



Tick Surveillance Practices in the Northeast

Webinar Supplemental Materials

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Egizi AM, Occi JL, Price DC, Fonseca DM. Leveraging the expertise of the New Jersey mosquito control community to jump start standardized tick surveillance. <i>Insects</i> . 2019 Jul 24;10(8). pii:E219. doi:10.3390/insects1008219.....	202
Wisely SM, Glass GE. Advancing the science of tick and tick-borne disease surveillance in the United States. <i>Insects</i> . 2019 Oct 19;10(10). pii:E361. doi:10.3390/insects10100361.....	217



Working Outdoors



**NYS Department of Health
Occupational Health & Safety Program
(518) 474-8130**



Part 1 of 2

With thanks to the
NYS Department of Environmental Conservation
Health and Safety
and the
NYS Department of Health
Bureau of Communicable Disease Control



Reviewed and revised 7-2017



This presentation was originally developed by the NYS Department of Conservation, Health & Safety.

It was adapted by the Department of Health Occupational Health and Safety Program with assistance from the Health Education Unit of the Bureau of Communicable Disease Control, with input from the Communicable Disease Investigation Unit, in June 2010. For questions or comments on this presentation , please contact Occupational Health and Safety (OHS) at 518-474-8130.



Objectives

- Understand the hazards associated with working outdoors
- Know how to prevent hazards
- Know what to do if an exposure or injury occurs



At completion of this presentation, at -risk employees will:

- Understand the hazards associated with working outdoors
- Know how to prevent hazards
- Know what to do if an exposure or injury occurs

Hazards Associated with Working Outside

- **Physical Hazards**
 - Heat stress
 - Sun exposure
 - Cold stress
- **Biological Hazards**
 - Poisonous plants
 - Animal bites
 - Venomous snake bites
 - Flying insect stings
 - Mosquito and tick bites



The hazards associated with working outdoors are both physical and biological. The physical hazards include heat stress, sun exposure and cold stress. The biological hazards include poisonous plants, animal bites, venomous snake bites, flying insect stings, and mosquito and tick bites. We'll learn more about these hazards and how to prevent them in the following slides.

OSHA Act of 1970

OSHA General Duty Clause, Section 5

(a) Each employer –

(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;

(b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.



OSHA/PESH does not have a specific regulation regarding the hazards of working outdoors, however the General Duty Clause of the OSHA Act of 1970 mandates employers to ensure employees are free from recognized hazards that are likely to cause death or serious physical harm to the employees. Whereby hazards associated with working outdoors cannot be eliminated completely, the employer has the obligation to provide employees who work outside with safety and awareness training to protect themselves against such hazards.

Information on the OSHA Act of 1970 was obtained at the following website:
http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=OSHACT&p_toc_level=0&p_keyvalue=&p_status=CURRENT

Sec. 5. Duties:

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=3359&p_table=OSHACT

THE NEW YORK STATE SUN SAFETY LAW

- § 218-a. Sun safety education for state employees.
- 1. Any state employee who spends more than a total of five hours per week outdoors shall be provided information about
 - (a) the potential dangers of diseases caused by over-exposure of the sun, such as skin cancer,
 - (b) the existence of available protections and their proper uses, and
 - (c) any other information necessary to afford an employee his or her best opportunity to protect themselves from the sun.



THE NEW YORK STATE SUN SAFETY LAW

- 2. An employer of any employee subject to subdivision one of this section shall ensure that any necessary information is given to each employee for his or her use during their employment, at no cost to the employee.
- 3. The commissioner, in consultation with the commissioner of education, shall determine the form and content of the information supplied to the state employees who are subject to the provisions of this section.



NYS Public Employees Sun Safety Law



- NYS Dept of Labor regulation
- Effective November 14, 2006
- NYS public employers must provide sun safety education to state employees who spend more than 5 hours per week outdoors:
 - Must include information on:
 - Potential dangers of over-exposure of the sun
 - Existence & proper use of available protections
 - How employees can best protect themselves from the sun
 - Information must be given during employment
 - At no cost to employee



The NYS Dept of Labor enacted a new regulation in November 2006 which addresses sun safety for public employees who spend more than 5 hours per week outdoors. The law requires employers to provide training to those employees regarding the hazards of over-exposure of the sun, and how they can protect themselves from over-exposure. See NYS Department of Labor at http://www.labor.state.ny.us/workerprotection/safetyhealth/PDFs/Sun%20Safety%20Law%20%20NYS%20Public%20Employee%20_4_%20_6_%20_2_.pdf

Heat Rash

- Caused by excessive sweating during hot, humid weather

Symptoms:

- Red, itchy pimples or small blisters
- Normal to slightly high body temperature

First aid:

- Gently clean affected area with cool water & nondrying soap
- Let skin air-dry instead of toweling
- Calamine lotion or cool compresses may help relieve discomfort

Prevent heat rash!

- Reduce sweating—keep skin clean & dry
- Wear loose, lightweight clothes that wick away moisture
- Stay in a cooler, less humid environment when possible



Heat Rash is also called prickly heat or miliaria (not to be confused with malaria)

Source: Mayo Clinic: <http://www.mayoclinic.com/health/heat-rash/DS01058>

Heat Illnesses

Common causes include:

- High temperatures or humidity
- Prolonged or excessive exercise
- Dehydration
- Too much or too heavy clothing
- Use of certain prescription medications
- Heart disease

Drinking alcohol in hot temperatures can also cause heat illnesses!

- 3 categories that can increase in severity:
 1. Heat cramps
 2. Heat exhaustion
 3. Heatstroke



Heat illness results when the body is unable to cool itself by sweating causing the body temperature to rise.

Some medications place you at a greater risk of heatstroke and other heat-related conditions because they affect your body's ability to stay hydrated and respond to heat. Be especially careful in hot weather if you take medications that narrow your blood vessels (vasoconstrictors), regulate your blood pressure by blocking adrenaline (beta blockers), rid your body of sodium and water (diuretics), or reduce psychiatric symptoms (antidepressants or antipsychotics). Additionally, stimulants, such as amphetamines and cocaine, increase your body's heat production, making you more vulnerable to heatstroke. Source: Mayo Clinic:

<http://www.mayoclinic.com/health/heat-stroke/DS01025/DSECTION=risk-factors>

Source for ALL heat illness slides:

•CDC NIOSH: http://www.cdc.gov/niosh/topics/heatstress/#_Heat_Stroke

•MedlinePlus: MedlinePlus:

<http://www.nlm.nih.gov/medlineplus/ency/article/000056.htm> and

<http://www.nlm.nih.gov/medlineplus/heatillness.html>

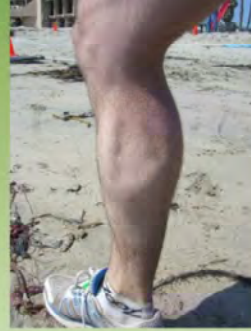
•Mayo Clinic: <http://www.mayoclinic.com/health/heat-exhaustion/DS01046> and

<http://www.mayoclinic.com/health/heat-stroke/DS01025>

•Merck Manual: <http://www.merck.com/mmpe/sec21/ch318/ch318d.html>

1. Heat Cramps

- Painful, involuntary muscle spasms
- Caused by performing physical labor in hot environment
- Electrolyte imbalance caused by sweating
- Inadequate fluid or electrolyte consumption /replenishment
- Muscles often affected:
 - Calves
 - Arms
 - Abdominal wall
 - Back



