Interim report

Nantucket Tick-borne Disease Committee

Malcolm W. MacNab MD, PhD
President, Great Point Research LLC
Committee Chairman
The deliberations of the Nantucket Tick-borne Disease Committee are ongoing. We are in a fact-finding phase and we have not developed any recommendations.

Any opinions expressed are not necessarily those of the Committee.

The purpose of this presentation is to present an update on the Committee work to-date without any specific recommendations.
Today’s presentation

- Defining the problem – why we need to intervene
  - Tick-borne disease on Nantucket
  - Epidemiology of tick-borne disease
  - Medical aspects of tick-borne disease
  - Health care & social costs associated with tick-borne diseases

- Finding a solution
  - Formation of the Nantucket Tick-borne Disease Committee
    - Update on the Committee activities
  - Modes of Intervention / Possible Solutions

- Next Steps
Defining the problem

Tick-borne disease on Nantucket
Do we have a problem?
Tick-borne diseases on Nantucket

Blacklegged (or deer) ticks (*Ixodes scapularis [=I. dammini]*) can transmit several tick-borne diseases; three are found on Nantucket:

- **Lyme disease** (*Borrelia Burgdorferi*)

- **Anaplasmosis** (*Anaplasma phagocytophilum*) – also known as human granulocytic anaplasmosis (HGA) or previously as human granulocytic ehrlichiosis (HGE)

- **Babesiosis** (*Babesia microti*)

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<th>County</th>
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<td>Putnam County, NY</td>
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</table>

* Per 100,000 population.
Nantucket Cottage Hospital Statistics

- Reported cases on Nantucket (diagnosed on-island)

<table>
<thead>
<tr>
<th></th>
<th>Lyme</th>
<th>Ehrlichiosis</th>
<th>Babesiosis</th>
<th>Total</th>
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<td>2007</td>
<td>190</td>
<td>15</td>
<td>53</td>
<td>258</td>
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<tr>
<td>2008</td>
<td>325</td>
<td>17</td>
<td>69</td>
<td>411</td>
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</tbody>
</table>

Based upon laboratory diagnosis confirmed by Infection Control Nurse
Survey conducted of the voting members of the Tom Nevers Civic Association in December 08 and January 09 – 37.1% response rate

- 60% of households responding reported being infected with a tick-borne disease – family members, guests or renters ever having a tick-borne disease reported:
  - Lyme disease...............61.3 %
  - Babesiosis..................17.2 %
  - Ehrlichiosis...............8.6 %

- On average, 2.3 people per household have been infected in households having had a tick-borne disease.

* Survey may have “response bias”
Tom Nevers Civic Association Survey

- Off-island diagnosis and treatment – as many as 9-out-of-10 being non-resident short term visitors:
  - Percent diagnosed......31.6 %
  - Percent treated..........35.0 %

- Multiple infections over time were reported ranging from 3 to as high as 9 (based upon write-in comments).
Tom Nevers Civic Association Survey

- Percent reporting an initial miss-diagnosis:
  - Lyme disease..............18.6 %
  - Babesiosis...................15.8 %
  - Ehrlichiosis................30.0 %

- Percent reporting an ongoing health problem related to a tick-borne disease:
  - Lyme disease..............10.8 %
  - Babesiosis...................15.8 %
  - Ehrlichiosis................20.0 %
Tick-borne diseases on Nantucket - Conclusions

- The true incidence of tick-borne disease on the island is difficult to determine:
  - Constant changing nature of our population – unknown and changing “denominator”;
  - Many cases are acquired on-island but diagnosed off-island;
  - Under reporting because of an inadequate reporting system;
  - Missed diagnosis; and
  - Clinical diagnosis was made without laboratory confirmation and not captured in the official statistics.

- We can conclude that we have a high incidence of tick-borne disease and the official 2008 statistics reporting 411 cases is an underestimation of the true number of cases acquired on the island.

