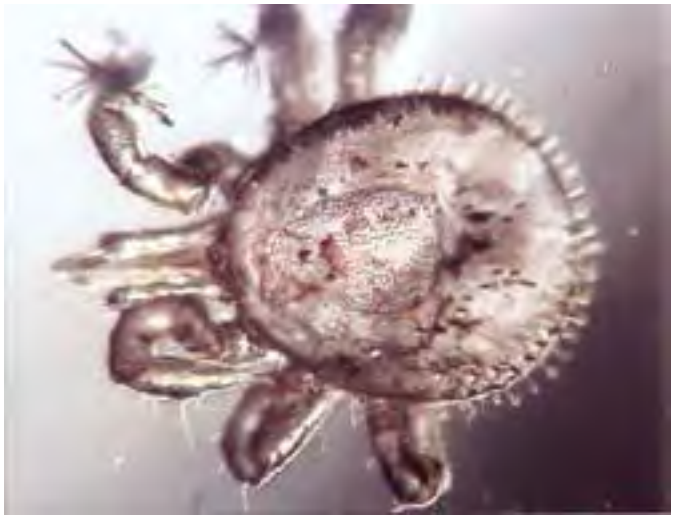
Ticks are not insects; they are large mites



Phylum Arthropoda; Subphylum Chelicerata; Class Arachnida; Subclass Acari; Superorder Parasitiformes; Order Ixodida

Carios jerseyi, found in amber excavated in New Jersey, is estimated to be 90 million years old

Arthropods as vectors

- **Ticks and mites:** *viruses* (tickborne encephalitis, Colorado tick fever, Crimean-Congo hemorrhagic fever); *bacteria* (rickettsioses, spirochetoses, ehrlichioses, tularemia); *protozoa* (piroplasmoses, trypanosomiases, hepatozoonosis); *helminths* (Dipetalonema rugosicauda)
- **Mosquitoes:** *viruses* (yellow fever, EEE, hundreds of others); *bacteria* (tularemia?); *protozoa* (malaria); *helminths* (filariases)
- **Flies** (deer flies, tsetse flies): *bacteria* (tularemia); *protozoa* (trypanosomiases); *helminths* (loaisis)
- **Sandflies, midges and blackflies:** *viruses* (pappataci fever, bluetongue); *protozoa* (leishmaniases, malaria); *helminths* (onchocerciasis)
- **Fleas:** *bacteria* (plague, bartonellosis, murine typhus); *protozoa* (trypanosomiases); *cestodes* (dipylidium)
- **Lice:** *bacteria* (typhus, bartonellosis, relapsing fever)
- **Bugs:** *protozoa* (trypanosomiasis)

Attributes of ticks that make them good vectors

- Extended life cycle with 2 or more opportunities for acquiring infection
- Host specificity (1-host ticks with very narrow host range; 2 host ticks allow zoonotic bridge)
- Long duration of feeding allows for possibility of low dose inocula
- High reproductive potential (BRN of pathogen can be great)
- Exploit disturbed environments

Other reasons to be interested in ticks

- Role as pests
- Dermatitis/ hypersensitivity
- Toxic reactions
  - Tick paralysis: acute ascending flaccid paralysis, like Guillain-Barre syndrome; patients become ataxic and may require ventilation
  - Small protein toxin acts presynaptically and inhibits Ach release
- Exsanguination- secondary anemia
  - Tick infested cows give less milk, cattle grow more slowly, generally less healthy

Zoonoses to consider as differential diagnoses for febrile patients from Massachusetts

- **Tick borne:** Lyme, Babesia microti, human granulocytic ehrlichiosis, Powassan fever, tularemia, Rocky Mountain spotted fever
- **Mosquito borne:** Lacrosse encephalitis, Jamestown Canyon virus, Eastern equine encephalitis, West Nile virus, Cache Valley virus




- **Flea borne:** cat scratch disease, Rickettsia felis
- **Mite borne:** rickettsialpox
- **Louse borne:** epidemic typhus, trench fever
- **Rodent borne:** hantavirus (Seoul and Sin Nombre groups)
- **Agents in search of an emerging disease:** Borrelia cf. miyamotoi, Bartonella vinsonii, deer tick virus, MO-1 babesia, Anaplasma bovis

- “Nantucket Fever” (babesiosis) – first case in 1969
- Fever, chills, muscle aches, headache, night sweats, fatigue, brown urine
- Caused by protozoan similar to malaria, long known as parasite of rodents

