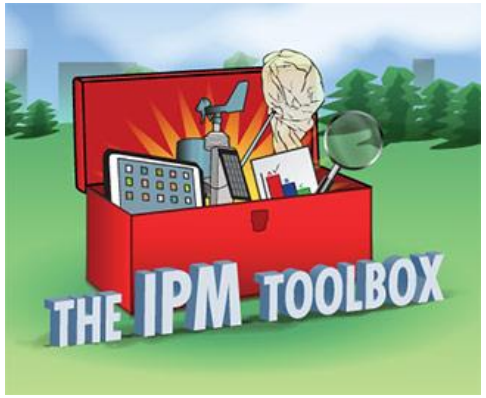
Northeastern IPM Center

Tick IPM Series

Part 7: Tick-Borne Disease Expansion & Management Strategies: Role of Leaf Litter and Snow on Tick Survival

October 7, 2020



USDA United States Department of Agriculture National Institute of Food and Agriculture

Webinar Details

- Welcome

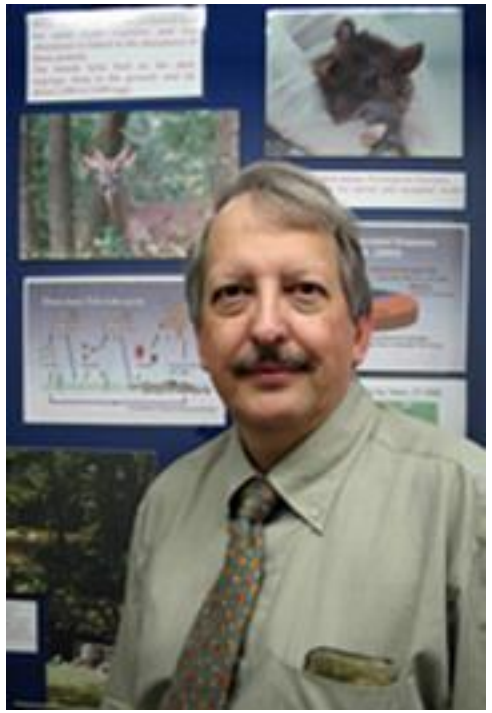
- A recording of this webinar will be available within a week at
- http://www.neipmc.org/go/ipmtoolbox

We Welcome Your Questions

- Please submit a question **at any time** using the Q&A feature to your right at any time

- If you'd like to ask a question anonymously, please indicate that at the beginning of your query.

Webinar Presenter



Kirby C. Stafford III, Ph.D.
Chief Scientist, State Entomologist
Department of Entomology
Center for Vector Biology & Zoonotic Diseases
CT Agricultural Experiment Station
New Haven, CT

Some Questions for You

Tick Emergence and Expansion

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Ticks as Vectors

"Habitat diversity, **environmental factors** influencing survival and tick activity, and geographic distribution of the ticks impacts risk of tick-borne disease."

Eisen, R. J. et al. 2012. What do we need to know about disease ecology to prevent Lyme disease in the Northeastern United States? Journal of Medical Entomology 49(1): 11–22.

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Outline

- Overview of drivers for emergence and expansion of ticks and TBD's
- Highlight some research on climate factors and ticks
- Present our overwintering research on the role of leaf litter, snow and vegetation on tick overwintering survival and management strategies for *Ixodes scapularis* and *Amblyomma americanum*
- Vegetative management in tick IPM

Broad drivers of tickborne disease emergence

- Reforestation
- Overabundant deer
- Expansion of suburbia into wooded areas
- Abundant habitat around homes for reservoir hosts
- Increased numbers of ticks
- Increased exposure opportunities in people
- *Geographic expansion of ticks*
- *Changing climate*

K. Stafford

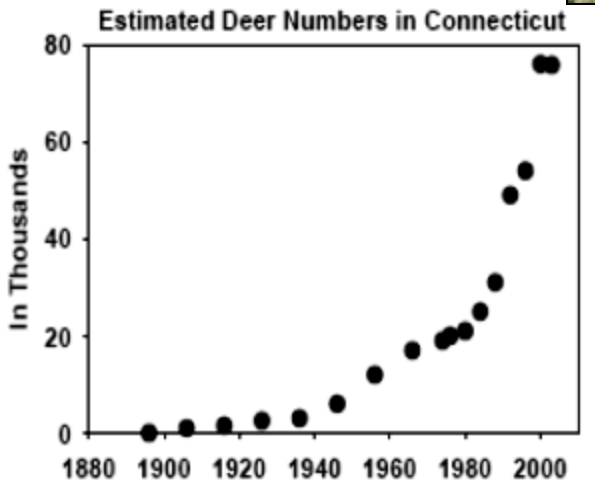

Photo by Skip Weisenburger, The Day

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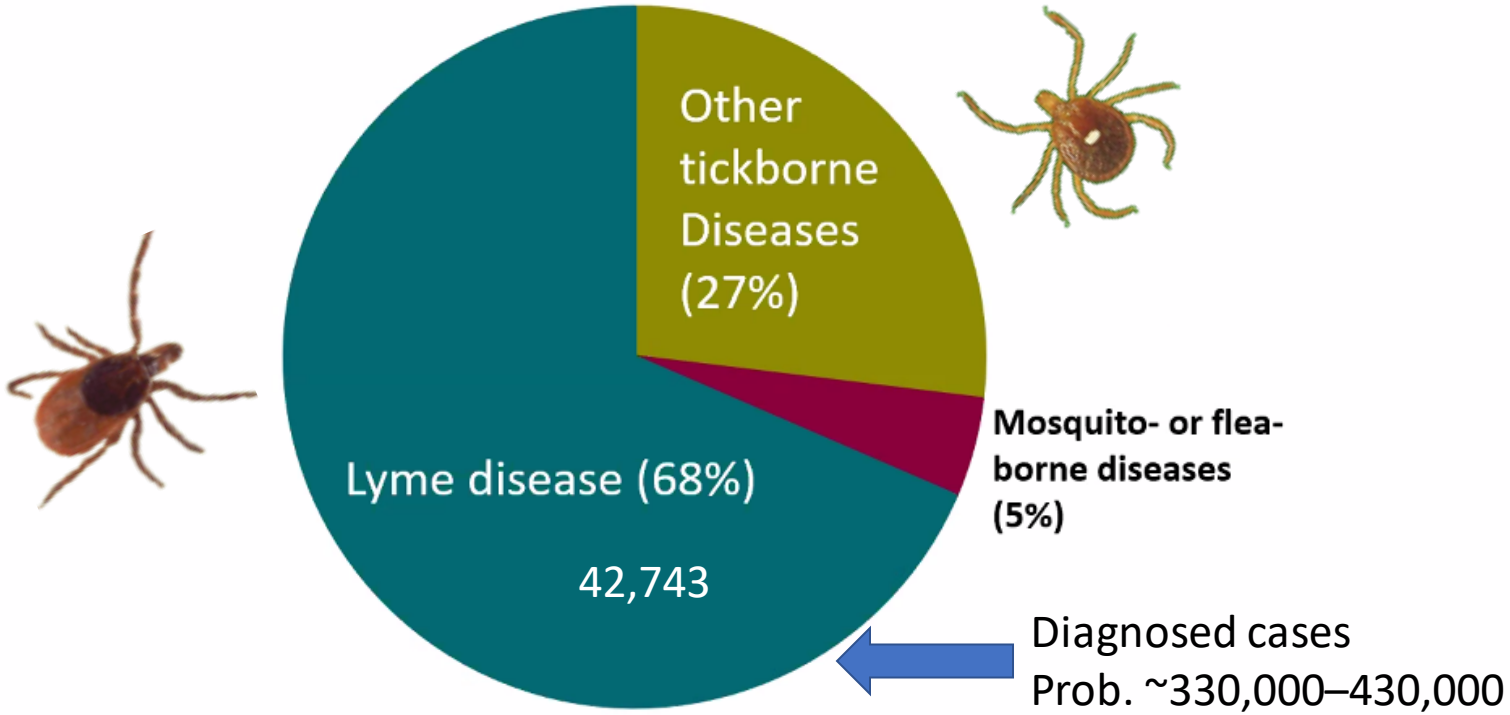
Majority of Reported Vector-Borne Diseases are Spread by Ticks



Cases of Nationally Notifiable Vector-borne Diseases Reported in the U.S., 2017

N= 62,399 cases

Proportions did not change much in 2018 with other tickborne diseases making up 27.8% total

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Major Ticks of Concern Eastern U.S.

- Native ticks expand their range
- New disease pathogens discovered and more people potentially exposed
- Detection of exotic tick species from humans from foreign travel and animal trade
- Establishment of the invasive Asian longhorned tick

Blacklegged Tick
Ixodes scapularis

American Dog Tick
Dermacentor variabilis

Lone Star Tick
Amblyomma americanum

Gulf Coast Tick
Amblyomma maculatum

CDC/James Gathany

Asian longhorned tick
Haemaphysalis longicornis

CDC/James Gathany

Others may include *Rhipicephalus sanguineus (brown dog tick)*

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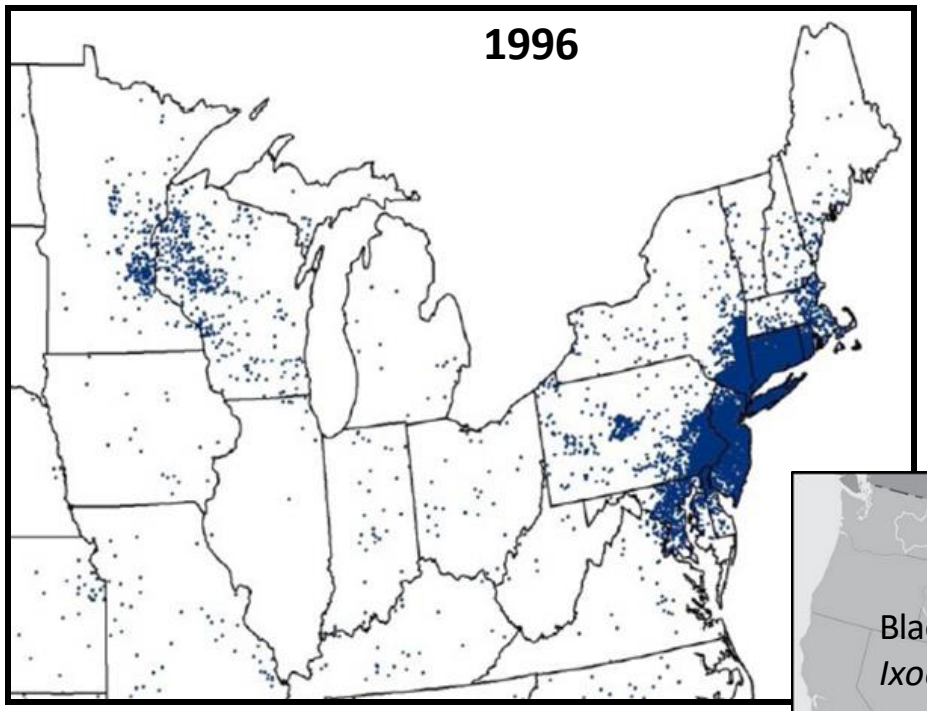
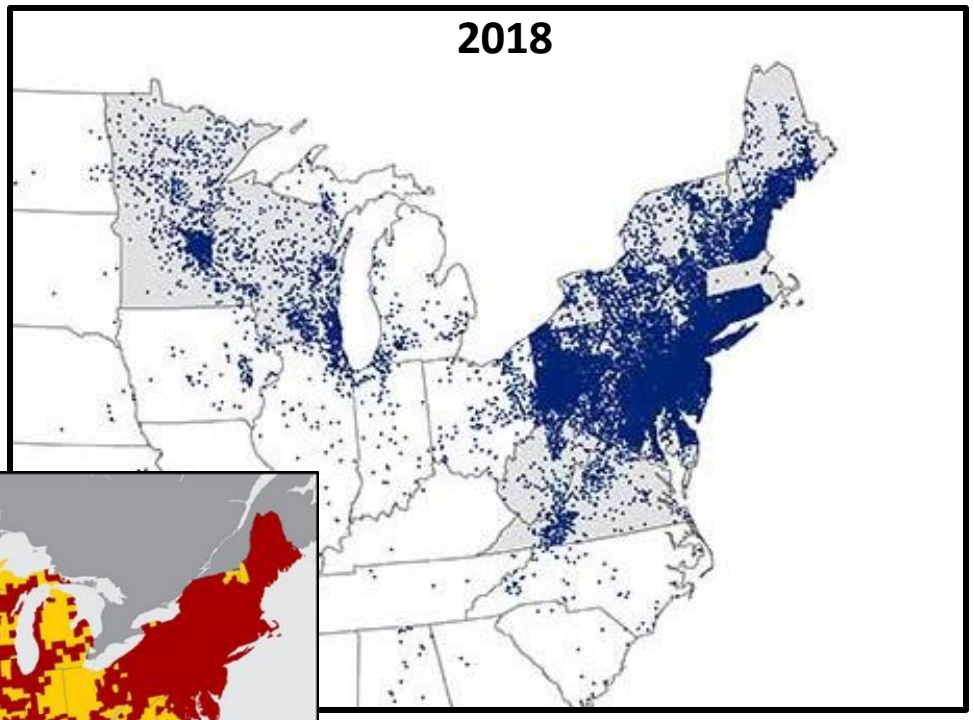
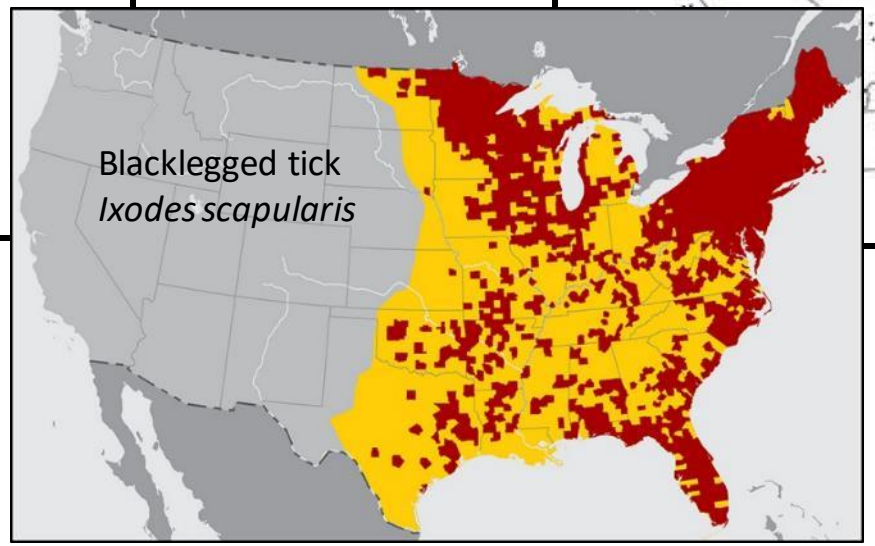
Lyme Disease Case Distribution – 22 Year Expansion
Expansion Distribution of *Ixodes scapularis*







http://www.cdc.gov/lyme/stats/maps/interactiveMaps.html

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Expansion of Lone Star Ticks, *Amblyomma americanum*, in the Northeastern United States

Map from; Steven Mufson, Chris Mooney, Juliet Eilperin, and John Muyskens. 2°C: Beyond the Limit: Extreme climate change has arrived in America. Washington Post, August 13, 2019.

