Lyme Disease Prevention

April 24, 2013

Presentation by

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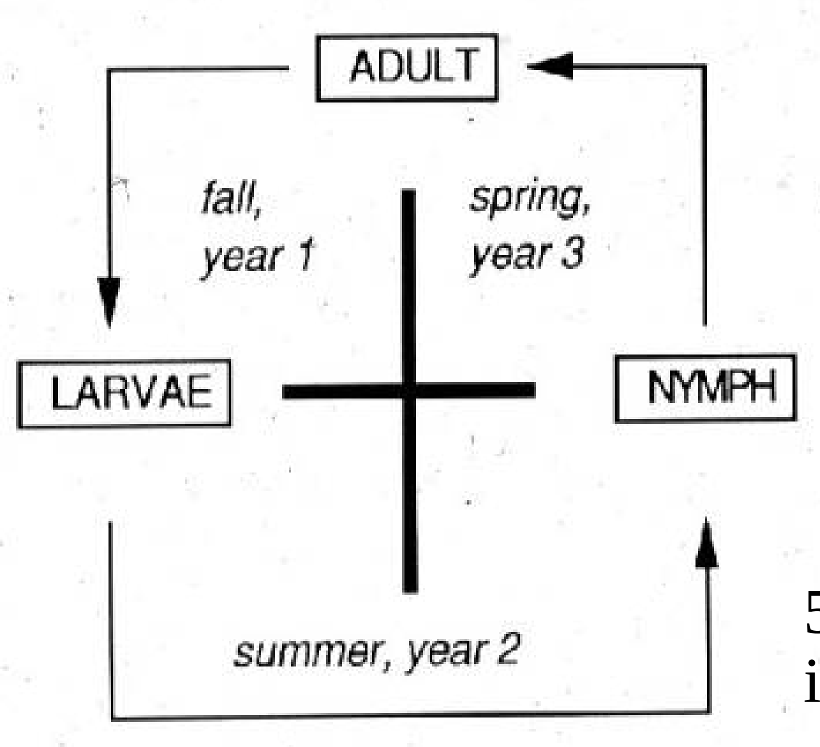
11 tick borne infections to consider as differential diagnoses for febrile patients from Massachusetts

- **Deer ticks:**
  - Lyme disease (*Borrelia burgdorferi*)
  - *Borrelia miyamotoi* disease
  - Babesiosis due to *Babesia microti*
  - Human granulocytic ehrlichiosis/anaplasmosis (*Anaplasma phagocytophilum*)
  - Deer tick virus
- **Dog ticks**
  - Tularemia
  - Rocky Mountain spotted fever
- **Lone Star ticks**
  - Masters' Disease (*Borrelia lonestari*?)
  - "Spotless fever" (*Rickettsia amblyommii*)
  - Monocytic ehrlichiosis (*Ehrlichia chaffeensis*)
- **Woodchuck ticks**
  - Powassan fever
- **Agents demonstrated to exist in human biting Massachusetts ticks:** *Borrelia andersoni*, MO-1 babesia, *Babesia odocoilei*, *B. lotori*, *Anaplasma bovis*
- **Agents likely to be found in human biting Massachusetts ticks:** *Ehrlichia muris*, St. Croix River virus (or other Tribec group orbivirus)