BOARD OF SELECTMEN

NANTUCKET, MASSACHUSETTS

PUBLIC

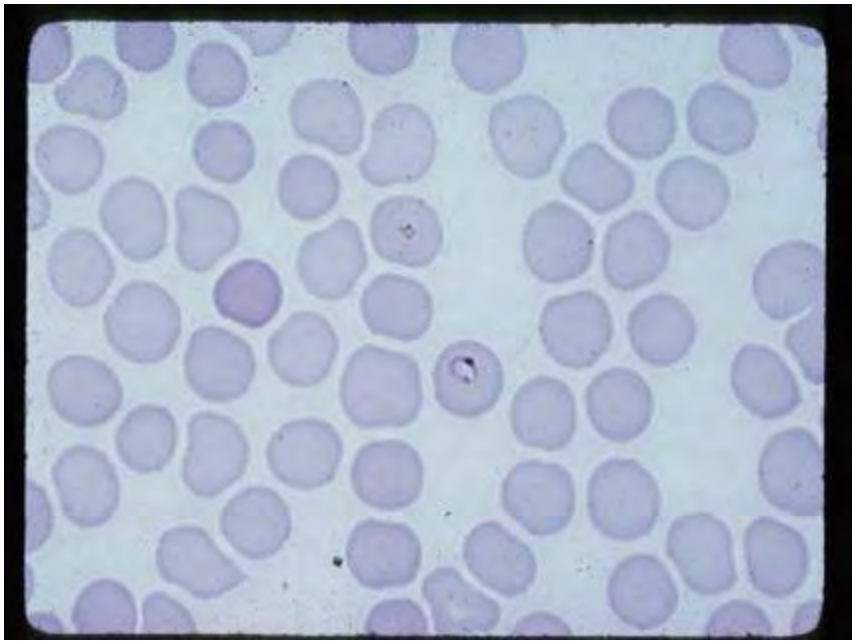
HEALTH NOTICE

This notice is occasioned by the occurrence on Nantucket of the fifth case of babesiosis to be diagnosed this summer. Babesiosis is an uncommon febrile and, usually, mild disease; only seven cases having been observed on Nantucket in the last six years. The agent is carried by a tick, probably by only one of several varieties present on the Island. Symptoms appear about a month following tick bite. They include weakness, fever, chills, headache, and pain in the muscles and joints. Recovery may be spontaneous, or may require chloroquine and drugs for symptomatic treatment.

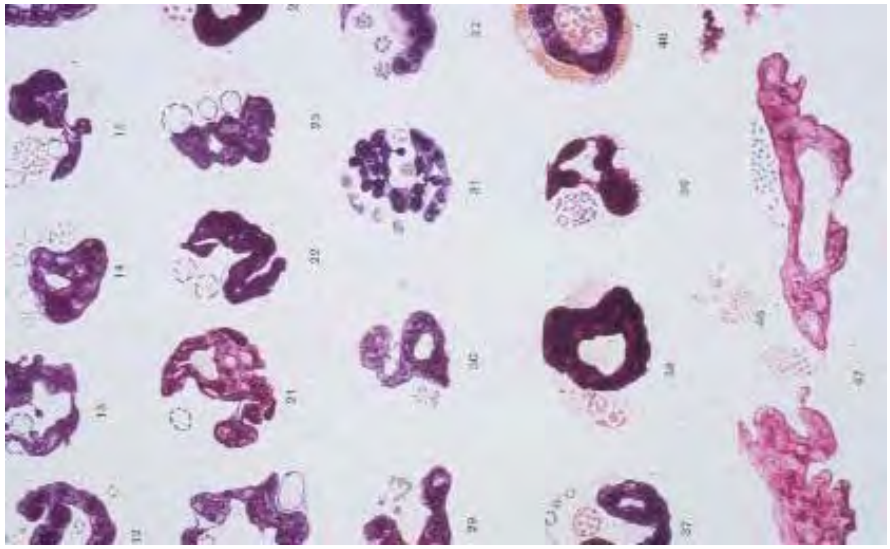
Currently, the avoidance of exposure to ticks is the principal means of prevention. Should tick bite occur, and symptoms like those cited above appear, the patient should report to a physician, mentioning the history of tick bite.

An investigation of babesiosis is now underway with Nantucket physicians, Nantucket Board of Health, the Nantucket Inspector of Health, the Massachusetts Department of Public Health, and the Harvard School of Public Health guiding the current studies.

NANTUCKET BOARD OF HEALTH



- Outbreak of arthritis in children in Old Lyme; odd rashes precede arthritis, usually after bug bite
- Lyme arthritis and erythema migrans caused by spiral bacteria (spirochetes) transmitted by deer ticks
- Nantucket fever cases often preceded by “spider bite”



Human Granulocytic Ehrlichiosis in the Upper Midwest United States

A New Species Emerging?

Jonan S. Bakken, MD; J. Stephen Dumler, MD; Sheng-Mei Chen, MD; Mark R. Eckman, MD; Linda L. Van Etta, MD; David H. Walker, MD

Objective.—To characterize the clinical presentation and course, laboratory findings, and treatment outcome of 12 patients with human granulocytic ehrlichiosis.

Setting.—The 12 patients were male, ranged in age from 29 to 91 years, and contracted their illness in Wisconsin or Minnesota.

Methods.—Cases were recognized by the presence of intracytoplasmic inclusions (morulae) in peripheral neutrophils of patients presenting with temperature of 38.5°C or higher, chills, severe headache, and myalgias. All patients had a complete blood cell count and blood chemistry profile. Blood smears were examined by light microscopy. All available paired serum samples were analyzed for presence of indirect fluorescent antibodies against *Ehrlichia chaffeensis*, *Ehrlichia phagocytophila*, and *Ehrlichia equi*. Blood samples from 12 patients were subjected to polymerase chain reaction analysis using primers specific for the *E phagocytophila*/*E equi* group, primers that include the agent identified in our patients, as well as *E chaffeensis*.

Most cases of *E chaffeensis*
described have been contract
south central and southeaste
States,[9] and many patients h
oped their illness following a ti
Recent studies demonstratin
fessensis in *Amblyomma ame*
tiata[10] support the concept th
ehrlichiosis is a tick-borne d
By 1986, at least 21 states ha
cases of human ehrlichiosis t
ters for Disease Control and P
(CDC).[9-11]

The upper Midwest repres
for endemic region for several
illnesses, including Lyme dis

[From PARASITOLOGY, Vol. XXX, No. 2, 8 July, 1938.]
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PRINTED IN GREAT BRITAIN

CYTOECETES MICROTI, N.G., N.SP., A PARASITE DEVELOPING IN GRANULOCYTES AND INFECTIVE FOR SMALL RODENTS

By ERNEST E. TYZZER
Medical School of Harvard University, Boston, Mass.

