richness because the movement of species in and out of the ecosystem is more difficult than land-locked or coastal ecosystems. Additionally, there have been connections made between humidity and the prevalence of disease-carrying ticks. In a study conducted in Rhode Island over the course of 14 years, it was determined that extended episodes of low humidity led to significant tick mortality after exposure times of eight hours or more (Berger et al. 2014). Islands tend to have high humidity levels, especially in warm seasons. This is another reason islands present a fascinating ecosystem in which to study Lyme disease incidence.

The first deer to inhabit Nantucket was found swimming across Nantucket Sound in 1922. There are approximately 2,500 deer on the island of Nantucket, for a density of 50 deer per square mile (Nantucket Tick-borne Disease Committee 2009). Because of the high deer density on Nantucket, the island has one of the highest rates of Lyme disease since 1992 (Nantucket Tick-borne Disease Committee 2009).

By discussing our project with the head of the Nantucket Conservation Foundation, Mr. Jim Lentowski, we concluded that the best way to reduce rates of Lyme disease on the island would be to target tourists during the summer months. Because Nantucket tourists are typically from areas that do not have a high rate of Lyme, these people may not notice ticks on their skin or symptoms they may be exhibited as a result of a tick bite. By surveying the tourist population on the island we can gauge the knowledge of Lyme disease and ticks, thereby providing us with critical information we need to address the issues on the island. We decided to gauge awareness of Lyme disease to tourists by creating a survey that is distributed on a poster. The poster also had additional information about the risk of Lyme disease on Nantucket.

Acknowledgments

The team would like to acknowledge Professor Marja Bakermans for her continued support and dedication throughout the duration of this project. We would also like to thank the IGSD office for their advice on travel arrangements to Nantucket. We would also like to thank Jim Lentowski of the Nantucket Conservation Foundation for his valuable input and insight in to the need for public awareness of Lyme disease on Nantucket.

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- Relationship Between Ticks and Deer
- Ticks and Humans
- Lyme Disease Incidences on Island Communities
- Methods
- Results
- Conclusions

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- Citizen Science
- Potential Partnerships
- Methods
- Results
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Introduction

Goals and Methods

The goal of this project is to evaluate past and present methods of public awareness of tick-borne diseases toward tourists that have been implemented on Nantucket, as well as administer a novel approach to this problem by creating a new awareness campaign and using it to survey temporary residents and visitors for tick exposure via mobile devices.

Methods to fulfill these objectives include:

- Perform detailed background literature research on the incidence of Lyme disease on both island and non-island communities.
- Research Nantucket Island and determine the community's need for Lyme disease intervention.
- Utilize our personal knowledge and the resources available at Worcester Polytechnic Institute, including previous IQPs and other people with specialized knowledge, to assess public health awareness campaigns used for zoonotic diseases.
- Investigate old means of public awareness for tick-borne diseases on the Nantucket.
- Interview Nantucket-based Lyme disease experts to gather more information about tick-based public outreach and public safety.
- Create a survey targeted towards tourists that assesses their risk of exposure to Lyme disease, as well as allows for input of information about ticks that they may have found.
- Make this survey easily accessible via smartphone or tablet to increase its use, and make it more appealing to tourists.
- Create a Nantucket-specific advertisement that increases awareness and risk of Lyme disease, as well as advertises the availability of our survey for more information about ticks, and tracking incidences on the island.

Lyme Disease

Lyme disease, a debilitating disease caused by the bacterium *Borrelia burgdorferi*, is the most commonly reported vector-borne illness in the United States. However, incidence of Lyme disease is found primarily in the northeast and upper Midwest regions of the country. According to the Centers for Disease Control and Prevention of Bacterial Diseases, in 2013 95% of confirmed Lyme disease cases were reported from 14 states: Connecticut, New Jersey, Delaware, New York, Maine, Pennsylvania, Maryland, Rhode Island, Massachusetts, Vermont, Minnesota, Virginia, New Hampshire, and Wisconsin (Cdc.gov 2013). The map below, Figure 1, indicates the prevalence of Lyme disease in the aforementioned regions.

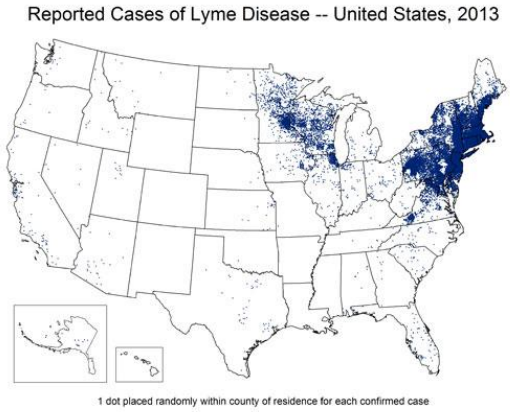

Figure 1: Reported Cases of Lyme disease in the United States (Cdc.gov 2013)

It is generally accepted amongst the scientific community that Lyme disease prevalence is highest at sites near the terminal moraine of the glaciers 15,000 years ago (Steere 1994). At that time, what is now the Northeastern and upper Midwestern parts of the United States, was covered by tundra (Steere 1994). As the glaciers melted, these areas became primarily forested, and these forests eventually became populated with large numbers of deer. Accounts from as early as colonial New England include descriptions of an abundance of deer and human encounters with "annoying ticks" (Steere 1994).

While Lyme disease is concentrated in the area it affects, the disease is non-discriminating in the human demographics that it targets. People of all ages and both sexes are affected by Lyme disease (Steere 1994). Traditionally, humans populating more heavily wooded areas, areas with higher deer

densities, and people who spent more time exposed to the natural habitat of ticks were most affected by Lyme disease. According to a study conducted by the Centers for Disease Control surveilling Lyme disease, between 1992 and 2006 incidence was highest among children aged 5-14 years old and 53% of all reported cases occurred among males (Bacon et al. 2008). Within the two decades Lyme has become more prevalent among suburban and urban dwelling humans (Steere 1994). One potential reason for this is the advent of increased accessibility to the areas where deer live due to the rise of affordable automobile travel and the establishment of superhighways (Steere 1994). As urban areas continue to expand to accommodate additional citizens, "susceptible suburbanites" who lack exposure to the bacteria that causes Lyme disease are taking up residence in areas with a dense deer population (Steere 1994). Other significant links between Lyme disease and human demographics such as gender, ethnicity, or socioeconomic status have not been made.

Black-legged Ticks

Borrelia burgdorferi is transmitted to humans through the bite of infected blacklegged ticks, also known as the deer tick or the bear tick (*Ixodes scapularis*). According to the Minnesota Department of Health, blacklegged ticks live from two to three years and have three blood meals over the course of their life cycles. The cycle begins when a female lays her eggs. Like other insects and arachnids, the eggs then eventually develop into larvae, nymphs, and then adults (Health.state.mn.us 2014). Figure 2, (below), illustrates four different blacklegged ticks. The tick on the leftmost side is an adult female blacklegged tick, which is red and dark brown. Moving from left to right, the next tick pictured is the adult male, followed by a nymph, followed by a larva.

Figure 2: Morphology of Ixodes scapularis based on sex and life stage (Health.state.mn.us 2014)

The eggs hatch into larval ticks from May to September. Interestingly, larvae do not initially carry diseases, but may pick up diseases during its first meal from a potentially diseased host. Larvae tend to feed on small mammals, such as white-footed mice (*Peromyscus leucopus*). After their initial feeding, larvae molt into nymphs and are dormant until the following spring. In the spring and summer of a tick's second year, the nymph becomes active again and engages in a second feeding. If the nymph already carries disease, it will spread disease to the mammal it feeds on. If the nymph is not already carrying disease, it will contract disease if it feeds upon an infected host. In the fall of the second year, nymphs molt into adult ticks. In the fall or early spring the female feeds on mates or large animals, and dies after laying her eggs. A female tick's last blood meal occurs over the course of several days. The female's body will engorge with blood during the feeding and it is at this point that the tick will transmit Lyme disease to its host. Conversely, adult male ticks attach but do not feed or become engorged. Because the adult males do not take a blood meal, they do not transmit disease (Health.state.mn.us 2014).

One of the most interesting aspects of the seasonal life cycle of black legged ticks is their vitality in cold and frost. Adult ticks that do not get a blood meal in the fall will go dormant over the winter and seek another meal again in the spring. The frost does not kill blacklegged ticks and they are occasionally spotted during temporary thaws in the winter (Health.state.mn.us 2014). During the winter of 2013, Portland, Maine experienced close to 80 inches of snowfall, ten days of below-zero temperatures, and the coldest March in 50 years, but the tick population did not suffer at all. "The snow acts as a nice insulating blanket for ticks… [and] it would require about two weeks of extremely cold weather to have any impact

on the tick population" (Lawlor 2014). This vitality contributes greatly the success of Lyme disease in Northeastern and Midwestern regions due to the region's prevalent and cold winters.

Additional facts about the feeding process of Blacklegged ticks offer further insight into the way in which they transmit Lyme disease. Blacklegged ticks feed on blood by inserting their mouthparts into the skin of the host (Health.state.mn.us 2014). As previously mentioned, they are slow feeders and will feed for 3-5 days. If the tick is infected, it must be attached for 24-48 hours before it transmits Lyme disease (Health.state.mn.us 2014). This is why frequent tick checks and immediate removal upon discovery are recommended for preventing the spread of Lyme disease.

Relationship between Ticks and Deer

While ticks are known to feed on various hosts, two common hosts often linked to transmission of Lyme disease to humans are white-tailed deer (*Odocoileus viginianus*) and mice. White-tailed deer serve as the primary host for the adult blacklegged tick and as a result there is a strong correlation between deer density and Lyme disease incidence (Tickencounter.org 2014). Many notable studies have been completed in order to examine and analyze this correlation. One such study was performed in the Mumford Cove community located in Groton, Connecticut over a 13-year period. During that time, researchers surveyed 90-98% of all permanent residents of the community in order to document both human exposure to tick-related diseases and the number of tick observations. The table below (Figure 3) shows the results of these surveys over the course of study.

Year	Winter aerial surveys (km^2)	% residents observing deer daily	% residents reporting group size ≥ 4 deer	Nymphs (SEM)/100 m^2 lawn[a]	Nymphs (SEM)/100 m^2 woods[a]	% infected (n[b])	ERI[c] lawn	ERI[c] woods	Cases of Lyme disease/100 households
1995	54.5	80	59.3						NS
1996	39.8								13.1
1997	NS								14.1
1998	NS								28.8
1999	46.3	58	52.7						18.3
2000[d]	NS								16.3
2001[e]	NS	14		0.91 (0.26)	5.00 (1.22)	18.8 (16)	0.17	0.94	4.8
2002[f]	0			0.79 (0.17)	3.50 (0.81)	12.0 (25)	0.09	0.42	4.6
2003[f]	5.1			0.22 (0.07)	0.33 (0.23)	na	na	na	1.9
2004[f]	5.1			0.18 (0.06)	0.67 (0.36)	12.5 (8)	0.02	0.08	2.8
2005[f]	1.7	<1	16.5	0.35 (0.09)	0.44 (0.31)	11.1 (27)	0.04	0.05	2.8
2006[f]	9.8			0.04 (0.03)	0.50 (0.50)	na	na	na	3.1
2007[f]	6.5			0.54 (0.13)	2.75 (2.76)	10.0 (10)	0.05	0.28	5.2

[a] Nymphal densities are representative of adult tick abundance two years prior. Therefore, nymphal tick densities were compared with deer densities two years prior.
[b] Total number of ticks tested.
[c] Entomological risk index.
[d] Twenty-seven deer removed from two tracts of open space during November controlled hunt.
[e] Twenty-three deer removed from three tracts of open space during November controlled hunt.
[f] Archery hunters removed three to five deer per year.
NS, no survey; na, not available.

Figure 3: Mumford's Cove Lyme incidence data collection table (Kilpatrick, Labonte and Stafford III 2014)

Following initial data collection, an increase in deer hunting was initiated. After a notable reduction in deer density, results collected indicated that the number and frequency of deer observations in the community were greatly reduced, as were resident-reported cases of Lyme disease. By reducing deer density from 39.8-54.5 deer per square kilometer to an average 5.1 deer per square kilometer, there was a 76% reduction in tick abundance, a 70% reduction in the entomological risk index, and an 80% reduction in resident-reported cases of Lyme disease (Kilpatrick, Labonte and Stafford III 2014). The following graph (Figure 4) illustrates the correlation between Lyme disease and tick density over the course of the entire study.