http://www.marvistavet.com/assets/images/Lone_Star_Tick.gif

Cheryl Beaton, Nantucket

40-75%
infection rate

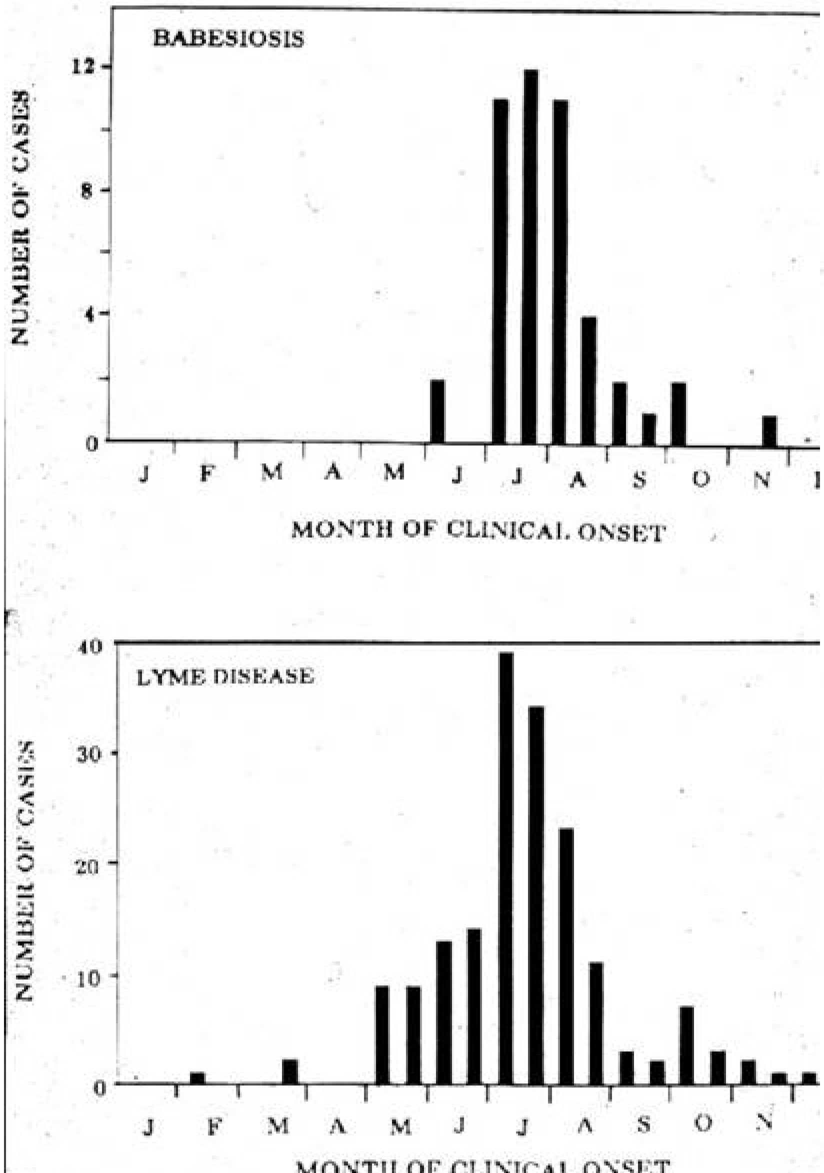


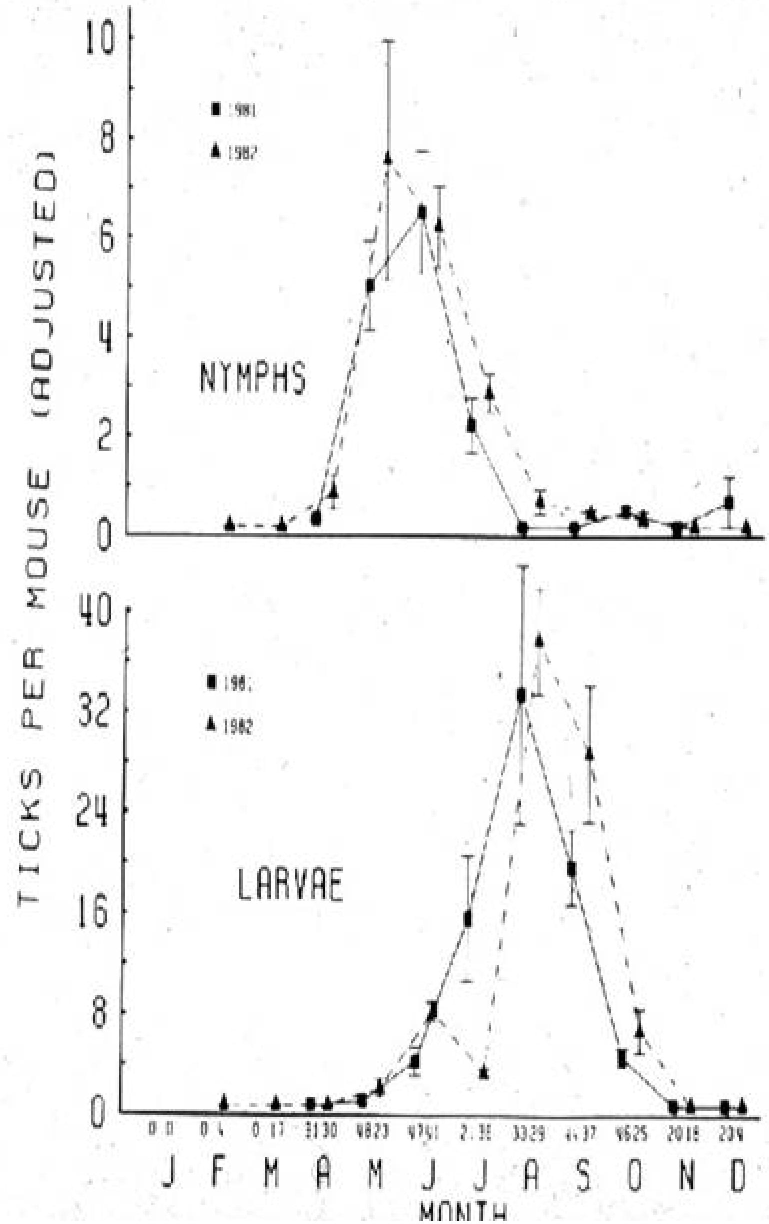
“born”
uninfected

5-30%
infection rate

Perpetuation of Lyme disease spirochetes depends on two largely INDEPENDENT factors