(With Plates X and XI, containing Figs. 1–50)

A MICRO-ORGANISM of unusual type, henceforth designated *Cytoecetes microti*, was discovered by the author in the blood of field voles (*Microtus pennsylvanicus*) which had been inoculated with a suspension in saline of pooled, mortar-ground liver and splenic tissue of a number of voles of the same species and of one white-footed or deer mouse (*Peromyscus leucopus*). This organism occurred

Proc. Natl. Acad. Sci. USA
Vol. 93, pp. 6209–6214, June 1996
Microbiology

Perpetuation of the agent of human granulocytic ehrlichiosis in a deer tick–rodent cycle

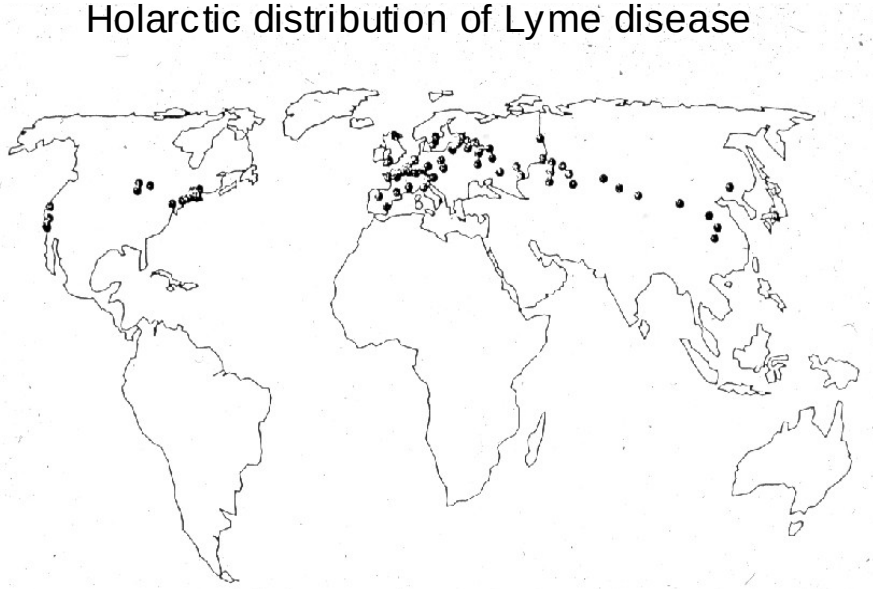
(Ehrlichia/Ixodes dammini/mice/vector/reservoir)

SAM R. TELFORD III*†, JACQUELINE E. DAWSON‡, PAULA KATAVOLOS*, CYNTHIA K. WARNER‡, CHRISTOPHER P. KOLBERT§, AND DAVID H. PERSING§

*Department of Tropical Public Health, Harvard University School of Public Health, Boston, MA 02115; ‡Division of Viral and Rickettsial Diseases, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA 30333; and §Mayo Foundation, Rochester, MN 55905.

Communicated by William Trager, The Rockefeller University, New York, NY, March 5, 1996