First Aid for Heat Cramps

- Stop activity & rest
- Move to cooler place
- Drink water*, clear juice or sports drink with electrolytes
- Gently stretch and massage affected muscle group
- Seek medical attention if cramps do not subside in 1 hour

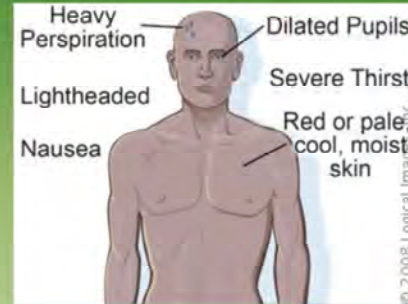


*Add 1 teaspoon salt to 1 quart/liter water



2. Heat Exhaustion

- Symptoms:
 - Heavy sweating
 - Fast & shallow breathing
 - Fast & weak pulse
 - Dizziness, lightheadedness
 - Nausea
 - Cool, moist skin
 - Extreme weakness or fatigue
 - Dark urine



First Aid for Heat Exhaustion



- Follow the tips shown in the illustration and
- Seek medical attention if symptoms don't subside within 1 hour
- Can progress to heatstroke



3. Heatstroke



- Heat stroke is an **extremely dangerous** medical emergency that can cause:
 - Shock
 - Brain damage
 - Organ failure
 - Death
- Occurs when body loses ability to control its temperature (due to depletion of water and salt)



3. Heatstroke – continued

- Symptoms:
 - Fever (temperature above 104 °F)
 - Lack of sweating (dry, hot, flushed skin)
 - Neurological symptoms
 - Rapid & shallow breathing
 - Racing heart & strong pulse
 - Throbbing headache



Body temperature can rise to 106F or higher in 10 to 15 minutes

The distinguishing feature of heat stroke is the lack of sweating...hot, dry, skin

Neurological symptoms include:

Extreme confusion

Dizziness

Slurred speech

Irrational behavior (possible hallucinations)

Seizures

Unconsciousness

Coma



First Aid for Heatstroke

- Call 911 first if person:
 - Shows signs of shock (bluish lips & fingernails and decreased alertness)
 - Starts having seizures
 - Loses consciousness
- Move affected person to a cool, shaded area
- Cool the person:
 - Soak their clothes with water
 - Spray, sponge & shower person with water
 - Fan their head & body



- ✓ Notify Supervisor
- ✓ Complete Accident Report form





Prevent Heat Illness!

- Schedule heavy work during the coolest parts of the day, whenever possible
- Condition yourself for working in hot environments, gradually build up to heavy work
- Drink lots of liquids (not caffeinated or alcoholic beverages)
- Take breaks in the shade or a cool area
- Take a break if you are getting a headache or start feeling overheated
- Wear lightweight, light colored clothing, avoid non-breathable synthetics.
- Take advantage of fans & air conditioners
- Be aware that PPE may increase the risk of heat-related illness
- Know what prescription medications you take- do they increase your risk?



Effects of Ultraviolet (UV) Exposure

- UV radiation causes sunburn, premature aging of the skin, wrinkles, cataracts and skin cancer
- The amount of damage from UV exposures depends on:
 - Strength of the light
 - Length of exposure
 - If the skin is protected
- People more susceptible to sun damage include those with:
 - Numerous, irregular, or large moles
 - Freckles or fair skin
 - Blond, red or light blond hair

There are no safe UV rays or safe suntans.



For more information see CDC at <http://www.cdc.gov/niosh/topics/uvradiation/>

Skin Cancer

- 3 types linked to sun exposure:
 1. Basal cell cancer
 2. Squamous cell cancer
 3. Malignant melanoma
- Risk of developing skin cancer increases with the amount of time over the years you spend in the sun without protection plus the intensity of the sun
- Sun intensity is greatest in the summer from 10 a.m. - 3 p.m.
- Work surfaces such as metal roofing or concrete can reflect up to 50% of the sun's radiation and intensify the exposure



Malignant melanoma is rarer and more likely to be fatal if treatment is delayed.
Every hour an American dies from skin cancer
~ 10,000 Americans die from skin cancer each year

Types of Skin Cancer

Basal cell carcinoma:

Often start as small fleshy bumps on the face, ears, lips or around the mouth; bumps may become crusty.



Squamous cell carcinoma:

Scaly patches or raised growths on tip of nose, forehead, lower lip, or hands.



Melanoma:

Most danger skin cancer. Leading cause of skin disease death. Lesions are asymmetrical, have irregular edges, a mixture of colors within one sore & usually about the size of a pencil eraser.



Melanoma Source: MedlinePlus
(<http://www.nlm.nih.gov/medlineplus/ency/article/000850.htm>)

Be on the Lookout for Skin Cancer!

- Perform a monthly skin check to look for signs of possible skin cancer
- Recognize any spots on the skin that are changing in size, shape or color
- Skin cancers may appear as:
 - Pale, wax-like, pearly nodules
 - Red, scaly, sharply outlined patches
 - Sores that do not heal
 - Small, mole-like growths (may indicate melanoma)
- If you find such unusual skin changes, see a healthcare professional immediately.



Skin cancers detected early can almost always be cured

Protect Against Sun Exposure!

- Limit sun exposure between 10:00 a.m. and 3:00 p.m. when possible
 - Wear protective clothing & glasses:
 - Long sleeves shirts and long pants
 - Wide brim hat
 - Sunglasses
 - Use sunscreen water resistant to withstand humidity and sweat*:
 - For UVB protection- minimum SPF 15 (sun protection factor):
 - SPF determines how long a person will be protected from a burn. SPF 15 means a person can stay in the sun 15 times longer before burning.
 - For UVA protection, look for products containing zinc oxide or Parsol 1789
 - Avoid products such as baby oil, cocoa butter or skin oils which do not protect against sunburn.
- *If also using an insect repellent, apply sunscreen 1st, then repellent



A really good fact sheet for workers on protecting against sun exposure can be found at : CDC NIOSH at <http://www.cdc.gov/niosh/docs/2010-116/pdfs/2010-116.pdf>

FDA:

<http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm048022.htm>:

Beware of Bug Bites & Stings

The FDA regulates sunscreen as an over-the-counter (OTC) drug. The Environmental Protection Agency (EPA) regulates insect repellent products.”

Cold Stress

- Prolonged exposure to freezing temperatures can result in serious health problems:
 - Trench foot
 - Frostbite
 - Hypothermia
- Environmental conditions that cause cold stress:
 - Low temperatures
 - Dampness
 - High winds
 - Cold water



At risk: Employees who work outdoors or within cold spaces for prolonged periods during the winter months.

What is your risk from working in cold weather?

- Cold is a physical hazard in many outdoor workplaces. When the body is unable to warm itself, serious cold-related illnesses and injuries may occur that could lead to permanent tissue damage or worse.
- Your body tries to maintain an internal (core) temperature of approximately 98.6°F (37°C) by reducing heat loss and increasing heat production. Under cold conditions, blood vessels in skin, arms and legs constrict, decreasing blood flow to extremities. This minimizes cooling of the blood and keeps critical internal organs warm. At very low temperatures, however, reducing blood flow to the extremities can result in lower skin temperature and higher risk of frostbite.



What other RISK FACTORS are associated with cold injury?

- Various medical conditions such as heart disease, asthma/bronchitis, diabetes and vibration/white finger disease can increase the risk of cold injury.
- Check with your health practitioner to learn whether medications you are taking could also have adverse effects in a cold environment.