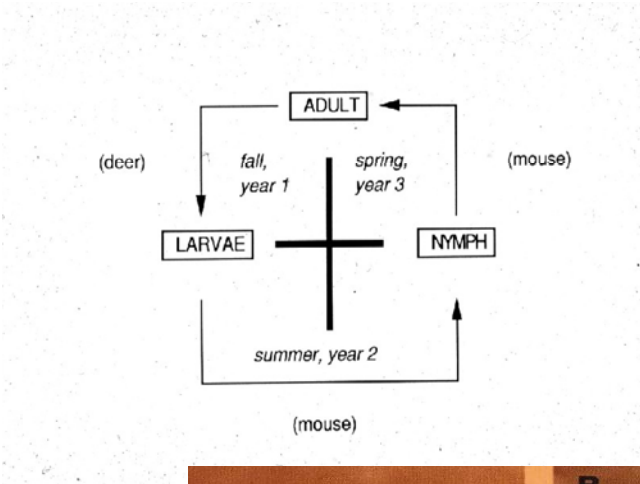
- **Tick production**: Reproduction of the tick.
  - Adult female tick acquires a bloodmeal; blood becomes eggs; eggs hatch and become larvae; such larvae are NOT infected
  - The source of the reproductive bloodmeal is a larger animal (deer, dog, coyote, bear, moose, human, cat)
  - Adult ticks do not feed on mice, shrews, squirrels, rabbits, birds
- **Infection of the tick**: uninfected larvae need to get infected
  - White footed mice, 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

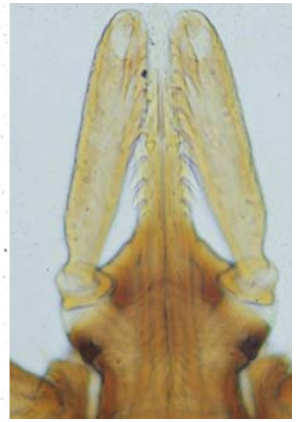


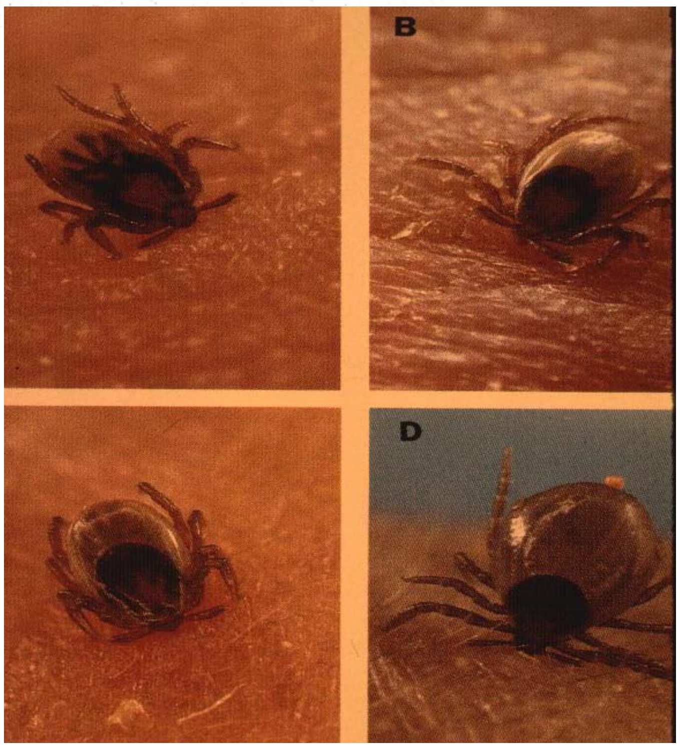


NCH case reports, cumulative, 1981-1986, GJ Dammin

Grace period: Adaptations to extended life cycle







Borrelia burgdorferi: 24-48 hours (upregulation of OspC, migration from gut to salivary glands)

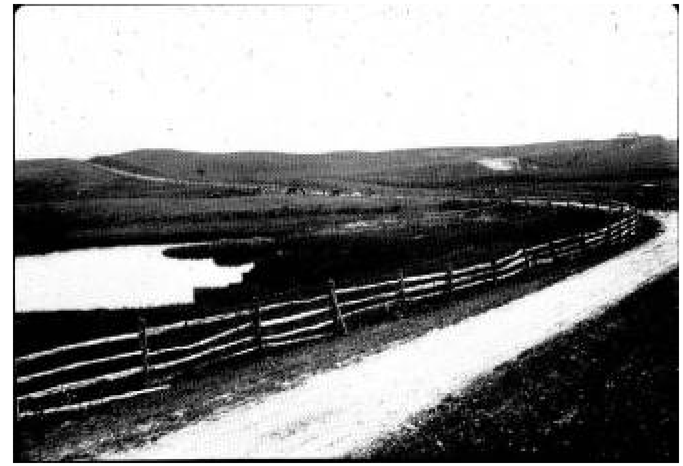
Babesia microti: 48-62 hours (sporogony from undifferentiated salivary sporoblast)

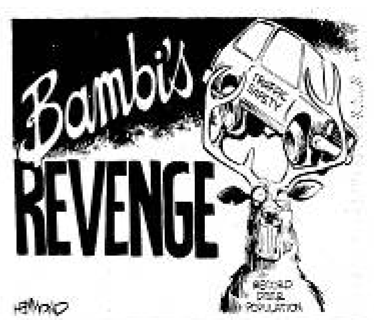
Anaplasma phagocytophilum: 24-36 hours (acquisition of “slime layer”?)

Tickborne encephalitis virus: none

Why coastal New England, and why the 1970s?