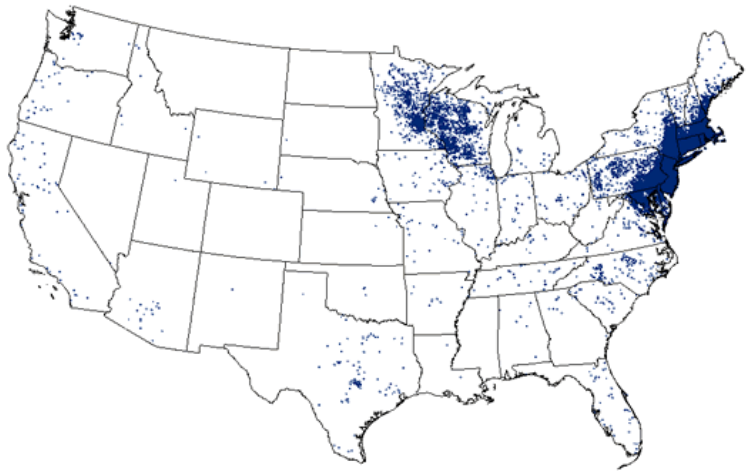
Holarctic distribution of Lyme disease



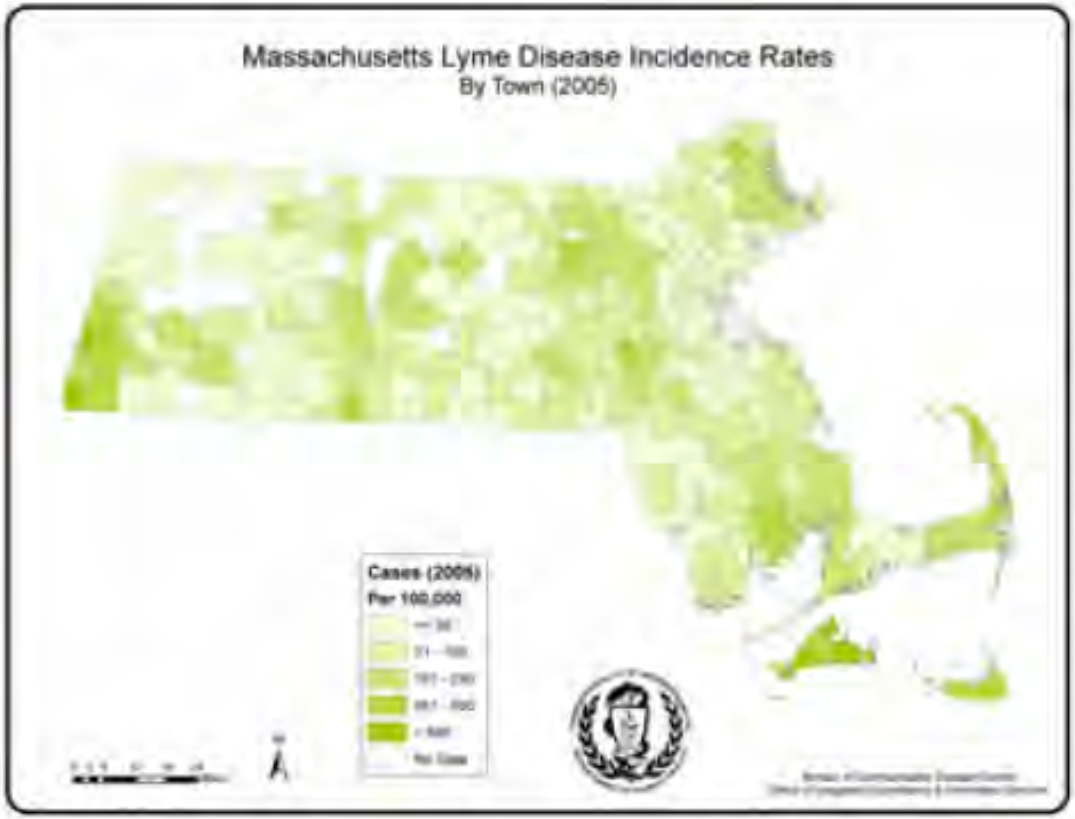
Estimates of Lyme disease attack rates

Study author	Site	#subjects	incidence
Hanrahan	Fire Island, NY	129	3.1
Steere	Great Island, MA	162	1.1
Lastavica	Ipswich, MA	190	4.0
Alpert	Chappaqua, NY	114	2.6
Feder	East Lyme, CT	445	2.7
Miller	Westchester, NY	774	2.5
Krause	Block I., RI	553	2.0
Telford	coastal MA, RI	360	1.7
Wormser	Westchester, NY	1634	3.9
Steere	Northeast	10,936	0.7
Sigal	Northeast	10,305	0.4
		median	2.5

Reported Cases of Lyme Disease -- United States, 2004



1 dot placed randomly within county of residence for each reported case



County*	2005 Confirmed Cases (#)	Incidence Rate (per 100,000)
Barnstable	229	101.1
Berkshire	66	50.1
Bristol	148	27.1
Dukes	90	577.2
Essex	254	34.4
Franklin	24	33.2
Hampden	118	25.6
Hampshire	68	44.3
Middlesex	444	30.4
Nantucket	29	285.2
Norfolk	252	38.6
Plymouth	320	65.0
Suffolk	45	6.9
Worcester	238	30.4
State Total	**2341**	**36.3**

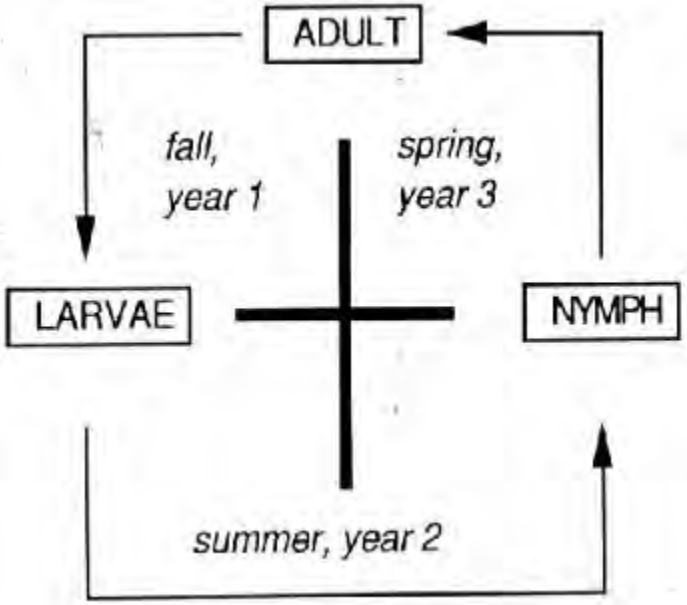
* County was unknown for 16 cases

http://www.mass.gov/dph/cdc/epii/lyme/lyme_disease_surveillance_2005.pdf

Canine Lyme disease

- 8 year old Lab/German shepherd mix worries foot over the course of a week (March 2005); no evidence of trauma
- Prior to moving to Grafton in 2003, lived in Boston
- Frontline used during tick season; no Lyme vaccine
- 1 engorged adult deer tick removed during spring 2004; no signs or symptoms in the interim
- Abrupt onset of swelling, cannot put weight on left rear foot; inappetence, neediness, depression
- Did not improve (no treatment) within a week
- Western blot positive; negative IFAT for HGE
- Doxycycline 100 mg p.o. b.i.d. 21 days; no improvement for 8 days; sudden improvement of swelling when corticosteroid was added and within 2 days foot returns to normal and limp disappears
- July 2005 swelling reappears but not as bad; foot is favored but weight could be placed on it; no other signs or symptoms; no treatment; foot returns to normal within a week

SRT1



J. Med. Entomol. Vol. 15, no. 3: 218–234 23 March 1979

HUMAN BABESIOSIS ON NANTUCKET ISLAND, USA: DESCRIPTION OF THE VECTOR, *IXODES (IXODES) DAMMINI*, N. SP. (ACARINA: IXODIDAE)[1]

By Andrew Spielman[2], Carleton M. Clifford[3], Joseph Piesman[2] and Melvin D. Corwin[3]

Slide 12

SRT1 Understanding the life cycle of the tick is critical to efforts to reduce their density. Adult ticks (male and female) are around from October through the winter, disappearing at the end of May. They feed only on larger animals, usually deer. If the female feeds successfully, she will lay eggs that hatch in July. The larvae that come out of the eggs look for something small, like mice or birds (but will feed on anything, even deer) during August and September. If they feed successfully, the engorged (fed) larvae turn into nymphs the following spring, emerging to feed on virtually anything, including humans, during May, June, and July. If they feed successfully, they turn into adult ticks and the cycle is completed.