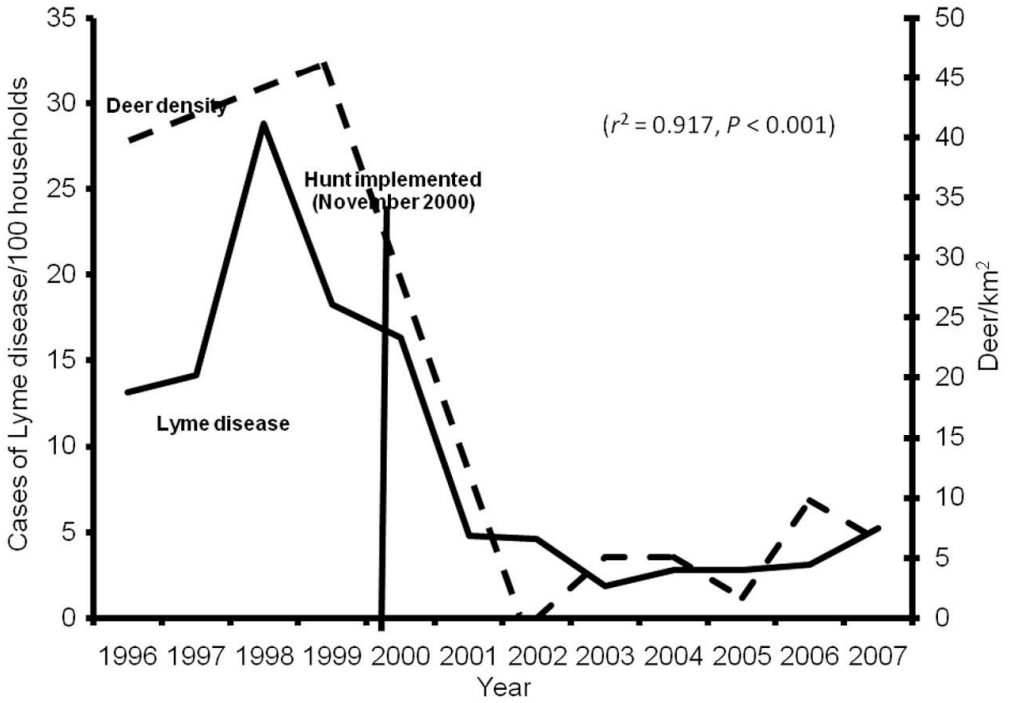

Figure 4: Graph of Lyme disease incidence versus deer density (Kilpatrick, Labonte and Stafford III 2014)

Similar results have been determined by studies conducted across the Northeast including Bridgeport, Connecticut, Great Island and Crane Beach in Massachusetts, and Monhegan Island in Maine (Kilpatrick, Labonte and Stafford III 2014). One instance where a decrease in deer population did not work was in Bernards Township, New Jersey. The deer population was decreased from approximately 118 deer per square mile to approximately 63 deer per square mile, but there was no effect on the local tick population. It is possible that this happened because the township is surrounded by "several other towns of similar ecology and human population with few impediments to deer movement", where the other subjects of similar tests were geographically isolated (Nantucket Tick-borne Disease Committee 2009).

Deer are so important to the blacklegged tick/Lyme disease system because they are the primary reproductive hosts in the system. In the study of vector-borne disease, hosts that provide the blood necessary resources for arthropod vectors to develop and reproduce are categorized as either reservoir hosts or reproductive hosts. Reservoir hosts contribute infectious pathogens along with their blood while reproductive hosts contribute blood but no pathogens. On average, the female adult blacklegged tick lays 1,500-2,000 eggs per year; this would not be possible without the proteins provided to the tick by the

white-tailed deer (Tickencounter.org 2014). A greater deer population is proportional to a greater blacklegged tick population, due to the larger number of reproductive hosts. According to Kilpatrick et al., "Deer serve as the primary tick host with greater than or equal to 90% of female *I. scapularis* feeding on deer...without sufficient deer available, tick populations can't be sustained or are sustained at much lower levels"(Kilpatrick, Labonte and Stafford III 2014). While a reduction in the number of white-tailed deer is necessary in order to decrease the incidence of Lyme disease in the human population, complete deer eradication is not necessary. Prior to the study conducted in Mumford Cove, Connecticut, it was suggested that deer populations needed to be reduced to < 3 deer per square kilometer to reduce zoonotic overflow of the disease to humans. However, the Mumford Cove study found that an average of 5.1 deer per square kilometer proved to be an effective and long-lasting reduction in Lyme disease cases in humans (Kilpatrick, Labonte and Stafford III 2014).

Due to the prominent relationship between ticks and deer, many methods to reduce Lyme disease infection in deer have been tested for viability. One such study occurred on Fire Island and Shelter Island, New York between 2008 and 2011. The objective of the study was to assess the efficacy of 4-poster devices on tick populations and Lyme disease rates. The 4-poster system works by rubbing rollers that apply an acaricide called Permetherin on the deer's head and neck by attracting deer by using corn (Cornell University College of Agriculture and Life Sciences 2011). These devices were deployed in up to 60 locations around Shelter Island, and up to 8 locations around western Fire Island. It was found that tick abundance at all 4-poster treatment sites in 2010 significantly decreased from 2008 levels, specifically in nymph populations. However, the 4-poster devices were difficult to maintain because the rollers often dried out between weekly applications of the acaricide. Also, the overall cost of the system was very high, due to the cost of maintenance, including applicator replacement, corn, and Permetherin. Each unit costs $425, and about $500 to $600 to maintain every year, and the system implemented on Fire and Shelter Islands cost about $1.2 million (Nardiello 2008). Further studies would also need to be done to assess the number of 4-poster devices needed in a certain area to affect tick populations significantly (Cornell University College of Agriculture and Life Sciences, 2011).

Relationship between Ticks and Mice

In ecological systems, there are two types of hosts for zoonotic diseases, reproductive hosts and reservoir hosts. Reservoir hosts contribute pathogens along with their blood. Reproductive hosts contribute only their blood. While deer act as reproductive hosts in the spread of Lyme disease, small rodents, especially mice and chipmunks, are key reservoir hosts. Immature ticks feeding on infected mice become infected and later pass that infection on to a larger host when they engage in a blood feeding (Tickencounter.org 2014). The study of mice in relation to Lyme disease is especially relevant when studying incidence of Lyme disease amongst humans who live near fragmented forests. According to the National Science Foundation fragmented forests have a lower biodiversity, and therefore are home to fewer predators (Nsf.gov 2014). In such an environment, mice reproduce heavily, and in turn both ticks and Lyme disease thrive. In order to address this problem, researchers have conducted various experiments to determine the best method for eliminating the mouse reservoir with varying degrees of success. In one experiment an oral bait vaccine was distributed to white-footed mice, causing the mice to create antibodies against Lyme disease. When ticks were allowed to feed on the mice with the antibodies, the *Borrelia* was killed and transmission of the disease was prevented (The Huffington Post 2014). While this technology is promising, a few issues stand in the way of any significant advances, such as funding the oral vaccine, delivering it to mice efficiently, and determining which areas have the most need for such a solution. Another promising experiment that is currently in progress involves the placement of bait boxes to reduce Lyme disease incidence. The bait boxes are set up like mazes and contain food to lure the mouse into the box. In order to retrieve the food, the mice have to walk through soft fabric wicks treated with Fipronil, the insecticide commonly used to kill ticks on pets (NewsTimes 2013). While these bait boxes have been on the market for years, the experiment previously described intends to take the next step and determine if the bait boxes can reduce the number of human cases of Lyme disease as opposed to only a reduction in overall tick number and the number of ticks infected with the Lyme bacteria (NewsTimes 2013). Issues associated with this approach are mainly related to the cost of bait boxes, their overall impact on human health, and methods for mandating their use among citizens if they are found to

have a positive impact. In general, attempts to control Lyme disease transmission to humans are less focused on the mouse population since it is so massive and methods of control tend to be very expensive and difficult to implement.

Another study that tested the relationship between fragmented forests, blacklegged ticks, and mice was conducted in Dutchess County, New York over the course of two years (Allan, Keesing and Ostfeld 2003). Researchers selected forest patches separated by at least 1.6 km that were dominated by either sugar or red maple trees. Nymphal and larval ticks were collected during known peak-activity periods of the respective life stages based on long-term monitoring in Dutchess County. They found that "in a highly fragmented landscape, the density of infected [blacklegged tick] nymphs was inversely proportionate to the forest patch areas", therefore the risk of Lyme disease is greater (Allan, Keesing and Ostfeld 2003). This is most likely caused by a loss of most vertebrate species, including potential predators, as a result of forest fragmentation except for the white-footed mouse, which is unaffected by this. Because the populations of white-footed mice are greater in these forest patches, the rates of black-legged ticks that carry Lyme disease is greater, thus posing a greater threat to humans who live in suburban areas. (Allan, Keesing and Ostfeld 2003).

Ticks and Humans

Humans are a common host for blacklegged ticks who carry Lyme disease. Ticks can attach to any part of the human body; however, they are most commonly found on areas of the body that emit the most heat, such as the groin, armpits, and scalp (Cdc.gov 2013). The majority of humans infected with Lyme disease are infected by nymphs (Cdc.gov 2013). This is because most adult ticks are large enough to be noticed before they have been attached long enough to transmit Lyme disease. Once a human is infected with Lyme disease, symptoms begin manifesting over the course of the three general stages. The first stage, known as the early localized stage, occurs 3-30 days post-tick bite. Symptoms that occur during this time period include fatigue, chills, fever, headache, muscle and joint aches, and swollen lymph nodes. Another common symptom is a red, expanding rash called erythema migrans (EM) or the "bulls-eye" rash, as seen in Figure 5 below. This rash appears at the site of the tick bite approximately 7 days

after the host is bitten, and occurs in approximately 70-80% of infected persons. The rash gradually expands over several days and in some cases can reach up to 12 inches in diameter. Parts of the rash have a tendency to clear as it enlarges, resembling a bulls-eye. Despite its appearance, the rash is rarely itchy or painful, but feels warm to the touch (Cdc.gov 2011).

Figure 5: Erythema migrans (EM) or "bulls-eye" rash (Cdc.gov 2011)

The next stage is the early disseminated stage, which occurs days to weeks after the host is bitten. This stage occurs most often when the infection goes untreated and spreads from the site of the bite to other parts of the body. This increases the possibility of a variety of symptoms including additional Erythema migrans lesions in other areas of the body, severe headaches and neck stiffness due to meningitis (inflammation of the spinal cord), pain and swelling in the large joints, shooting pains that may interfere with sleep, heart palpitations and dizziness due to changes in heartbeat, and facial or Bell's palsy (loss of muscle tone on one or both sides of the face) (Cdc.gov 2011).

The third stage is referred to as the late disseminated stage, which occurs several months to a year after the host has been bitten. According to the Centers for Disease Control, approximately 60% of patients with an untreated infection may begin to have intermittent bouts of arthritis, along with symptoms such as severe joint pain and swelling. Additionally, up to 5% of untreated patients may develop chronic neurological issues months to years after infection. These include shooting pains, numbness, or tingling in the hands or feet, and problems with short-term memory (Cdc.gov 2011).

Individuals who contract and are treated for Lyme disease and are still at risk of lingering symptoms after treatment, referred to as post-treatment Lyme disease syndrome (PTLDS). Approximately 10-20% of patients with Lyme disease have symptoms that last months to years after undergoing treatment with antibiotics. Symptoms include muscle and joint pains, cognitive defects, sleep disturbance, and fatigue. While the exact cause of PTLDS is not known, there is some evidence that it is caused by an autoimmune response, during which a person's immune system continues to respond to Lyme, doing damage to body tissue after the infection has been cleared (Cdc.gov 2011).

Lyme Disease Incidences on Island Communities

Past studies of Lyme disease incidence have isolated islands as an ideal ecosystem for the spread and transmission of the disease. One recent and relevant study examines the ways in which geography, deer populations, and host biodiversity shape the pattern of Lyme disease emergence in the Thousand Islands archipelago of Ontario, Canada. According to the authors, "Differences in host abundance, competence, and quality (lower quality hosts are more likely to groom off and kill ticks that attempt to feed) can affect the number of ticks, the prevalence of infection in ticks, and thus human risk. Hence, it has been hypothesized that high species richness, with the associated relatively lower abundance of more competent hosts and higher abundance of less competent and low-quality hosts, may lead to a decrease in human risk, as measured by the abundance of infected nymphal ticks" (Werden et al. 2014). Islands as ecosystems tend to lack species richness because the movement of species in and out of the ecosystem is more difficult than land-locked or coastal ecosystems.

Additionally, there have been connections made between humidity and the prevalence of disease-carrying ticks. In a study conducted in Rhode Island over the course of 14 years, it was determined that extended episodes of low humidity led to significant tick mortality after exposure times of eight hours or more (Berger et al. 2014). Islands tend to have high humidity levels, especially in warm seasons. This is another reason islands present a fascinating ecosystem in which to study Lyme disease incidence.

Although low humidity is directly correlated with tick mortality, prescribed burns, which theoretically eliminate humidity from the land, have little to no effect on black-legged tick populations.

Prescribed burns consist of applied and controlled fires to specific areas of land. Researchers conducted burns on plots of land located in both the Cockaponset State Forest in Chester, Connecticut and privately owned land in East Haddam, Connecticut (Stafford, Ward and Magnarelli 1998). All plots were 4 hectares in size, and each plot was burned with varying intensities ranging from light to moderate intensity, to severe intensity. After each burn, the abundance of ticks was determined twice per month for six months. Initially, 97% of all black-legged ticks were eliminated at all severe burn sites, and all plots maintained a low abundance of nymphal ticks during the summer, but the impact was temporary, judging by their presence at all four sites in the fall, as seen in Figure 6 (Stafford, Ward and Magnarelli 1998).