- Changes in the landscape – forest to farm to forest
- Increased development and recreational use in reforested sites
- Burgeoning deer herds





“We know how to kill ticks. We just don’t know how to get people to do it.”

Dr. Joe Piesman

Chief, Lyme Disease Vector Studies

Centers for Disease Control and Prevention

11th International Conference on Lyme Borreliosis and Other Tickborne Diseases, Irvine, CA, October 2008

Tick Management Handbook

An integrated guide for homeowners, pest control operators, and public health officials for the prevention of tick-associated disease

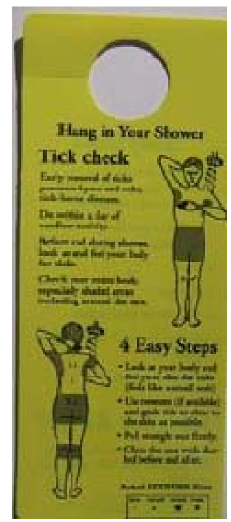
Revised Edition

Prepared by:

Kirby C. Stafford III, Ph.D.
Vice Director, Chief Entomologist
Connecticut Agricultural
Experiment Station, New Haven

Modes of intervention

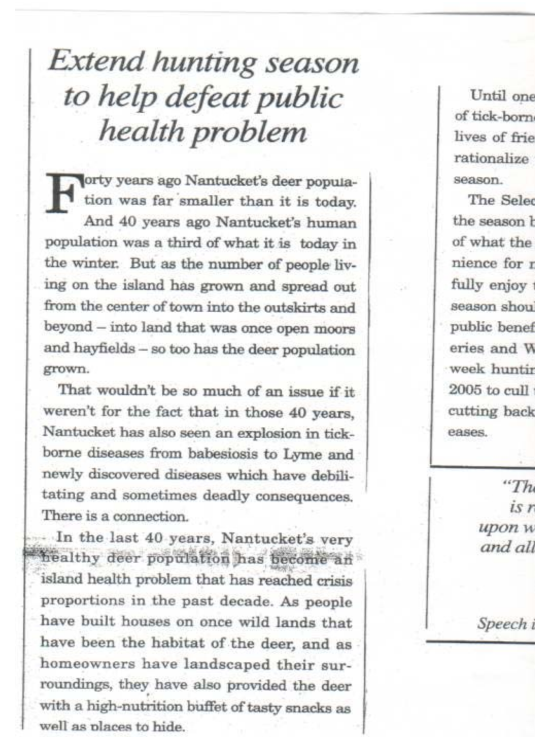
- At the level of the individual:
  - –Repellants and toxicants (permethrin, deet)
  - –Appropriate clothing
  - –Tick check
  - –Education and awareness
  - –Habitat avoidance
  - –Source reduction around homes



Modes of intervention

- At the level of communities
  - –Habitat management (brush clearing, fire, dessicants)
  - –Education and awareness
  - –Spraying
  - –Host-targeted acaricides (Damminix, 4-poster)
  - –**Deer reduction**

K. Stafford

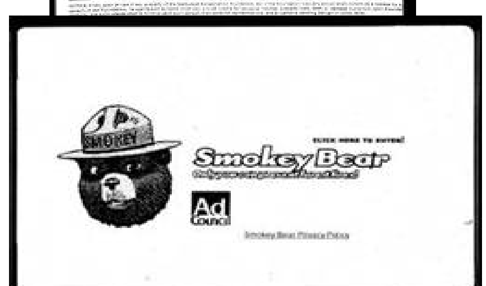


Extend hunting season to help defeat public health problem

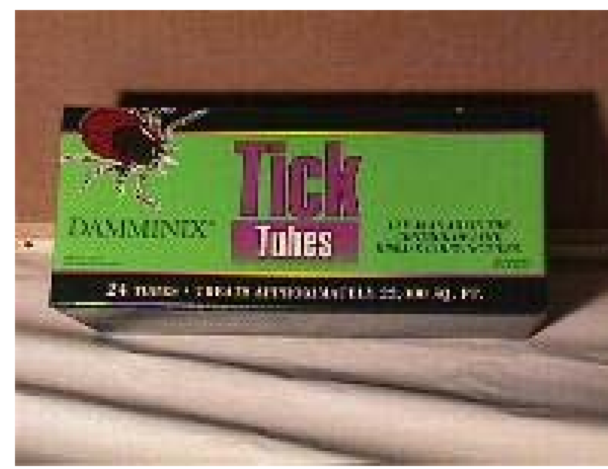
Forty years ago Nantucket's deer population was far smaller than it is today. And 40 years ago Nantucket's human population was a third of what it is today in the winter. But as the number of people living on the island has grown and spread out from the center of town into the outskirts and beyond – into land that was once open moors and hayfields – so too has the deer population grown.

That wouldn't be so much of an issue if it weren't for the fact that in those 40 years, Nantucket has also seen an explosion in tick-borne diseases from babesiosis to Lyme and newly discovered diseases which have debilitating and sometimes deadly consequences. There is a connection.

In the last 40 years, Nantucket's very healthy deer population has become an island health problem that has reached crisis proportions in the past decade. As people have built houses on once wild lands that have been the habitat of the deer, and as homeowners have landscaped their surroundings, they have also provided the deer with a high-nutrition buffet of tasty snacks as well as places to hide.