Sam Telford III, 7/27/2005

Dog/wood ticks (Dermacentor variabilis)

- Most common tick in New England
- Found in grassy sites (beach grass)
- Raccoons, skunks, foxes, coyotes are definitive hosts
- Small mammals (mice, voles) feed immature ticks
- Transmits tularemia and RMSF
- Only adult ticks (large, about ¼ inch) feed on humans: season of activity April-July

www.uky.edu/.../entfacts/ struct/amdogtik.gif

SRT3

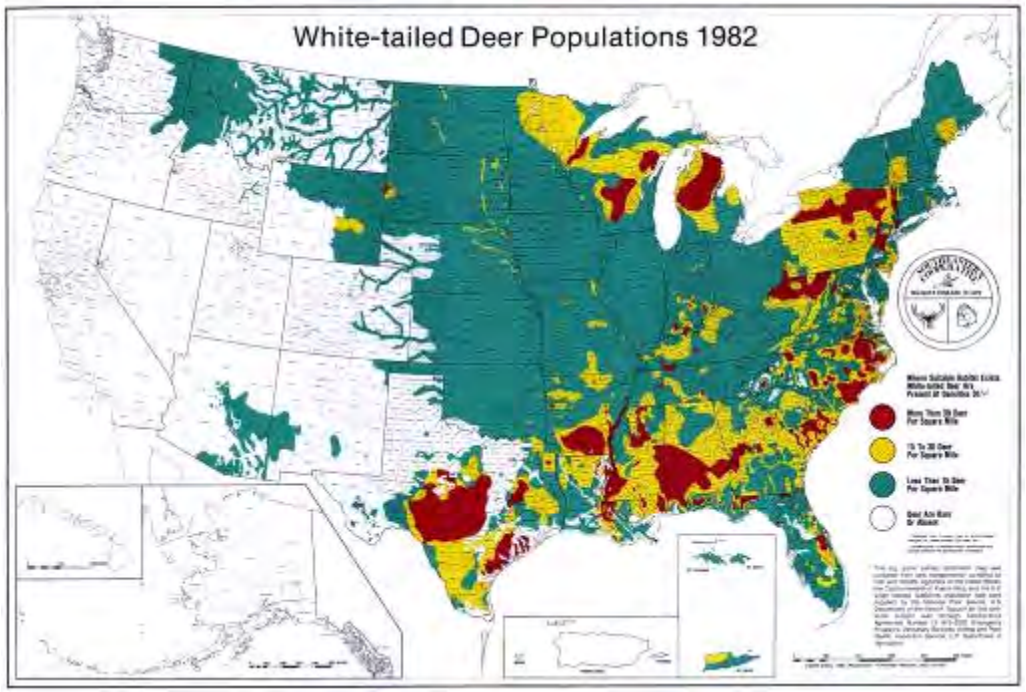
Why coastal New England, and why the 1970s?

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

Slide 14

SRT3 The pictures on the right are from Peter Dunwiddie's nice before and after book of Nantucket...showing Polpis Road in the 1880s and in the 1980s. The heavy brush that has grown up is vital to the ticks (which need high humidity) and a great place for mice to breed and deer to browse. One could reduce ticks over the longterm by promoting a return to the pastoral landscape that Nantucket used to be, but this will never happen. And, wish as we all might, the tourists and developers will not go away either. That leaves deer as the focus for intervention.