- Tick-borne disease is a significant public health issue on the island.
Defining the problem

Epidemiology of tick-borne disease
How are the diseases transmitted
Life cycle of blacklegged ticks

Eggs

Nymph

Risk of human infection greatest in late spring and summer

Eggs

Larva

Adults

SPRING

WINTER

SUMMER

FALL

CDC/DVBD
Life cycle of blacklegged ticks

- 2-year life cycle with 3 feeding stages

- First year:
  - Eggs laid in the spring → hatch into six-legged Larva

- Second year:
  - Larva → molt into eight-legged Nymphs in the spring
  - Nymphs → molt into Adults in the fall
Perpetuation of Lyme disease organism depends on two factors:

- **Tick production**: Reproduction of the tick
  - Adult female tick acquires a bloodmeal → blood becomes eggs → eggs hatch and become larva – Larvae are not infected
  - The source of a reproductive bloodmeal is a larger animal (deer, dog, coyote, bear, moose, human, cat)
  - Adult ticks do not feed on mice, shrews, squirrels, rabbits, birds

- **Infection of the tick**: uninfected larvae need to get infected
  - White-footed mice (primary reservoir), shrews, rabbits, squirrels and certain birds (yellowthroats, wrens, robins, pheasant) are known to infect ticks
  - Larvae also feed on deer, cats, many ground-foraging birds but do not become infected as a result

Scott White DVM, Sam Telford DSc and Centers for Disease Control
Tick-borne disease transmission factors [2]

- Perpetuation of the Lyme disease organism depends on two largely independent factors
  - **Tick production**: Reproduction of the tick
    - Adult female tick acquires a bloodmeal → blood becomes eggs → eggs hatch and become larva – Larvae are not infected
    - The source of a reproductive bloodmeal is a larger animal (deer, dog, coyote, bear, moose, human, cat)
    - Adult ticks do not feed on mice, shrews, squirrels, rabbits, birds
  - **Infection of the tick**: uninfected larvae need to get infected
    - White-footed mice are the primary reservoir.
    - Shrews, rabbits, squirrels and certain birds (yellow throats, wrens, robins, pheasant) are known to infect ticks
    - Larvae also feed on deer, cats, many ground-foraging birds but do not become infected as a result

Scott White  DVM, Sam Telford  DSc and Centers for Disease Control
Tick-borne disease transmission factors [3]

- Transmission of anaplasmosis, babesiosis and Lyme disease are similar.
- One, two, or all agents can be acquired when larva and nymphs feed on reservoirs and more than one disease can infect an individual human.
- Tick stages responsible for transmission to humans are principally the nymph, followed by the adult.
- Tick attachment duration affect transmission likelihood.
- Exposure potential (risk) is directly related to:
  - Disease endemic levels
  - Season of the year
  - Activities and / or expansion in tick laden areas
  - Deer tick levels and tick infection rates
- Deer are the main reproductive hosts for the deer tick
  - Each female tick produces about 2000 eggs
## Tick-borne disease transmission factors [4]

**Deer are the main reproductive hosts for the deer tick**

<table>
<thead>
<tr>
<th>Host</th>
<th>Number present on site *</th>
<th>Number of ticks per host</th>
<th>% of all ticks</th>
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<tbody>
<tr>
<td>Deer</td>
<td>24</td>
<td>38.3</td>
<td>94</td>
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<tr>
<td>Raccoon</td>
<td>51</td>
<td>0.7</td>
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<td>Possum</td>
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<tr>
<td>Cat</td>
<td>11</td>
<td>0.1</td>
<td>0.1</td>
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* Long Island study area

Defining the problem

Medical aspects of tick-borne disease
Lyme Disease cases distribution by age

FIGURE 3. Number* of reported Lyme disease cases, by age group — United States, 1992-2006

* N = 241,931.

Lyme Disease [1]

- **Pathology:**
  - The bacteria are inoculated into the skin by the bite of the deer tick.
  - At the site of inoculation a skin rash develops in the majority of people who develop symptomatic disease (erythema migrans) - this is characteristic of the disease and is the finding that leads to diagnosis of acute Lyme disease in the vast majority of cases.
  - The organism may localize in joints, heart and nervous system causing symptoms in each of these areas.
  - It also leads to immunologic reactions that may lead to symptoms of arthritis at later times.

- **Symptoms:** Skin rash, fever, myalgias, arthralgias, facial palsy, headache, fatigue and a variety of other symptoms may be seen.
Lyme Disease [2]

◆ **Diagnosis:**
  
  • The acute disease is diagnosed primarily by the skin rash, but may also be diagnosed in endemic areas by the presence of the other symptoms, especially when tick exposure has been documented or suspected.

  • Serologies are not useful in the acute phases of the illness since the antibody responses arise later in the course of the illness (weeks to months).