Trench Foot



- Characteristics:
 - Feet become numb & turn red or blue
 - As the conditions worsens, feet may swell
 - Advanced immersion can lead to open sores and blisters
- Caused when feet are cold and damp while wearing constricting footwear
- Does not require freezing temperatures- can occur in temps up to 60 degrees
- Prevent trench foot!
 - Keep feet warm and dry
 - Change socks frequently



Frostbite



- Characteristics:
 - Freezing in deep layers of skin and tissue
 - Paling, numbing and hardening of the skin
 - Fingers, hands, toes, feet, ears, nose are particularly susceptible



Frostbite First Aid

Seek medical attention as soon as possible!

- Move the person to a warm, dry area. Do not walk on frostbitten feet or toes, unless necessary.
- Remove any wet or tight clothing that may cut off blood flow
- Gently place the affected area in a warm (105° F) (not hot) water bath to slowly warm the tissue. Do not use a heating pad to warm the area. After the affected area is warm, it may become puffy and blister.
- Do not massage the frostbitten area- may cause more damage
- When normal movement, color & feeling return, dry and wrap the affected area to keep it warm



Employees who suffer from frostbite due to a job-related task should complete and submit an Accident Report form.

Hypothermia



- Characteristics:
 - Body loses heat faster than it can be produced
 - Abnormally low body temperature – below 95 F
 - Eventually, body's stored energy is depleted
- Early Symptoms:
 - Shivering
 - Loss of concentration
 - Fatigue
 - Confusion and disorientation**
- Late Symptoms: occurs when temp falls below 92 F
 - Dilated pupils
 - Shivering stops
 - Slowed pulse & breathing
 - Blue skin
 - Loss of consciousness

**Confusion /disorientation-Often hear of people getting lost while trying to find safety.



Hypothermia First Aid

- Move affected person into a warm room or shelter
- Begin cardiopulmonary resuscitation (CPR) if person has no pulse
- Call 911
- Notify supervisor
- Remove person's wet clothing



Alert supervisor, seek medical assistance, call 911 if necessary.

Hypothermia First Aid – continued

- Warm the center of the body first (chest, neck, head and groin) by using:
 - Electric blanket
 - Skin-to-skin contact under loose, dry layers of blankets, clothing, towels or sheets
- After person's body temperature has increased, keep person dry and wrapped in blankets
- If conscious, give warm beverages- no alcohol



✓ Complete Accident Report form



Also complete an Accident Report form.

Prevent Cold Stress!

- **General Employee Protective Measures in cold weather:**
 - Ensure that wind-chill factor is understood by workers, especially those working on bridges or out in the open on high buildings.
 - Ensure that workers are medically fit to work in excessive cold, especially those subject to the risk factors highlighted above.
 - Make sure that workers understand the importance of high-caloric foods when working in cold environments. Warm sweet drinks and soups will serve to maintain caloric intake and fluid volume.
 - Coffee should be discouraged in cold conditions because it increases water loss and blood flow to extremities.
 - Personnel working in isolated cold environments, whether indoors or outdoors, should have backup for monitoring purposes.
 - Also, if applicable, employees should use shelters or other protected areas regular intervals.
 - Warm drinks and regular breaks are beneficial under extremely cold working conditions.



Prevent Cold Stress!

- **Select protective clothing to suit the cold, the job, and the level of physical activity.**
 - Wear several layers of clothing rather than one thick layer. Air captured between layers acts as an insulator.
 - Wear synthetic fabrics such as polypropylene next to the skin because these whisk away sweat. Clothing should not restrict flexibility.
 - If conditions are wet as well as cold, ensure that the outer clothing worn is waterproof or at least water-repellent.
 - Wind resistant fabrics may also be required under some conditions.
 - At air temperatures of 2°C (35.6°F) or less, workers whose clothing gets wet for any reason will need an immediate change of clothing and may need treatment from hypothermia. Encourage the use of hats and hoods to prevent heat loss from the head and to protect ears. Balaclavas or other face covers may also be necessary under certain conditions.
 - Tight-fitting footwear restricts blood flow. Footwear should be large enough to allow wearing either one thick or two thin pairs of socks. Wearing too many socks can tighten fit and harm rather than help.
 - Workers who get hot while working should open their jackets but keep hats and gloves on.



Biological Hazards – Exposure to Poisonous Plants

Plants to Avoid

- Poison Ivy
- Poison Oak
- Poison Sumac
- Giant Hogweed



“Leaves of three—let them be”



These are only some of the poisonous plants you want to avoid...there are others. In addition to the allergic reactions caused by contact with the oil of these plants, burning these plants produces smoke that, when inhaled, can cause severe lung irritation.

Poison Ivy



Spring



Summer



Fall

- Grows as a vine or low shrubs
- Has smooth glossy green leaves
- Many people get an itchy rash if they touch the plant, clothes, or any object that has contact with it
- Rash is caused by urushiol, an oily substance in the plant that can cause allergic reaction on contact
- Urushiol is active in live AND dead plants



Poison Ivy...Different Looks



It's a bush



It climbs



It creeps



Poison Oak

- A shrub
- Leaves are divided into 3 leaflets, resemble oak leaves
- Has white berry-like fruits
- Like poison ivy, contains urushiol, which causes an allergic skin reaction on contact for some people



Poison Oak...Different Looks



It's a shrub



It climbs



It has pretty flowers



Severe Allergic Reactions to Urushiol



Poison Ivy



Poison Oak

If exposed, do not rub your eyes or face!



Poison Sumac

- Shrub that can grow to over 27 feet tall
- It has alternate compound leafstalks with 7 to 13 leaflets
- Flowers are greenish-yellow and followed by white or pale yellow berries
- Grows only in wet, acidic swamps in North America
- Touching any part of the shrub can cause serious contact dermatitis at all times of the year because it contains urushiol



Poison sumac can be identified by its row of paired leaflets that contains an additional leaflet at the end. Often the leaves have spots that resemble blotches of black enamel paint. These spots are actually urushiol, which when exposed to air turn brownish black. Before urushiol is exposed to the air, it is colorless or pale yellow.

Poison Sumac





Giant Hogweed

- DON'T TOUCH!
- Exudes a watery sap that sensitizes skin to UV radiation
- Can result in severe burns, blistering, painful dermatitis and scars, even blindness**
- Can grow 8 – 15 feet tall
- Dark reddish-purple stem & spot leaf stalks
- Grows along roadsides, stream banks and abandoned sites
- Do not touch, mow, cut or weed whack the plant— seek advice from professional plant control specialists



**Giant hogweed can cause blindness if gotten in the eyes and exposed to sunlight.

Source: <http://www.dec.ny.gov/animals/39809.html>

Very good fact sheet:

<http://www.agmkt.state.ny.us/CAPS/pdf/Giant%20Hogweed%20Poster.pdf>

NYSDOH fact sheet:

http://www.health.state.ny.us/environmental/outdoors/hogweed/giant_hogweed.htm

Giant Hogweed



Wild Parsnip

- From the same family as giant hogweed
- Grows 2 – 5 feet tall
- Grows along roadsides, in waste places, old fields, meadows & along railroad tracks
- Can cause similar burn as giant hogweed
- If you must touch wild parsnip, wear gloves, long sleeves and long pants for protection



Sources: <http://www.uvm.edu/mastergardener/pdf%20files/wild-parsnip-3.pdf>

Wild Parsnip



Prevent Contact with Poisonous Plants!

- BEST: Avoid contact with poisonous plants!
- Learn to identify the different types of plants
- Wear protective clothing: long sleeves, long pants, gloves
- Consider use of an over-the-counter skin-block product (bentoquatam) before going outdoors—protects against poison ivy, oak and sumac—does NOT protect against giant hogweed or wild parsnip.