Sam Telford III, 7/27/2005


White-tailed Deer Populations 1982

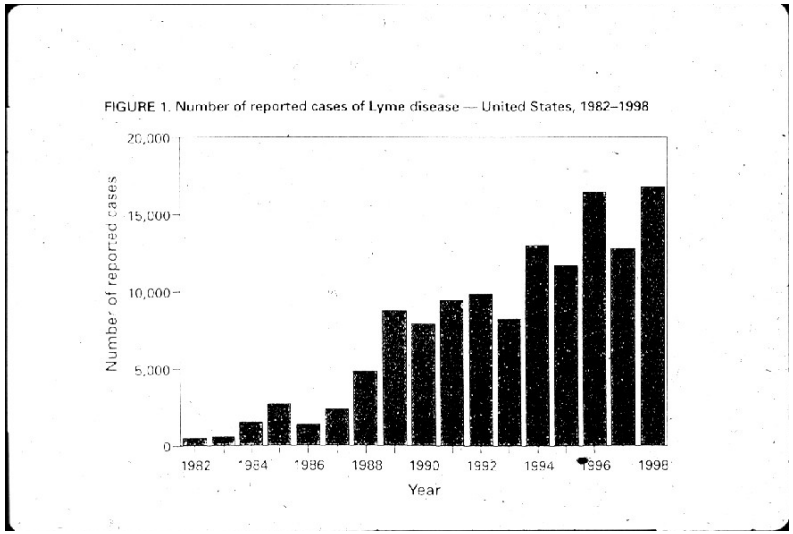
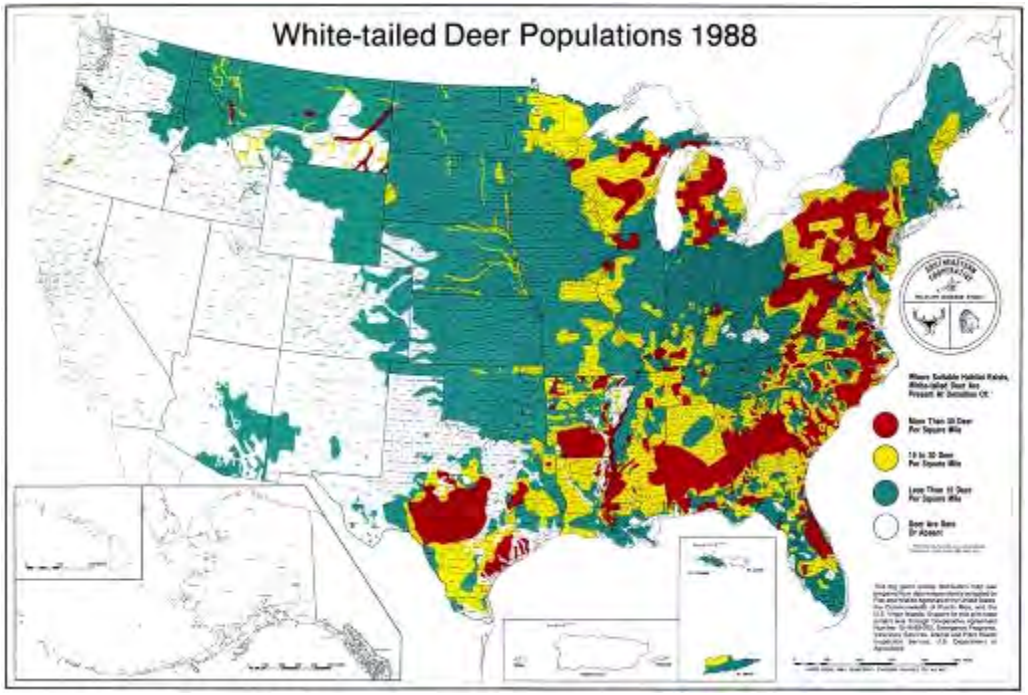
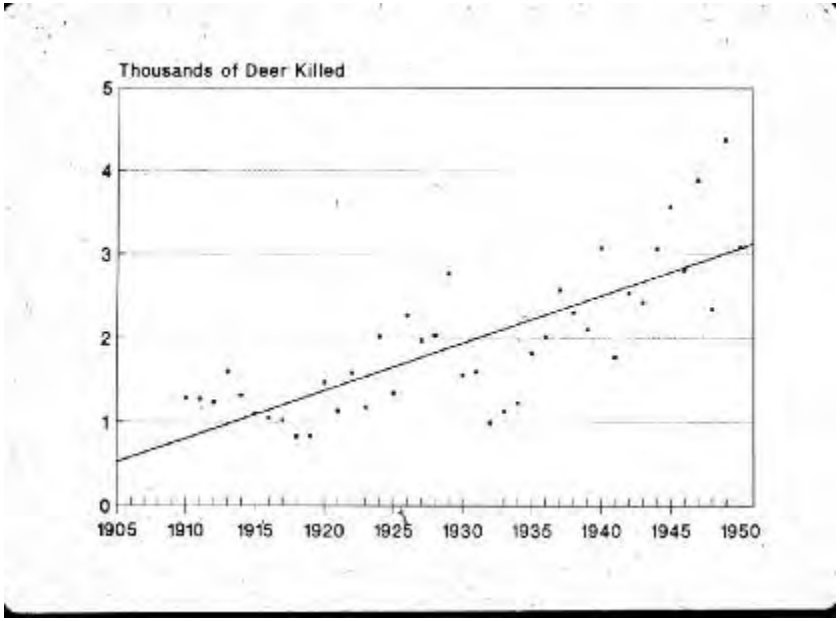


FIGURE 1. Number of reported cases of Lyme disease — United States, 1982–1998
Number of reported cases
20,000
15,000
10,000
5,000
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year


White-tailed Deer Populations 1988


Thousands of Deer Killed
5
4
3
2
1
0
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950

SRT5

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

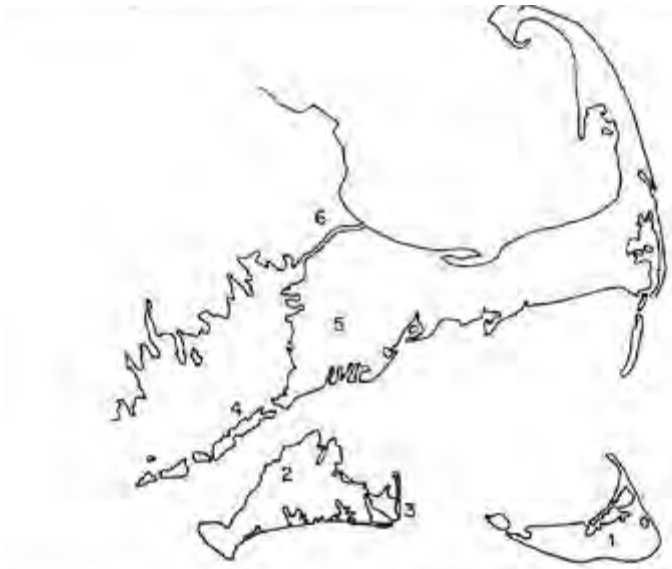
Deer tick egg mass = 2000 larvae

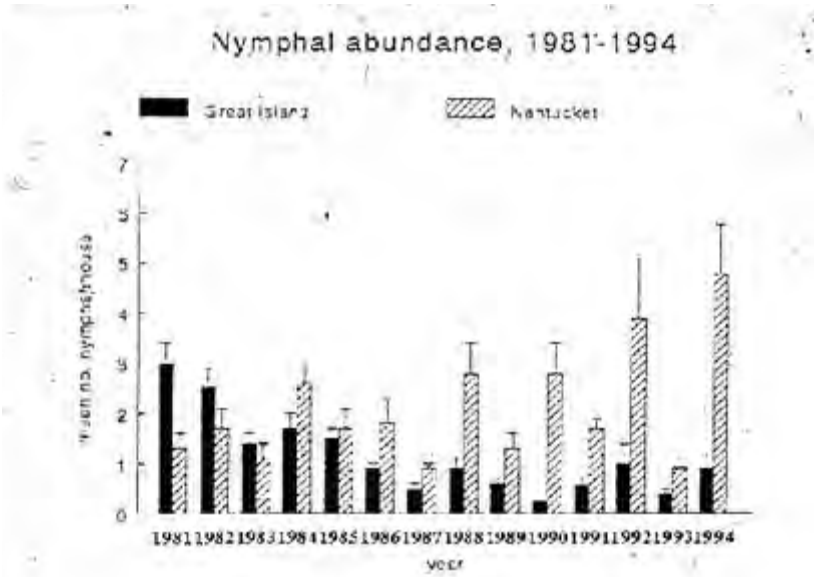
Host	No. present on site	No.ticks per host	% of all ticks
deer	24	38.3	94
Raccoon	51	0.7	3.7
possum	8	1.2	1.0
cat	11	0.1	0.1