◆ **Treatment:** Appropriate antibiotic therapy

John Goldman  MD
Anaplasmosis (Ehrlichiosis) [1]

**Pathology:**
- The organism enters the bloodstream after inoculation from the bite of a deer tick.
- The organisms concentrate in circulating white blood cells and travel throughout the body.
- They cause low white cell and platelet levels and elevated liver enzymes.

**Symptoms:** Fever, chills, headache, anorexia, nausea, fatigue and myalgias are the most common symptoms.
Anaplasmosis (Ehrlichiosis) [2]

**Diagnosis:**
- Various immunofluorescence assays are used to detect anti-anaplasma antibodies.
- One may occasionally find intracellular inclusions in white blood cells on stained blood smears and these can be diagnostic in the right clinical setting.

**Treatment:** Appropriate antibiotic therapy
Babesiosis [1]

**Pathology:**
- The protozoa enter the bloodstream after inoculation from a deer tick bite.
- They localize and replicate in red blood cells in a manner similar to malaria leading to a hemolytic anemia.
- There may be splenomegaly and hepatomegaly.
- Most cases in otherwise healthy individuals are asymptomatic and self limited. Especially in persons who are asplenic or have underlying immunologic diseases or malignancies, the disease may be severe.

**Symptoms:** Fever, chills, myalgias, arthralgias, nausea, vomiting and fatigue are seen.
Babesiosis [2]

- **Diagnosis:**
  - Signs of hemolytic anemia, low platelet count, elevated liver function tests, elevated renal function tests may be seen.
  - Intraerythrocytic protozoa may be seen, but the percentage of parasitized erythrocytes is usually small.
  - Fluorescent antibody tests are usually positive in 4 to 6 weeks.

- **Treatment:** Appropriate antiprotozoa and antibiotic therapy

John Goldman  MD
Health care & social costs associated with tick-borne diseases

- Lost school and work time
  - Lost wages

- Nantucket Island reputation
  - Lost tourism

- Direct Health Care Costs – no sequelae
  - Office visits, antibiotics, laboratory costs

- Direct Health Care Cost – with sequelae
  - Treatment of cardiac, neurological and arthritic complications; ruptured spleen; hospitalizations etc.
Finding a solution

Formation of the Nantucket Tick-borne Disease Committee
Tick-borne Disease Committee Members

- Malcolm MacNab; MD, PhD (Chairman)
- Scott White; DVM, MPH (Vice-chairman)
- David Boyce
- Tristram Dammin; MD
- John Goldman; MD
- Bruce Hopper; MD
- Meredith Lepore; RN-NP
- Kevin Madden
- Beverly Mclaughlin
- Patricia Roggeveen
- Elizabeth Tri1los
- Helen Weld; RN
Tick-borne Disease Committee Mission Statement

In recognizing the increased incidence of tick borne disease on Nantucket, it shall be the responsibility of the Tick-borne Disease Committee to review all pertinent remediation and disease reduction approaches for known and emergent tick-borne disease's including but not limited to, public education, sterilization, four poster use, and selective deer herd culling and present their findings, with a recommended plan of action, to the Nantucket Board of Health prior to December 1, 2009.
Nantucket Tick-borne Disease Committee Goals

- Develop a *sustainable* program to reduce the incidence of tick-borne disease on Nantucket
  - There are no short-term solutions
  - Complementary actions will need to be developed
    - There is no single “magic bullet”

- Develop achievable measurable milestones

- Achieve community wide acceptance of the plan
Finding a solution

Update on the Committee’s Activities
## Tick-borne Disease Committee Work Plan [1]

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Speakers</th>
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<tr>
<td>May 29</td>
<td>Tick-borne disease on Nantucket</td>
<td>R. Ray - Nantucket Health Director</td>
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<td>May 29</td>
<td>Epidemiology of Tick-borne diseases</td>
<td>S. White, DVM, MPH * - Nantucket Veterinian</td>
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<td>May 29</td>
<td>Effects of Tick-borne disease in humans</td>
<td>J. Goldman, MD * - Prof. Medicine, Penn State Hershey Medical Center</td>
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<td>June 19</td>
<td>The New England / Nantucket experience</td>
<td>S. Telford, DSc. - Assoc. Prof., Tufts School of Veterinary Medicine</td>
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<td>July 10</td>
<td>Deer Management Programs</td>
<td>R. Deblinger, PhD – Deputy Director MA Division of Fisheries &amp; Wildlife</td>
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* Committee member
## Tick-borne Disease Committee Work Plan [2]