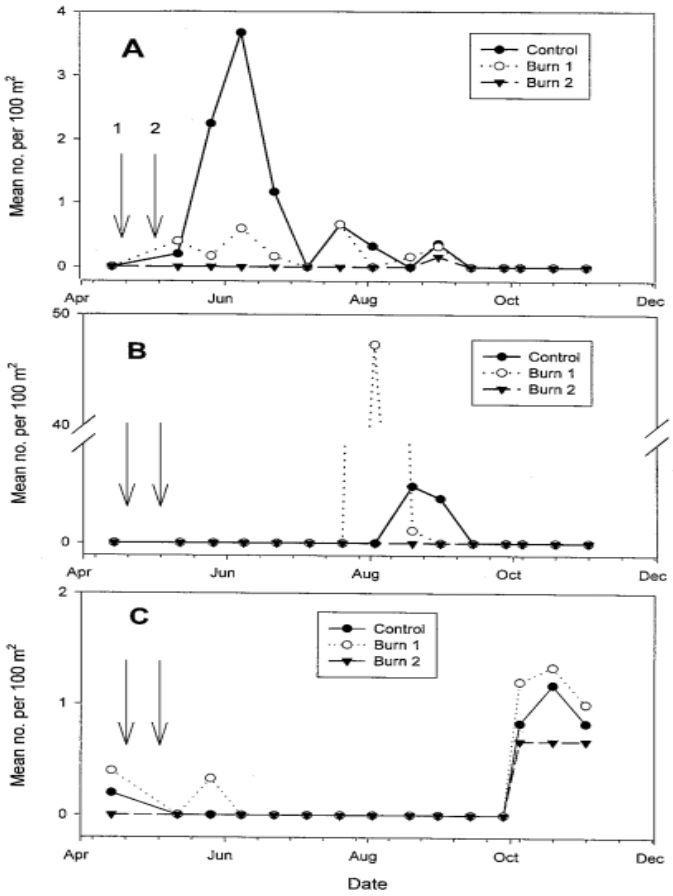

Figure 6: Mean number of I. scapularis collected per 100 square meters from April through November 1992 at the control and burn sites in Cockaponset State Forest. (A) Nymphs. (B) Larvae. (C) Adults (Stafford, Ward and Magnarelli 1998).

One additional factor that makes islands unique is the difficulty associated with hunting. The least complex and most cost-effective method of deer population control in the majority of communities is deer hunting. While hunting is permitted on the majority of islands where Lyme disease incidence is high,

social and logistical factors complicate the process, often leading to an overpopulation of white-tailed deer. Many islands serve as tourist destinations in summer and fall months, with year-round residents using those months to generate the revenue they need to keep the island functioning when tourist traffic slows in the winter and fall seasons. As a result, many island residents have concerns about the impact hunting will have on the tourist experience. Additionally, the majority of islands with a notable Lyme disease problem have wooded regions that are protected by public and private conservation societies. Hunting is often banned in these conservation areas, and as a result deer populations are allowed to thrive there, specifically impacting island-residents who live in close proximity to wooded regions.

Both in and out of the scope of island communities, host and reservoir competency and infection prevalence amongst certain species play an important role in understanding and preventing Lyme disease. Models have determined that the infection prevalence of nymphal ticks is dramatically reduced when the relative abundance of non-mouse hosts is increased (Ostfeld and Keesing 2000). The same model also showed that the diversity of hosts reduced disease risk as measured by the infection prevalence of nymphal ticks (Ostfeld and Keesing 2000). These results have been described by scientists as a "dilution effect." Any factor that decreases the number of white-footed mice relative to other potential hosts in the vertebrate community that are not as competent as the white-footed mouse would reduce the proportion of ticks infected with bacteria that causes Lyme disease (Ostfeld and Keesing 2000).

Nantucket

The island of Nantucket is located approximately 30 miles south of Cape Cod, Massachusetts. It is both a town and a county. According to the 2010 Census, the island is 45 square miles in size, and has a total population of 10,172 people, which makes it the least populated county in Massachusetts (Quickfacts.census.gov 2014). The island was first settled by the English in 1641, although the island had been the home of the native-American Wampanoag tribe prior to English settlement for quite some time. The population of the island increased significantly when the hunting of whales became more profitable to merchants, who sold the carcasses for oil. In fact, "from the mid-1700s to the late 1830s,

Nantucket was the indisputable "Whaling Capital of the World, with as many as 150 ships making port [there] during its peak" (Nantucket Island Chamber of Commerce 2014).

After the whaling era and the Civil War, Nantucket became a major tourist destination, as it remains to this day. In fact, according to the traveler's guide *Cape Cod, Martha's Vineyard and Nantucket: An Explorer's Guide*, the author states that, "With a daily summer population of 56,000, today's tourist industry is about as well-oiled as the whale industry once was" (Grant 2011). Despite the island's ability to sustain such a high population density, approximately 45% of the island's total acres are naturally preserved by organizations such as the Nantucket Conservation Foundation and the Massachusetts Audubon Society (Grant 2011). These protected lands include some of the most unique ecosystems in the world, and are home to many animal and bird populations, including the white-tailed deer. However, the white-tailed deer did not always inhabit the island of Nantucket.

The first deer to inhabit Nantucket was found swimming across Nantucket Sound in 1922. A fishing sloop found the buck, later nicknamed Old Buck, struggling in the water, brought it aboard their ship, and released it on the island. Soon after, two female deer were imported from Michigan to keep Old Buck company (Belluck 2009). Old Buck died in 1932, but his progeny comprise the large deer population that is found on Nantucket today. In the state of Massachusetts, there are 85,000 to 95,000 deer in total (Energy and Environmental Affairs 2014). There are approximately 2,500 deer on the island of Nantucket, for a density of 50 deer per square mile (Nantucket Tick-borne Disease Committee 2009). According to Figure 7, Nantucket and Martha's Vineyard have some of the densest deer populations in all of the Northeastern United States.

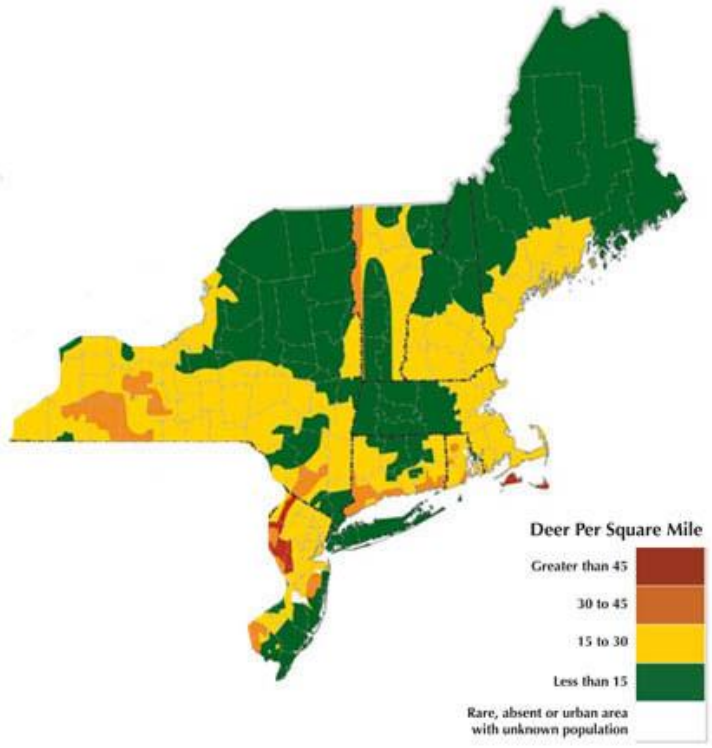

Figure 7: Deer Density in the Northeastern United States (Bodin 2014)

A second organism that is found in abundance on Nantucket is the blacklegged tick, which is known to thrive proportionally with deer populations. According to the Centers for Disease Control, Nantucket has consistently one of the highest rates of Lyme disease since 1992, and most experts state that this can be attributed to the excessively high deer population (Nantucket Tick-borne Disease Committee 2009). According to the Massachusetts Division of Fisheries and Wildlife, the ideal sustainable deer population for Nantucket is 6-8 deer per square mile, and this lower rate of population density would significantly decrease the human incidences of Lyme disease (Nantucket Tick-borne Disease Committee 2009).

Previous Projects About Lyme Disease on Nantucket

In 2010, a previous IQP group from WPI worked with the Nantucket Tick-borne Disease Committee to "develop a health-risk communication strategy which targets specific audiences through diverse communication channels" (Alfieri, Broberg and Kaiser 2010). Their communication strategy encompassed a variety of methods to reduce the number of people infected with tick-borne diseases on

the island. This IQP group first evaluated the variety of methods used for communicating health risks for diseases across the nation, such as campaigns to raise awareness of West-Nile Virus and seat belt safety, and compared these to the communications methods for health risks of Lyme disease used on Nantucket.

The group also assessed previous and current campaigns to educate the public about ticks and tick-borne diseases on the island by conducting interviews with key members of the Nantucket community. They used these interviews to assess opinions of efforts to curtail incidence of tick-borne diseases, specifically information about health communication and proposed methods for decreasing the deer population on the island.

Their third step was to gauge the level of existing knowledge and awareness of ticks and tick-borne diseases as well as disease prevention on Nantucket surveying students at Nantucket High School, and found that 44% of households on the island had reported cases of Lyme Disease, with a higher percentage for households with pets, and yet only 30% of the students took precautionary measures against tick bites.

The final product of this IQP was a comprehensive list of recommendations for "various possible health communication strategies" that this group presented to the Nantucket Tick-Borne Disease Committee to be implemented on the island (Alfieri, Broberg and Kaiser 2010). These recommendations included a comprehensive methodology for increasing awareness of health risks associated with ticks and Lyme disease, focusing on students enrolled in the Nantucket Public School system.

Citizen Science

When collecting data for research on a larger scale, scientists do not always have the means to observe all sources of relevant data due to its high volume and the available resources. In these situations, researchers often rely on passive surveillance, or the collection of data through submissions from individuals. Passive surveillance can be categorized under a broader term of data collection known as Citizen Science, also known as crowdsourced science, or participatory science. Citizen science is defined as "the public participation in organized research efforts" (Dickinson and Bonney 2012). With the increasing popularity of the internet, citizen science has evolved traditional research data collection into a

public participation effort that has allowed scientists to expand their research horizons with the assistance of amateur scientists who have similar interests, and wish to contribute their knowledge to something of a larger scale.

There are three main approaches to data collection for a Citizen Science project. They are contributory projects, collaborative projects, and co-created projects. Contributory projects are designed by scientists and implemented by participants, who collect, contribute, and sometimes analyze data. Collaborative projects are also designed by scientists, but allow for further amateur participation in more than one part of the process, such as detailed analyses of data and implementation of methods. Co-created projects involve the cooperation of participants and scientists for most, if not all, steps of the project (Tweddle et al. 2012).

The oldest and most notable example of Citizen Science is the Audubon Christmas Bird Count, which is a competition that has taken place every Christmas Day since 1900. The purpose of the bird count is to survey local bird populations all over the United States by counting the number of birds spotted in surveyors' local areas. More than one hundred years of data collection has contributed to "over two hundred scientific publications in fields like populations dynamics, species distribution, and community ecology" (Bowser and Shanley 2013). For example, researchers in California used the data from the Christmas Bird Count as well as one other Citizen Science data collection to assess the accuracy of population viability analysis (PVA) on the Peregrine Falcon population in California after changes in management actions, such as captive breeding. The researchers used the data from the CBC to determine that "PVA can quantitatively anticipate population trajectories following changes in management" (Wootton and Bell 2014).

In conjunction to scientific contributions, data from the annual Christmas bird count collected through the years has increased conservation efforts for various species of birds through increased awareness of environmental concerns. In 2011, researchers from the University of Kentucky used locally collected data from the Christmas Bird Count to determine a decline in Eastern bluebird populations in the Ohio River Valley Region. They found that this decline was a result of the birds' susceptibility to cold

winters and increased competition for nest boxes (Wetzel and Krupa 2013). Although the Christmas bird count is one of the longest and most successful citizen science projects, it is no longer an accurate representation of what this type of research represents.

With the prominence of the technology and the internet in today's society, one of the most common means of Citizen Science is through digital participation, including online games such as the protein folding puzzle that contributed to the study of HIV/AIDS, mobile apps to record data in real time, and informational websites that allow input and analysis of collected information (Tweddle et al. 2012). The ability to access the internet almost anywhere in the world, and its presence in virtually every location, from pockets to thermostats, in conjunction with the decrease in cost of transmission and storage of data has made the world-wide web one of the most valuable resources for the sharing, tracking and contributing information to research projects, especially those that incorporate amateur researchers (Clarke 2014). As a result, using the internet as a means of data collection has become one of the most cost-effective means of research, especially for scientists who do not have adequate funding.

Potential Partnerships

Nantucket Tick-Borne Disease Committee

The Nantucket Tick-borne Disease Committee was established in 2009 to assess the impact of tick-borne diseases on the island of Nantucket. The committee is comprised of a variety of individuals who are of the medical and political profession. Accurate statistics of Lyme disease contraction on Nantucket are hard to come by because the population of the island varies from season to season, and it is hard to determine whether the disease was contracted on the island or on the mainland, especially for tourists. However, the Centers for Disease Control has listed Nantucket among the top three Lyme disease counties since 1992 (Nantucket Tick-borne Disease Committee 2009).

In 2009, the committee published a comprehensive report of the disease and preventative measures for Nantucket County, which includes a variety of preventative and educational measures to decrease the number of people afflicted by tick-borne diseases. Some of these measures include decreasing the number of deer to 10 per square mile, vegetation management, the use of acaricides, implementation of a public education program, and development of a passive and active surveillance program to monitor progress (Nantucket Tick-borne Disease Committee 2009).

Nantucket Conservation Foundation

"The purpose of the Nantucket Conservation Foundation is to assist in the preservation of Nantucket's character by permanently conserving, maintaining, and managing natural areas and habitats and to encourage an appreciation of and interest in the Island's natural resources" (Nantucketconservation.org 2014). This organization currently owns 8,858 acres, close to ⅓ of Nantucket, divided up among 213 properties (Nantucketconservation.org 2014). In addition to owning these properties, the Conservation Society works to develop effective land management strategies in order to effectively protect the natural resources on their land. These stewardship projects include shorebird monitoring, controlled deer hunting, and trail restoration and native plant propagation (Nantucketconservation.org 2014).