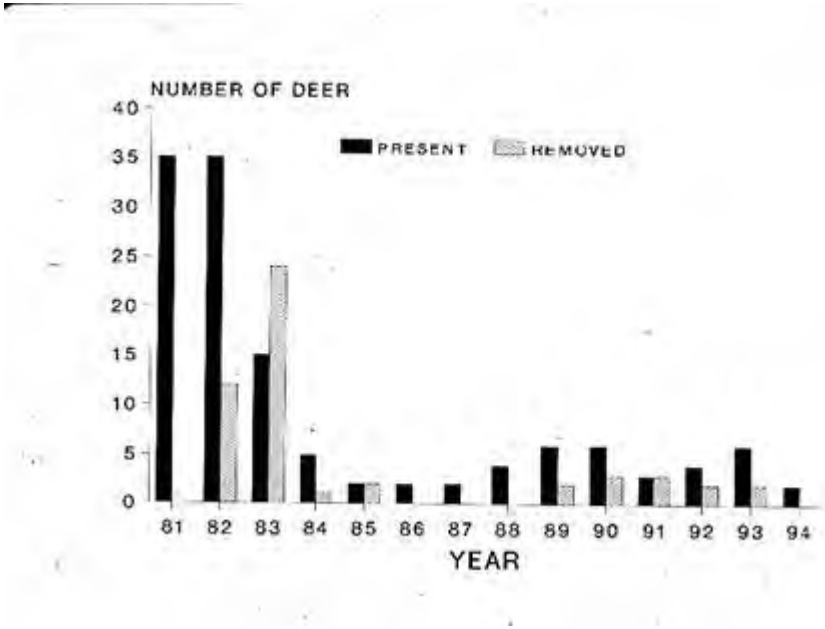
Slide 16

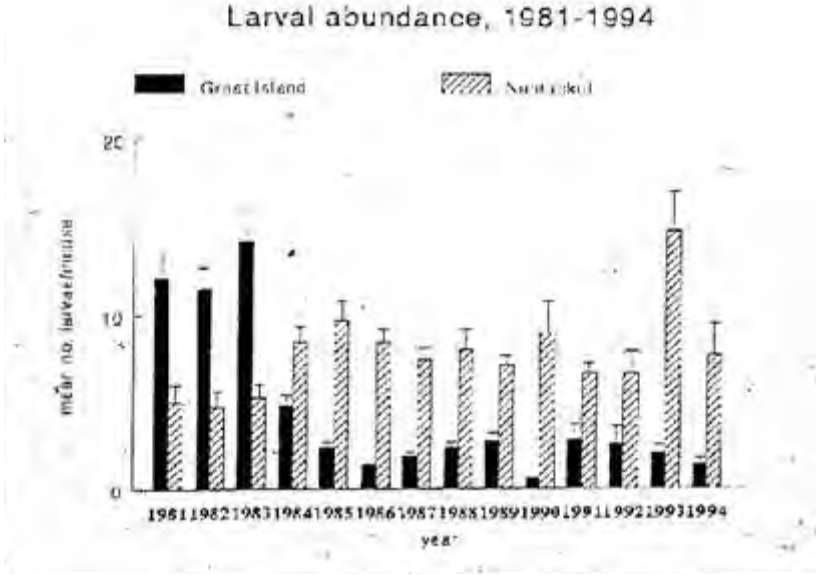
SRT5 Deer are the main reproductive hosts for the deer tick. Although many other animals may be infested, in this site on Long Island it is clear that deer were feeding more than 90% of the adult deer ticks. The importance of this is that one engorged female deer tick, left picture, may lay 2000 or more eggs. Why Nantucket is not 10 feet deep in deer ticks is the focus of the Telford lab's current Lyme ecology research.