What if You're Exposed?

- Immediately rinse skin with rubbing alcohol, or dishwashing soap and lots of water. Rinse frequently.
- Scrub under nails with a brush
- Apply wet compresses, calamine lotion or hydrocortisone cream to reduce itching and blistering
- Using gloves, clean exposed tools with rubbing alcohol or soap and water after use.
- Wash clothing separately in hot water and detergent after exposure to poisonous plants
- Seek medical attention if severe allergic reaction, or if rash is on face or genitals or previous severe reaction
- If exposed due to a job-related task, complete an Accident Report form





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Animal Bites

- What to do immediately:
 - If minimal blood, wash the wound thoroughly with soap & clean water
Apply an antibiotic ointment & a clean dressing
 - If the bite is actively bleeding, apply direct pressure with a clean, dry cloth until the bleeding stops. If possible, keep the area of bite raised
- See a medical provider for all bites (regardless of severity):
 - Bacterial infection
 - Possible rabies exposure
- Symptoms of an infected bite:
 - Pain, tenderness, redness, heat, swelling
 - Pus under the skin or oozing drainage
 - Swollen lymph nodes in area of bite



If you sustain an animal bite when performing a job-related task, complete an Accident Report form

Sources: NYSDOH:

<http://www.nyhealth.gov/diseases/communicable/zoonoses/rabies/precauti.htm>,
http://www.nyhealth.gov/press/releases/2007/2007-09-07_world_rabies_day.htm,

CDC: <http://wwwnc.cdc.gov/travel/yellowbook/2010/chapter-2/animal-associated-hazards.aspx>, <http://www.cdc.gov/niosh/topics/emres/Animals.html>),

<http://emergency.cdc.gov/disasters/animalspubevac.asp>,

<http://www.cdc.gov/Features/RabiesAndKids/>, MedlinePlus:

<http://www.nlm.nih.gov/medlineplus/ency/article/000034.htm>

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Rabies

- An acute viral infection of the central nervous system that affects mammals:
 - Not spread by birds, reptiles, amphibians or fish
- Transmitted by introducing the rabies virus into cuts, wounds or mucous membranes
- Most commonly transmitted by bites from infected animals



Bites from mammals (warm-blooded animals with fur or hair and whose females produce milk to feed their young) pose rabies exposures.
Only a few human cases are reported each year in the US

Rabies – Commonly Affected Species



- Bats
- Red & gray fox
- Raccoons
- Skunks
- Other carnivorous wild animals
- Domestic animals (cats, dogs, cattle, horses)
- Woodchucks



This list is not exhaustive--any warm-blooded mammal can transmit rabies. Source: CDC (<http://www.cdc.gov/healthypets/diseases/rabies.htm>)

Rabies

- Transmitted through specific bodily excretions & tissue:
 - Saliva
 - Brain/nervous system tissue
- Not transmitted by:
 - Petting or handling an animal (without salivary or nervous tissue contact)
 - Contact with blood, urine or feces
- Diagnosed in animals by testing brain tissue at NY State Rabies Lab



Rabies – Fast Facts

- Rabies virus usually transmitted by bites, but contamination of open cuts or wounds or mucous membranes (e.g., eyes, mouth) with saliva or nervous tissue can result in infection
- Rabies virus can live a few hours outside the body in saliva & certain body fluids
- Rabies virus can live for days in a dead animal
- Freezing extends the life of the rabies virus after the animal's death
- All potential exposures must be reported to County Health Department:
www.nyhealth.gov/diseases/communicable/zoonoses/rabies/contact.htm



Rabies – Symptoms

- Incubation period is usually several weeks to several months
- Don't take chances—untreated rabies is almost always fatal
- Early symptoms:
 - Irritability
 - Headache
 - Fever
 - Itching or pain at the site of exposure
- Within days of early symptoms:
 - Paralysis
 - Spasms of throat muscles
 - Convulsions
 - Delirium
 - Death



How to Safely Dispose of Dead Animals

- Use Personal Protective Equipment (PPE):
 - Heavy duty rubber gloves over disposal vinyl or latex gloves
 - Face protection
 - Protective clothing – launder separately
 - Calf-high boots
- Equipment & materials:
 - Flat blade shovel (clearly marked for this purpose only) **
 - Heavy, doubled plastic bags or large sheets of plastic for large carcasses
 - 10% fresh bleach solution (1 part bleach to 9 parts water)



**Paint the handle red. Use shovel for roadkill only and store in a safe readily available location

How to Safely Dispose of Dead Animals – continued

- Put on PPE and use shovel:
 - Small carcass: pick up, empty into doubled plastic bags, tie securely
 - Large carcass: push onto plastic sheets
- **If human exposure to rabies is suspected, place carcass on ice & retain for rabies examination. Otherwise....
- Dispose per state and local regulations**
- Disinfect equipment & areas where carcass laid with bleach solution
- Remove gloves and wash hands and exposed skin with soap and clean water (if unavailable, use $\geq 60\%$ alcohol-based hand sanitizer)
- Report all wounds, injuries or contamination of mucous membranes (such as splashes to eyes or inside mouth or nose) to both:
 - OHS
 - The County health department



NYSDEC (<http://www.dec.ny.gov/animals/32131.html>):

**** How do I safely dispose of a dead animal?**

Use care when disposing of any dead animal. Wear gloves. Pick up the animal with a shovel. Then bury it (deep) or double-bag it and put it in the garbage. To kill the virus, sprinkle the ground and wash the shovel/gloves with a 10% solution of bleach in water (9 parts water, 1 part bleach).

From the CDC (<http://www.bt.cdc.gov/disasters/animaldisposal.asp>):

If rabies is not suspected, how do I dispose of the remains?

Wear gloves.

Cover your gloved hand with a plastic trash bag, pick up the remains, then invert the trash bag over the remains and seal the bag.

For larger animals, use a shovel to place remains inside a plastic trash bag, then rinse off the shovel with water.

Call your local animal care and control agency for further instructions and to request pickup.

Wash your hands.

Safe Disposal: buried 3 feet deep or incinerated

Disposable gloves: bag, bury or incinerate

Disinfect non-disposable utility gloves

Bleach: sodium hypochlorite solution...Allow to air dry

What to Do if You Have a Possible Rabies Exposure

- Do not panic! Rabies is preventable with prompt and appropriate post-exposure treatment
- Thoroughly wash any wounds or areas contaminated by saliva or nervous tissue
- Seek medical attention immediately
- If possible, safely capture the animal for rabies testing
- Report exposures to your local health department directly and your supervisor
- Complete Accident Report form

Watch "How to Safely Catch a Bat" at
www.nyhealth.gov/diseases/communicable/zoonoses/rabies/



Preventing Rabies: Vaccination for Employees at Risk

- Pre-exposure vaccination** is offered to employees who have the potential for rabies exposure while performing usual work duties
- Employees can decline the series—must sign a declination form
- Any worker assigned to pick up roadkill or potentially rabid animals as collateral duties are not required to be pre-vaccinated
- OHS maintains vaccination records
- Staff should have a rabies titer every 2 years



**Pre-exposure basis series of 3 shots day 0, 7 and 14 or 21
How long the vaccination is effective varies among individuals

Venomous Snakes



Timber rattlesnake



Northern Black Racer



Copperhead



*Eastern Massasauga
Rattlesnake*



Eastern Hognose



Northern Redbelly



There are only 3 species of poisonous snakes in NY:

Timber Rattlesnake

Eastern Massasauga Rattlesnake

Copperhead.....