American Lyme Disease Foundation



Deer feed most adult deer ticks

Wilson ML et al. 1990. Host dependent differences in feeding and reproduction of Ixodes dammini (Acari:Ixodidae). Journal of Medical Entomology 27:945-954

Deer tick egg mass = 2000 larvae

Host	No. present on site	No.ticks per host	% of all ticks
deer	24	38.3	94
Raccoon	51	0.7	3.7
possum	8	1.2	1.0
cat	11	0.1	0.1

Reduced Abundance of Immature *Ixodes dammini* (Acari: Ixodidae) Following Elimination of Deer

MARK L. WILSON,[1,2] SAM R. TELFORD III,[1]
JOSEPH PIESMAN,[1,3] AND ANDREW SPIELMAN[1]

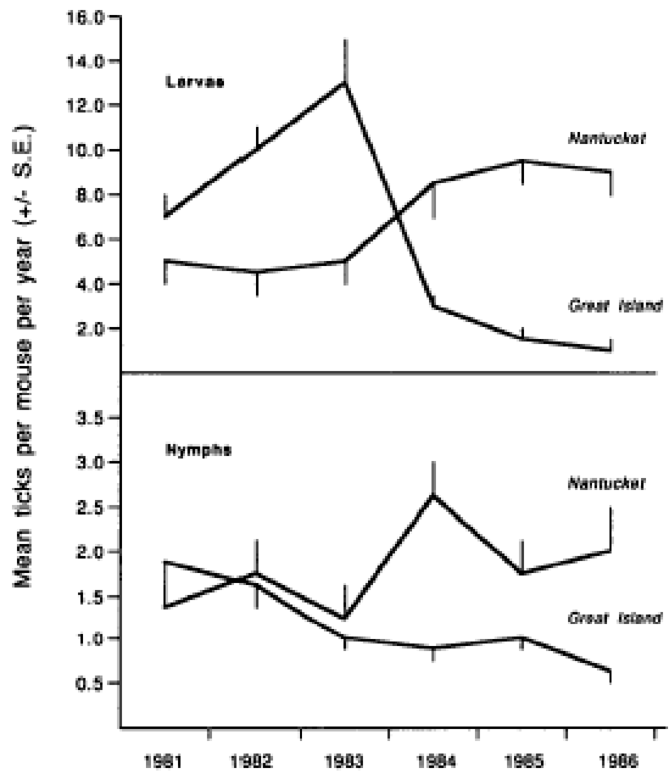
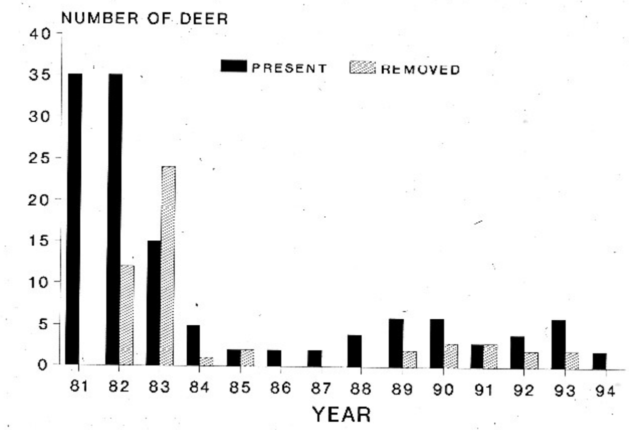
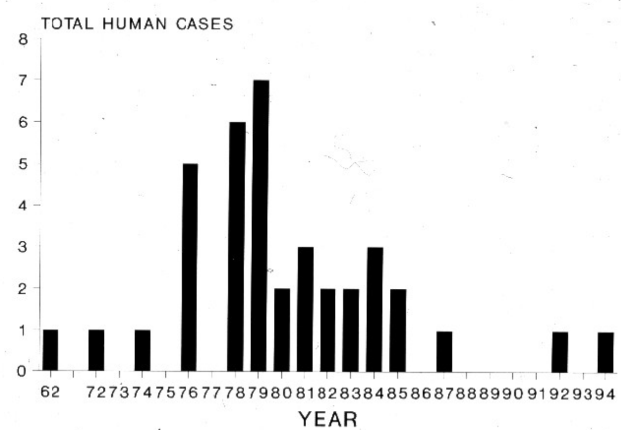


Fig. 2. Abundance of larval and nymphal *I. dammini* on Great Island and on Nantucket Island.