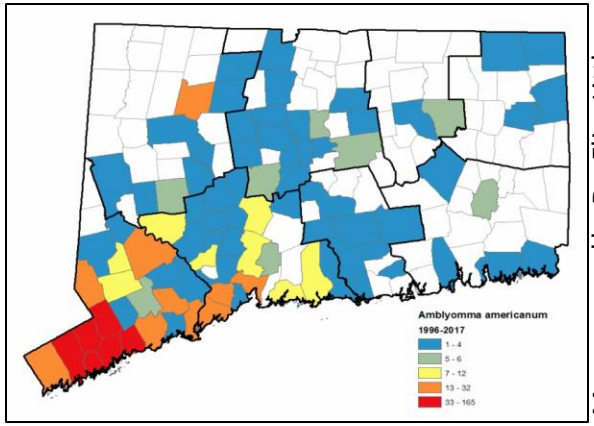
Journal of Medical Entomology, 55(6), 2018, 1561–1568
doi: 10.1093/jme/tjy115
Advance Access Publication Date: 25 July 2018
Research Article
OXFORD
Vector-Borne Diseases, Surveillance, Prevention

Distribution and Establishment of the Lone Star Tick in Connecticut and Implications for Range Expansion and Public Health

Kirby C. Stafford III,[1,5] Goudarz Molaei,[1,2] Eliza A. H. Little,[1] Christopher D. Paddock,[3] Sandor E. Karpathy,[3] and Andrew M. Labonte[4]

Stafford et al. 2018. J. Med. Entomol. 55(6): 1561–1568 (July 25, 2018).

J. Nivolo/DEEP



Map prepared by Dr. Eliza Little

NOAA data shows that in every Northeast state except Pennsylvania, the temperatures of the winter months of December through February have risen by 2 degrees Celsius since 1895–1896

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Contents lists available at ScienceDirect

International Journal for Parasitology: Parasites and Wildlife

journal homepage: www.elsevier.com/locate/ijppaw

Climate change, biodiversity, ticks and tick-borne diseases: The butterfly effect

Filipe Dantas-Torres [a, b, *]

Dantas-Torres, F. 2015. International Journal for Parasitology: Parasites and Wildlife 4: 452–461.

Tick questing activity, reproduction, and survival, depend on several factors that, in turn, have a direct impact on tick distribution and abundance. These include vegetation coverage, host availability, moisture and temperature conditions, photoperiod, and human activities.

It may be anticipated that warmer winters and extended autumn and spring seasons will continue to drive the expansion of the distribution of some tick species (e.g., *Ixodes ricinus*) to northern latitudes and to higher altitudes.

The so-called "butterfly effect" is the principle that small changes in the initial conditions will result in different outcomes in dynamical systems; that is they are sensitive to initial conditions.

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Questions

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Climate and Ticks

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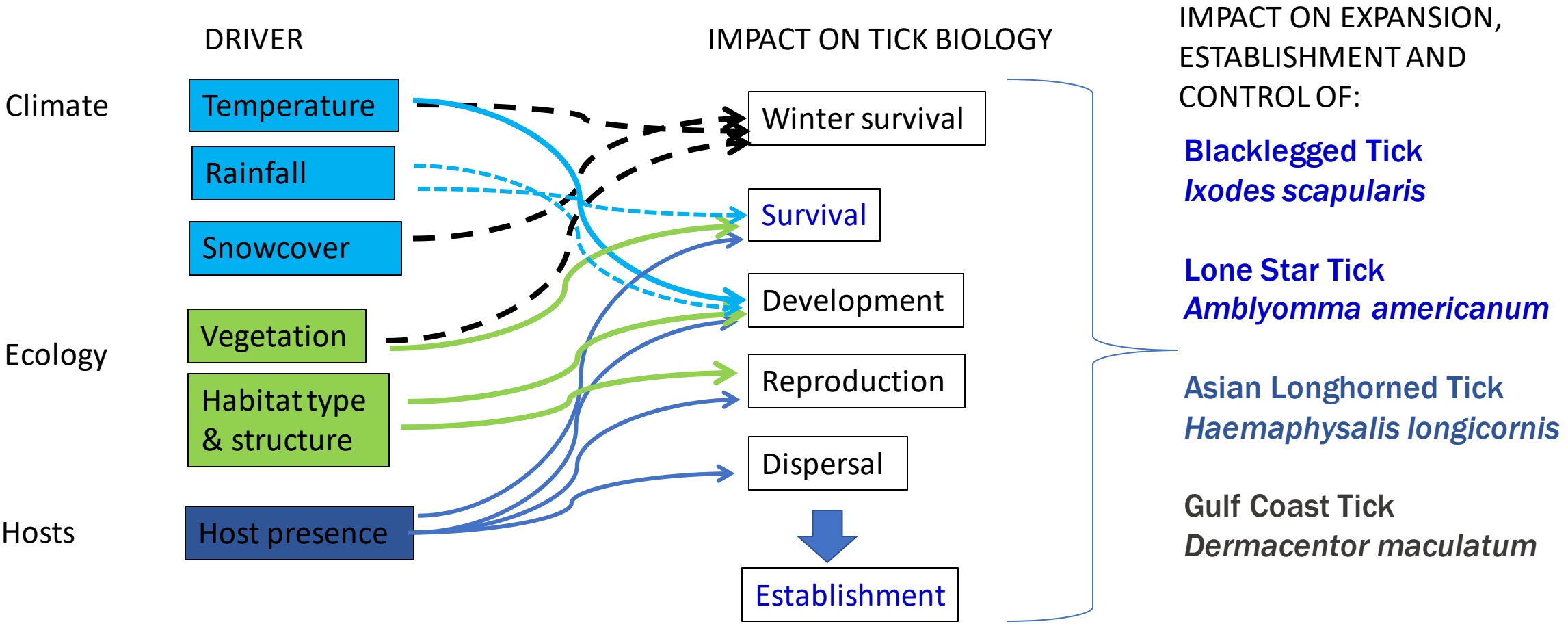
Drivers for Change in Geographical Distribution and Establishment of Ticks

Adapted from: Medlock, Jolyon M. et al. 2013. Driving forces for changes in geographical distribution of *Ixodes ricinus* ticks in Europe. Parasites & Vectors. 6 (1): 1–11.



IMPACT ON EXPANSION, ESTABLISHMENT AND CONTROL OF:

Blacklegged Tick
Ixodes scapularis

Lone Star Tick
Amblyomma americanum

Asian Longhorned Tick
Haemaphysalis longicornis

Gulf Coast Tick
Dermacentor maculatum

The limiting temperature for winter survival depends on a range of factors, including tick species, developmental stage, number of days of tick exposure to a given temperature, and snow cover.

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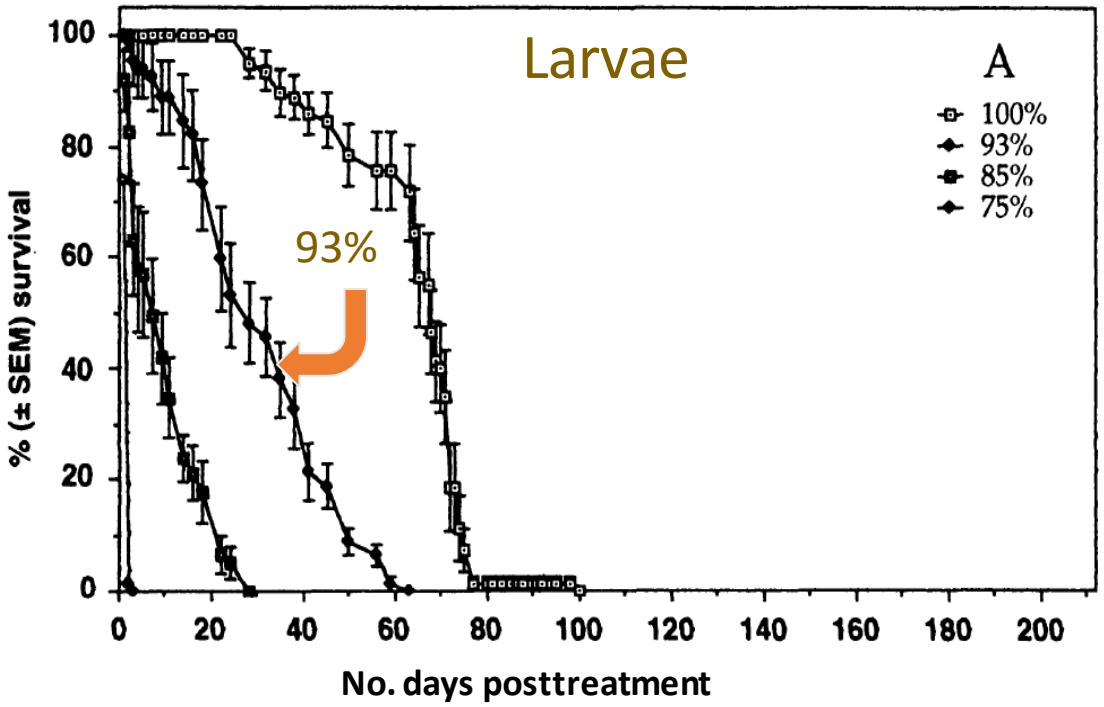
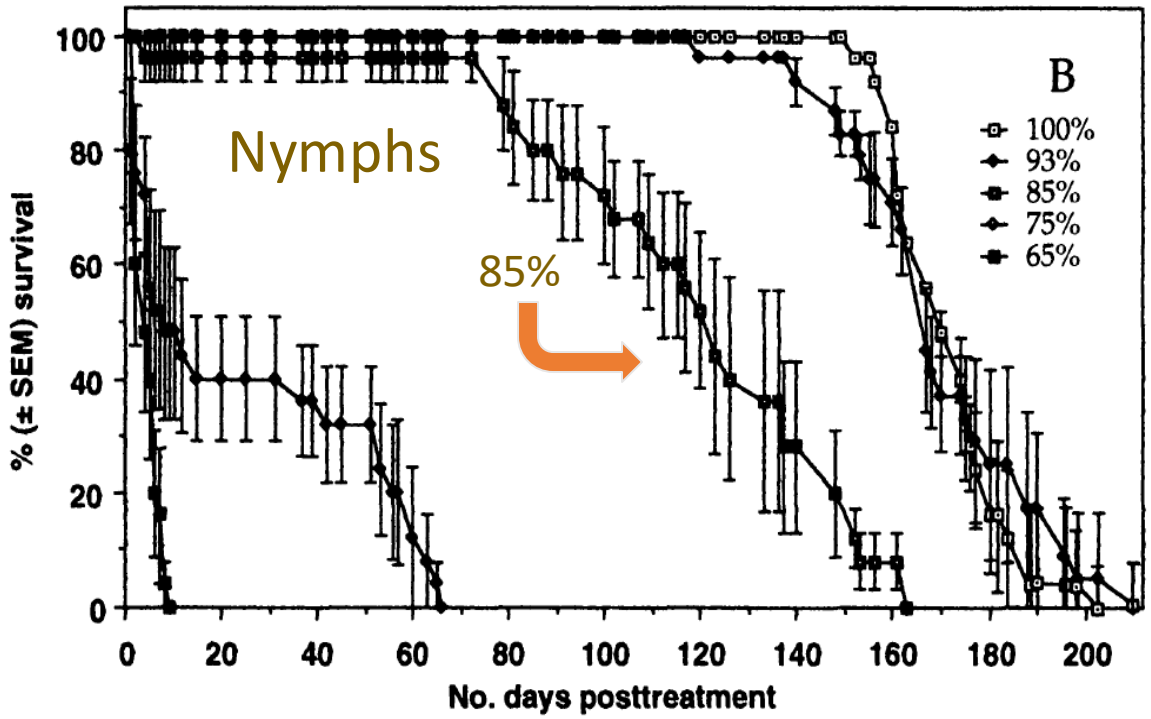
Survival *Ixodes scapularis* at Different Relative Humidities in the Laboratory

At room temperature





Many *Ixodes* ticks require higher humidities for survival than other ticks and quickly die from desiccation when held below their critical equilibrium activity (CEA), the threshold humidity at which ticks can maintain their water level by the active uptake of atmospheric water vapor

Stafford. 1994. J. Med. Entomol. 30:310–314.