All 3 are uncommon. They are listed as threatened.

Many other kinds of poisonous snakes may be found in homes of private individuals

Venomous Snakes

Has broad
triangular
head with
many
scales
down the
crown



Timber rattlesnake

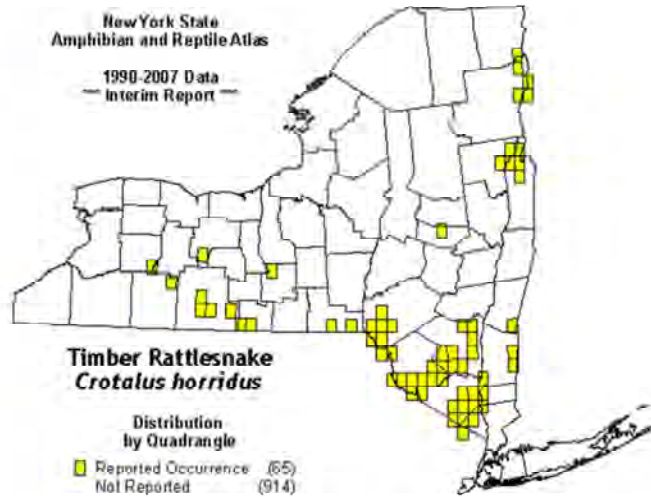
For more information about snakes in NYS:
<http://www.dec.ny.gov/animals/7483.html>



Timber rattlesnake found in the southeastern part of the state except LI and NYC with scattered populations as far north as Lake George and along the southern tier. In Lake George timber rattlesnakes can be found on Tongue Mountain.

New York State
Amphibian and Reptile Atlas

1990-2007 Data
— Interim Report —



Venomous Snakes



Has 9 large scales
on the crown of
the head

Eastern Massasauga Rattlesnake



Occurs in only 2 locations, both large wetlands. One is located northeast of Syracuse and the other is west of Rochester
9 large scales on the crown of the head

New York State
Amphibian and Reptile Atlas

1990-2007 Data
*** Interim Report ***



Venomous Snakes



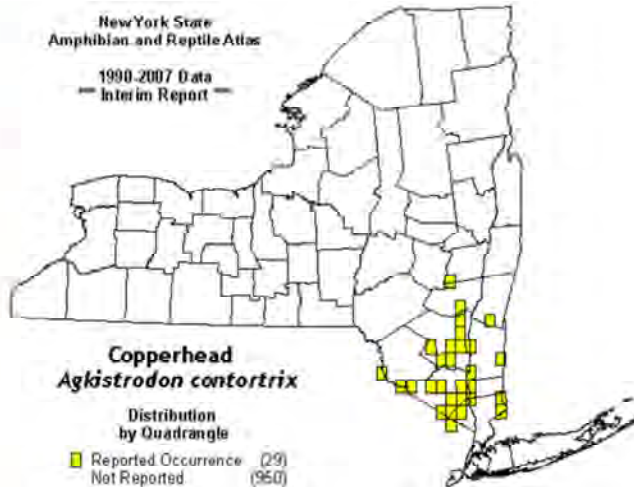
Copperhead



Found mainly along the lower Hudson Valley south of Kingston. Essentially absent from the Catskills and points further west.

New York State
Amphibian and Reptile Atlas

1990-2007 Data
— Interim Report —



Prevent Snake Bites!

- BEST: Leave the snake alone!
- Stay out of tall grass unless you wear thick leather boots
- Remain on hiking paths as much as possible
- Make noise to scare snakes away
- Keep hands and feet out of areas you cannot see into
- Be cautious and alert when climbing rocks



Snakes rarely bite when left alone!



Many people are bitten because they try to kill a snake or get too close to it.

Snakebite – Sign & Symptoms

- A pair of puncture marks at the wound
- Redness and swelling around the bite
- Severe pain at the site of the bite
- Nausea and vomiting
- Labored breathing
- Disturbed vision
- Increased salivation and sweating
- Numbness or tingling around your face and limbs



If you must handle a snake be sure to wear heavy duty gloves
Signs of snake bites...these are depending upon the type of snake

What to Do if You are Bitten by a Snake

- Stay calm!
- Try to remember the snake's color and shape for identification and treatment
- Seek immediate medical attention—call 911:
 - If you can't seek medical attention immediately, apply first aid:
 - Keep the bite below the level of the heart
 - Wash wound with soap and clean water



✓ Notify Supervisor and complete Accident Report form



Prevent Flying Insect Stings!

- Reduce your risk of being stung:
 - Wear light-colored clothing
 - Avoid perfumed soaps, shampoos and deodorants
 - Bath daily and wear clean clothing
 - Cover as much of your body as possible
 - Avoid flowering plants when necessary
 - If a bee, hornet or wasp flies inside your vehicle:
 - Pull off road and slowly stop vehicle
 - Lower all windows completely
 - Allow time for it to fly out



Most insects will not attack if left alone!



Sweat angers bees

Nests and Hives can be found in trees, roof eaves or on equipment such as ladders

Allergic Reactions to Flying Insect Stings

- Signs of an allergic reaction:
 - Swelling that moves to other parts of the body (especially to the face and neck)
 - Difficulty in breathing or wheezing or dizziness
 - A drop in blood pressure
- If you have a known allergy:
 - Always carry an insect sting allergy kit (EpiPen)
 - Wear a medical ID bracelet
 - Seek medical attention immediately if stung



What to Do if You are Stung

- If you don't know if you're allergic to bee, hornet or wasp stings, have someone stay with you in case you have a reaction
- Wash the site with soap and clean water or an antiseptic wipe
- Remove the stinger by wiping area with gauze or by scraping a fingernail over the area
- Apply ice to reduce the swelling
- Do not scratch or squeeze the sting



You do not want to squeeze the stinger or use tweezers as this will likely cause more venom to go into the skin and injure the muscle. Scratching will cause the site to swell and itch more, increasing the chance of infection

Mosquito-Borne Disease in New York State

Diseases endemic to New York State

- West Nile virus (WNV)
- Eastern Equine Encephalitis virus (EEE)



Travel-acquired diseases with potential for local transmission

- Zika
- Chikungunya
- Dengue
- Malaria



Current and historic nationwide surveillance information on mosquito-borne illnesses in the United States can

be found at <http://diseasemaps.usgs.gov/mapviewer/>.

- Specific information about WNV, including statistics and maps, can be found at <http://www.cdc.gov/westnile/>.

- Specific information about EEEv, including statistics and maps, can be found at <http://www.cdc.gov/EasternEquineEncephalitis>.

- Specific information about Zika virus, including statistics and maps of areas with active mosquito-borne transmission of Zika virus can be found at <http://www.cdc.gov/zika/>.

- Specific information about chikungunya virus, including statistics and maps, can be found at <http://www.cdc.gov/chikungunya/>.

- Specific information about dengue fever, including statistics and maps, can be found at <http://www.cdc.gov/dengue/>.

- Specific information about malaria, including statistics and maps, can be found here at <http://www.cdc.gov/malaria/>.