Reduction of risk on Great Island

- *Principle of overflow*: more reproductive units generated than can be "used" by the natural hosts
  - Pre-intervention 17 mice/ha x 132 larvae/mouse = production of 2244 nymphs/ha
    - But only 17 mice/ha x 26 nymphs/mouse = 442 nymphs "removed" per ha, therefore "overflow" is 2244 – 442 or 1802 "extra" nymphs/ha
  - Post-intervention 17 mice/ha x 25 larvae/mouse = production of 425 nymphs/ha
    - But only 17 mice/ha x 8 nymphs/mouse = 136 nymphs "removed" by feeding on mice on each ha, therefore "overflow" is 425-136 or 289 extra nymphs/ha
    - Risk of seeing an "extra" nymph is 289/1802 or nearly 80% less than pre-intervention

Population and Community Ecology

Effects of Reduced Deer Density on the Abundance of *Ixodes scapularis* (Acari: Ixodidae) and Lyme Disease Incidence in a Northern New Jersey Endemic Area

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Freehold Area Health Department, 1 Municipal Plaza, Freehold, NJ 07728

J. Med. Entomol. 44(5): 752–757 (2007)

ABSTRACT We monitored the abundance of *Ixodes scapularis* Say (Acari: Ixodidae) and the Lyme disease incidence rate after the incremental removal of white-tailed deer, *Odocoileus virginianus* Zimmermann, within a suburban residential area to determine whether there was a measurable decrease in the abundance of ticks due to deer removal and whether the reduction in ticks resulted in a reduction in the incidence rate within the human population. After three seasons, the estimated deer population was reduced by 46.7%, from the 2002 postfawning estimate of 2,899 deer (45.6 deer per km^2) to a 2005 estimate of 1,540 deer (24.3 deer per km^2). There was no apparent effect of the deer culling program on numbers of questing *I. scapularis* subadults in the culling areas, and the overall numbers of host-seeking ticks in the culling areas seemed to increase in the second year of the program. The Lyme disease incidence rate generated by both passive and active surveillance systems showed no clear trend among years, and it did not seem to vary with declining deer density. Given the resources required to mount and maintain a community-based program of sufficient magnitude to effectively reduce vector tick density in ecologically open situations where there are few impediments to deer movement, it may be that deer reduction, although serving other community goals, is unlikely to be a primary means of tick control by itself. However, in concert with other tick control interventions, such programs may provide one aspect of a successful community effort to reduce the abundance of vector ticks.

KEY WORDS *I. scapularis*, deer reduction, Lyme disease risk

Table 1. Annual deer harvest, road kill estimate, and estimate total deer population in Bernards Township, 2002–2005

Yr	Total harvest	Road kill	Total deer killed	Pop estimate
2002 prehunt				2,899 (45.6/km^2)
2002–2003	435	379	814	2,484 (39.9/km^2)
2003–2004	543	356	899	2,120 (33.5/km^2)
2004–2005	641	323	964	1,540 (24.3/km^2)

Per sq mi = 2.6x

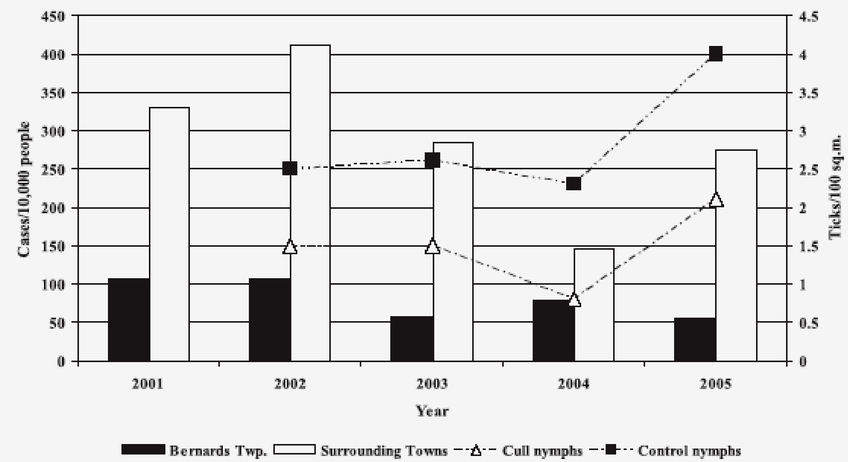

Fig. 1. Lyme disease incidence rates (cases per 100,000 people) in Bernards Township and mean incidence rate for 10 surrounding municipalities (bars) during the period 2001–2005; mean nymphal *I. scapularis* abundance ± SE at deer culling and control areas (lines) for the period 2002–2005.

Table 2. Results of ANOVA comparing tick abundance (mean ± SE) at 10 cull and 10 control sites between years 2002–2005

Life stage	Yr 2002 Cull sites	2002 Control sites	2003 Cull sites	2003 Control sites	2004 Cull sites	2004 Control sites	2005 Cull sites	2005 Control sites	ANOVA results
Spring adults	1.2 ± 0.2a	4.9 ± 0.8b	1.3 ± 0.2a	4.8 ± 0.8b	0.9 ± 0.1a	2.3 ± 0.3a	3.6 ± 0.3b	5.1 ± 0.3b	$F = 16.92$, $P < 0.01$
Nymphs	1.5 ± 0.2a	2.5 ± 0.2b	1.5 ± 0.2a	2.6 ± 0.2b	0.8 ± 0.1c	2.3 ± 0.3b	2.1 ± 0.3a,b	4.0 ± 0.3d	$F = 13.89$, $P < 0.01$
Larvae	6.7 ± 0.7a	37.7 ± 6.0b	3.9 ± 0.6c	34.7 ± 5.8b	12.9 ± 0.8a	45.0 ± 6.0b	16.1 ± 0.9a	48.0 ± 5.9b	$F = 16.22$, $P < 0.01$
Fall adults	1.5 ± 0.2a	6.5 ± 0.9b	1.1 ± 0.2a	4.3 ± 0.5c	1.2 ± 0.3a	6.4 ± 0.3b	3.6 ± 0.4c	7.9 ± 0.4b	$F = 28.18$, $P < 0.01$

Numbers in the same row followed by the same letter are not significantly different ($P < 0.05$; Tukey's HSD test).