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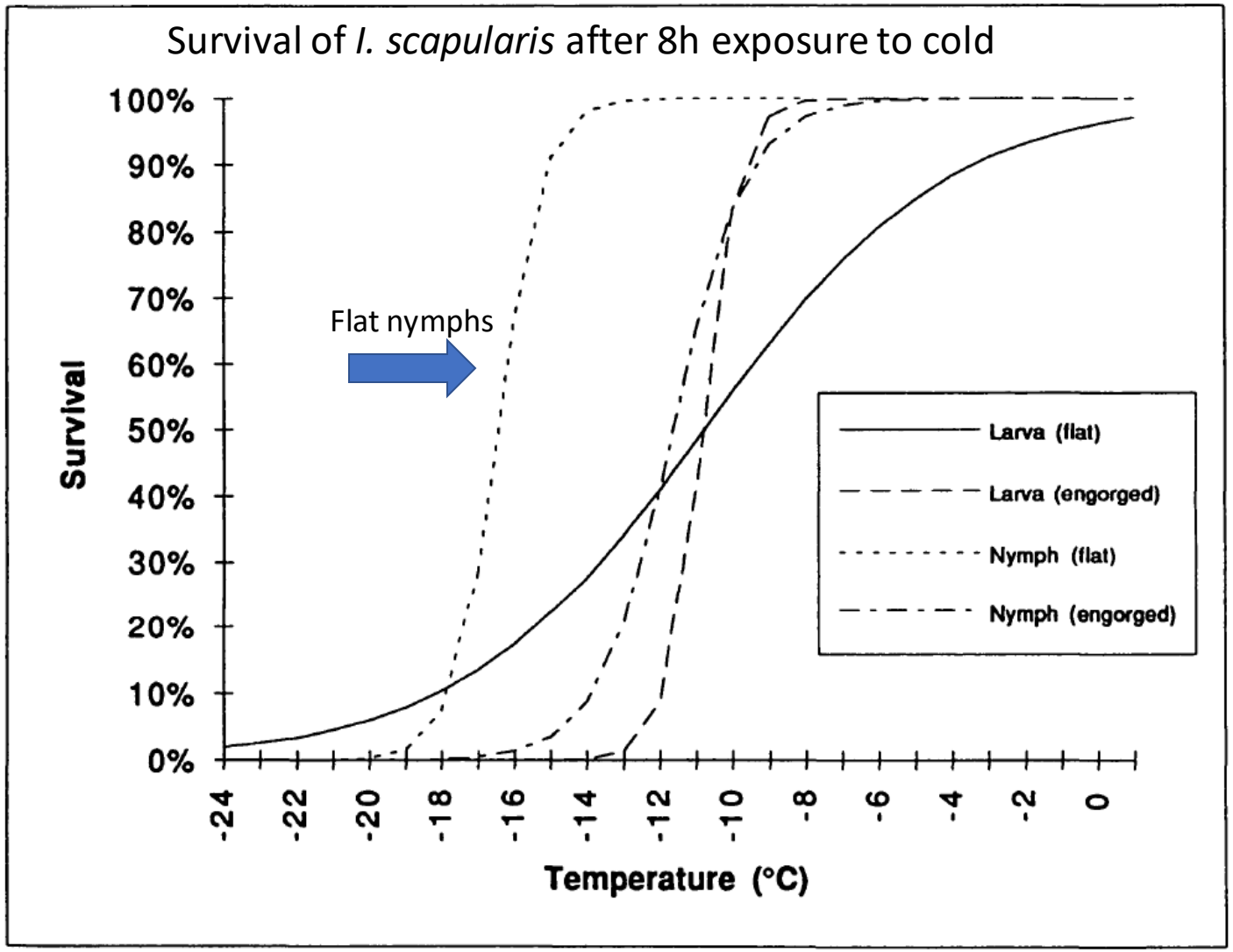
Survival *Ixodes scapularis* Exposed to Cold



Unengorged nymphs were the most cold-hardy life stage. Future studies using soil microclimate measurements and geographic information systems may be able to provide models for the potential geographic distribution of *I. scapularis.*

Vandyk, J.K. et al. 1996. Survival *Ixodes scapularis* exposed to cold. J. Med. Entomol. 33(1):6–10

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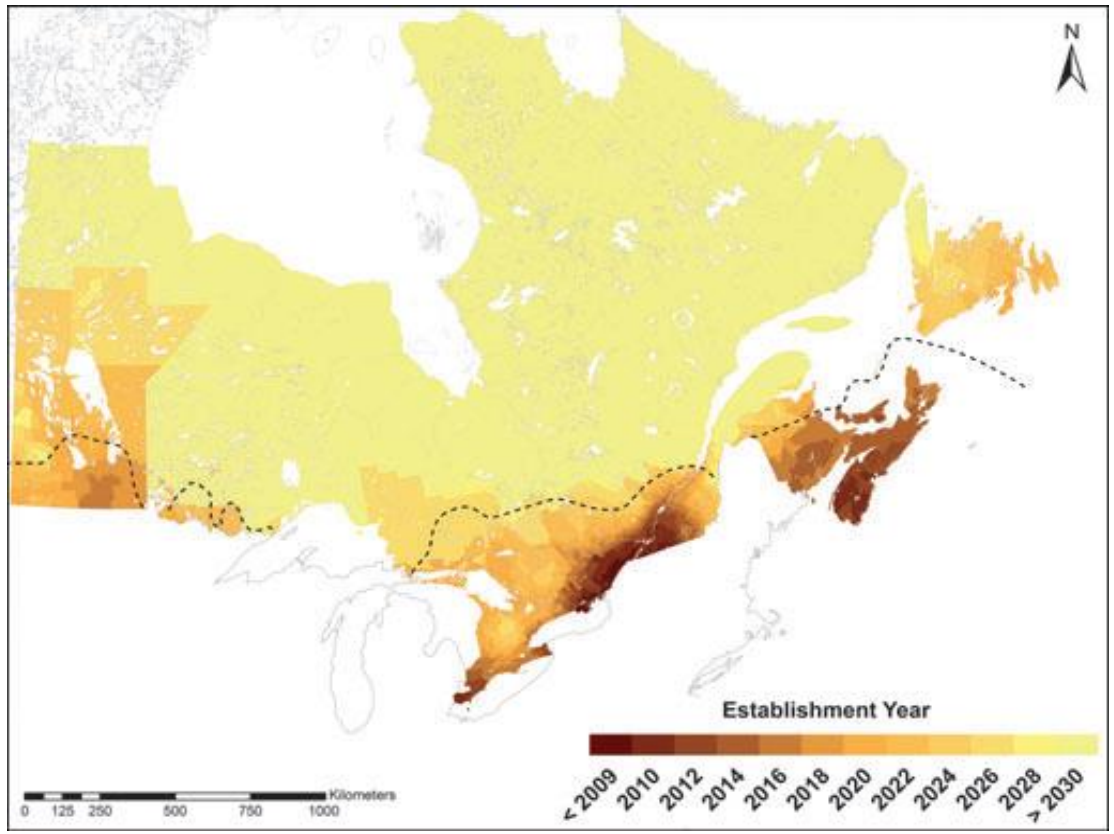
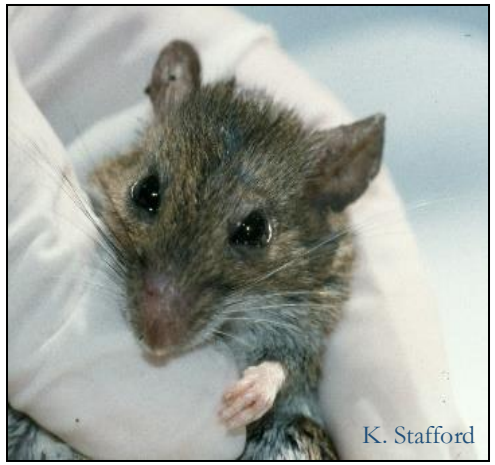
- In Canada, temperature most important determinant of environmental suitability for tick establishment.
- Climate warming will accelerate range expansion *I. scapularis*, currently modeled at 28 miles per year, with human population at risk increasing from 18% in 2010 to over 80% by 2020.





Mild and shorter winter is also favoring the northern expansion of the white-footed mouse in Quebec by 3° latitude.

Roy-Dufresne, Emily et al. 2013. PlosOne. 8(11): e80724

Leighton, Patrick A. et al. 2012. J App Ecol. 49(2): 457–464

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Modeled Potential Distribution Lone Star Tick in the United States

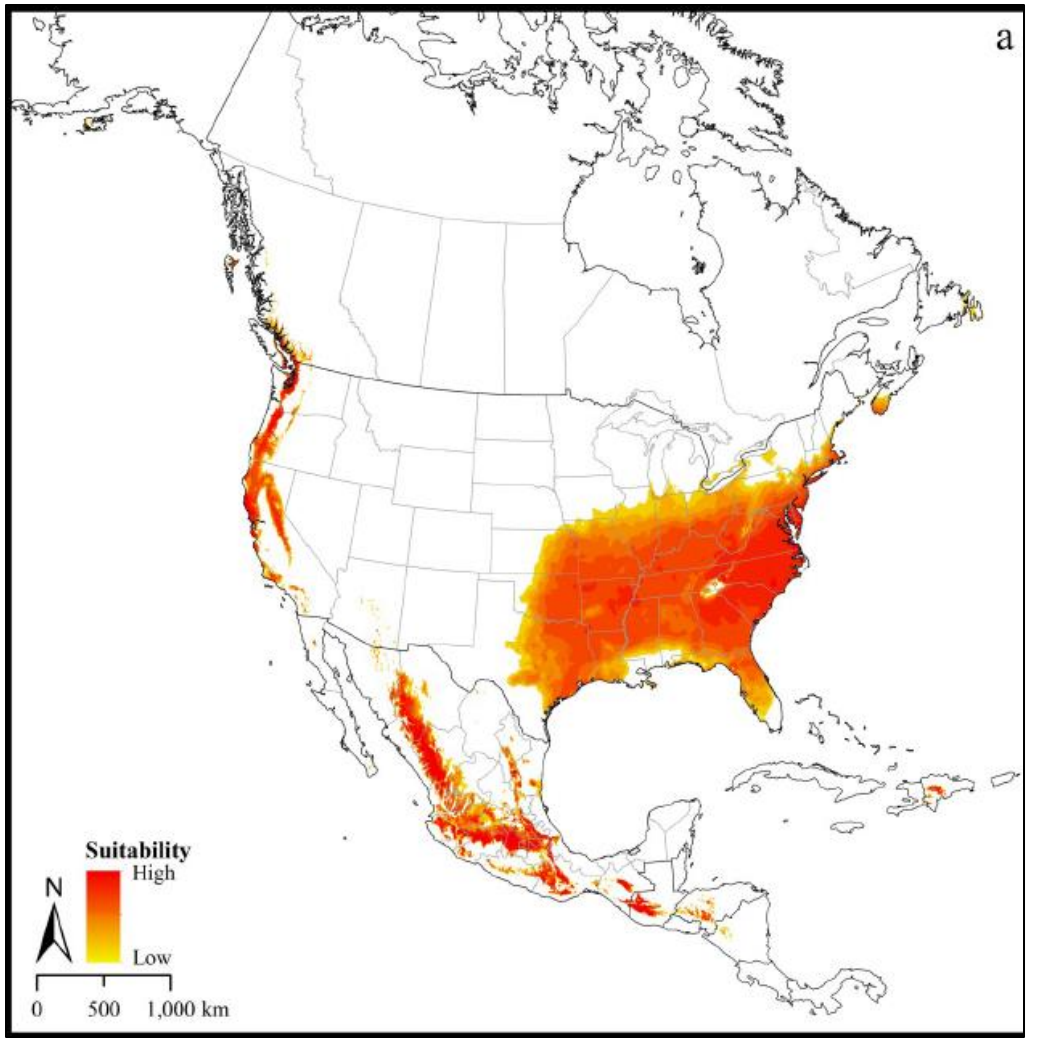
RESEARCH ARTICLE

Current and Future Distribution of the Lone Star Tick, *Amblyomma americanum* (L.) (Acari: Ixodidae) in North America

Ram K. Raghavan[1]*, A. Townsend Peterson[2], Marlon E. Cobos[2], Roman Ganta[1], Des Foley[3]

From: Raghavan, R. K., A. T. Peterson, M. E. Cobos, R. Ganta, and D. Foley. 2019. Current and future distribution of the lone star tick, *Amblyomma americanum (L.) (Acari: Ixodidae) in North America. PLOS ONE 14: e0209082.*

Acarological surveys in areas outside the currently believed leading edge of the distribution of lone star ticks (*Amblyomma americanum*), coupled with recent reports of their identification in previously uninvaded areas in the public health literature, suggest that this species is more broadly distributed in North America than currently understood. Further northward and westward expansion of these ticks can be expected as a result of ongoing climate change.