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<td>July 31</td>
<td>Pesticide control (pesticide use, four poster, Daminex tubes)</td>
<td>D. Simser – Barnstable County Extension Service A. Ganak – Daminex tick tube distributor J. Cook – Bartlett Tree Service</td>
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<td>Aug. 21</td>
<td>Pesticide control programs – Review</td>
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<td>Sept. 11</td>
<td>Deer Management Programs – Review</td>
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<td>Nov. 13</td>
<td>Complete Final Report</td>
<td>Committee</td>
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** Nantucket physicians’ perspective to be scheduled
Finding a solution

Modes of Intervention

Possible Solutions
Modes of intervention

Modes of intervention

- **Tick interventions**
  - **Acaricides**
    - Area-wide spraying
    - 4-poster (permethrin)
    - Damminix tubes
  - **Vegetation management**
  - **Repellents**
    - DEET ($N,N$-diethyl-$m$-toluamide)
  - **Inspection and removal**

- **Deer interventions**
  - **Deer reduction**
  - **Deer exclusion**
Finding a solution

Tick Management
4- Poster Device

- Consists of a central bin containing whole kernel corn (± apples) used as a bait and two application/feeding stations located at either end of the device.

- The deer feed on the bait - the design of the device forces them to rub against permethrin (10%) impregnated applicator rollers – the permethrin transferred to the head, neck and ears.

- Method is ongoing at Shelter Island, New York
Maryland study

- **Treated location**: NASA facility in Beltsville
- **Non-treated site**: Patuxent Wildlife Research Center

- Results for 3rd year of treatment
  - Adult, nymphal and larval questing ticks were reduced by 91-100% from sample plots
  - Nymphal and larval ticks were reduced 70-95% on sampled mice
4- Poster Device: Results [2]

- Massachusetts study [Needs updating]
  - Treated locations: Seven sites (Nantucket, Martha’s Vineyard, Chappaquiddick, and Barnstable County)
    - Four stations on Nantucket are situated within the Linda Loring Nature Center property
  - Non-treated sites: Seven comparable sites
    - Nantucket site around Almanack Pond
  - Results to-date

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<td>71 nymphs / hr</td>
<td>34 nymphs / hr</td>
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<td>Untreated sites</td>
<td>78 nymphs / hr</td>
<td>49 nymphs / hr</td>
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<tr>
<td><strong>Nymphs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-poster sites</td>
<td>146 nymphs / hr</td>
<td>113 nymphs / hr</td>
<td>?</td>
</tr>
<tr>
<td>Untreated sites</td>
<td>102 nymphs / hr</td>
<td>206 nymphs / hr</td>
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Damminix Tick Tubes®

- Cardboard tubes filled with permethrin treated cotton balls
- Mice collect the cotton to build their nests → ticks that feed on mice in the Spring and the Fall are exposed to permethrin
Some questions & potential issues concerning tick management

- Small property control vs. local area control vs. island-wide control?

- Environmental impact of pesticides?

- Long-term safety?

- Development of pesticide resistance in ticks?

- The role of deer reduction in regulating tick abundance?
Modes of intervention

Deer Management
To cull, or not to cull: that is the question:
Whether 'tis nobler in the mind to suffer
The slings and arrows of outrageous fortune,
Or to take arms against a sea of troubles,
And by opposing end them?
Relationship of tick density to deer abundance

- Deer density positively correlated with tick abundance.

Mumford Cove Connecticut experience [1]

- **Study site**
  - 150 homes surrounded by significant open space and woodlands, bordered by Noank Connecticut's Haley's Farm nature preserve, Palmer's Cove, and Fisher's Island Sound

- **Immunocontraception project failed and controlled deer hunts were started in 2000**

- **Deer were reduced by 82%**
  - 100 deer/mi² → 10 - 12/mi²

- **Reduced Lyme infection rate**
  - 30 new cases a year → 2 - 3 /year


(2) Connecticut Department of Environmental Protection
Mumford Cove Connecticut experience \[2\]

Changes in deer density and cases of Lyme disease in Mumford Cove, CT 1996-2004


(2) Connecticut Department of Environmental Protection
Great Island Massachusetts experience