Mosquito-Borne Disease – West Nile Virus

- West Nile virus (WNV) is a virus that:
 - People can be infected with
 - In most people, causes no symptoms
 - In some people, causes milder symptoms
 - In a few people, causes serious disease and/or permanent damage
 - Very rarely, can be fatal
- How do people get infected with WNV?
 - Almost always by the bite of infected mosquito
 - Not spread from person to person (not contagious)



Mosquitoes are infected by feeding on birds with WNV, then the infected mosquitoes can infect people, birds, and animals by subsequent bites

Other routes of transmission:

Very rare: through donated blood or organs:

- Donated blood **screened for WNV since 2003:** Red Cross
(<http://www.redcrossblood.org/learn-about-blood/what-happens-donated-blood/blood-testing>)
- Organ transplantation: CDC
(<http://www.cdc.gov/ncidod/dvbid/westnile/qa/transfusion.htm>, <http://optn.transplant.hrsa.gov/news/newsDetail.asp?id=303>)

EXTREMELY RARE: One documented case each pregnant woman with WNV infection to her unborn child and woman infected with WNV to baby through breastfeeding

- Transmission: NYSDOH
(http://www.nyhealth.gov/diseases/west_nile_virus/fact_sheet.htm)
- CDC
(<http://www.cdc.gov/ncidod/dvbid/westnile/qa/transmission.htm>)

Info on birds with WNV, see CDC:

http://www.cdc.gov/ncidod/dvbid/westnile/qa/wnv_birds.htm

- Sources:
- NYSDOH: <http://www.nyhealth.gov/publications/2746/>
 - CDC: http://www.cdc.gov/ncidod/dvbid/westnile/wnv_factsheet.htm

West Nile Virus Infection in Humans

- About 80% infected with WNV do not develop symptoms
- About 20% develop symptoms:
 - 3-14 days after bite
 - Fever
 - Headache
 - Body aches
 - Skin rash (occasionally)
 - Sometimes swollen glands (enlarged lymph nodes)
- Symptoms last a few days to a few weeks
- Most people completely recover



Sources: NYSDOH: http://www.nyhealth.gov/diseases/west_nile_virus/ and CDC: <http://www.cdc.gov/ncidod/dvbid/westnile/qa/symptoms.htm>

Severe WNV Illness in Humans

- 1 in 150 people infected with West Nile virus develop WNV encephalitis, meningitis or poliomyelitis
- Symptoms include:
 - Headache
 - High fever
 - Neck stiffness
 - Confusion
 - Tremors
 - Muscle weakness
 - Paralysis
 - Coma
- Can cause permanent neurological damage
- Death is very rare (less than 1 person in 1,000)



Encephalitis = inflammation of the brain

Meningitis = inflammation of the lining of brain and spinal cord

Poliomyelitis = inflammation of the spinal cord

Source: CDC (<http://www.cdc.gov/ncidod/dvbid/westnile/qa/symptoms.htm>) :The symptoms of **severe disease** (also called **neuroinvasive disease**, such as **West Nile encephalitis** or **meningitis** or **West Nile poliomyelitis**). Serious illness can occur in people of any age, however people over age 50 and some immunocompromised persons (for example, transplant patients) are at the highest risk for getting severely ill when infected with WNV. Can also cause serious disease that affects brain tissue. At its most serious, it can cause permanent neurological damage and can be fatal.

Fewer than 1% of people infected with West Nile virus develop encephalitis, and among those hospitalized with West Nile encephalitis, the case fatality rate ranges from 3% to 15%. Therefore, less than 1 in 1,000 of people infected with West Nile virus die.

Mosquito-Borne Disease – Eastern Equine Encephalitis

- Eastern Equine Encephalitis virus (EEEV) is a virus that:
 - People can be infected with
 - In most people, causes no symptoms
 - Causes a rare but severe illness called Eastern equine encephalitis (EEE)
- How do people get infected with EEEV?
 - By the bite of infected mosquito
 - Not spread from person to person (not contagious)



Mosquitoes are infected by feeding on birds with EEE, then the infected mosquitoes can infect people, birds, and animals by subsequent bites

Eastern equine encephalitis virus (EEEV) is maintained in a cycle between *Culiseta melanura* mosquitoes and avian hosts in freshwater hardwood swamps. *Cs. melanura* is not considered to be an important vector of EEEV to humans because it feeds almost exclusively on birds. Transmission to humans requires mosquito species capable of creating a “bridge” between infected birds and uninfected mammals such as some *Aedes*, *Coquillettidia*, and *Culex* species.

Horses are susceptible to EEEV infection and some cases are fatal. EEEV infections in horses, however, are not a significant risk factor for human infection because horses (like humans) are considered to be “dead-end” hosts for the virus (i.e., the concentration of virus in their bloodstreams is usually insufficient to infect mosquitoes).

Sources:

- CDC: <https://www.cdc.gov/easternequineencephalitis/index.html>

EEE virus Infection in Humans

- About 95% infected with EEEv do not develop symptoms
- Symptoms appear 4-10 days after bite
- Systemic infection is characterized by:
 - Chills
 - Fever
 - Malaise
 - Body aches
 - Joint pain
- Symptoms last 1-2 weeks
- Most people completely recover if central nervous system is not involved in infection.



The incubation period for Eastern equine encephalitis virus (EEEV) disease (the time from infected mosquito bite to onset of illness) ranges from 4 to 10 days. EEEV infection can result in one of two types of illness, systemic or encephalitic (involving swelling of the brain, referred to below as EEE). The type of illness will depend on the age of the person and other host factors. It is possible that some people who become infected with EEEV may be asymptomatic (will not develop any symptoms). Systemic infection has an abrupt onset and is characterized by chills, fever, malaise, arthralgia, and myalgia. The illness lasts 1 to 2 weeks, and recovery is complete when there is no central nervous system involvement.

Source: CDC: <https://www.cdc.gov/easternequineencephalitis/tech/symptoms.html>

Severe EEE Illness in Humans

- Persons over age 50 and under age 15 seem to be at greatest risk for developing severe disease
- Symptoms include:
 - Headache
 - High fever
 - Restlessness or irritability
 - Drowsiness
 - Anorexia
 - Nausea, vomiting or diarrhea
 - Convulsions
 - Coma
- Many survivors have permanent neurological damage
- A third of people with EEE die from the disease
- Death usually occurs 2 to 10 days after onset of symptoms



Encephalitis = inflammation of the brain

In infants, the encephalitic form is characterized by abrupt onset; in older children and adults, encephalitis is manifested after a few days of systemic illness. Signs and symptoms in encephalitic patients are fever, headache, irritability, restlessness, drowsiness, anorexia, vomiting, diarrhea, cyanosis, convulsions, and coma. Approximately a third of all people with EEE die from the disease. Death usually occurs 2 to 10 days after onset of symptoms but can occur much later. Of those who recover, many are left with disabling and progressive mental and physical sequelae, which include can range from minimal brain dysfunction to severe intellectual impairment, personality disorders, seizures, paralysis, and cranial nerve dysfunction. Many patients with severe sequelae die within a few years.

Source: CDC: <https://www.cdc.gov/easternequineencephalitis/tech/symptoms.html>

Mosquito-Borne Disease – Testing & Treatment

- If bitten by a mosquito, you do not need to be tested for WNV or EEE because:
 - Most mosquitoes are not infected with WNV or EEE
 - Illnesses related to mosquito bites are rare
 - People with mild symptoms usually completely recover on their own
 - There is no specific medicine to treat WNV or EEE; treatment is supportive
- HOWEVER... See a medical professional immediately if you develop:
 - High fever
 - Confusion
 - Muscle weakness
 - Severe headache
 - Stiff neck
 - Your eyes become sensitive to light



Source: NYS: <http://www.nyhealth.gov/publications/2746/>, CDC: http://www.cdc.gov/ncidod/dvbid/westnile/wnv_factsheet.htm



Prevent Mosquito-Borne Illness!