Climatologically suitable regions for *Amblyomma americanum* distribution in North America

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Asian Longhorned Tick
Haemaphysalis longicornis

- From August 2017 to August 10, 2020, reported from fifteen U.S. states (Arkansas, Connecticut, Delaware, Kentucky, Maryland, New Jersey, New York, North Carolina, South Carolina, Pennsylvania, Tennessee, Virginia, West Virginia, Ohio, and Rhode Island)
- Known distribution is expanding as surveillance efforts increase
- Not a vector for *B. burgdorferi*, but in lab for *R. rickettsii*
- Mainly of veterinary concern at this point
- Control data needed for U.S. populations
- **Look at overwintering ALT.**

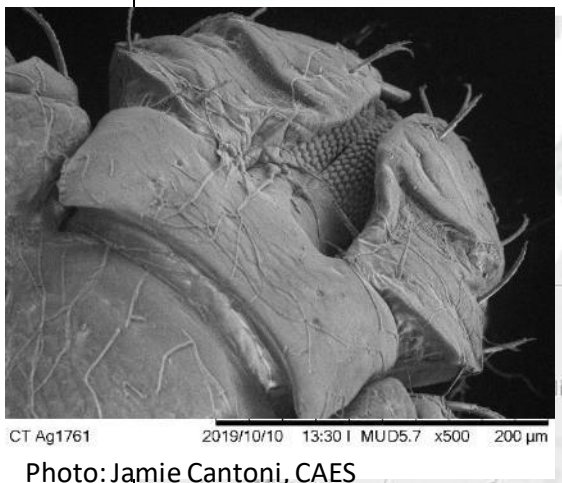

Photo: Jamie Cantoni, CAES

Counties and county equivalents* where *Haemaphysalis longicornis* has been reported (N = 118 — United States, as of October 2, 2020)

Source: National *Haemaphysalis longicornis* Situation Report, USDA NVSL, October 2, 2020

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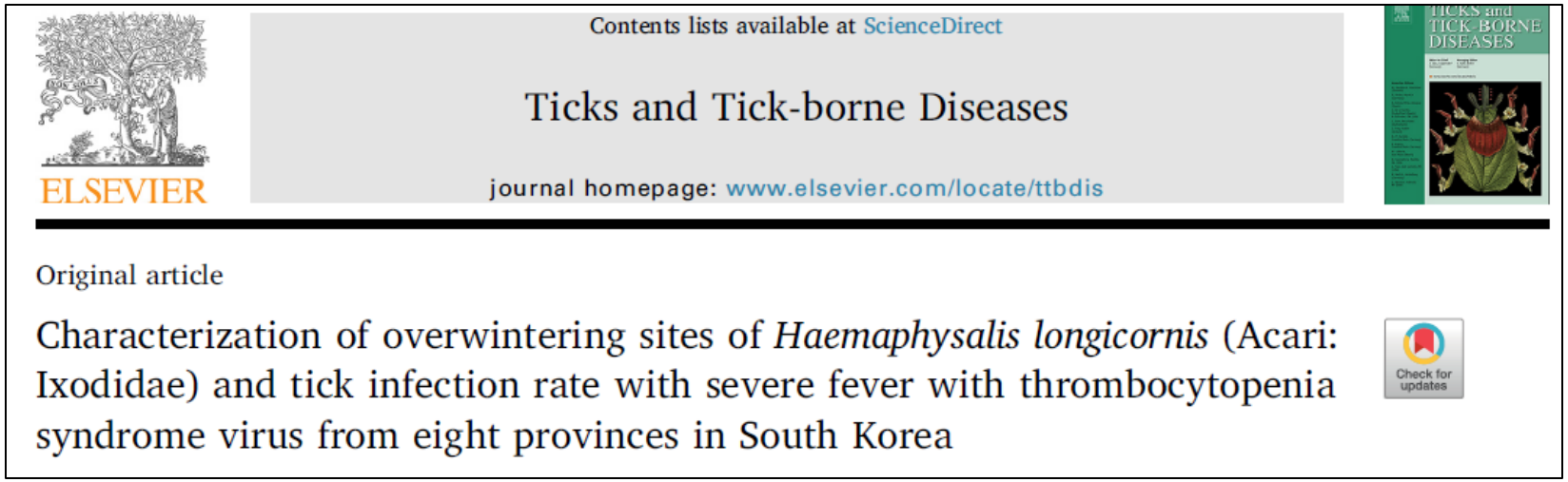
Asian Longhorned Tick

What type of environment is it found? What stage primarily overwinters? (Nymph)
Does leaf litter or other vegetative characteristics impact survival?

New Jersey; J. Occi, Rutgers

New York; R. Falco, NYSDPH

Most abundant on trail edges with short to medium height grass



Contents lists available at ScienceDirect

Ticks and Tick-borne Diseases

journal homepage: www.elsevier.com/locate/ttbdis

Original article

Characterization of overwintering sites of *Haemaphysalis longicornis* (Acari: Ixodidae) and tick infection rate with severe fever with thrombocytopenia syndrome virus from eight provinces in South Korea

James Gathany/CDC

Kim, J.-Y., M. Jung, J.-W. Kho, H. Song, K. Moon, Y. H. Kim, and D.-H. Lee. 2020. Characterization of overwintering sites of *Haemaphysalis longicornis (Acari: Ixodidae)* and tick infection rate with severe fever with thrombocytopenia syndrome virus from eight provinces in South Korea. *Ticks and Tick-borne Diseases 11: 101490.*

- *H. longicornis* prefers herbaceous areas including grassland and shrub vegetation as their overwintering habitats
- Among the overwintering *H. longicornis* collected, 77 % of ticks were retrieved from the topsoil layer, whereas 19 % and 4 % of overwintering individuals were found in the leaf litter and the soil surface, respectively.
- Results of this study indicate that *H. longicornis* might crawl into the soil and prefer to settle in the topsoil layer as an overwintering habitat.

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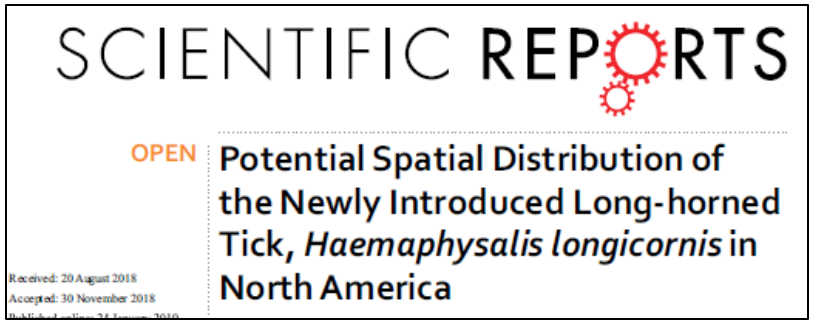
Modeled Potential Distribution *Haemaphysalis longicornis* in the United States


SCIENTIFIC REPORTS

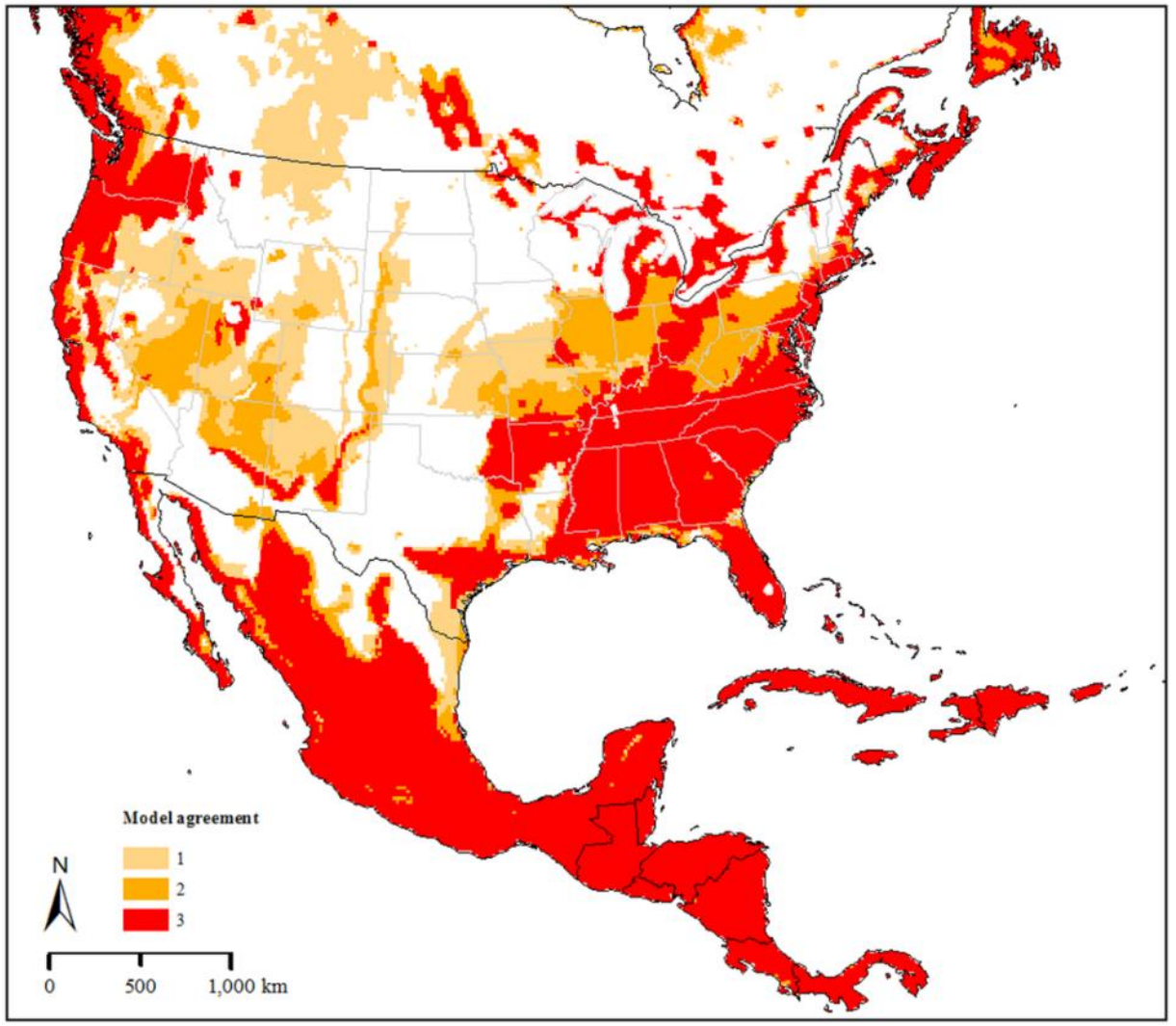
OPEN

Potential Spatial Distribution of the Newly Introduced Long-horned Tick, *Haemaphysalis longicornis* in North America

Received: 20 August 2018
Accepted: 30 November 2018

From: Raghavan, R. K., S. C. Barker, M. E. Cobos, D. Barker, E. J. M. Teo, D. H. Foley, R. Nakao, K. Lawrence, A. C. G. Heath, and A. T. Peterson. 2019. Potential spatial distribution of the newly introduced long-horned tick, *Haemaphysalis longicornis* in North America. *Scientific Reports* 9: 498.

Predicted suitable areas for *Haemaphysalis longicornis* across North America. 1, 2, and 3 represent areas that were predicted to be suitable for the establishment of *H. longicornis* in North America by one, two and three models, respectively. Darker areas represent progressively higher agreement between the models.



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Questions

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THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

Overwintering Research

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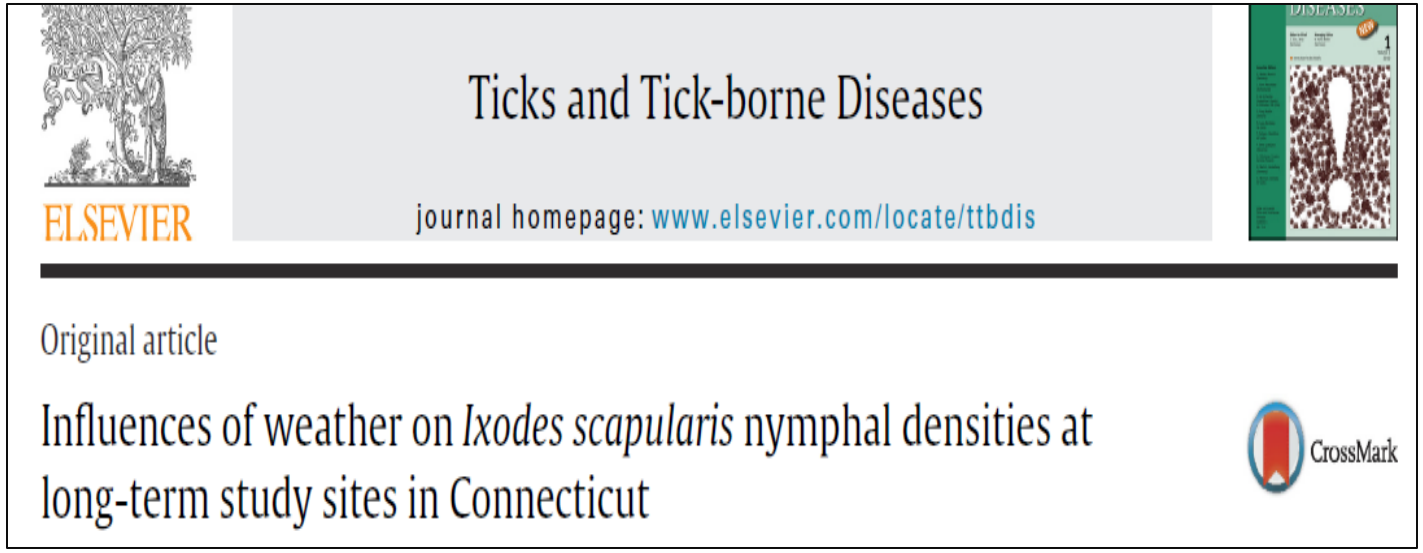


USDA/Scott Bauer

- We used a 25-year dataset of *Ixodes scapularis* drag-sampling surveys at two locations in CT, to investigate the relationship between average nymphal density and regional weather variables.
- We found an association between greater summer nymphal *I. scapularis* population sizes and higher winter (i.e., January) precipitation (Standardized Precipitation Index). Nymphal tick density increased with regional winter precipitation and total snow cover.
- Previous studies that have found that snow reduces energy loss keeps soil temperatures much higher than air temperatures in winter and may reduce detrimental freeze-thaw cycles.

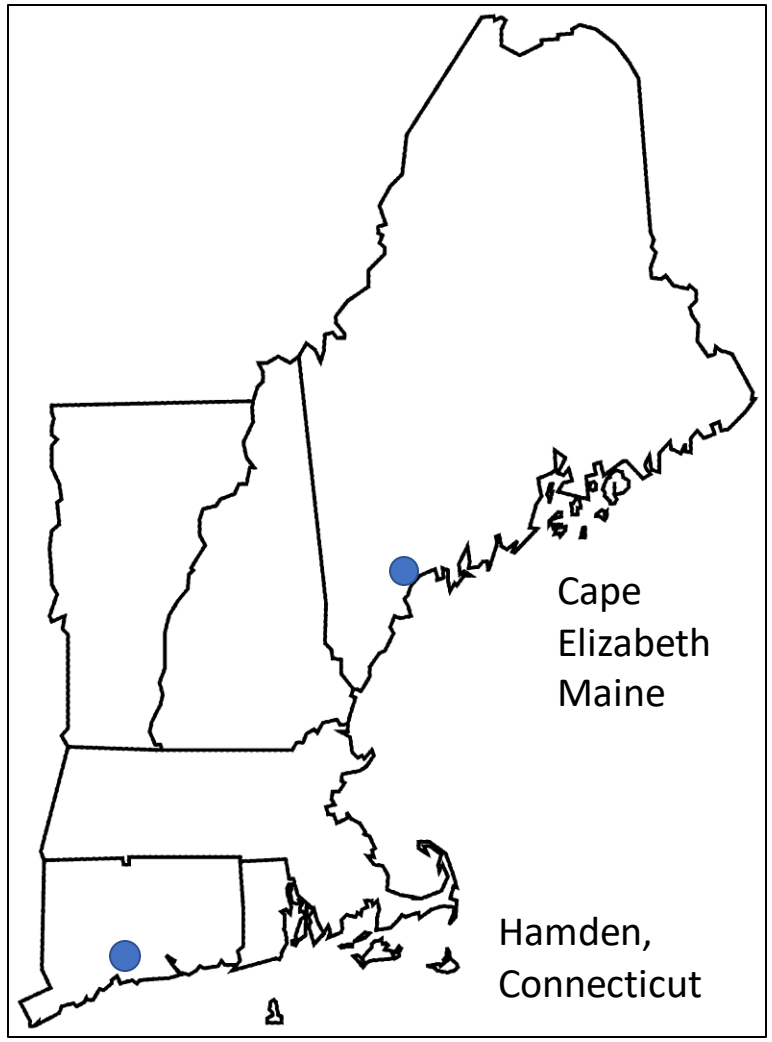
Hayes, Laura E, Jennifer Scott, and Kirby C. Stafford III. 2007. J. Med. Entomol. 44:372–375.