In addition to stewardship projects, the Nantucket Conservation Foundation also "undertakes focused research, inventory, and monitoring projects aimed at providing increased understanding of the rare resources found on [their] properties." Many of these projects involve collecting information in the field with the help of field assistants and volunteers (Nantucketconservation.org 2014).

The Nantucket Conservation Foundation has dedicated an entire page of their website to tick awareness, due to the increasing risk of infection on the island. The page entails details on ticks and tick-borne diseases, such as prevention methods, tick removal procedures, early indications of Lyme disease, symptoms of advanced stages of the disease, and diagnoses and treatment (Nantucketconservation.org 2014). The information, though basic, provides enough information for a visitor of the organization's properties to take precautionary measures and be aware of the potential threat.

Methods

After conducting extensive background research relating to the topics of Lyme disease, ticks, and Nantucket Island, we worked to identify a specific need for Lyme disease awareness on Nantucket. During B-term, our Interactive Project team had the pleasure of conversing with Mr. Jim Lentowski, the head of the Nantucket Conservation Foundation. In our conversation with Mr. Lentowski, we outlined the methods we had completed and discussed the prospect of working with the Nantucket Conservation Foundation in order to complete our intended methods. At that time, we had created a survey to be distributed to residents in order to determine their level of exposure to ticks, Lyme disease transmission, Lyme disease prevention, and education materials. We intended to use the data collected with this survey to map areas of Nantucket with the highest concentration of reported incidences of ticks and Lyme disease and create a database that could be utilized to actively track Lyme on the island. Our ultimate goal was to implement this database directly onto the webpage that the Nantucket Conservation Foundation maintains on Lyme disease after updating the information on this page.

Over the course of our conversation, Mr. Lentowski highlighted flaws in our methods to help us consider a novel approach to reducing disease incidence on the island. Mr. Lentowski discussed with us the fact that our survey likely wouldn't be effective, as most questions could only be answered by people who had an active knowledge of Lyme disease and were actively tracking ticks in their household. These people are likely the people who are most informed, and are therefore least likely to need information on preventing Lyme disease. Mr. Lentowski described what he called "complacency" among residents of the island, stating that most residents view contracting Lyme disease as an "occupational hazard" of living on the island. Therefore he felt we should shift our focus to preventing Lyme disease amongst visitors to Nantucket Island. Visitors to the island are a susceptible population for a variety of reasons. The majority of visitors to the island do not hail from areas with high rates of Lyme disease, meaning they are usually unaware of methods for preventing Lyme disease. Most visitors coming to the island are coming for vacation, and tend to be less receptive to public awareness campaigns. Additionally, since Nantucket's economy depends on a high volume of tourists in the summer season, scare tactics must be avoided in the

creation of public awareness methods. Lastly, tourists who contract Lyme disease on Nantucket often don't experience manifestation of their symptoms until they have traveled back home, and often present their symptoms to doctors who have little exposure to, and understanding of, the symptoms of the disease.

In addition to targeting tourists as a demographic, Mr. Lentowski also described a sizeable population of non-English speaking migrant workers who populate the island for agricultural and hospitality purposes. He informed us that attempts have been made to increase awareness among this demographic by translating educational materials into the native languages of these workers.

Mr. Lentowski described some public awareness campaigns that have been implemented in the past, which ultimately failed to be effective. These methods included distributed brochures and pamphlets, newspaper advertisements, public awareness in the form of a tick mascot on the ferry bringing visitors to the island, and signage in heavily wooded areas with high tick density. He was very quick to discount these methods as entirely ineffective; however, our team believes that by modifying these methods, creating novel methods, and targeting the correct demographics in the correct ways, a successful public awareness campaign is possible.

Public awareness campaigns (PSAs) have demonstrated high effectiveness rates in isolated incidences; however, there are a large number of common pitfalls that lead to their ineffectiveness. According to Bill Goodwill, CEO of Goodwill Communications, Inc.,"bad PSAs are those that reflect poor planning and execution. Promoting an issue that is not important, a subject that is irrelevant to mainstream Americans, or an issue that is too controversial for the media to use... Bad PSAs fail to recognize that PSAs are not going to change the world; they are but a single arrow in a quiver full of communications tools" (Goodwill 2014). Ruth Wooden, the president of The Advertising Council, New York and Washington, has released similar statements, stating "PSAs falter for a number of reasons: lack of impact, relevance, courage or clarity, from wallowing in the problem rather than steering the public toward a solution and, of course, too little media. Many falter because they address situations where advertising and the individual choices it affects can't make much difference" (Wooden 1994). Wooden goes on to advise that effective public awareness campaigns are "focused, sharp, lively, and applied for

the long pull" (Wooden 1994). Our challenge, based on the above information, is to create exactly the kind of public awareness campaign that Wooden described. In order to make our campaign focused, sharp, lively, and applicable for the future of Nantucket, we will begin our campaign with background research in the form of a survey.

The primary purpose of surveying prior to a public service campaign is to gain demographic and knowledge-level information about the people that are to be educated. "Perhaps the single most important… task that should be completed is pre-campaign research. Campaign planner need to learn all they can about three fundamental factors: the problem or behavior that is being addressed via the campaign; the demographics (age, sex, race) and psychographics (lifestyle) of the primary target audience; and finally, what needs to be in the creative message to generate the desired action" (Goodwill 2014). Within the context of this Interactive Project, we have learned about the problem, and now need to focus the rest of our project on determining the other two factors. Similar studies to our project have been done, and these studies have produced surveys that can serve as a strong foundation for the survey we would like to create. One particular research project examined Lyme disease awareness and was conducted in Europe. The researchers developed a self-administered questionnaire because initial studies determined that "interview-based questionnaires did not yield more meaningful results, were expensive to carry out and were also severely limited by their achievable sample size" (Gray, Granstrom, Cimmino, et al. 2014). Knowledge questions were scored numerically with a mark of 10 if correct, zero if incorrect, and the overall score was expressed as a percentage. The researchers then determined four selected groups that they used to track awareness. From their particular data, the researchers in this study where able to determine where the highest and lowest levels of awareness occurred and that differences in levels of awareness were primarily due to media coverage of the topic in the various countries where the survey was distributed. As previously stated, the survey generated inquired about both demographic and knowledge-level information, in order to get more useful data. Demographic questions included: country and locality of residence, age, and gender. Knowledge-level questions included:

Have you ever heard of a tick?

What do ticks eat?

How long do ticks feed for?

Do ticks feed on humans?

[If answered to "yes" to question above] How do ticks get onto humans?

Would you remove a tick attached to the skin?

Have you heard of Lyme disease? [If answer "no", do not continue]

Did you know that ticks transmit Lyme disease?

What is the most typical early symptom of Lyme disease?

Can Lyme disease be treated (or prevented) by…[list of potential treatments]

Where did you hear about Lyme disease?

Does Lyme disease occur in this country?

(Gray, Granstrom, Cimmino, et al., 2014)

By creating and implementing a survey similar to the one above, it is our intent to survey the residents and visitors of Nantucket. Utilizing the information for the survey above, the researchers in the study were able to create and effectively distribute and education pamphlet that "markedly increased awareness" in demographic groups that scored poorly on the survey initially (Gray, Granstrom, Cimmino, et al. 2014). It is focus of this campaign that makes it unique and a solid model for our research on Nantucket Island.

In addition to extensive examination of the methods of the survey discussed above, the IQP team conducted research relating to the scientific principles of survey methodology. Many survey methodologists trace the origins of modern survey research to Charles Booth, who produced a landmark study titled Life and Labor of the People of London, which he conducted between the years of 1889 and 1903 (Groves, et al. 2004). According to experts, "a prominent early reason for surveys was to gain understanding of a social problem" (Groves, et al. 2004). The science of survey methodology "seeks to identify principles about the design, collection, processing, and analysis of surveys that are linked to the

cost and quality of survey estimates" (Groves, et al. 2004). Due to the fact that human beings nearly always involved in survey-taking, as either interviewers or respondents, a variety of principles from the social science disciplines apply to surveys. In this way, survey methodology is an interdisciplinary science (Groves, et al. 2004). When selecting an audience to survey, investigators begin by identifying a frame population, which is the set of target population members that have a chance of being selected into the survey sample. In simple cases, the "sampling frame" is a list of all unit (e.g., people, employers) in the target population. A sample is then selected from the sampling frame. This sample is the group from which measurements will be sought. In our case, this sample is tourists to Nantucket Island. In most surveys, the attempt to measure the selected sample is not entirely successful due to non-respondents, therefore those successfully measured are commonly called "respondents" (Groves, et al. 2004).

According to survey methodologists, "the [survey] design steps...typically have a very predictable sequence" (Groves, et al. 2004). A survey moves from the design stage to the execution stage. Without a good design, there will be a lack of good survey statistics. "As the focus moves from the design to execution, the nature of work moves from the abstract to the concrete. Survey results then depend on the inference back to the abstract from the concrete" (Groves, et al. 2004). First the objectives of the survey are established. This helps make two decisions, one regarding the sample and another regarding the process for measurement. Next is the decision on the mode of data collection, which is an important determinant of how the measurement instrument (the survey) is shaped. Following creation of the survey, it needs to be pretested before it can be used to collect survey data. In summary, the choice of sampling frame, when combined with a sample design, produces the realized sample for the survey. Additionally, the measurement instrument and the sample come together during a data collection phase, during which attention is paid to obtaining complete measurement of the sample. Following data collection, the data is edited and coded. "Coding" is the process of translating nonnumeric material into numeric data for the purpose of analysis. The data file often undergoes some post-survey adjustments, mainly for coverage and errors related to nonresponses. These adjustments finalize and define the data used in the estimation and

final analysis step, which forms the statistical basis of the inference back to the target population (Groves, et al. 2004).

The other important component of survey methodology relevant to this project relates to respondents, the process by which they answer survey questions, avoiding misinterpretation that would confound data, and creating questions that will maximize the probability of getting useful data. Researchers have attempted to follow the mental process set in motion by survey question. The majority of the resulting models include four groups processes: "comprehension" (in which respondents interpret the questions), "retrieval" (in which respondents recall the information they need to answer the question), "judgement" (in which they combine or summarize the information they recall), and "reporting" in which they formulation their response and put it in the required format) (Groves, et al. 2004). In order to prevent the disruption of this process via question misinterpretation, it is recommended to avoid grammatical ambiguity, excessive complexity, faulty presupposition (the question assumes something that is not true), vague concepts and qualifiers, unfamiliar terms, and false inference (Groves, et al. 2004). Prominent survey methodologists Sudman and Bradburn give recommendations to avoid misinterpretation for the three most prominent types of survey questions. In our survey, we utilize non-sensitive questions about behavior and attitude questions. Recommendations for non-sensitive questions about behavior include (Groves, et al. 2004):

- With closed question, include all reasonable possibilities as response options.
- Make the questions as specific as possible.
- Use colloquial words.

Recommendations for attitude questions include (Groves, et al. 2004):

- Specifying the attitude clearly.
- Measure the strength of the attitude.
- When asking general and specific questions about a topic, ask the general questions first.
- When asking questions about multiple items, start with the least popular one.

There are also suggestions for creating a survey of self-administered questions (Groves, et al. 2004):

- Place directions where they are to be used and where they can be seen.
- Present information that needs to be used together in the same location.
- Ask one question at a time.

The survey created by our IQP team is intended to survey the residents of Nantucket Island for demographics, knowledge, and favored method of consuming public health awareness information in a concise and user-friendly format. Our survey was created using the online survey software Qualtrics. Qualtrics assists in the generation of quality surveys, offering multiple question formats for gathering data and allowing for flexibility in aesthetic qualities, privacy, and distribution options. Additionally, the Qualtrics software contains sophisticated features for survey response tracking and data analysis in the form of relevant statistics, graphs, and tables. After a survey has been created on Qualtrics, it is assigned a unique URL that can be distributed to potential survey participants and utilized on a PC or mobile device. All responses to the survey are taken and recorded electronically online. The copy of the survey, including the survey skip and display logic, has been included in the appendix of this paper. The initial survey questions are intended to collect demographic information relating to location of residence and level of education. Since the goal of the project is to create targeted educational materials for populations most susceptible lack of awareness relating to Lyme disease, these questions are intended to assist us in targeting the specific demographic that would benefit from our materials and determining at which literary levels these materials should be created. The knowledge assessment portion of the survey is divided into two pieces, tick knowledge and Lyme disease knowledge. Tick knowledge questions are intended to determine how effectively visitors to Nantucket can distinguish a tick from other insects, identify the preferred physical location and diet of the tick, recognize the correlation between the presence of ticks with that of white-tailed deer and white-footed mice, and recognize that ticks do spread disease. Lyme disease knowledge questions are intended to determine how effectively visitors to Nantucket can recognize the correlation between ticks and Lyme disease, identify the species of tick that spreads Lyme disease, recognize the initial symptoms of Lyme disease, evaluate the long term symptoms of Lyme disease, and recognize the proper way to remove a tick following a bite. All of these knowledge questions

are directly related to common misconceptions about ticks and Lyme disease and information that must be understood by the general public in order to reduce the incidence of Lyme disease. The final section of the survey relates to the way people currently look for information on public health issues and the way people would be most interested in getting information relating to public health awareness in the future. The IQP team identified that one major barrier to an effective public health campaign is utilizing an unpopular and ineffective method of information dispersion. As a result, the final questions were added to assist us in identifying popular and effective methods of dispersing information.