The successful USDA 4-poster trial is independent evidence that deer are critical for deer tick density!

VECTOR-BORNE AND ZOONOTIC DISEASES
Volume 9, Number 4, 2009

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ORIGINAL ARTICLE

Evaluation of the United States Department of Agriculture Northeast Area-Wide Tick Control Project by Meta-Analysis

Brandon Brei,[1] John S. Brownstein,[2] John E. George,[3] J. Mathews Pound,[3] J. Allen Miller,[3]
Thomas J. Daniels,[4] Richard C. Falco,[4] Kirby C. Stafford, III,[5] Terry L. Schulze,[6] Thomas N. Mather,[7]
John F. Carroll,[8] and Durland Fish[1]

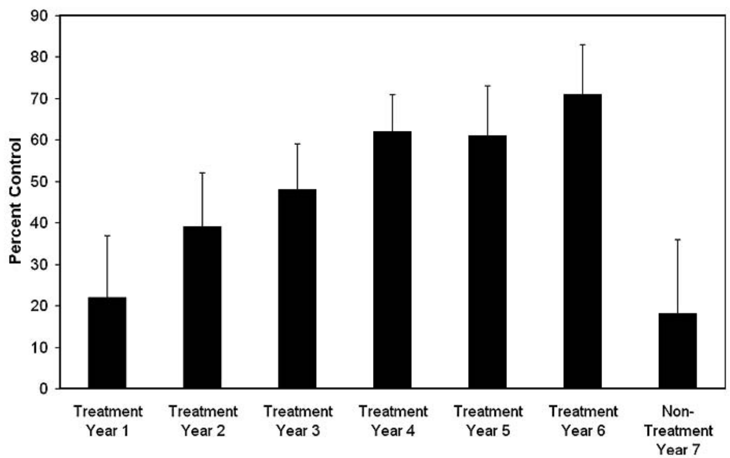
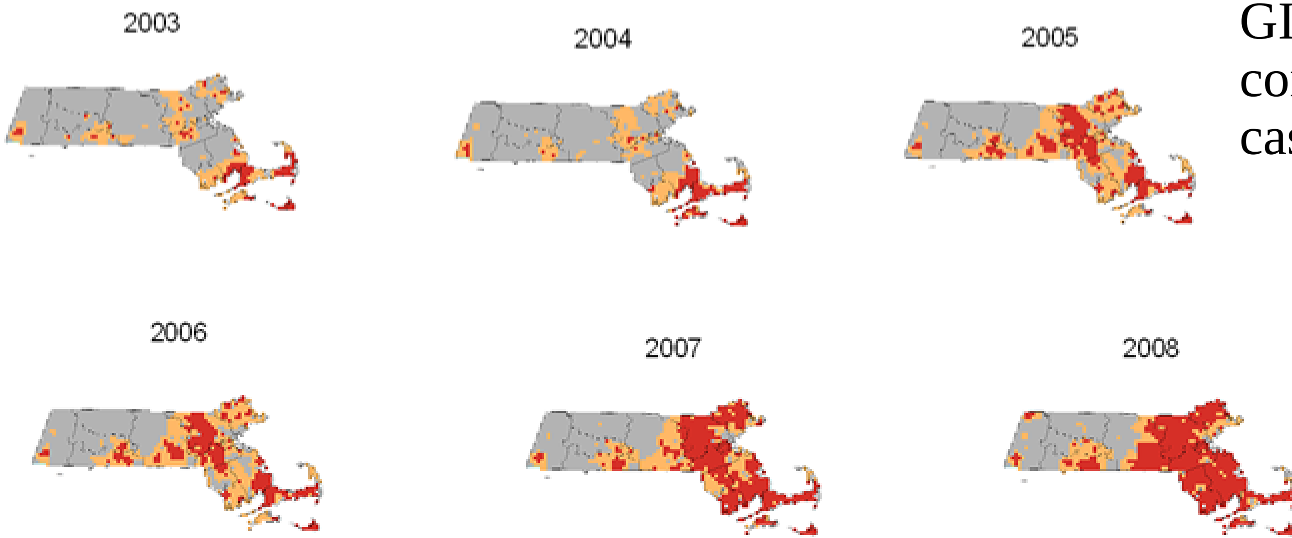


FIG. 1. Percent nymphal control for each of the 6 treatment years and the final nontreatment year 7. Means are shown with 95% confidence intervals.