- **Study site**
  - 200-ha island connected to Cape Cod by causeway
  - Initial deer population of 30
  - 100-300 summer residents
- **An effort to capture deer and treat with acaricide failed to reduce tick density**
- **Deer were reduced by approximately 90% resulting in:**
  - Reduced tick density
  - Reduced Lyme disease infection rate from >3 cases /100 people/ yr to <0.2 / 100/yr

(2) Wilson ML and Childs JE. Vertebrate abundance and the epidemiology of zoonotic diseases. Pages 224-248
   McShea WJ, Underwood HB and Rappole JH, eds. The science of overabundance: deer ecology and population management. Smithsonian Institution Press.
Crane Reservation Massachusetts experience

- Study site
  - Costal, 2.2 mile\(^2\)
  - Initial deer population of ~350
- Deer were reduced by 82% over a six yr. period
  - 350 → 60 or a density of 171 deer/mi\(^2\) → to 29 deer/mi\(^2\)
- Annual tick density fluctuations were large
  - Mean larval: 20.8 per white-footed mouse → 10.3 per mouse
  - Mean nymphal: 2.7 per mouse → 1.6 per mouse
- The number of feeding adult female ticks on deer increased as deer density decreased


Average number of larvae & nymphs
A: Monthly means May – Sept
B: Monthly means when most abundant
  - Larvae: Aug – Sept
  - Nymphs: May - July
Monhegan Island Maine experience

- **Study site**
  - 237-ha island lying 16 km off the coast of Maine
- **White-tailed deer were introduced in 1955**
- **Deer density reached 100/mi² by the mid-1990s**
- **The intermediate host was the Norway rat**
- **By 1996, 13% of year-round residents had contracted Lyme Disease**
- **From 1990 to 1998 the tick density was 6-17 adult ticks/h, of which 24-41% were infected with the Lyme Disease**
- **From November 1996 to March 1999, all deer were removed from the island**
- **Initially, the density of host-seeking adult ticks and infection prevalence rose substantially to 28/h and 75.0%, respectively**
- **By the summer of 2003, however, no sub-adult ticks were found on rats, and that Fall, the adult tick density was 0.67 adult ticks/h**
- **In 2007, ticks were very scarce - not eradicated**
- **The incidence of Lyme Disease is now reported as practically nil**

2. S. Telford - personal communication
Bernards Township NJ experience

- **Study site**
  - North-central New Jersey – rural, semirural, open space, residential, farmland
  - 63.5 km² or 24.5 miles²
  - Population in 2000: 24,500; 2008: 28,000

- **Surrounding towns served as a control**

- **Between 2002 and 2005 deer were reduced by 46.7%**
  - Estimated 2,899 (45.6 deer/km²) → 1,540 (24.3 deer /km²)

- **There was no apparent effect on the numbers tick subadults**

- **The Lyme Disease incidence rate did not vary with declining deer**

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Dutchess County New York experience

- Assessment of Lyme Disease risk (density of tick-infection prevalence of nymphal ticks)
- 13 year data on several field plots within Dutchess County
- Model comparison approach
- In predicting entomological risk:

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Risk</th>
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</thead>
<tbody>
<tr>
<td>Deer abundance</td>
<td>No predictive power</td>
</tr>
<tr>
<td>Precipitation in the current year and temperature in the prior year</td>
<td>Weak effect on risk</td>
</tr>
<tr>
<td>Abundance of mice, chipmunks and acorns 2 yr. previously</td>
<td>Strongest predictors of risk</td>
</tr>
</tbody>
</table>

Potential for deer management on Nantucket?

- Island - 48.5 miles²
- Approximately 40 miles² of deer range
- Habitat
  - Few Forested Acres - 5.3 miles² of forest
  - Understory of Shrubs including Oak
  - High Nutritional Value for Deer (Mast)
  - Good Cover
  - High Biotic Potential
  - Ecological Carrying Capacity – HIGH!!