While the results of the survey will ultimately determine which method we recommend for increasing public awareness of Lyme disease amongst visitors to Nantucket Island, we are very interested in the use of cell phone apps to track the incidence of Lyme disease on the island and off the island after visitors leave, and provide up-to-date Lyme disease awareness and information via push notifications. Other novel ideas include interactive and family-friendly community information sessions on Lyme disease, the creation of a commercial that could be aired on local television, ensuring it reaches residents in their homes and tourists in restaurants and public areas with televisions, the improvement of current public awareness pamphlets and signage to make it more appealing and effective, the creation of awareness day, and the establishment of a Lyme disease awareness month. A successful awareness day was hosted at the University of Rhode Island in 2007 (Daley 2007). The state of Maryland has declared each May Tick-borne Disease Awareness Month (DHMH.maryland.gov 2014). Both campaigns exhibited impressive effectiveness in raising public awareness.

After our IQP team created the survey, we determined that the most effective way to distribute it would be to utilize a unique QR code, and a shortened hyperlink. Although our survey was online, the target audience was not, and we wanted to distribute our survey through physical materials such as posters and handouts. We needed a way to bridge the gap between real-world people and a digital interface. This process is called “hard linking”, and is not uncommon in today’s marketing and publicity fields (Pupa 2012).

Quick response codes, or QR codes are similar to barcodes, except it has the ability to handle more information due to the number of characters in the code. It also requires a tenth of the space to convey this information, while also maintaining a high error-correction capacity, and can be read in any direction (Schumack 2013). QR codes regularly appear in advertisements and online, and can be used to convey many types of information, whether it be supplementary materials for a reader to access more information on a subject, or a coupon in an advertisement; however, they are most commonly used to direct a user to a website, or to display plain text on a mobile device (Schumack 2013).

QR codes are relatively simple to implement in advertising campaigns. All that is required for the process is the information you'd like to convey or the hyperlink you'd like people to visit. Various websites can be used to translate this information into a QR code. Some of these sites include qrstuff.com and the-qr-generator.com, which is what we used to make our code. The code is generated in the form of a digital image, which can be resized and replicated as needed; however, not all QR code generators are the same. In order to compete with the numerous free services on the internet, different companies market their QR codes as more customizable, and able to support more sources of information. In order to make these codes more attractive to consumers and users, some websites will allow different shapes, such as faces, logos, and words, to be integrated into the code's design. Other sites will integrate the code itself into a colorful image, such as the shape of a continent, or symbol and allow for makers to track the use and popularity of the code based on the number of scans (Castellano 2015). These code design techniques enable a poster or advertisement to really attract users, and increase the chance of use.

Although some say that QR codes are the best tool to integrate digital information into physical advertisements and marketing campaigns, they also have some disadvantages. One of the major disadvantages to QR codes is that, although they are almost exclusively used on mobile platforms such as phones and tablets, no mobile platform (iPhone, Android or Windows) includes a QR code scanner on the phone. Instead, consumers must download one of many independently developed code scanners (Savitz 2012). These scanners are almost always ridden with advertisements, which can make the code scanning experience all the more undesirable. Another aspect of QR codes that repels consumers is the destination

of the code. More often than not, companies will forget to create a mobile site that is compatible with mobile browsers, which can lead to unattractive web pages, and the loss of consumers (Savitz 2012).

For our QR code, we ensured that the survey generator that we used supported both desktops and mobile browsing. Although we did not change the color or the design of our code, we did this to make the code and the poster or handout that it would be placed polished and more professional in order to attract the general tourist on Nantucket Island.

To increase our survey participation, we decided to include two ways that people could access our code, in order to account for those who may not want or have a QR code reader on their mobile device. In conjunction to a QR code, we included a shortened URL. URL shortening is a technique by which a URL, or a link to a page, is associated with a smaller redirect link that is easier to transmit through social media, email, and online advertisements.

URL shorteners are often used as a way of decreasing the character length of a URL to make these links more appealing on social media. Most popularly used on Twitter due to the 140 character limit per tweet, these services allow users and advertisers to communicate more information in less space. Some of the most popular URL shortening services are Google's goo.gl, bit.ly, and tinyurl. Not only are URL shorteners appealing for their size, but they also allow for a cleaner, more professional way of conveying website information. Although this service is now widely used around the world, it can pose as a security threat to some users. Because URL shortening services do not allow consumers to see the destination of the link, spammers can use these services to draw unsuspecting customers to sites that contain malware or phishing scams. In April of 2010, 18% of all spam emails used shortened URLs to disguise the true destinations of included links (Weafer 2010).

With the idea of a potential threat lingering in the minds of consumers, we decided to use a URL shortening service called tinyarrows.com, which allows consumers to see the destination link before they visit the page. When a link from this service is clicked on, users are directed to an intermediary page that displays this information, and allows them to decide whether they want to continue. If they do not close the page when they see the destination URL, they will be directed to it. This allows for people to be more

informed about where the shortened URL is taking them. Tinyarrows.com also allowed us to customize our shortened URL. Traditionally shortened URLs are a string of characters that is hard to remember and hard to type. Our shortened URL, ta.gd/lymesurvey, is much easier to type into a mobile browser, and also shows the intention of the link, to reassure potential survey-takers that it is not malicious.

Although the QR code and shortened hyperlink were the primary ways of communicating our survey link to consumers, we decided to tie both these resources together by putting them on a poster in order to spearhead our public awareness campaign. We gained inspiration for our poster by looking at the posters used for other public health awareness campaigns. All the posters we looked consistently had four key elements: a catchy phrase, a few tips for how to decrease your chance of being bitten by a tick, and occasionally sources to find more information. Some of the posters that we looked at include a poster for tick awareness published by Porcupine Health Clinic in Ontario, Canada. The poster, Figure 8, is part of a public health awareness campaign targeting Lyme disease in Ontario. The poster lists ways to prevent tick bites, such as wearing repellant, as well as the name of the campaign sponsored by the Ministry of Health and Long-term Care, "Let's Target Lyme!" Porcupinehu.on.ca 2015).

Figure 8: A public awareness poster from the Porcupine Health Clinic (Porcupinehu.on.ca 2015)

We wanted our poster to alert people of the prevalence of ticks that carry Lyme disease on the island, as well as the best ways of preventing the spread of this disease, without scaring tourists away. We used a catchphrase to capture the attention of viewers, and to increase curiosity about our awareness campaign. The catchphrase we used was, "Don't let Lyme disease be your Nantucket Souvenir!" The poster also had a pad of detachable handouts, with links to credible sites such as the Centers for Disease Control where they can find more information about Lyme disease and prevention, as well as the QR code and shortened URL so they can take our survey at a time that is more convenient to them. These links are also found at the end of the survey for people who are seeking more information about ticks and Lyme disease prevention (Appendix figure C). In order to expand our potential awareness campaign from Nantucket, we also created a second poster to target visitors to New England. Because our survey was compatible with to both areas, we did not have to change our survey (Appendix figure D).

Results

Due to the time constraints of the IQP project, the seasonal timing, and accommodations that needed to be made as the goals and methods of our project changed, we were not able to distribute our survey and collect data to present in this report. However, due to our extensive background research and the care with which we created our survey and public information poster, we can make predictions relating to reception of our poster and survey and the results of our survey.

By creating an aesthetically pleasing poster that includes an original and location-specific slogan, we greatly increased the likelihood that visitors to Nantucket Island will take the time to view our poster. In addition, by utilizing detachable paper slips on the poster with information guiding people to our Qualtrics survey, we have increased the likelihood that people will complete the survey. By allowing people to take this information with them, we are giving them the opportunity to fill out our survey on their time and in an environment in which they are comfortable, which will also likely improve the quality of our data.

Despite the excellent execution of our poster and survey, it is very likely that we would encounter challenges if we went forward with data collection for this project. Most visitors to Nantucket Island in the summer months are vacationing, and may be unwilling to take the time to complete a survey while on vacation. There is the potential that our posters could be removed by island natives who do not wish to draw attention to the issue of Lyme disease on the island to a lucrative tourist population. In order to minimize costs, our poster is currently printed on a standard cardstock paper, which would not hold up well if placed outdoors. This is an issue due to the fact that we could likely get excellent data from tourists visiting conservation areas and trails on the island, as these visitors are likely to be savvier to environmental issues like Lyme disease. Additionally, each of our posters is equipped with 50 detachable pieces of paper containing the information for accessing our survey. In order to keep people engaged and provide them with the information they need, it will be important that all posters are routinely checked and more detachable notes are attached should the need arise. Also of important note is the issue of

people taking a detachable sheet and never completing the survey. While this is potentially wasted printing cost, the detachable sheets are cost effective enough that this loss should be negligible.

If printed at the printing services department at Worcester Polytechnic Institute, the total cost of one poster with handouts is $5.The poster itself is $2, and one pad of 50 handouts is $3, including the cost of cutting, gluing, and attaching cardboard and double-sided sticky tape to the back. If we were to place these posters in areas such as the Nantucket Airport, Steamship Authority terminal, and downtown Nantucket, we would increase tourist visibility while also ensuring that the posters do not get ruined by natural elements. If we were to place 20 posters at both the airport and ferry terminal, as well as 10 posters around the city, we project that the printing costs of this campaign would cost $250.

Based on our knowledge of the prominence of Lyme disease around the country and current general trends in public knowledge relating to the disease, we can also predict the results we would gather from the survey if it were distributed. We predict that the majority of visitors to Nantucket will reside in New England, with a large number also residing somewhere along the East Coast. We predict there will be some visitors from other regions of the United States or other countries in the world; however, the number of visitors of this demographic will likely be quite small compared to the demographics from the Northeast and from New England. Breaking down these two specific demographics further, it is likely that a large number of tourists will be from developed areas with higher median incomes, including New York City, NY; Philadelphia, PA; Boston, MA; Providence, RI; Hartford, CT; and Portland, Maine. Since these areas do tend to be more developed and offer citizens less access to areas where Lyme disease would be easily contracted, it is a reasonable hypothesis that they will have less knowledge on the basics of Lyme disease than people who live in the same states in more rural areas.

Due to the high cost of being a tourist on Nantucket, the island generally attracts visitors who have completed at least a Bachelor's degree, and usually some sort of Masters, PhD, or professional degree.

We estimate that people will have the least issues answering the following questions:

Are you familiar with ticks? (Yes/No)

Do ticks spread disease? (Yes/No)

Lyme disease is directly transmitted from the bite of a tick (True/False)

These questions encompass the extreme fundamentals of knowledge relating to ticks and Lyme disease. By answering these questions correctly, an individual indicates that he or she understands the principle of the disease, which is that ticks exist, they spread disease, and one of those diseases is referred to as Lyme disease.

We estimate that people will have the most issues answering the following questions:

Select the tick (Photos provided)

What species of tick spreads Lyme disease (Multiple choices provided)

Check ALL of the initial symptoms of Lyme disease (Multiple choices provided)

Lyme disease is incurable (True/False)

These questions encompass a colloquially advanced understanding of ticks in particular, requiring that individuals be able to distinguish a tick from a lineup of similar insects and know the scientific name for the deer tick. A subject who correctly answers false to the statement "Lyme disease is incurable" likely has an understanding that Lyme disease treatment is available if the disease is caught in its early stages, which is crucial for limiting the impacts of the disease should an individual be bitten by an infected tick.

In response to survey inquires about where subjects currently look for information about public health issues, we anticipate the majority will respond that they seek information from their doctors, reference sources on the internet, pamphlets and handouts, the newspaper. These sources of information will likely have high rates of usage due to the fact that they tend to be accurate, non-biased, clinical, and readily available to the majority of visitors to Nantucket Island. Other possible responses, including social media sources on the internet and the televised news will likely be less popular due to the fact that social

media can contain inaccurate data and resources and information and the televised news tends to either exaggerate or trivialize public health information for the sake of creating better media.

In response to the survey question asking subjects to select the most effective format for a public awareness campaign on a health issue, we anticipate that the majority of people will select a cell phone app for information and tracking, social media (Facebook, Twitter, etc.), and television. While we understand that these are not currently likely the way people consume information relating to public health issues, they are three of the most commonly consumed forms of media in the United States today, and therefore will likely be popular choice. In order for an app to be effective it would require a smooth interface, privacy for users, and a wealth of information available quickly. Additionally, the use of push alerts to remind people to check the app for new information or to inform them that they are in an area with a high density of ticks would likely keep people engaged in an app for an extended period of time post download. In order for a social media public awareness campaign to be effective, it would be necessary that posts were engaging, relevant, and coming from a source that people trusted for reliability. This suggests that an effective social media public health campaign would be most effective if conducted by a national or state organization focused on public health, such as the Centers for Disease Control (CDC). A television public health campaign would be most effective if it were delivered by a source that people viewed as non-biased and non-sensationalized media. While the issue of finding such a network is a potential issue, further consideration calls for consideration of creation of a local or national television channel that serves the purpose of providing objective and accurate information on important health issues via easily consumed and family friendly programming.

Based on these hypothetical results, we would make two recommendations to the leadership of the Nantucket Island. First, that educational materials produced by the IQP team containing commonly unknown or misunderstood information (according to the results of our survey) about ticks and Lyme disease be distributed to tourists and visitors to Nantucket Island. Second, that production of a mobile application for providing information via push notifications and tracking the incidence of Lyme disease around the island should be developed. Additional recommendations, depending on the results of the

survey, would be creation of a social media public health campaign by an organization with a prominent impact and presence on the island and dedicating some television airtime on the island to objective and informative discussions about Lyme disease.