Influences of weather on *Ixodes scapularis* nymphal densities

- Our results support the idea that cold, dry winters may reduce overwintering survival.
- Hypothesis that greater snowfall increase tick overwintering survival rates — greater amount of snowfall during high January Standard Precipitation Index years supports higher rates of tick overwinter survival, and thus larger nymphal cohort sizes the following summer.
- Weather conditions during the coldest months of the year may serve as a bottleneck to tick populations, thereby functioning as an important correlate of not only annual blacklegged tick nymphal densities the following summer, but also entomological risk associated with tick-borne pathogens transmitted by this species.

Ixodes scapularis & Amblyomma americanum Overwintering Study Connecticut & Maine

2015–2016, 2016–2017, and 2017–2018



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CT Agricultural Experiment Station
Center for Vector Biology & Zoonotic Diseases

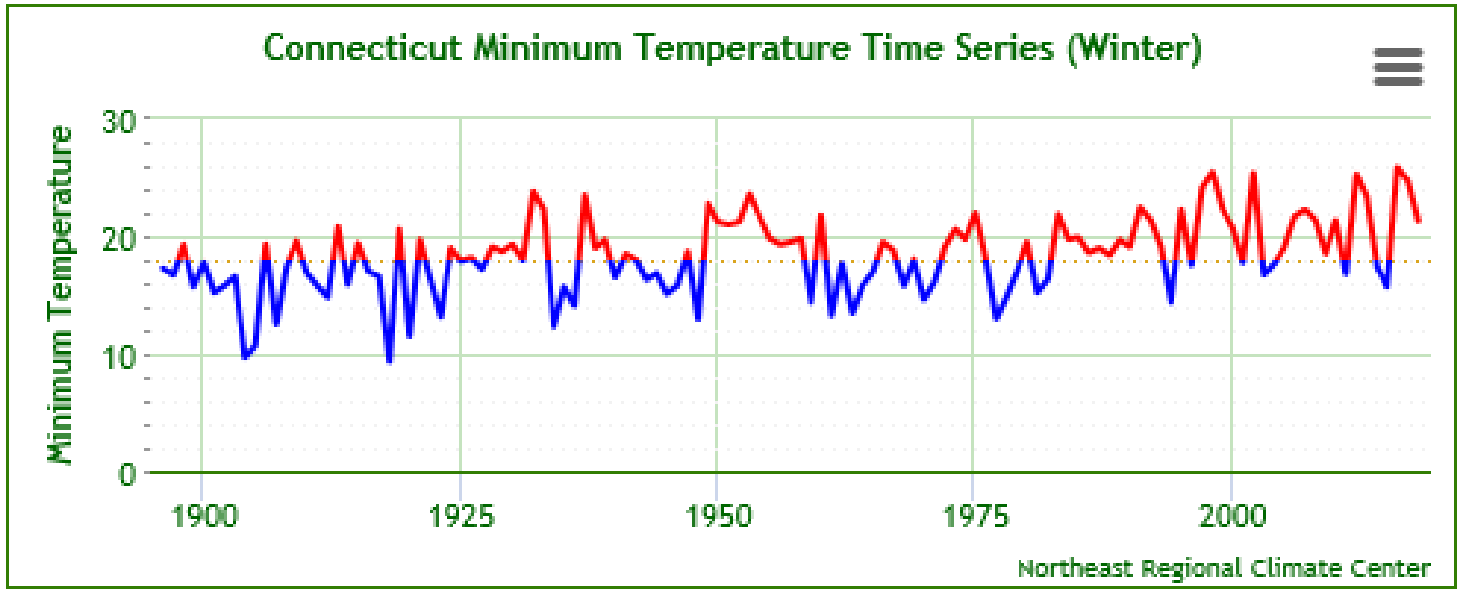
Maine Medical Center
Research Institute
centered around you

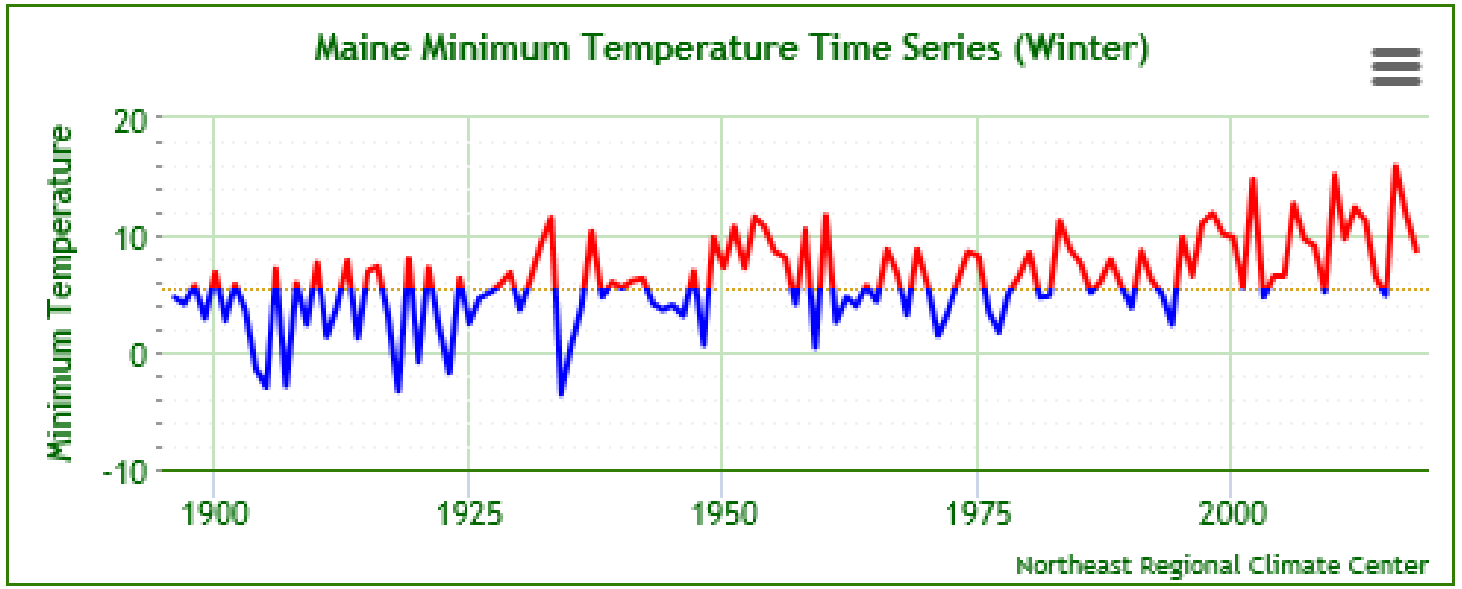
Maine Medical Center Research Institute
Lyme & Vector-Borne Disease Laboratory

Initial project supported by NE IPM Center
Continued under NEVBD CoE with CDC

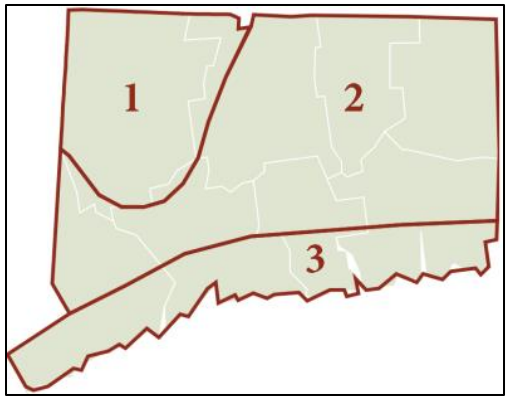
Northeastern IPM Center

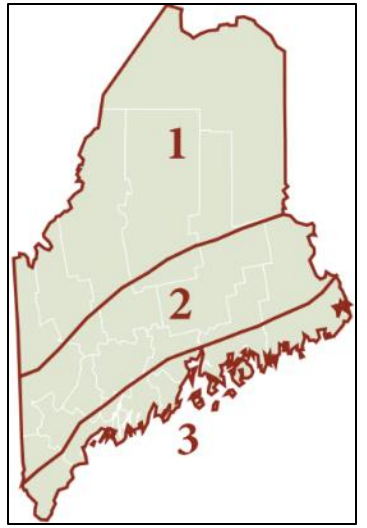
Northeast Regional Climate Center





Departures shown are based on the 20th century mean (1901–2000).





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Ticks (*I. scapularis* & *A. americanum*) placed in vials in tick "pots" buried in the ground in randomized block design with Hobo data loggers in a complete randomized block design with two factors (snow and leaf litter).

***I. scapularis* – Winters 2015–2016, 2016–2017, 2017–2018**

***A. americanum* – Winters 2016–2017, 2017–2018, 2018–2019**

Four treatment combinations:

Leaf and snow removal (LRSR)

No leaf removal and snow removal (NLRSR)

Leaf removal and no snow removal (LRNSR)

No leaf and no snow removal (NLRNSR)

1-9-17

1-13-17

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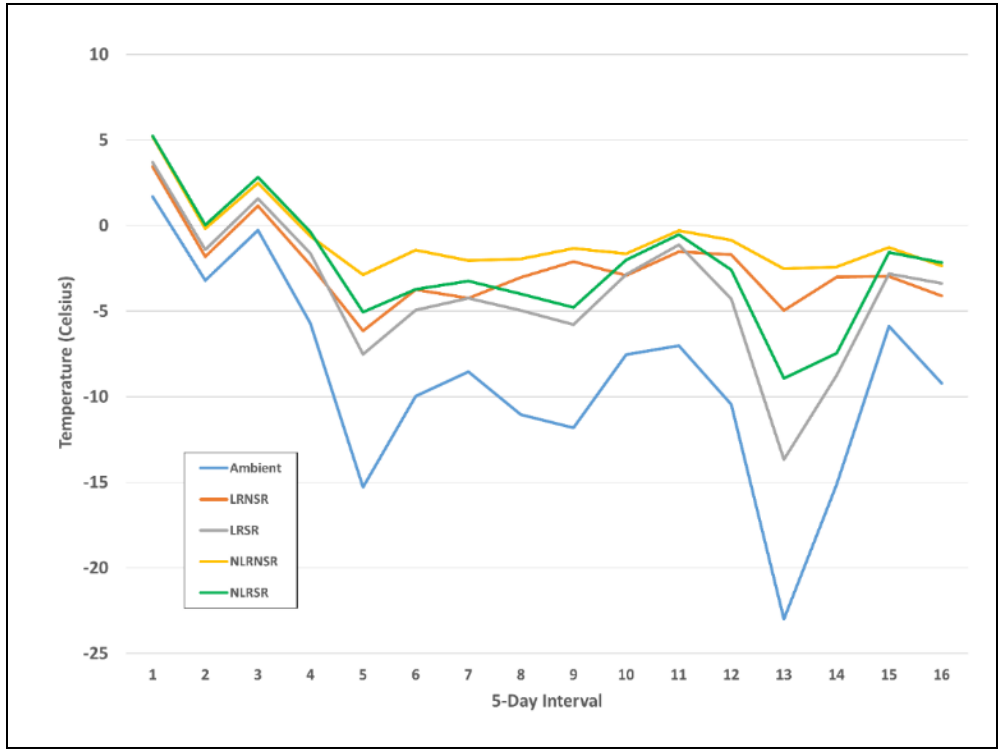


Year 1 minimum temperatures (°C) for all four treatment types and ambient temperature for 5-day intervals starting mid-December through the end of February.

Humidity was high under all conditions, not a factor.