- Nantucket has an estimated 2500 deer or approximately 50-60 /mile²

- Highest deer concentration in Massachusetts

- The Massachusetts Division of Fisheries and Wildlife goal is 6-8 / mile²
  - “Ecological carrying capacity” & “cultural carrying capacity”

R. Deblinger PhD and MA Division of Fisheries & Wildlife
Density estimate from harvest data only: 1986-2008

- Deer Harvest
- Deer Density

Post February hunt

MA Division of Fisheries & Wildlife
Deer density & harvest rates

![Graph showing deer density and harvest rates over 14 years. The graph indicates a decline in deer density with harvest rates set at 20% and 50%. The current density is also shown for comparison.](image-url)
Alternatives to hunting [1]

- Capture & Relocate
  - Attractive to some people = Non-lethal
  - Costly: $400 - $3,200/deer
  - All Habitat in NE already has deer
  - Transfers Problem
  - Requires F&W Board Approval

- Capture and Euthanize
  - Lethal but humane to MSPCA
  - Cost/Efficiency
  - Trap or Dart
  - Disposal?
  - Requires F&W Board Approval
Alternatives to hunting [2]

- **Paid Exterminators (i.e. “Sharpshooters”)**
  - Cost: $200 to $650 per deer
  - Firearms must comply with state gun laws
  - Efficiency? Carcass Disposal?
  - Ethics?
  - Requires F&W Board Approval

- **Birth Control –**
  - IMMUNOCONTRACEPTION: Experimental; No Hunting; No consumption
  - Treat >80% of Females
  - Multiple treatments per year/Requires tagging
  - Costly: $1,000/deer
  - No Oral Contraception
  - VASECTOMY: Capture, Immobilize, Surgery
  - Requires F&W Board Approval
The cost of alternative hunting programs

Nantucket 2004 Season

<table>
<thead>
<tr>
<th>Harvest</th>
<th>Number of deer</th>
<th>Capture &amp; Relocate</th>
<th>Paid Exterminators</th>
<th>Birth Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost / Deer (Range)</td>
<td></td>
<td>$400 to 3,200</td>
<td>$200 to 650</td>
<td>~$1,000/ deer</td>
</tr>
<tr>
<td>Regular Season</td>
<td>577</td>
<td>$230,000 to 1,846,400</td>
<td>$115,400 to 375,050</td>
<td>~$577,000</td>
</tr>
<tr>
<td>Special Winter</td>
<td>246</td>
<td>$98,400 to 787,200</td>
<td>$49,200 to 159,900</td>
<td>~$246,000</td>
</tr>
<tr>
<td>Total</td>
<td>823</td>
<td>$329,200 to 2,633,600</td>
<td>$164,600 to 534,950</td>
<td>~$823,000</td>
</tr>
</tbody>
</table>
Some questions & potential issues concerning deer management

- Birth control is experimental and expensive
- Relocation is impractical and expensive
- Hunting
  - Some community members have a moral objection to hunting.
  - The 2004 winter hunt was not well received by the community.
  - Is our isolation a benefit because of the impediment of deer movement from other locales considering our relative high human population and high deer density compared to other isolated areas where hunts have been “successful”? 
  - Does deer reduction just increase the tick density on the remaining deer and not reduce the total infected tick population?
  - To what degree would other hosts replace a lower deer population?
  - To what degree would ticks transported to the island by birds off-set a potential tick reduction?
  - What is the best season for hunting with the goal of reducing the incidence of tick-borne disease? Is the present season too late?
  - What is the deer density needed to reduce the incidence of tick-borne disease? How long will it take to achieve? Is it practical?
Modes of intervention

- At the level of the individual
  - Repellants
  - Appropriate clothing
  - Tick check and prompt removal
  - Education and awareness
  - Habitat avoidance
  - Source reduction around homes

- At the community level
  - Habitat management (brush clearing, fire, dessicants)
  - Education and awareness
  - Spraying
  - Host-targeted acaricides (Damminix, 4-poster)
  - Deer reduction
Next steps…………..

- Review the pros and cons of the efficacy of a deer reduction program.
  - IF deer culling is part of the final recommendations, developed an improved program compared to the 2004 hunt.

- Review the pros and cons of the efficacy of pesticide control

- Develop an improved method for collecting tick-borne diseases statistics.
  - We need a better way to measure our results.

- Develop a program to measure our progress
  - Tick abundance, infected ticks, deer density, tick-borne disease incidence etc.

- Review our present educational program and expand and improve as needed.

- Complete a sustainable, integrated and comprehensive approach to reduce the incidence of tick-borne disease on Nantucket by December.
  - Actions, timing and cost