In working on this project, the current IQP team has established an excellent foundation for the continuation of this project by another IQP team. It is the recommendation of this team that a future team take on the responsibility of placing our posters around the island the collecting survey data. While this project could be completed by an on-campus IQP team in the E term, it would also be an excellent project for future students visiting the WPI Nantucket project center. Since the posters will likely need consistent check-ins to ensure that they are in good condition and properly equipped with detachable notes, having a team located on the island during data collection would be advantageous. In addition, a team located on the island could complete some of their survey taking on the island as tourists entered via the ferry or the airport. This could likely ensure that the team would have more data to work with, as there is a much higher likelihood of people completing a survey when they are surveyed in person and required only to answer the questions, as opposed to seeking out and taking the survey on their own initiative and answering the questions themselves. This project would be an excellent project for students looking to complete their IQP over E term, as that is peak season for visitors to Nantucket Island. Following data collection, another IQP team could work on making recommendations to the leadership of Nantucket Island for combating the issue of Lyme disease, and putting some of those recommendations into place. Examples of effective projects would include creation of a mobile application, development of sample materials that Nantucket Island officials could utilize to run a successful social media public health campaign, and analysis of the feasibility of raising Lyme disease awareness amongst tourists via local television or radio.

Conclusion

Island communities that have isolated deer populations have higher rates of Lyme disease; however, it is easier to decrease the deer populations, thereby reducing these rates over time. Lyme disease is transmitted by the Ixodes scapularis, or the black-legged tick, which uses white-tailed deer and white-footed mice populations as reproductive and reservoir hosts, respectively. By researching Lyme disease and blacklegged ticks, in conjunction with interviewing members of the Nantucket community, we assessed the need for a new public awareness campaign directed at tourists to increase awareness and prevention of tick bites. In order to fully assess the rates of public awareness, we made a survey that will be distributed via QR code and shortened URL link on posters. The survey will assess the knowledge of ticks and Lyme disease of tourists that frequent the island of Nantucket.

The project completed by the current IQP team holds excellent potential for data analysis and implementation of practical solutions to the issue of Lyme disease on Nantucket Island. As a result, the current IQP team suggests that this project be continued by another team in the future. In conducting data collection and analysis, a future IQP team has the unique opportunity to provide Nantucket Island with the specific data they need to effectively reduce the incidence of Lyme disease amongst visitors to the island. This has the potential to positively impact global public health, as visitors to Nantucket are both domestic and international citizens.

In completing of a project of this scope, the IQP team encountered and overcame challenges, which we would like to discuss for the benefit of future project teams looking to take on an issue and project of a similar nature. The first suggestion of the team is to make finding a sponsor and/or contact the first priority of the project. After the establishment of this relationship, an interview should be conducted to determine the specific need of the sponsor or contact. This prevents the team from wasting time determining a need and drafting a methodology that turns out to not be useful to the sponsor. Our team experienced this, as we determined that the prominent need would be addressing and reducing the incidence of Lyme disease amongst year-long Nantucket Island residents and creating a survey targeted towards that particular demographic. However, after interviewing the director of the Nantucket

Conservation Foundation, Mr. Jim Lentowski, we shifted our need to targeting the demographic of tourists to the island, and made major adjustments to our survey as a result. While this was a positive change as it helped make our project more relevant and useful to the leadership of the island of Nantucket, the time spent identifying a need and methodology prior to establishing a contact was time that could have been spent completing additional components of the project.

Another challenge encountered by the current IQP team related to seasonality. This project commenced in late August, just as tourist season was winding down on Nantucket Island. Since the first term of project completion (late August-late October) was primarily dedicated to background research, the team lost the opportunity to travel to the island, interview and survey tourists, and examine current methods of Lyme disease awareness. Survey completion occurred in the second and third terms of project completion (early November-late January). As a result, by the time the survey was complete, there were very few tourists to Nantucket Island and the ticks were dormant due to harsh winter conditions and their cyclic lifecycle. In order to avoid these issues in the future, the current IQP team recommends that a continuation of this project, focused primarily on data collection and analysis, occur during peak tourist and tick season on Nantucket. These times include late D term, the entirety of E term, and early A-term. Ideally, the continuation of this project should be completed as an E term off-campus IQP opportunity.

A related challenge was the current IQP team's lack of proximity to Nantucket Island. Traveling to the island is an expense in the context of both time and funds, and as a result the IQP team was never able to visit Nantucket, interview officials and leaders, and observe tourist populations and current methods of Lyme disease awareness. Additionally, had this team been able to display the posters we created on Nantucket Island, we would have faced an issue checking on their condition and keeping them stocked with detachable paper slips detailing the link to our survey. As a result, the current IQP team suggests that the continuation of this project be completed on Nantucket Island, or that the group that takes on data collection and analysis appeals to the IGSD for a budget to cover multiple trips to the island to survey tourists and check the condition of displayed posters.

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Appendix

A. Interview highlights with Mr. Jim Lentowski (11/24/14)

Crystal: So our project for our IQP is to assess the need for different techniques of... so we'd like to create a database on the Nantucket Conservation Foundation website to keep track of ticks at different location on the property. It's almost like a citizen science project, only to assess the need of, um, tick treatments and eradication on certain areas of the island. We were hoping you could help us out in, um, this project because we'd like to assess what course of action would you recommend and would you think would be best for this project.

Jim: So you're looking for, if I can paraphrase what you just said, you're looking for a way of documenting the presence of ticks at various sites, uh, and coming up with, as you call it, eradication strategies for these sites.

Kathryn: So, we're very open and fluid in terms of, you on the island, you having the most experience, and you kind of understand, kind of the culture of the island and the ways things work, and we've done a lot of background research on the island, we're really interested in it. And we're just kind of, we'd love to be involved in, kind of, whatever capacity you'd be most interested in having us involved in.

Jim: So... the first part of that was to determine what the, uh, presence... what the, level of presence of ticks at a given site is. Who's doing that?

Kathryn: Um, so, the way we were planning on looking at that, uh, we have a survey that we've created. It's about, I think it's 28 questions, um, and it asked some demographic information but it also asks some information in terms of tracking where people are located verses how many ticks they encounter on their pets, on their children if they have children, and on themselves, um, and using that data, um, processing it, and looking at incidence across the island.

Jim: I don't think you're going to find that much information, uh, in making that kind... What you're looking for is the presence of ticks on people and on animals. Uh, you know ticks are not that common and therefore you're not going... it's not like the number of times you're bitten by a mosquito today when you're out walking.

Uh, people are not going to identify whether or not they have ticks on them until they get home and get their clothes off and start doing a search, and frankly, not many people do that. Uh, the... you know the... there's probably, I don't know if you're trying to get to a point where, uh, you're building public awareness on how they should, on various strategies, they should employ on how to protect themselves.

Uh, and, getting a sense of an infection, not an infection, a presence of ticks on a particular part of the island... the science behind that is that the epidemiologists that struggle with this issue go out there and do what are called sweeps. So what they do is they take a piece of fabric on the end of a stick and literally pass it back and forth over an area, and examine the

fabric, which is usually of very light color, a white or a something of light color, anyway, they'll pick the ticks off that and come to a conclusion as to what the density of ticks is in a given area.

Uh, asking people how many ticks they've encountered is not terribly scientific. I mean, it's... some people are going to be more aware than others, some people will take time to pick ticks off of their animals, um, most people don't really spend a heck of a lot of time doing that. And then to the issue of eradication, I don't know what you have in mind. You don't eradicate ticks (*laughs*). You don't eradicate ticks. You don't spray areas.

So, the first thing... the only experience that I've had relates back to mosquitoes when visiting an area down in Florida, they actually had a rating system that they used to alert visitors to a property that the incidence of mosquitoes on that particular day was either non-existent or was low, or medium or high, and it would give people an idea before they entered the property whether as to whether or not they really wanted to go out there. It was a marshy area, and it's a gorgeous spot often visited by tourists and locals who are interested in bird watching and etc. and people get there and they say, 'you know, jeez even though I made the effort to get out to this property, I don't know if I really want to go out on the boardwalk and get eaten to death.

Um, our struggle over the years has been to try and get people to be alert to the presence of ticks, and to be serious about checking themselves once they got home, dress appropriately when they go out on the property, stay in areas where they're not likely to become exposed to ticks, which means the well-worn paths and the roadways as opposed to walking through the high grass or along the shrubby areas. Uh, and you know when they get home, make sure they do a thorough tick check.

Kathryn: Right. So part of the survey that we've, um, so far, you know, where you're talking not, the possible or probably and effectiveness of you know asking people to survey where they found ticks, we have a large portion too that we've dedicated to asking people about how much they know about Lyme disease, how much they know about tick borne disease, if they know where to go to find resources, um, what way they would best like resources delivered to them, so exploring maybe the idea of, like, social media, or pamphlets, or mailings or maybe, like, you know town educational sessions. So where you've said the issue is kind of getting people aware of the things that they need to do to avoid Lyme disease, do you feel like that's somewhere where you could see us having an impact?

Jim: Improving public awareness, uh, it's been done many times, and I think you would find that the town's board of health which is just recently been established, before last year all the responsibilities of a local board of health were held by the board of selectmen. And they finally recognized the need to have a separate board of health and the board of health deals with lots of issues, but one of the issues that its chairmen, whose name is Malcolm McNabb, that I passed along in my email. Malcolm is a doctor now retired living on Nantucket, and he and a couple of the members of the board who are medical professionals understand that Nantucket is a little behind the curve in trying to get people, umm, it's a delicate balancing act. When you live in a tourist community, one of the things you don't want to do is to scare people.

Uh, the chamber of commerce was very reluctant for years to mention the occurrence of Lyme disease on Nantucket in any of its materials. We finally got them to acknowledge that now they're on our side, and know that they would rather have an informed visitor than a poorly

informed visitor, somebody that was totally unaware of, uh, tick-borne disease. One of the issues with tick-borne disease is that often the symptoms don't show up until long after you've been infected. And so people who come to Nantucket may go back to Dubuque, or out to California where the incidence of tick-borne diseases is not as, not nearly as often as it is here, start developing symptoms and their doctors out there have no idea of what they're looking for and this person goes undiagnosed and poorly treated for some period of time and just gets sicker and sicker, so part of what we try and do is, without scaring people, is to say, 'hey listen, it's like poison ivy.' You put a drawing on something of the three leaves of poison ivy and at least people are aware and become sensitized to, perhaps, looking for it as they're wandering around the beach, or coming... walking across the island and they see this three-leaved thing, and even if they startles them when they see it, at least they've become a little more aware. The problem with ticks is that as much as you can do to illustrate what these things look like, they're so tiny, I mean think of the period on a... at the end of a sentence. Some ticks are that small, and so what you have to get people to understand without frightening them is, at the end of the day, if you see a freckle moving around on your leg, that's not a freckle! It's a tick!

So, what I'm doing is, I think, encouraging you to think about raising public awareness in a way that informs people what they should do to themselves before they go out into nature, before they go out to the beach, because ticks are known to exist on the tall beach grass, I mean they live down there too. And at the same time, be prepared to deal with the consequences knowing that if you have a bull's eye rash, that if you develop a fever or a stiff neck, you know, these are the kinds of signals that you should call attention to your doctor when you go and visit them, finally, and hopefully sooner rather than later, and mention the fact that you've been in an area where there is a high incidence of tick-borne disease because some of these things... I've had Lyme disease a number of times. I've had babesiosis once, and I'll tell you I've never been so sick in my life. It was, now that I look back at it, a frightening experience. It came on so suddenly and it was so severe, that had I not been here and seen almost immediately by a doctor who really knows his stuff, Tim Lepry who is really a pro at this on Nantucket, and was able to quickly start medicating me so that, so that it knock back the symptoms and the disease itself, I probably would have been in a lot worse shape.

Crystal: So in terms of, um, creating and improving awareness on the island, would you say signage around the island, or pamphlets being mailed out... because I understand that there are different ways of increasing awareness, but what would find would be the best way of doing that?

Jim: Have you looked at the board of health's video?

Kathryn: We've not. No.

Jim: Yeah, that's a starting point because they worked on that last year, and that was, with a limited budget that they had to work with, I think I forgot what they cost them, I mean when you start talking about public awareness that is professionally done and presented in a way that the average consumer is going to say, this is sort of watching a commercial on television, and I'm used to doing that, and I will absorb that information as best I can because I'm going to watch it

once. Period. That's not to say that people can't go back to the website and watch it over and over again, but people don't want to be burdened by... if you stopped and watched every message that you should watch during the course of your life, you'd do nothing but sit in front of a television screen forever. And, so, uh, you know strategies have been employed in the past of presenting that message at the airport, at the steamship authority, on the boat, as people came over...

Kathryn: I was just about to mention that as maybe, you know, looking at um, you know, your airport, um and your ferry system and seeing if, you know, because I feel like a lot of people on Nantucket might have a bit of a better understanding of the presence of Lyme disease there, but when you're looking at tourists, maybe it's really targeting that group in terms of just, as they're coming across, you know.

Jim: Well those strategies have been employed and in fact, uh, it was not too many years ago that they actually had a character like a mascot for a college football team, walking around dressed as a tick on the boat. You know, people have tried a lot of different things and unfortunately, when you try it, it's a novelty the first time around. And if you're on that boat a couple of times a week as many of our travelers are, commuting back and forth to the mainland, it gets sort of back grounded. People forget it. I always described poison ivy and tick-borne diseases on Nantucket as an occupational hazard. It's something we're aware of, but we accept the fact that at some point or another we might be exposed to it, not because we want to be, but because that's part of living on Nantucket. And there's this complacency that comes along with it. You know we start talking to the average year round resident on the island about ticks and Lyme disease and babeiosis and erlichia they sort of look at you and say "So what?"