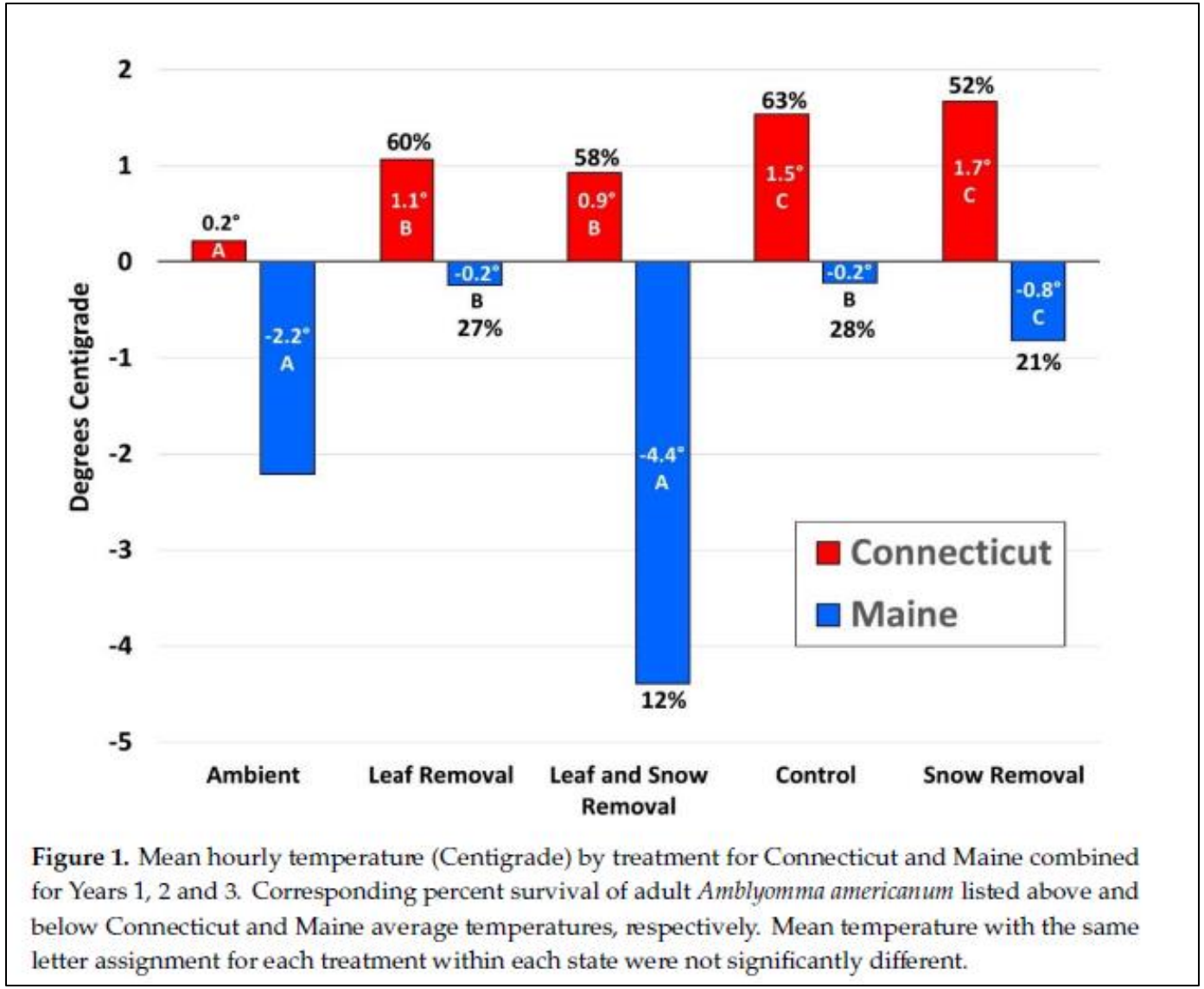
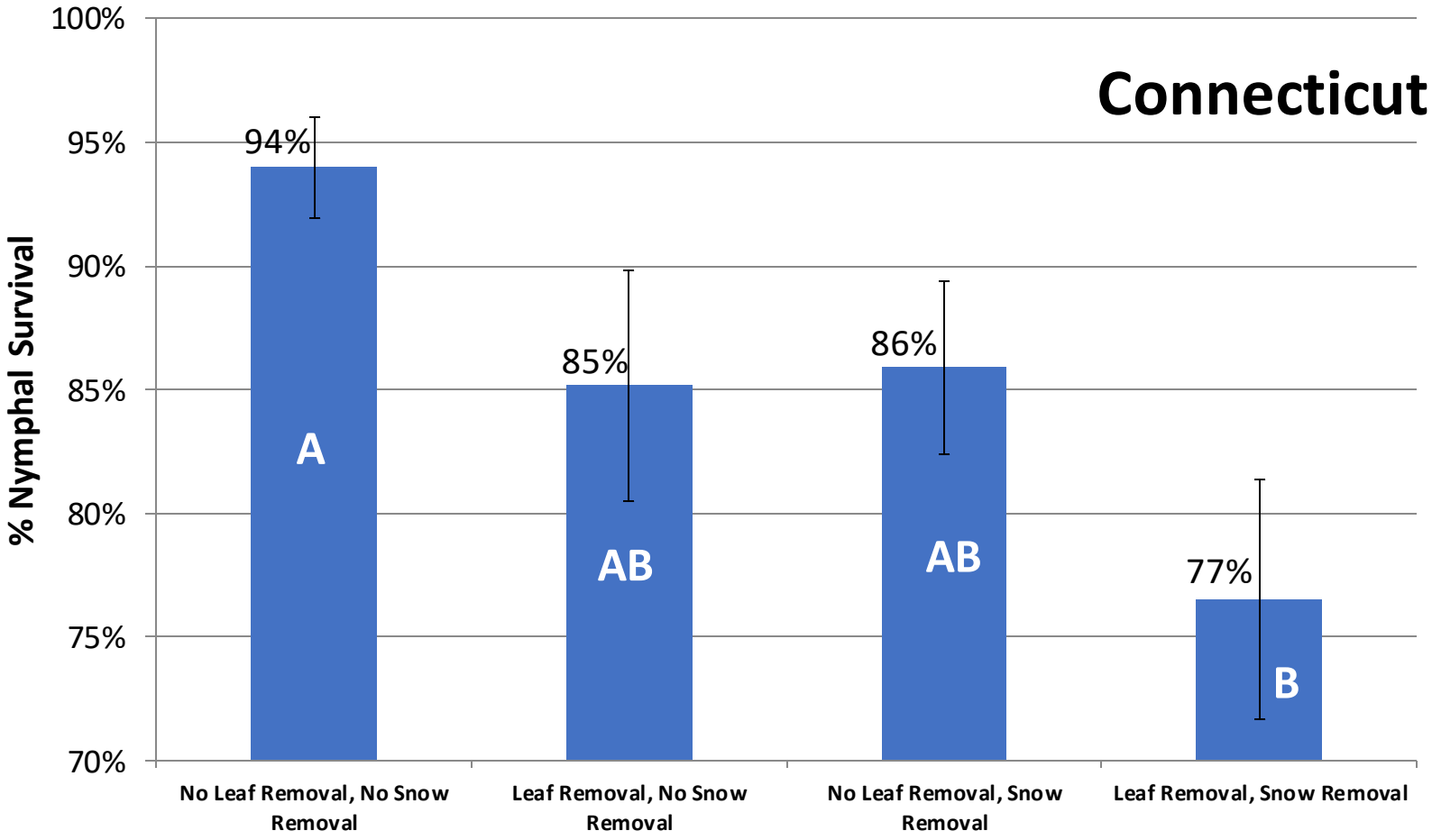


Figure 1. Mean hourly temperature (Centigrade) by treatment for Connecticut and Maine combined for Years 1, 2 and 3. Corresponding percent survival of adult *Amblyomma americanum* listed above and below Connecticut and Maine average temperatures, respectively. Mean temperature with the same letter assignment for each treatment within each state were not significantly different.

Overwinter survival in the field, 2015–2016



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insects

MDPI

Article

Impacts of Deciduous Leaf Litter and Snow Presence on Nymphal *Ixodes scapularis* (Acari: Ixodidae) Overwintering Survival in Coastal New England, USA

Megan A. Linske [1], Kirby C. Stafford, III [1], Scott C. Williams [1], Charles B. Lubelczyk [2], Margret Welch [2] and Elizabeth F. Henderson [2]

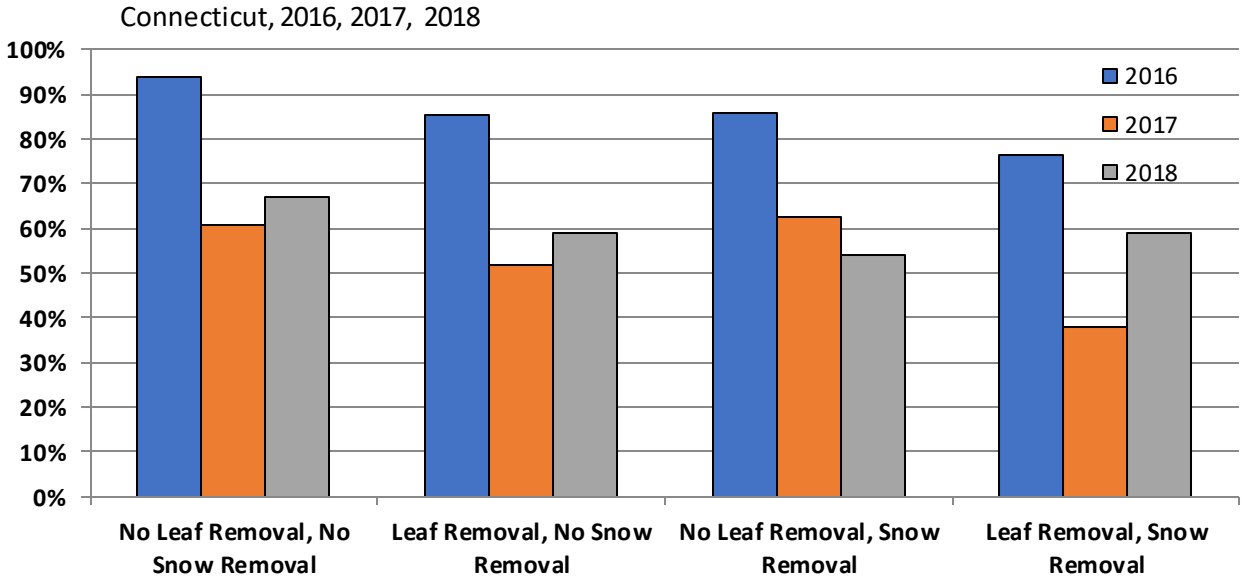
Insects **2019**, 10, 227; doi:10.3390/insects10080227

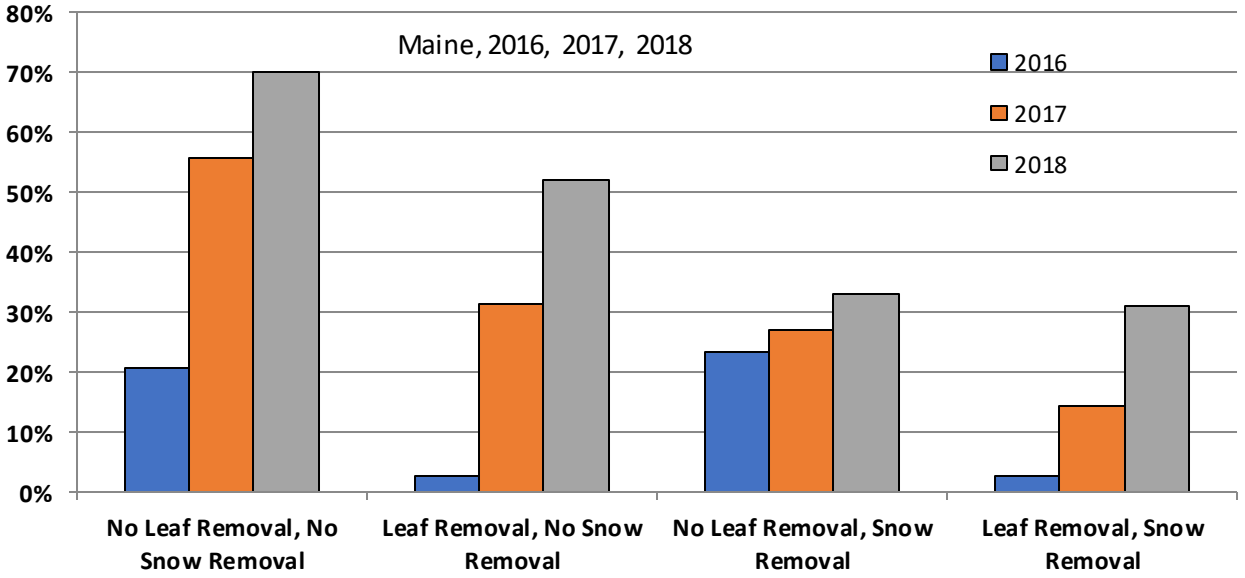
Overwintering survival
Blacklegged tick nymphs

<u>2015–2016</u>
Connecticut 77–94%
Maine 3–23%

<u>2016–2017</u>
Connecticut 38–63%
Maine 14–56%

<u>2017–2018</u>
Connecticut 54–67%
Maine 31–73%





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Overwintering conclusions for *I. scapularis*

- There were significant differences in blacklegged nymph overwintering survival between treatments. For all three winters, regardless of location, NLRNSR had significantly greater survival compared to LRSR and LRNSR.
- **These results indicate that leaf litter removal negatively impacted nymphal survival, which suggests that its presence provides a consistent insulative barrier from winter conditions.**
- However, we believe that the lack of statistical differences in multiple comparisons with snow removal in NLRSR and LRSR, and LRNSR is due in part to the inconsistent insulating effect of snow accumulation on overwintering ticks.
- **This field study determined that leaf litter plays a more significant role in overwintering nymph survival than previously reported.**

Treatment	2016–2017				2017–2018			
	Connecticut		Maine		Connecticut		Maine	
	F	M	F	M	F	M	F	M
Leaf and snow removal (LRSR)	69%	48%	11%	2%	73%	49%	29%	11%
No leaf removal and snow removal (NLRSR)	31%	44%	9%	6%	52%	47%	41%	35%
Leaf removal and no snow removal (LRNSR)	81%	56%	11%	2%	63%	59%	62%	56%
No leaf and no snow removal (NLRNSR)	56%	46%	7%	11%	69%	69%	79%	42%

Treatment	2018–2019			
	Connecticut		Maine	
	F	M	F	M
Leaf and snow removal (LRSR)	59%	50%	-	7%
No leaf removal and snow removal (NLRSR)	69%	65%	-	6%
Leaf removal and no snow removal (LRNSR)	65%	37%	-	4%
No leaf and no snow removal (NLRNSR)	78%	61%	-	18%

Overwintering survival adult lone star ticks

insects MDPI

Article

Determining Effects of Winter Weather Conditions on Adult *Amblyomma americanum* (Acari: Ixodidae) Survival in Connecticut and Maine, USA

Megan A. Linske [1], Scott C. Williams [2,*], Kirby C. Stafford III [1], Charles B. Lubelczyk [3], Elizabeth F. Henderson [3], Margret Welch [3] and Peter D. Teel [4]