4-poster images courtesy of Larry Dapsis, Barnstable Co./Cape Cod Extension Project

GIS analysis of MADPH confirmed Lyme disease cases by year



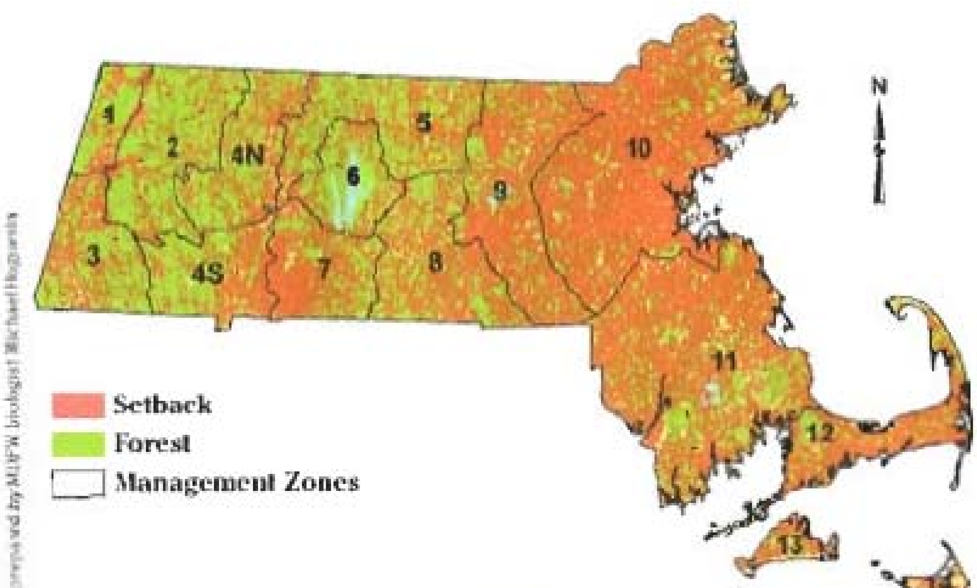


Figure 2: Discharge Setbacks in Massachusetts.

Based on data last compiled in 2003, at least 161 communities in Massachusetts have enacted local hunting restrictions. The percentage of such communities has increased from about 12% in 1956 to more than 45% today.

Deer serve as bloodmeal sources for many other pests, including mosquitoes and deerflies

www.agnews.tamu.edu

www.insects.tamu.edu

- Robertson et al. Bionomics of Anopheles quadrimaculatus and Culex erraticus (Diptera: Culicidae) in the Falls Lake basin, North Carolina: seasonal changes in abundance and gonotrophic status, and host-feeding patterns.
  J Med Entomol. 1993 Jul;30(4):689-98.
- Burkot & Defoliart. Bloodmeal sources of Aedes triseriatus and Aedes vexans in a southern Wisconsin forest endemic for La Crosse encephalitis virusAm J Trop Med Hyg. 1982 Mar;31(2):376-81.
- Apperson et al. Host Feeding Patterns of Established and Potential Mosquito Vectors of West Nile Virus in the Eastern United States.   Vector Borne and Zoonotic Diseases, Mar 2004, Vol. 4, No. 1: 71-82

Jamestown Canyon and Cache Valley viruses

Vector/ Pathogen/ Host Interaction, Transmission

Host-Feeding Patterns of Potential Mosquito Vectors in Connecticut, USA: Molecular Analysis of Bloodmeals from 23 Species of *Aedes*, *Anopheles*, *Culex*, *Coquillettidia*, *Psorophora*, and *Uranotaenia*

Goudarz Molaei,[1,2] Theodore G. Andreadis,[1] Philip M. Armstrong,[1] and Maria Diuk-Wasser[3]

J. Med. Entomol. 45(6): 1143–1151 (2008)

- California serogroup encephalitis
- Usually asymptomatic; can cause mild aseptic meningitis; self resolving. Rare severe cases (children) with neurologic disease. CVV is an animal teratogen.
- 10% seroprevalence among Nantucket residents
- Transmitted by *Aedes vexans* and other woodland mosquitoes
- Deer are reservoirs; virtually all deer are infected by 6 months of age.

Table 2. Number of mammalian-derived bloodmeals identified from 23 species of mosquitoes collected in Connecticut, 2002–2007

Mosquito species	Total no.	Deer	Human	Cat	Horse	Cow	Opossum	Chipmunk	Otter	Rabbit	Raccoon	Rat	Dog	Fox	Squirrel
Ae. abserratus	20	19				1									
Ae. aurifer	24	20	2						1		1				
Ae. canadensis	189	179	7	2			1								
Ae. cantator	50	45	3	2											
Ae. cinereus	72	55	7	2	1		1	3			1	1			1
Ae. communis	1	1													
Ae. excrucians	14	13		1											
Ae. japonicus	6	4	1					1							
Ae. sollicitans	7	6	1												
Ae. sticticus	24	23		1											
Ae. stimulans	24	21	1	1	1										
Ae. taeniorhynchus	20	19								1					
Ae. thibaulti	56	51	2		1	1			1						
Ae. triseriatus	21	15	1	3			1					1			
Ae. trivittatus	70	58	5	2	2	1				2					
An. barberi	1	1													
An. punctipennis	11	10	1												
An. quadrimaculatus	8	6			2										
An. walkeri	6	6													
Cq. perturbans	59	51	3			1	1		1				2		
Culex territans	1	1													
Ps. ferox	12	11												1	
Ur. sapphirina	3	2	1												

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