And we've got this further complication that we have a lot of migrant labor here on the island, lots of people who have immigrated to Nantucket that come from places that have had no prior experience with it. And when you talk to them, and many of them are foreigners and English is not their first language. Uh, they have a problem understanding it. The issue has come at the hospital of trying to translate some of the brochures that were originally developed for English speaking, English reading people into Portuguese and Spanish and Bulgarian. I mean we've got a, this is, this is the United Nations now, this is a place where people come to work, but also come to visit, who don't really understand what some of these issues are. I will also say that not a lot of people who visit Nantucket as vacationers actually get into areas where they're going to be exposed to these things. You know, ticks don't thrive on Main Street.

Uh, it's when you get out into the outlying areas, and I'm going to say a very small percentage of the overall visitors, visitor population, actually gets into Mother Nature. Uh, in a place where, you know, if they're renting a house out of town for a week and their kids are playing the backyard or they're taking their dog for a walk at one of the favored places out in nature that people go for dog-walks, uh, maybe they're going to run the risk of coming into contact with, uh, with a tick. Let me just jump to the issue of eradication. One of the major issues is the deer population. You know we have a deer population that has been documented as between, oh, 2700 and 3000 deer. And, with that comes an increased risk of ticks because an adult female tick taking a blood meal off of a deer drops to the ground and can lay as many as 2,000 eggs.

And there is this emotional push back for many people who don't understand, or don't want understand, who don't want to accept the fact that Bambi and Rudolph are part of the, uh, life cycle that is causing the explosion of tick-borne disease on Nantucket. If you talk to Tim Lepore he'll give you a lecture about how it is we should increase deer-hunting, if you talk to Sam Telford, who's a does a lot of work here on Nantucket, and is actually quite close by to you guys, and might be a good resource to make a day to go over and talk to him, he's in Grafton.

Uhm, uh, he's been studying ticks on Nantucket since the 70s, uh, he and his partner, Andy Stillman, now deceased, were the two guys that here on Nantucket identified the life cycle of the deer tick. And so their intimate, I mean Sam's got all sorts of ideas but his principle idea is, you know we've got to get people thinking that Bambi and Rudolph aren't necessarily our friends, they're our enemies, because they're the ones that are increasing, or helping to increase, the deer tick population here on the island. We've got the, the, triumphant with the, the uh, white footed mouse, which is the reservoir of the diseases, they, they get the, they get bitten by infected ticks, they don't get impacted by the disease but their blood supply suddenly becomes the host for holding on to those diseases, so the next generation of tick comes out, they are born without any diseases, their first blood meal usually is taken on the ground from a deer mouse, a white footed mouse. Uh, they contract the disease and off they go, looking for their next blood meal, which in many cases, is a human being. And that's when that transfer occurs.

So anyway, there are lots of issues, we can't, we can't kill the mice. Uh, there have been strategies employed, uh, you may be familiar with the tick tubes, also called, Damminix. Which people are encouraged to put on their properties, but, the, the rate at which those things have got to be installed and the cost of those installations make it prohibitive to think about using them anywhere outside of somebodies backyard. And if their neighbors aren't doing the same thing, uh, it's almost worthless putting it out, because the deer, and uh the mice, that you're trying to get to steal those, the uh, the treated cotton and take it down into their burrows, those mice have no regard for property lines. They may be in your backyard but they're also in your neighbors' backyard, and there are ticks in your neighbors' backyard that they come back into the burrows with if they haven't picked up some of the treated cotton, then the ticks will continue to flourish on your property. You know it's, it's messing around with Mother Nature. Mother nature has said, uh, "I've, I've got these two partners, mice and deer, that are required to, uh, perpetuate the, the ticks, in any environment, and it's particularly, uh, in a situation where Nantucket has become more developed over the years, there's less hunting taking place. Which means that a very productive animal, like a deer, uh, is going to thrive, uh, the vegetation here is good, the cover is good, uh, and people plant ornamental plants in their yards, which deer love. I've got a backyard that, I have few ornamental plants in, but you can now start to sense that there is almost an overpopulation of deer growing on the island, because you can see the browse lines in the vegetation.

Uh, their, their taking anything that's green, particularly in a tough winter, they're out there just gobbling away. I sit here in my office and look out the window during the winter months and I'll have a pack of 3 or 4 or 6 deer wondering through here in the middle of the day, they're nocturnal animals, they're not supposed to be out, but they're looking for browse. So it's, uh, you know, the, the other resource I encourage you to look at before you go much further is the Martha's Vineyard website. They've got some fabulous videos that they've pulled together. How they get people to watch those videos, I don't know. If I was a tourist going to Martha's

Vineyard for the first time, would I sit down and pull up that site? Probably not. But I'm the person you want to get the message to because this is my first time here, I don't know anything about tick-borne disease if I come from Manhattan, I've certainly read about it in the New York Times, but I've never personally experienced being exposed to it.

You know that's the other issue, that the kind of visitor that Nantucket and Cape and islands attract are people who don't necessarily have outdoor experiences, other than walking through Central Park. And so you have to tailor not only the message but also how that message is delivered in a way that is normal to them, that they're going to sit down and either read it or listen to it or watch it. Or hear about it in some, some fashion. So we've got, we've got what, three creative minds here?

Kathryn: We have two.

Crystal: Yeah, just two.

Jim: Uh, start out by watching the videos.

Kathryn & Crystal: Okay.

Jim: Uh, is there a plan on coming to Nantucket at some point?

Crystal: Potentially. We have about a month off for Christmas break. I know it's not the most ideal time to come visit, because it's going to be winter, but, if we do come to visit that's when it's going to happen.

Jim: Alright, well the guy that you really need to talk to, I think, is Malcolm McNabb.

Kathryn & Crystal: Okay.

Jim: When you're here. I mean I'm happy, if, if you do get to Nantucket, I'm happy to spend time with you and explore some of the things that the island has already done and the foundation and the Land Bank Commission and the other environmental groups on the island keep promoting awareness and protection, self-protection strategies. Uh, scaring people is not exactly, I mean making them more informed is not, uh, you know, I've got lots of friends and we sit down and we talk about, at dinner time or cocktail time, everybody, cause I've been the poster child for Lyme related issues, or tick related issues for years. I had one of the worst cases of Lyme disease back in 1990, actually, uh, broke some medical records in having it, and people have recognized since then that I'm probably a better informed layperson than most on the island. As a result the doctors and the other people who work on these issues on the island have tried various ideas out on me before they let them go and I was part of this group that worked on the board of health video last year. Sam, Tim Lepore, Malcolm McNabb, uh, there, there's a woman on the board of health, Helene Weld, uh, who is, um, our former governors' sister-in-law. Uh, she's a registered nurse, now retired, but Helene and her husband, who is a cardiologist now retired, uh, are both outdoors people and they are passionate about trying to get people to recognize the fact that ticks

are a fact of life out here. And that you've got to get serious about it, or otherwise be prepared to pay the consequences. And it's not like you stand at the boat or at the airplane when people get off and, uh, come onto the island for the first time or come back here as summer residents, and hope that they're not going to be affected by a deer tick bite, uh, it's, it's you know, you've just got to use your head, and say, if people are pointing this out to me, there must be something to it, and I should be aware of it if I go into those parts of the island where these things are common.

Uh, and as I've mentioned to you, we've put signs on our property entrance points, we mention ticks in all of our brochures, on our website. Uh, I don't know much more you do, you could stand at the gate of a property and hand out brochures, given our past experience, it's time wasted.

Kathryn: Excellent, well we really appreciate you taking the time to talk to us, we know, you know, it's, um, we've definitely, we've done a lot of background research, but it's, it's really, eye-opening to talk to somebody on the island and, you know, and kind of get a better idea of the culture of Lyme disease and especially what you were talking about, kind of that complacency...

Jim: Now, the other resource that you guys have, not as a research site, but as a place to possibly create, I mean if you're thinking that, awareness building, uh, you know, is a multifaceted thing, you don't do that in December, you do it in early spring when the ticks are starting to come out, I have a couple of reminders on my personal calendar that I send the editor of the newspaper and reminder with a fact sheet and sort of get them up to speed, thinking, you know, here's a news worthy article that now that people are starting to come out of their cocoons, and believe me the winters here are not such that you really want to do a lot of walking around outside unless you're going to get frozen to death, um, you know, come late April, early May people are starting to think about taking their dogs outside for a walks, or going out themselves. That's when you get back into the newspaper with an article and, uh, sometimes there's a willingness on the part of the newspaper and the publisher of the newspaper is actually a board member of our foundation, so it's easy for us to communicate with them, and because we're a small town, everybody knows everybody and we're happy to work with each other, as is the hospital. But to think in terms of reaching out via the newspaper we have a couple of cable stations that are okay, but not widely consumed. Uh, you know, you have to think of and go towards the distribution points where people are actually going to sit down and listen to it. Even, even getting into the newspaper, often it's just, you know, people see the word tick and they skim right over it.

They don't even want to be bothered reading it. So anyway, send your ideas, if you need more, uh, more uh, information from me, I'm happy to spend time with you on it, it's personally important, it's institutionally important, it's an important issue for the community and for the people who come here, it's just getting in people's faces in a way that feels non-threatening, that doesn't talk down them that, uh, you know, gives them some information but that doesn't bury them in information. It's a message that they receive quickly and its sinks in.

Kathryn: Absolutely. Excellent. Well we'll do some research then, based on...

Jim: Terrific!

Kathryn: ...what you've talked about and we'll...

Jim: Fantastic!

Kathryn: ...we'll get some ideas to you.

Crystal: Absolutely, we'll definitely stay in touch.

Jim: Alrighty. Thank you so much.

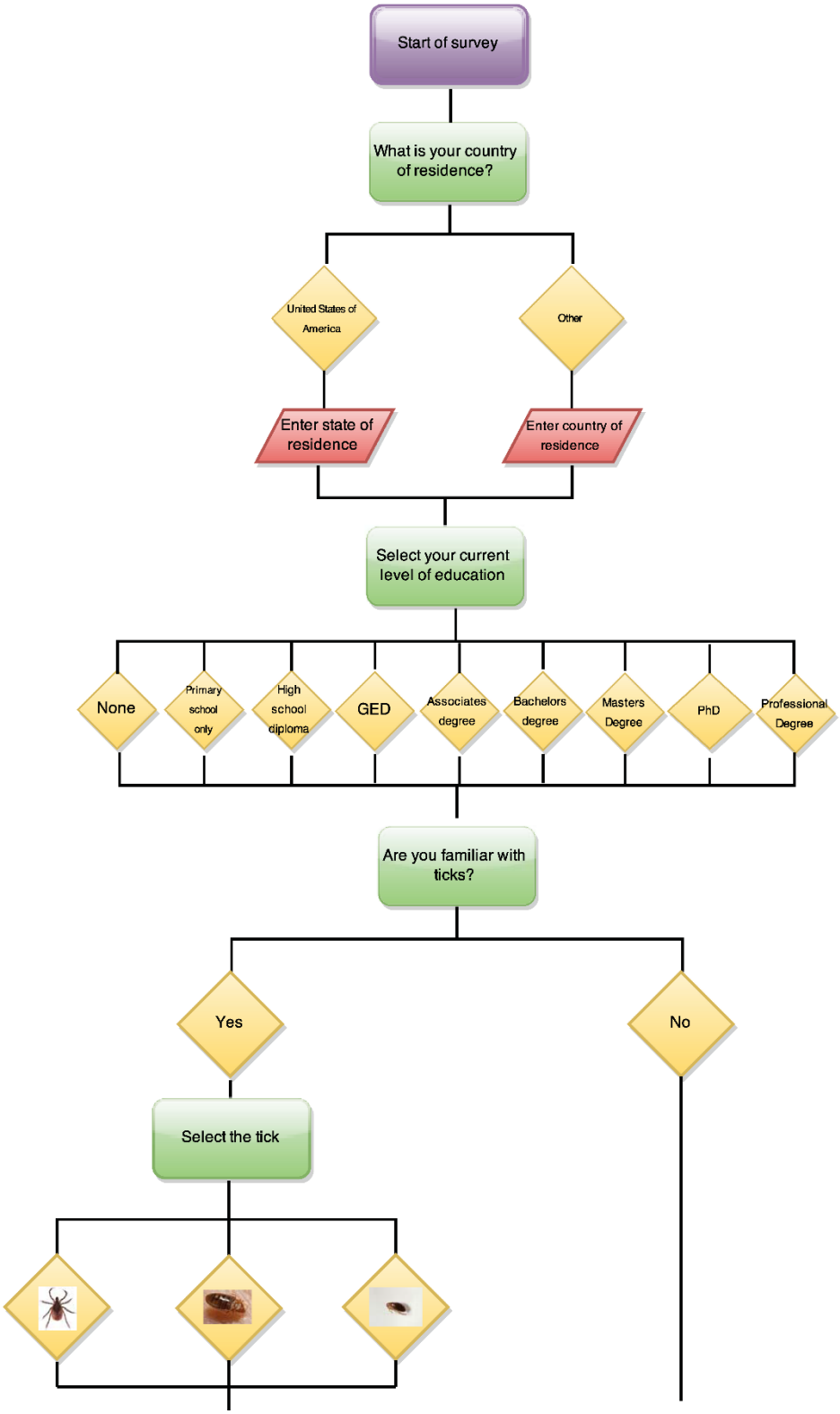
Kathryn: Thank you.

Crystal: Thank you, have a good afternoon.

Jim: You bet. Bye.

Kathryn & Crystal: Bye.