Sam Telford III, 7/27/2005


6
5
4
2
3
1

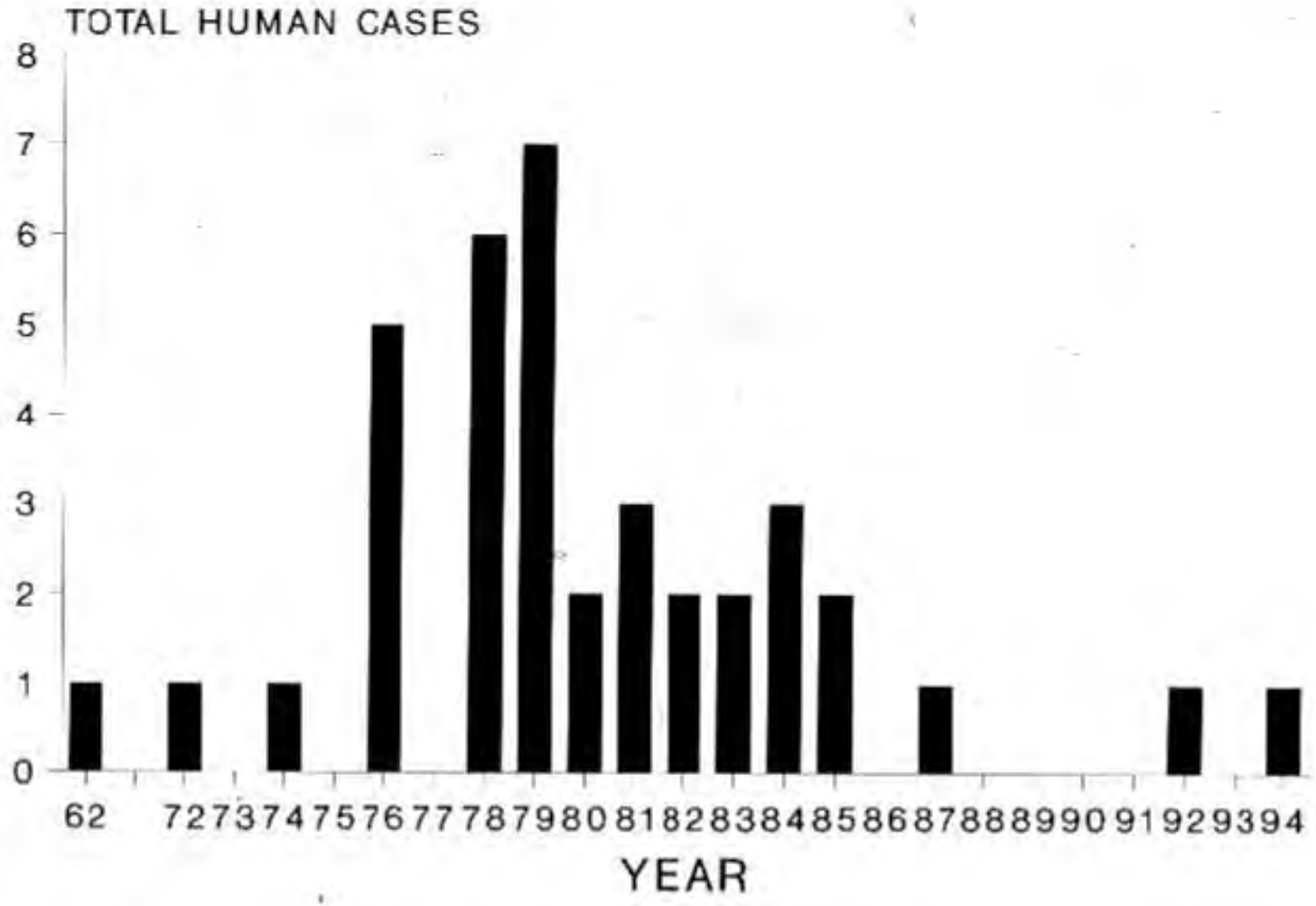

Nymphal abundance, 1981-1994
Great Island
Nantucket
mean no. nymphs/house
0
1
2
3
4
5
6
7
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
year


NUMBER OF DEER
PRESENT
REMOVED
0
5
10
15
20
25
30
35
40
81 82 83 84 85 86 87 88 89 90 91 92 93 94
YEAR


Larval abundance, 1981-1994
Great Island
0
10
20
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
year

The Great Island experiment: surveillance for Lyme and babesiosis cases

SRT



Slide 18

SRT6 We bled Great Island residents (150-200 of them) each summer from 1983 until 1994 and tested them for new antibodies to Lyme disease spirochetes. In addition, we asked residents to report to us any unexplained fever or physician diagnosed tickborne infection. Only a handful of cases have been reported there since the late1980s. Although some of the success can be attributed to awareness stimulated by our active work there, we interpret this data as evidence for a reduction in risk.

Sam Telford III, 7/27/2005

What to do about deer ticks?

- The Great Island experiment and other published reports demonstrate that deer reduction will reduce tick density and thereby risk for the deer tick-transmitted infections
- A target density of 6-8 deer/square mile comes empirically from such studies as well as from mathematical modelling. Such a density is similar to the 10-15 deer/square mile target density for MassWildlife management objectives.
- There are currently no other practical and economical means of reducing deer herds other than hunting. Hunting is preferable to sharpshooting because it is less catastrophic to a site's ecology and provides economic benefit to communities.

Modes of intervention

- At the level of the individual:
  - Repellants and toxicants (permethrin, deet)
  - Appropriate clothing
  - Tick check
  - Education and awareness
  - Vaccination?
  - Habitat avoidance

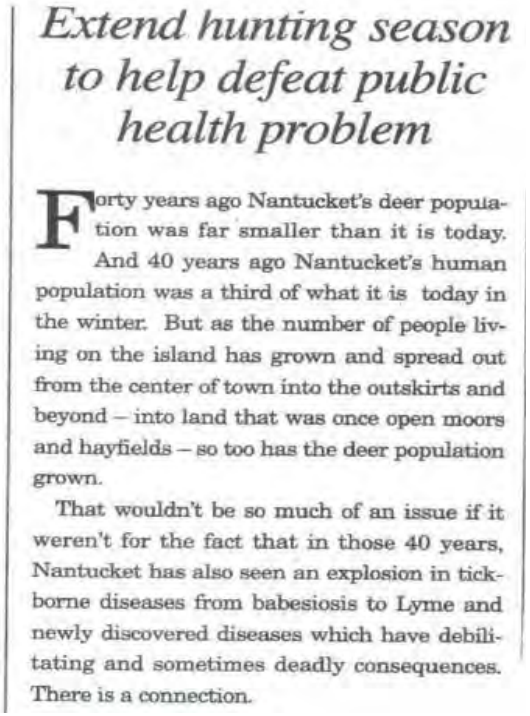
Host-seeking behavior

- Nidicolous: nest-dwelling
- Non-nidicolous: host seeking
- Passive questing-ambush predators
- Active hunter ticks-crawl or run toward host
    - Can detect movement, heat, shadows, odors, CO2

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.

American Lyme Disease Foundation