- BEST: Prevent mosquito bites!
- Mosquitoes in NYS:
 - Present from April – October
 - Most active between dusk and dawn, but can be present any time
- Wear protective clothing:
 - Long sleeved shirts
 - Long pants
 - Socks
- Consider using an EPA-registered insect repellent (more on repellents later!)

There are no vaccines against WNV and EEE, so prevention is key!





Prevent Mosquito-Borne Illness – continued

- Eliminate ALL unnecessary standing water outdoors:
 - Mow, cut, or remove overgrown vegetation
 - Dispose of unused items that can collect standing water (cans, containers, used tires*)
 - Drill holes in bottoms of recycling bins kept outdoors
 - Clean clogged gutters to ensure they drain freely
 - Turn over wading pools and wheelbarrows when not in use
 - Change water in birdbaths 2 times a week
 - Drain water from pool covers
 - Clean and chlorinate swimming pools, outdoor saunas and hot tubs



***Used tires are a significant mosquito breeding site—contact the local landfill or Department of Public Works to find out how to properly dispose of them.**



Sources:

NYS - <http://www.nyhealth.gov/publications/2746/>

CDC - http://www.cdc.gov/ncidod/dvbid/westnile/wnv_factsheet.htm

Ticks in New York State

- 30 species of ticks identified
- 10 species commonly bite humans
- 4 species can transmit diseases

Deer or Blacklegged tick
Ixodes scapularis



Lone Star tick
Amblyomma americanum



American Dog tick
Dermacentor variabilis



Woodchuck tick
Ixodes cookei



Illinois DOH (<http://www.idph.state.il.us/envhealth/pccommonticks.htm>)

- Ticks are **arachnids** (like scorpions, spiders and mites), not **insects**.

Adult arachnids

insects

8 legs (4 pairs)
pairs)

no antennae
antennae

Adult

6 legs (3

1 pair of

- Ticks are among the most efficient carriers of disease because they attach firmly when sucking blood, feed slowly and may go unnoticed for a considerable time while feeding.
- Ticks take several days to complete feeding.

Tick-borne Diseases in NYS



Disease	Type of Tick in NYS
<ul style="list-style-type: none"> • Lyme Disease • Human Granulocytic Anaplasmosis (HGA) <ul style="list-style-type: none"> • Babesiosis • <i>Borrelia miyamotoi</i> infection 	Deer tick
Human Monocytic Ehrlichiosis (HME)	Lone Star tick
Rocky Mountain Spotted Fever (RMSF)	American Dog tick
Powassan encephalitis	Woodchuck tick and Deer tick
Tularemia	American Dog tick and Lone Star tick

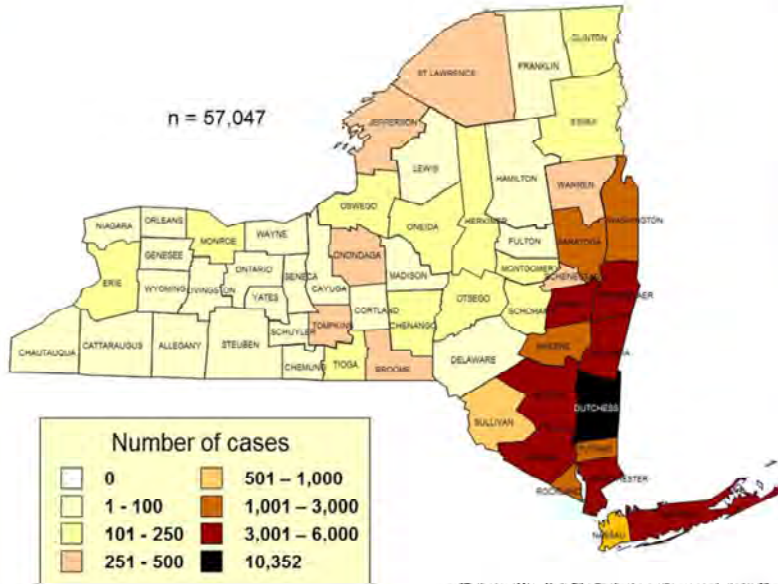
Some of the diseases can be caused by other ticks or through other insects or modes of transmission, but these are the 4 ticks reported to cause tick-borne disease in NYS. Tularemia (transmitted by American Dog and Lone Star ticks), *Borrelia miyamotoi* infection (transmitted by Deer ticks) and Powassan encephalitis (transmitted by Woodchuck and Deer ticks) are rare and emerging infections in NYS, with very few cases of these diseases reported.

Between 2001-2013, 18 cases of Powassan encephalitis were reported and 4 cases of tularemia. Five patients from the lower Hudson Valley region tested positive for *Borrelia miyamotoi* infection in a retrospective study of samples submitted for to the NYSDOH for anaplasmosis testing.

In descending order of number of reported cases by disease in NYS from 2001 – 2015:

- Lyme: 72,005
- HGA: 4,020
- Babesiosis: 3,650
- HME: 927
- RMSF: 240
- Powassan: 19
- *Borrelia miyamotoi* infection: 8
- Tularemia: 7 (4 in Suffolk Co., 2 in Clinton Co., and 1 in Westchester Co.)

Lyme Disease cases reported in New York State* 2001 - 2013



*Exclusive of New York City. Sentinel surveillance conducted in 19 counties in at least one year. Confirmed and probable cases, 2013 provisional data.

Deer Ticks – Fast Facts



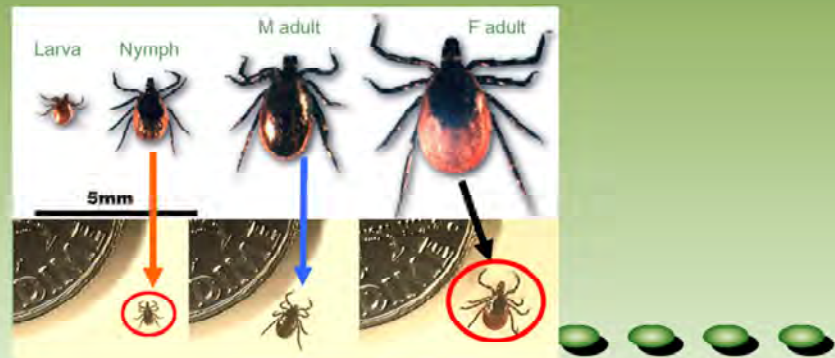
- Deer ticks crawl—they cannot jump or fly
- They prefer shady, grassy, wooded areas along trails with abundant wildlife (including suburban settings)
- They must have direct contact with a host (person or animal) to attach and feed (blood meal)
- Unless removed, nymphs & adults attach to a person or other animal and feed for several days



- *B. burgdorferi* (bacteria causing Lyme disease) are transmitted from an infected nymph or female adult deer tick when it bites a person (or other host) and feeds **for at least 36 hours or is not removed correctly.**
- **In NYS,** most cases are acquired through the bite of a nymph during the summer months.