B. Survey developed by IQP team



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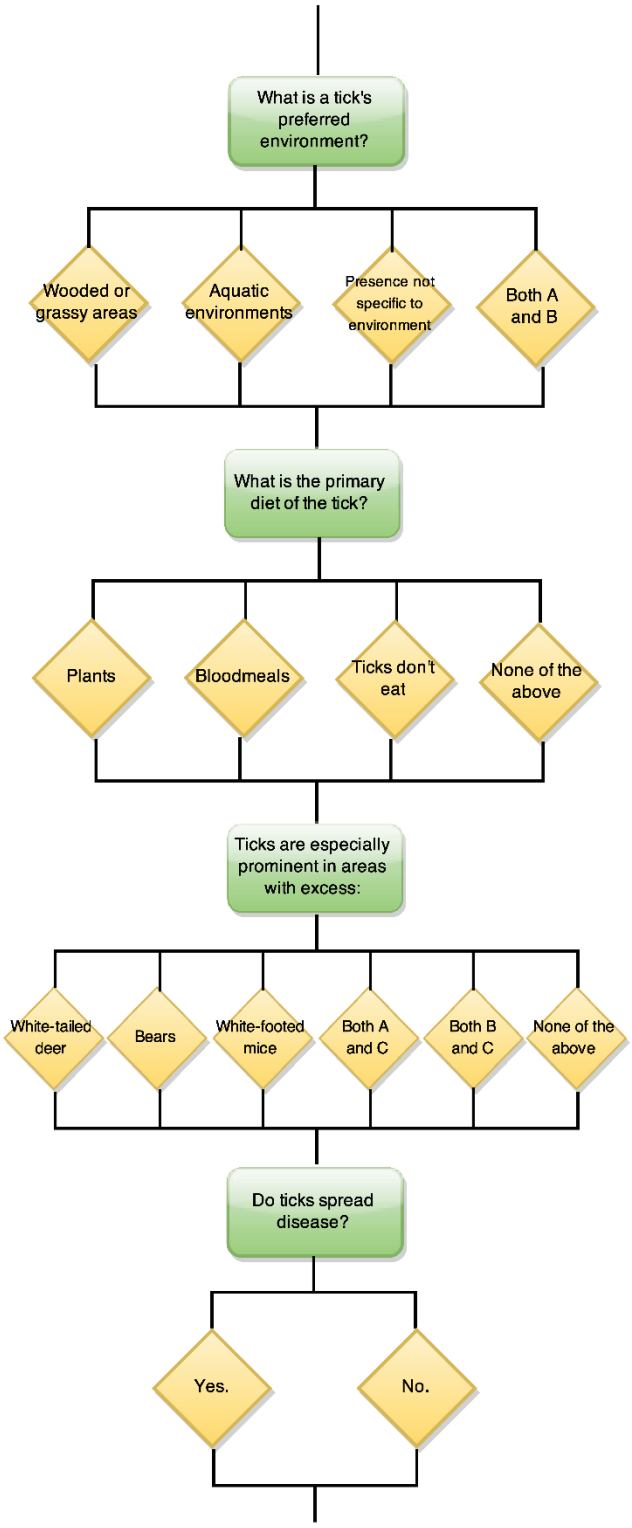
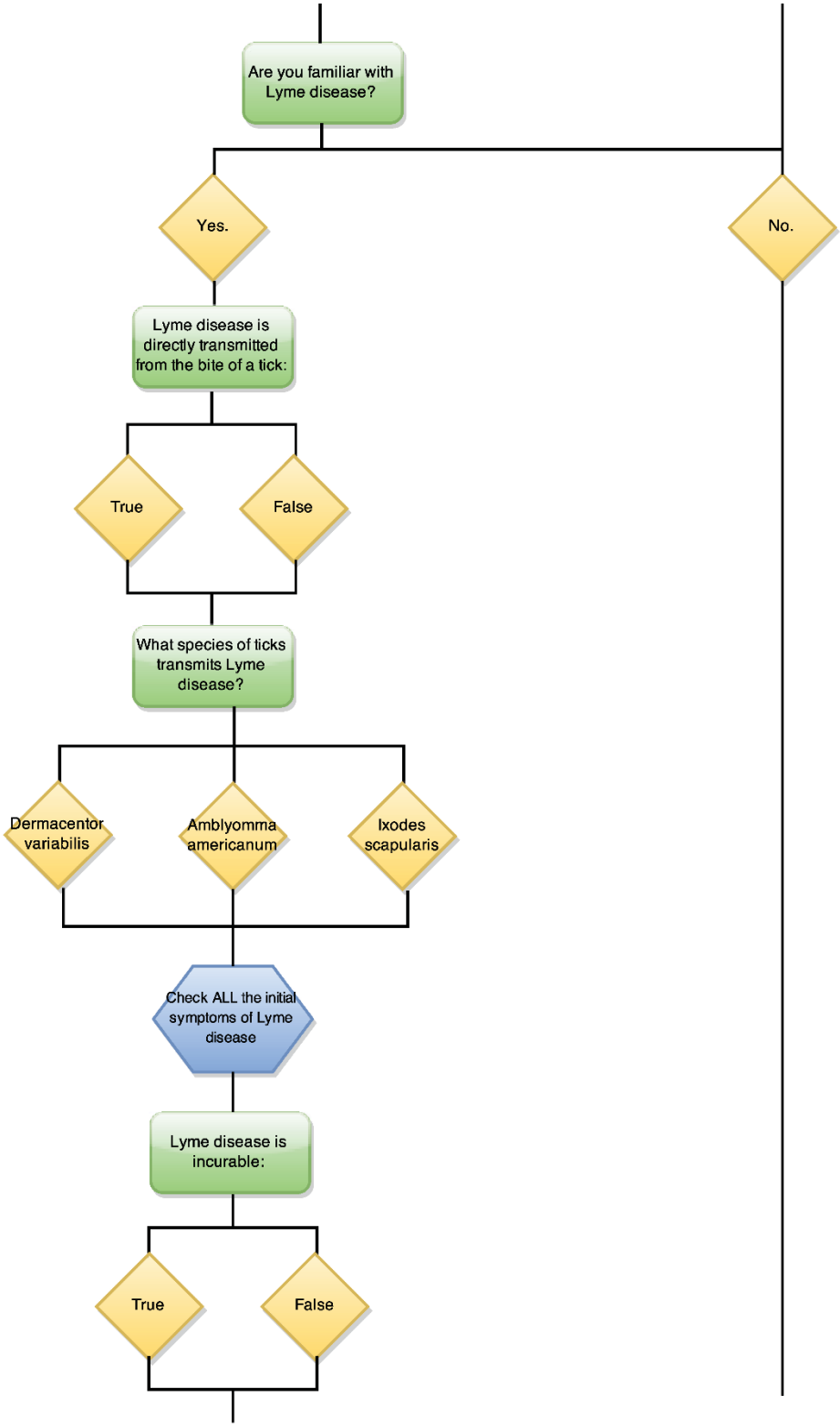
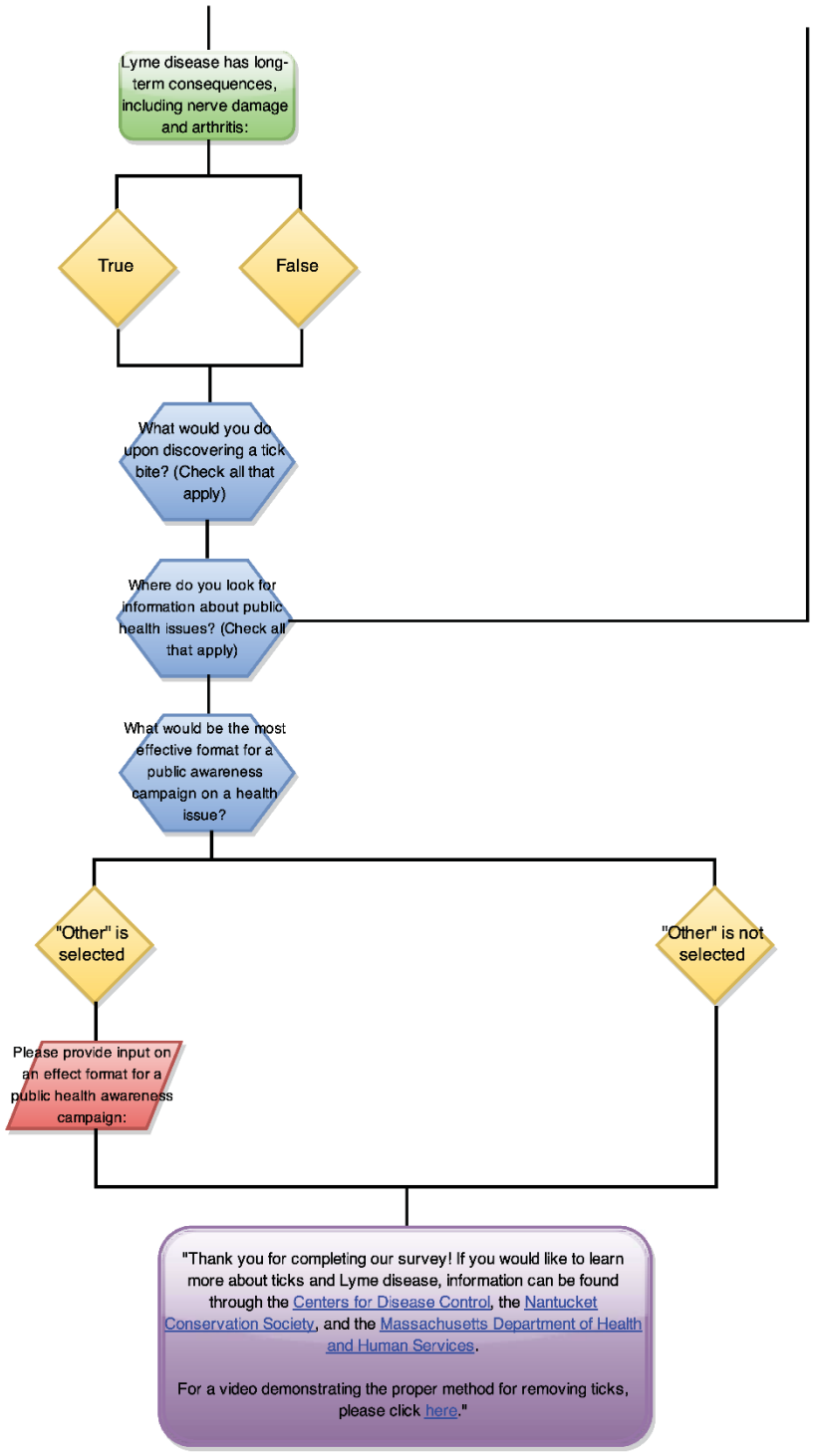

What is a tick's preferred environment?
Wooded or grassy areas
Aquatic environments
Presence not specific to environment
Both A and B
What is the primary diet of the tick?
Plants
Bloodmeals
Ticks don't eat
None of the above
Ticks are especially prominent in areas with excess:
White-tailed deer
Bears
White-footed mice
Both A and C
Both B and C
None of the above
Do ticks spread disease?
Yes.
No.

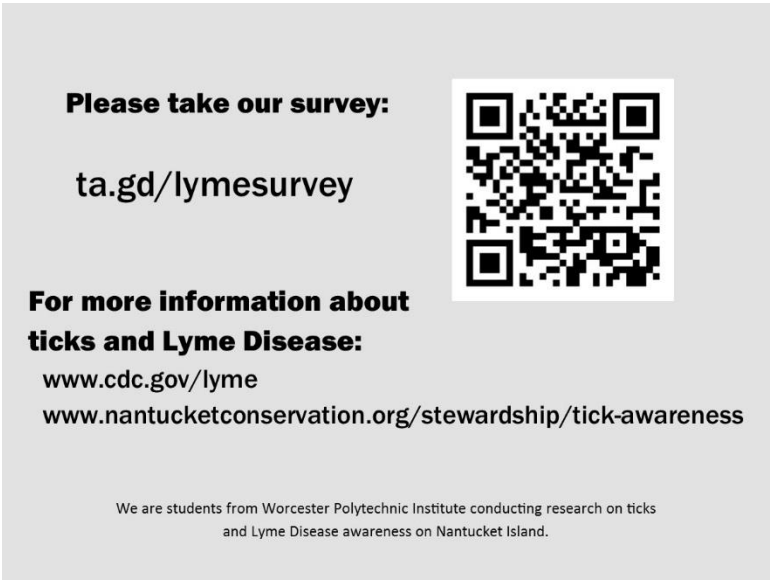

Are you familiar with Lyme disease?
Yes.
No.
Lyme disease is directly transmitted from the bite of a tick:
True
False
What species of ticks transmits Lyme disease?
Dermacentor variabilis
Amblyomma americanum
Ixodes scapularis
Check ALL the initial symptoms of Lyme disease
Lyme disease is incurable:
True
False


Lyme disease has long-term consequences, including nerve damage and arthritis:
True
False
What would you do upon discovering a tick bite? (Check all that apply)
Where do you look for information about public health issues? (Check all that apply)
What would be the most effective format for a public awareness campaign on a health issue?
"Other" is selected
"Other" is not selected
Please provide input on an effect format for a public health awareness campaign:
"Thank you for completing our survey! If you would like to learn more about ticks and Lyme disease, information can be found through the Centers for Disease Control, the Nantucket Conservation Society, and the Massachusetts Department of Health and Human Services.
For a video demonstrating the proper method for removing ticks, please click here."

C. Public Awareness Poster for Nantucket Island

D. Public Awareness Poster for New England

E. Handouts to be attached to posters



F. QR code that can be used to access the survey

G. Shortened URL that can be used to access the survey

ta.gd/lymesurvey