Insects. 2020. 11, 13; doi:10.3390/insects11010013

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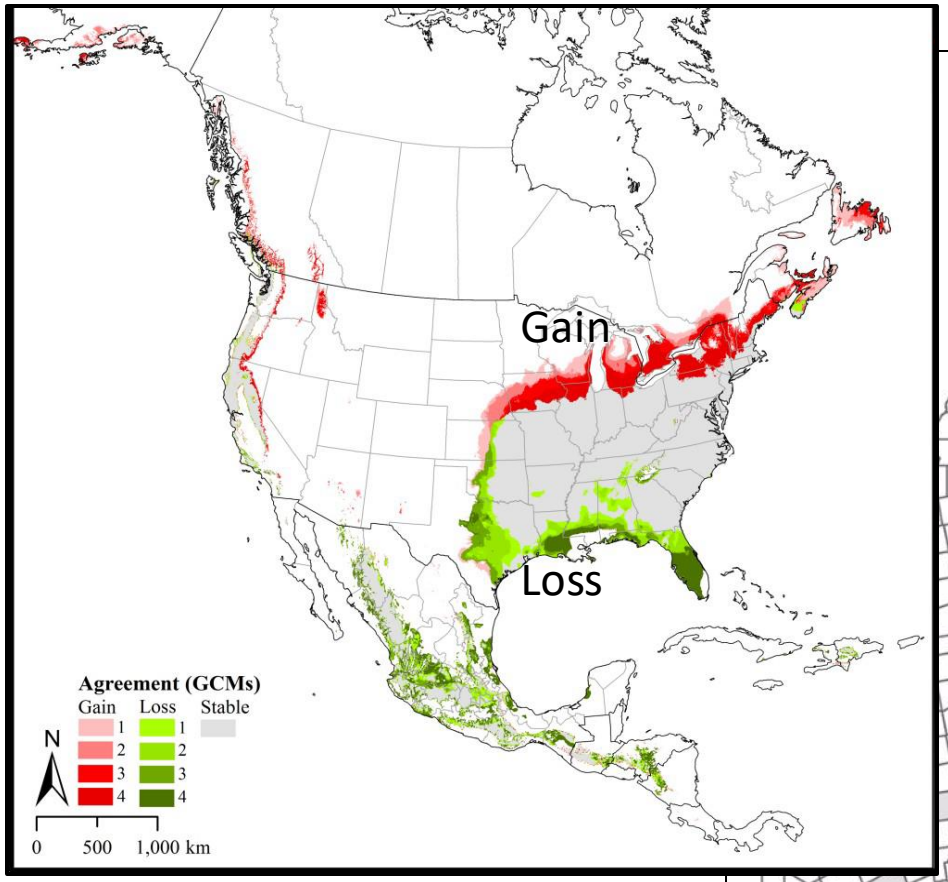
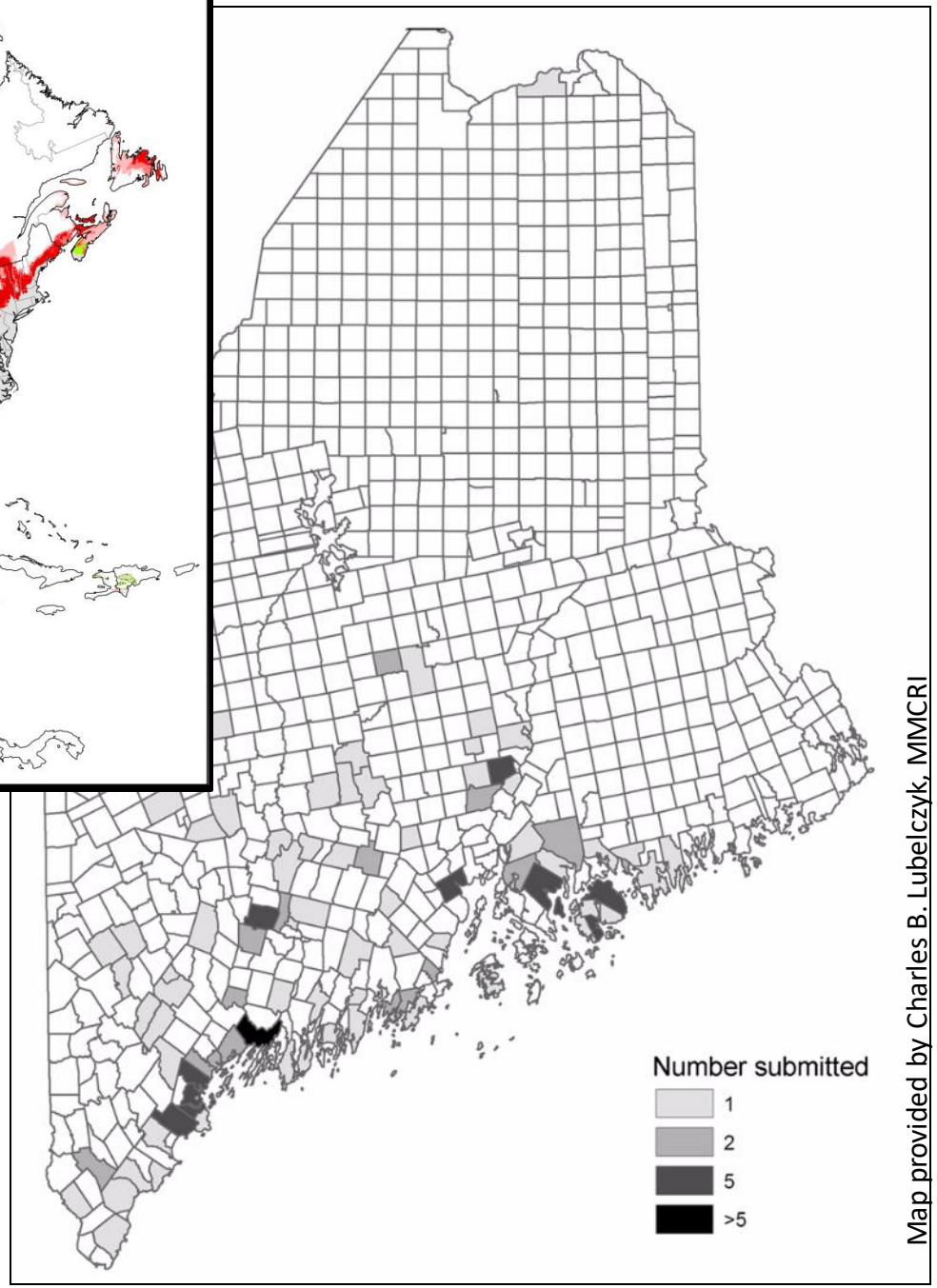


Predicted future suitable regions under climate change scenarios

Raghavan, et al. 2019. *PLOS ONE 14: e0209082.*



Map provided by Charles B. Lubelczyk, MMCRI

Submissions of Maine-acquired *Amblyomma americanum* collected from 1990–2013 (no out of state travel history).

No established populations have been detected.

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Questions

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USDA United States Department of Agriculture National Institute of Food and Agriculture

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VEGETATIVE MANAGEMENT

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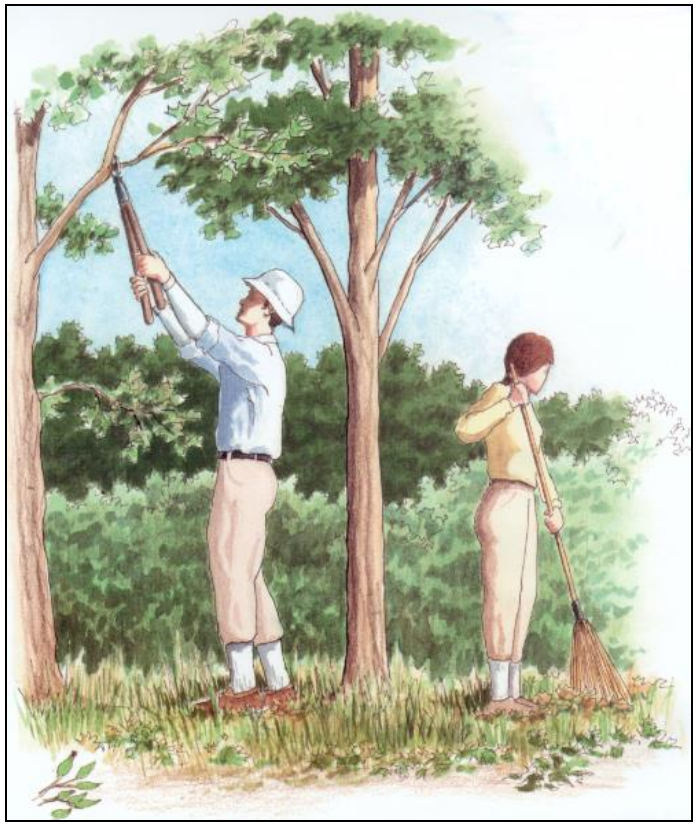
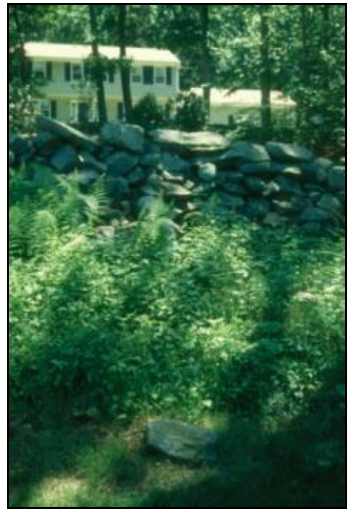


Barnstable Co. Coop Extension

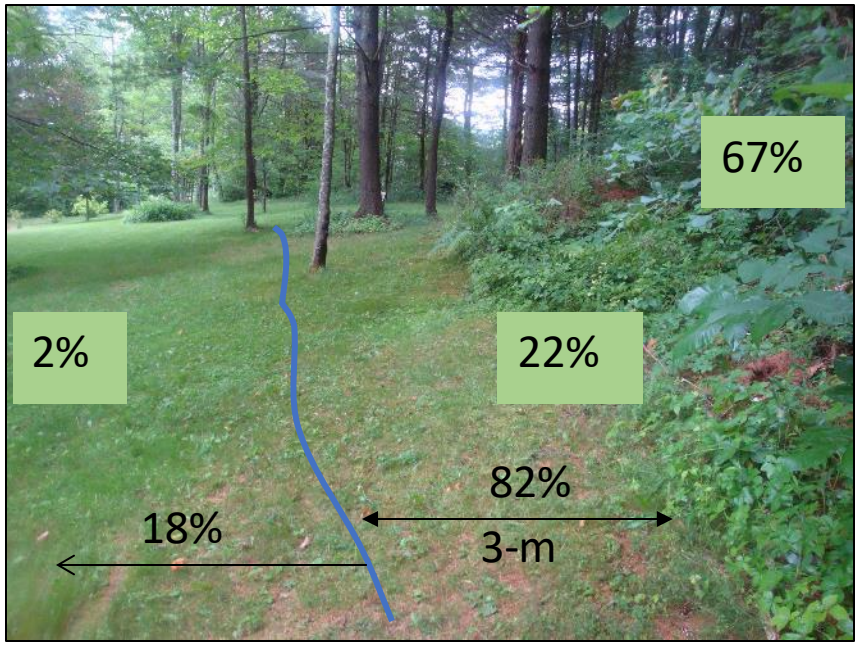


Landscape Characteristics

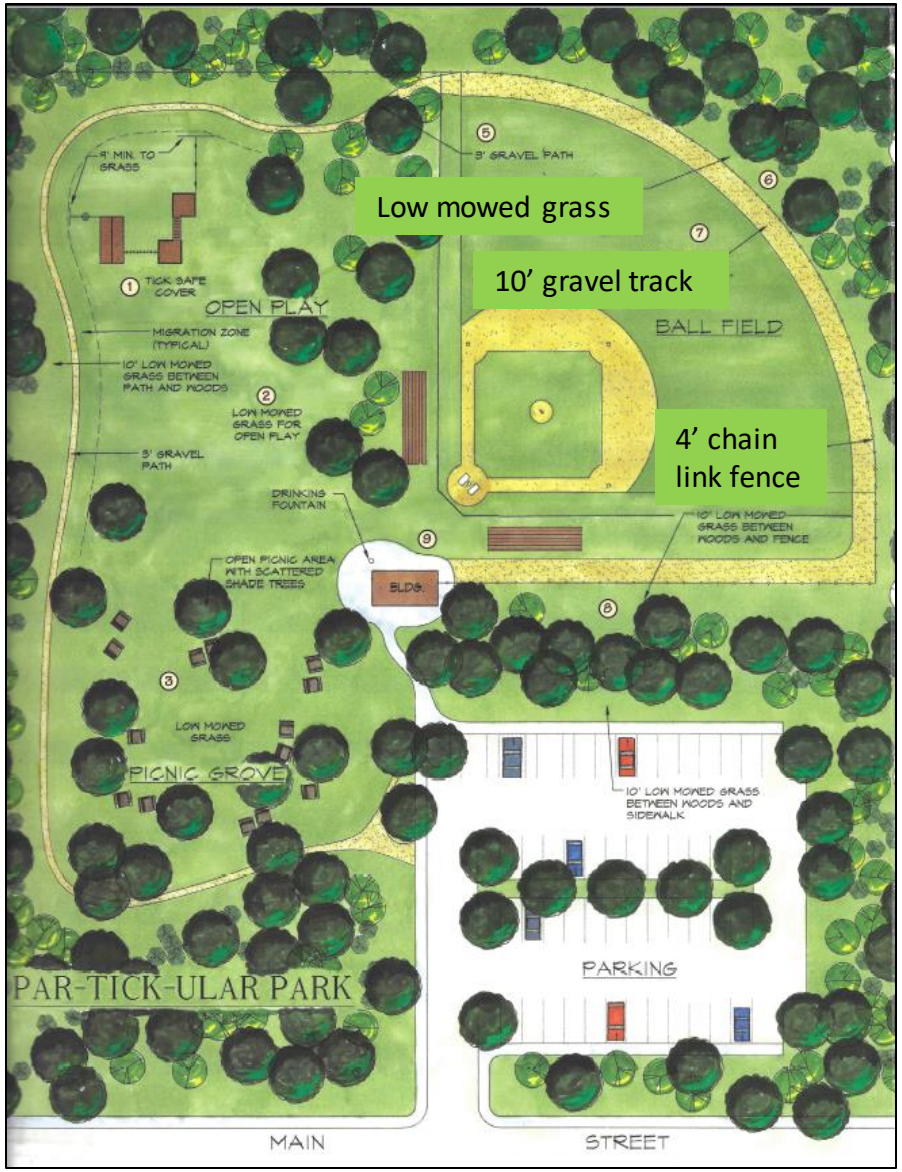
- Presence ticks depends on presence and abundance of appropriate hosts and the environment; simple arrival in new environment not sufficient for establishment…ticks are vulnerable to environmental conditions
- Most ticks require high humidity and cover (ground or vegetative cover)
- Most are found in leaf litter, ground cover, and lower vegetation woodland or ecotone
- Most hard ticks spend 95% of the time at or just below ground cover (duff) digesting blood meal, molting, in diapause, or host-seeking; ground conditions critical to survival

Schools, Parks, Campgrounds

- Parts of school & park grounds may be landscaped into a tick safe zone with lawns, mowed fields, play-grounds, and buildings, depending on tree cover.
- Landscaping the edge important
- Edges, campgrounds, paths through wooded areas are areas of greater risk



Distribution *I. scapularis*



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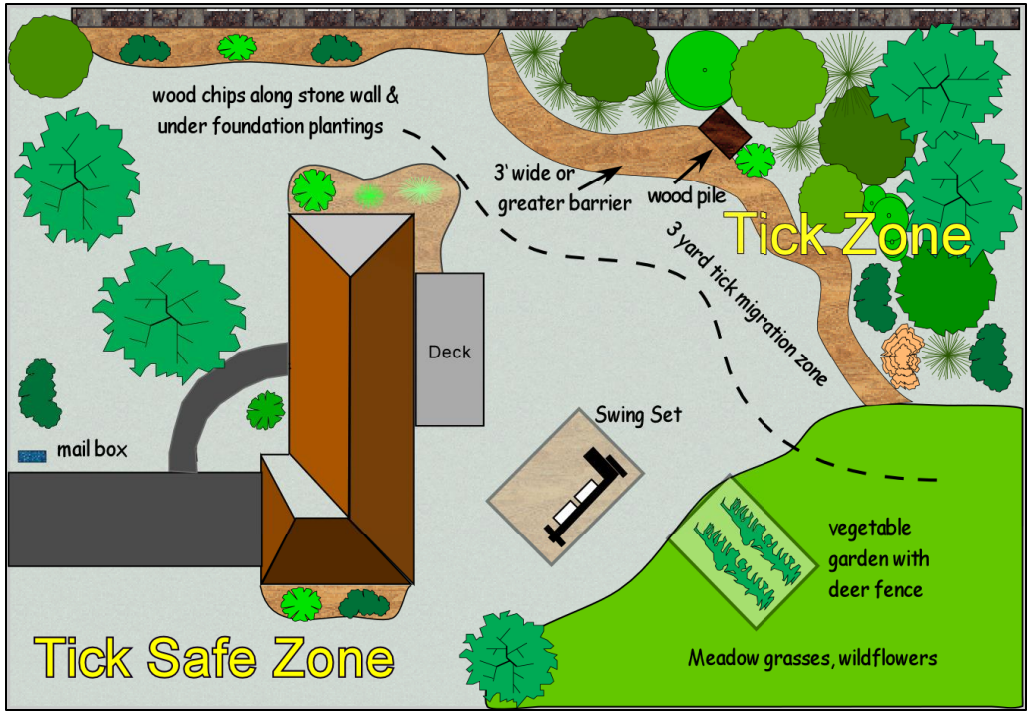
Residential Landscape Management for *I. scapularis*



Leaf litter removal lawn edge 49–70% reduction

Landscape barrier 35–77% reduction

Groundcover i.e., Pachysandra

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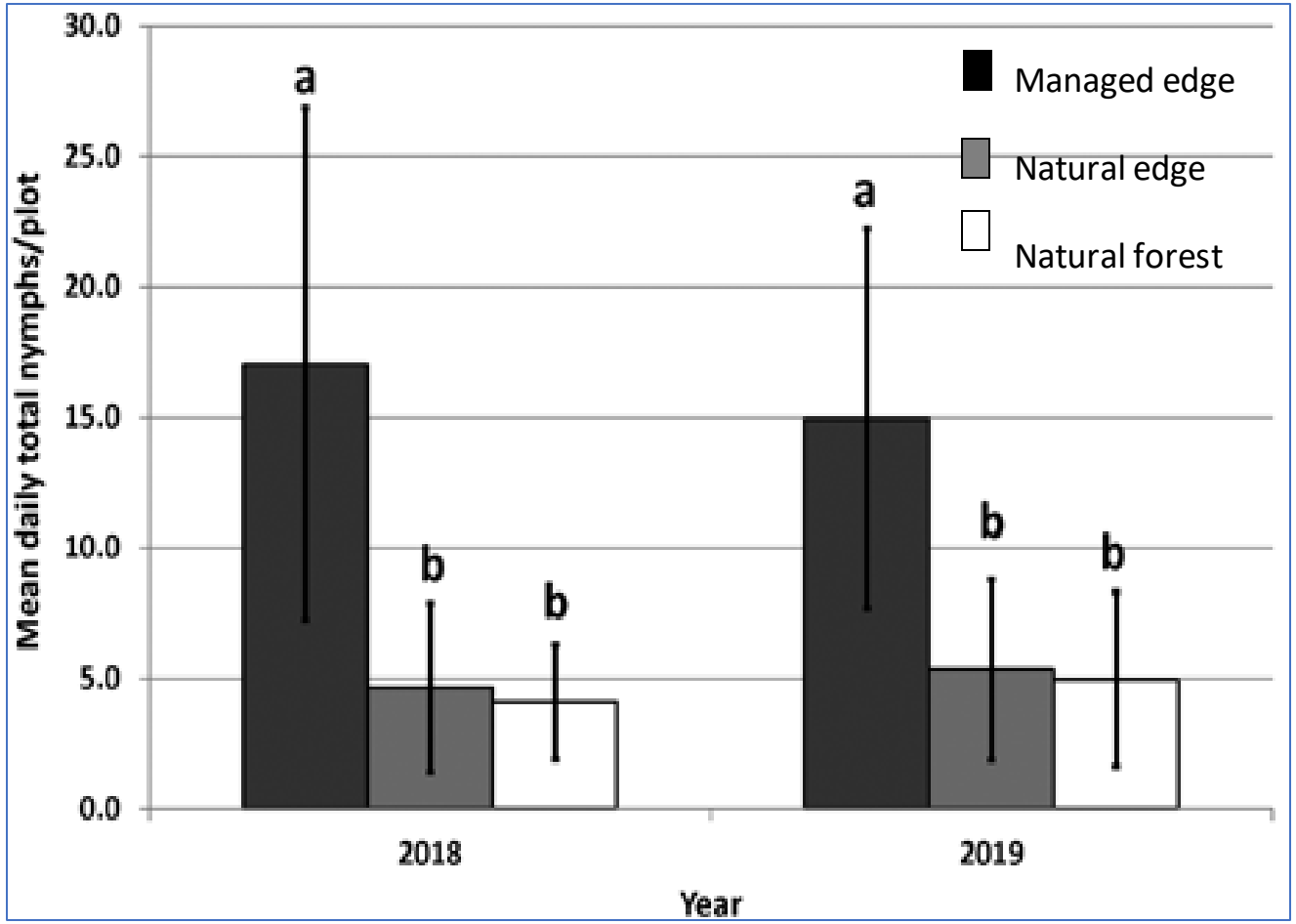
Leaf Litter management

- Leaf litter increases overwinter survival of *I. scapularis* nymphs and *A. americanum* adults
- Leaf blown or raked accumulations of leaves at lawn edge is associated with increased numbers of nymphal *I. scapularis*
- Removal off-site, bagging, mulching, and possibly composting of leaf litter may help reduce risk.



Jordon & Schulze. 2020. J. Med. Entoml. Advance article

Control Invasive plants for management of Ticks

- **Higher tick counts are associated with exotic invasive forest understory than native forest understory or open understory forests**
- Abundance adult blacklegged ticks, *Ixodes scapularis*, infected with *Borrelia burgdorferi*, was greatest in areas dense Japanese barberry
- Greater number lone star ticks, *Amblyomma americanum*, infected with *Ehrlichia* sp. was present in stands of invasive honeysuckle
- **Dense stands provide ideal microclimate for ticks and good host habitat**
- Reduction and long-term management barberry significantly reduced abundance infected ticks
- Removal honeysuckle decreased deer activity and numbers of *Ehrlichia* infected ticks

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Allan, B. F. et al. 2010. Proc. Nat. Acad. Sci. 107: 18523–18527.
Elias et al. J. Med. Entomol. 2006. 43: 1142–1152
Williams et al. J. Med. Entomol. 2009. 38:977–984
Williams et al. Environ. Entomol. 2010. 39:1911–1921.
Williams et al. Environ. Entomol. 2017. 48:1329–1338.

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Tick-borne disease toolbox

Personal protection measures	Treatment/ vaccination in humans	Landscape/ vegetation management	Killing host-seeking ticks	Rodent-targeted approaches	Deer-targeted approaches
Avoid tick habitat	Antibiotic prophylaxis after tick bite	Xeroscaping/ hardscaping	Synthetic chemical acaricide	Topical acaricide bait box	Topical acaricide feeding station
Protective clothing	Human vaccine	Short grass, remove weeds	Natural product-based acaricide	Oral vaccine	Deer reduction
Tick checks & prompt removal ticks		**Remove leaf litter and brush**	Fungal acaricide	Oral antibiotic bait	Deer fencing
Synthetic chemical repellent		Remove rodent harborage	Acaricide with semiochemicals	Oral tick growth regulator	Oral parasiticide
Natural product-based repellent					Oral tick growth regulator
Permethrin-treated clothing					Anti-tick vaccine for deer
Natural product-based soap/lotion					

denotes intervention used in combination with another tick control method

denotes intervention with some supporting data on reduction Lyme disease

Adapted from slide by Ben Beard, CDC-Division Vector-Borne Diseases

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Where do we go from here?

- Widespread, expanding, and difficult to control, ticks and tick-borne diseases are a major problem in the U.S. and worldwide.
- What do we need to know about disease ecology to prevent Lyme disease in the Northeastern United States? And other tick-borne diseases?
- Can vegetative approaches work for other ticks?
- Further studies are needed to investigate the complex relationships between landscape, climate, host communities (biodiversity), tick demography, pathogen diversity, human demography, human behavior, economics, politics, and human exposure to pathogens, considering all ecological processes.

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Acknowledgments – Tick Overwintering Studies

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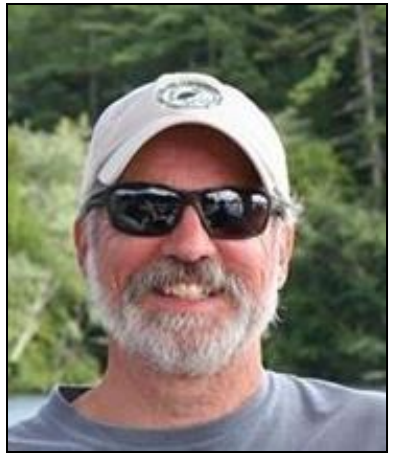

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Maggie Welch

Texas A&M University

Dr. Pete Teel

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Thank You

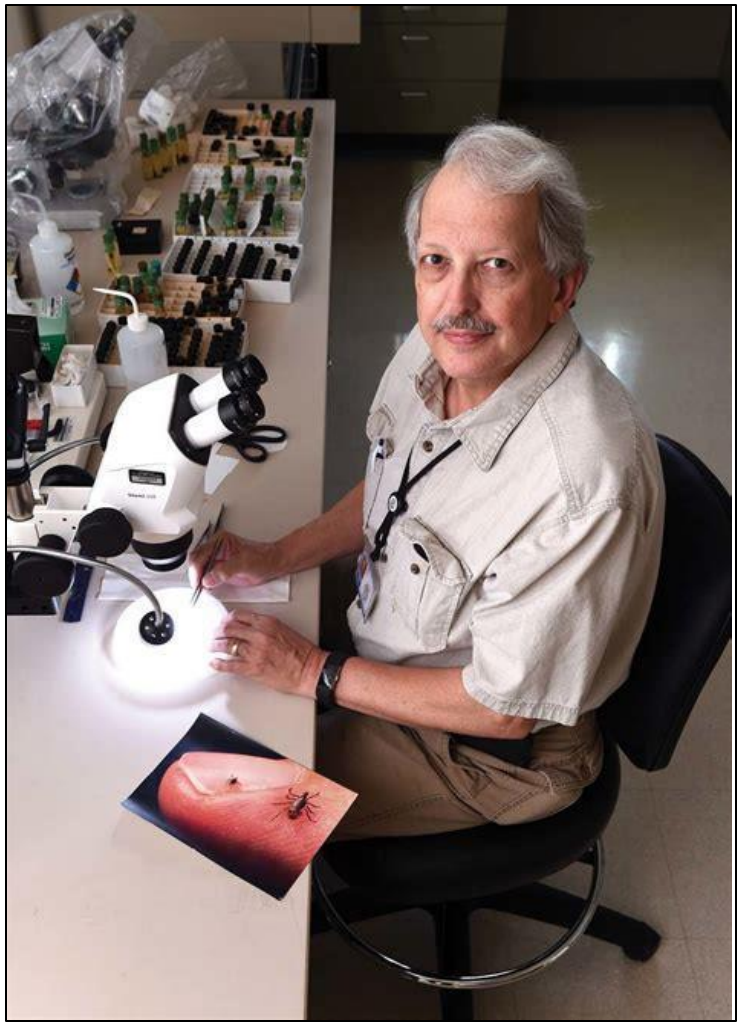

Photo: Arnold Gold © CT Magazine 2018

TICKS!

The foulest and nastiest creatures that be.

Pliny the Elder
Roman Writer, *Historia Naturalis*

This small vile creature [the tick] may, in the future, cause the inhabitants of this land [U.S.] great damage unless a method is discovered which will prevent it from increasing at such a shocking rate.

Pehr Kalm, 1754
Travels in North America

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Questions

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Some Questions for You

Find a Colleague

- To post a profile about yourself and your work: http://neipmc.org/go/APra
- “Find a Colleague” site http://neipmc.org/go/colleagues

Recording of Tick IPM Webinar Series

- Past recordings and today's Webinar will be available to view **on demand** in a few business days.
- http://www.neipmc.org/go/ipmtoolbox
- You can watch as often as you like.

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