Deer Ticks

- Scientific name of tick is *Ixodes scapularis* (*I. scapularis*)
- Infected nymphs cause most human cases of Lyme disease in the spring and early summer
- Infected adult females transmit the bacterium, mostly in the fall



Deer Tick Questing



How deer ticks find and attach to a host...
they do not fly, jump or drop out of trees



Female Deer Tick – From Hungry to Engorged



**Risk of infection is greatest if tick feeds for ≥ 36 hours
however transmission of some pathogens can
begin as soon as 15 minutes**



Degrees of engorgement—can be obtained from measurements of the tick or a subjective 0-5 scale:

- Lower risk of pathogen transmission if tick is level 2 or below (attached approximately less than 36 hrs)
- Risk increases with engorgement
- May aid in decisions regarding antibiotic therapy

Deer Tick Bites

- Not all deer ticks are infected with *B. burgdorferi*
- Even if tick is infected, not every bite results in Lyme disease
- Common tick bite locations:
 - Behind ears
 - Back of head
 - Behind knees
 - Abdomen
 - Arm pits
 - Groin
 - Back
 - Warm and moist areas of the body
- Some people can be infected, but do not become ill
- Lyme disease is not spread person to person



Deer tick attached & feeding from human host—tick may or may not be infected



Early Lyme Disease – Symptoms & Treatment

- Symptoms:
 - Usually begin 3-30 days after infected tick bite
 - Characteristic rash develops in 60-80% of people:
 - Called erythema migrans (EM)
 - Looks like a bull's eye or solid patch
 - Expands & painless
 - Without treatment, resolves within several weeks
 - With treatment, resolves within days
 - Fatigue, malaise, fever, headache, joint pain, muscle pain, or mild neck stiffness
- Antibiotics successfully treat most early cases
- No vaccine, but preventable



Lyme Disease: EM Rash



Disseminated, multiple EM rashes



Note: While 6-8 people out of 10 with Lyme disease develop a rash, the other 2-4 do not



Late, Disseminated Lyme Disease

- If no EM rash, infection may go undetected
- Weeks to years after infection, more serious symptoms can occur:
 - Arthritis in 60% of people (2 weeks-2 years after infection):
 - Knee (90%)
 - Chronic (5%)
 - Neurologic:
 - Spine pain or inflammation
 - Meningitis
 - Facial paralysis (Bell's Palsy)
 - Heart problems
- Diagnosed with laboratory blood tests
- Treated with antibiotics
- No vaccine, but preventable



Other Tick-borne Bacterial Diseases

1. Human granulocytic anaplasmosis (HGA)

- Transmitted by infected deer ticks



Deer tick

2. Human monocytic ehrlichiosis (HME)

- Transmitted by infected lone star ticks



Lone star tick

HGA and HME:

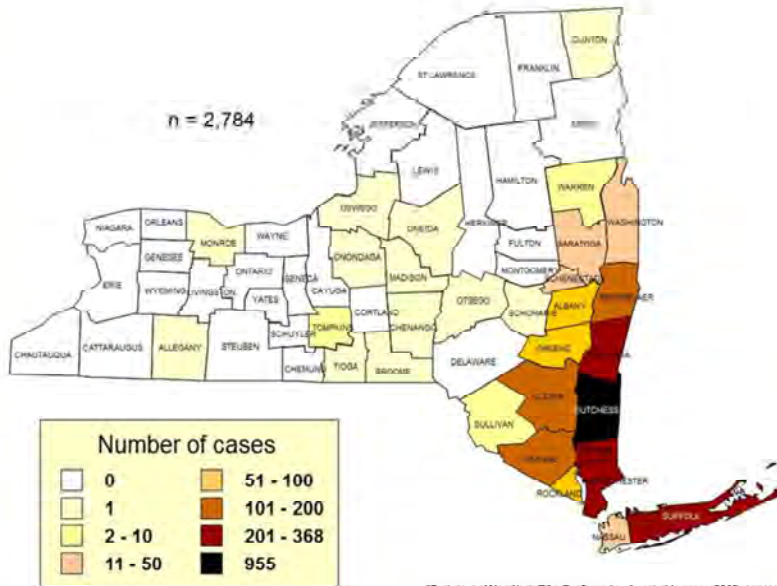
- Symptoms:
 - Usually begin in 5 – 21 days
 - Fever, fatigue, headache, muscle aches
 - May have nausea, vomiting, diarrhea, cough, joint pain, confusion, rash
- Treated with antibiotics
- Occasionally life-threatening and can be fatal
- No vaccine, but preventable



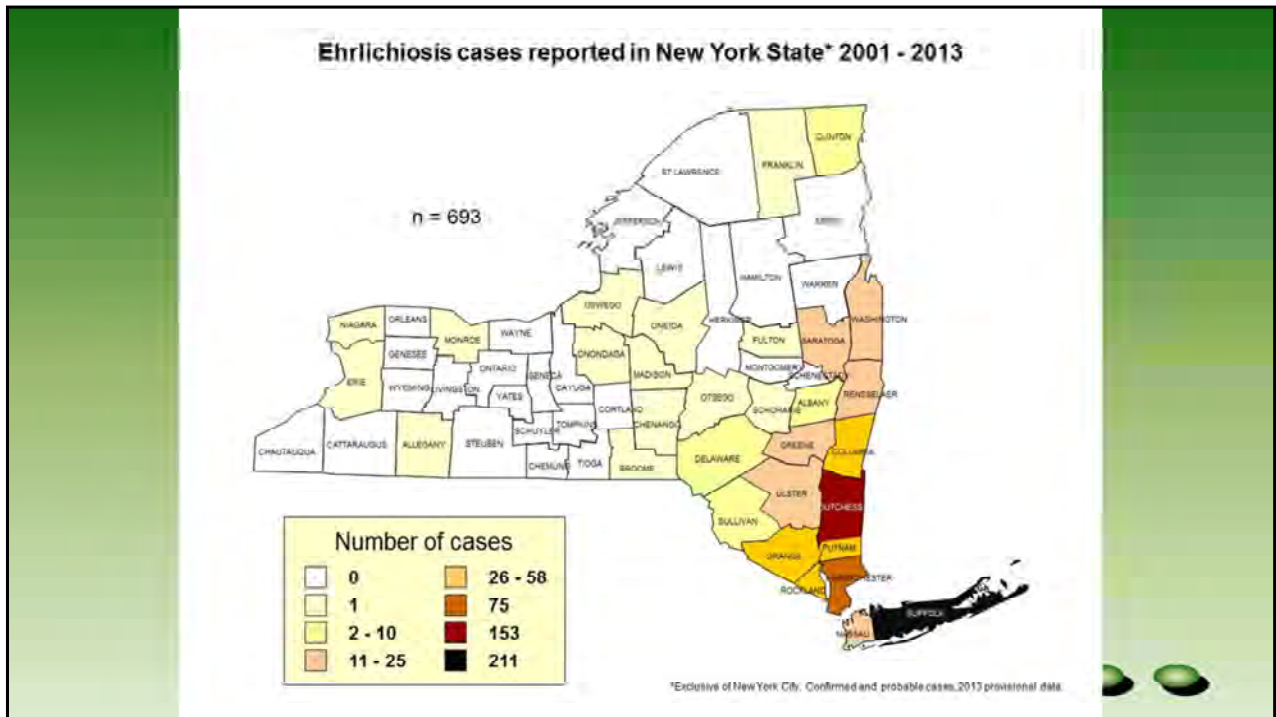
Reported cases in NYS between 2001-2015:

- HGA: 4,020
- HME: 927

Anaplasmosis cases reported in New York State* 2001 - 2013



HGA – Human Granulocytic Anaplasmosis



HME – Human Monocytic Ehrlichiosis

Tick-borne Bacterial Diseases – continued

3. Rocky Mountain spotted fever (RMSF)

- Uncommon in NYS
- In NYS, transmitted by infected American dog ticks
- Less than 1% of these ticks carry RMSF
- Bacteria unlikely to be transmitted if tick feeds < 20 hours
- If infected, symptoms usually begin within 2 weeks after bite- often non-specific and may resemble other diseases
- Three important components often seen first:
 1. Fever
 2. Rash
 3. Previous tick bite

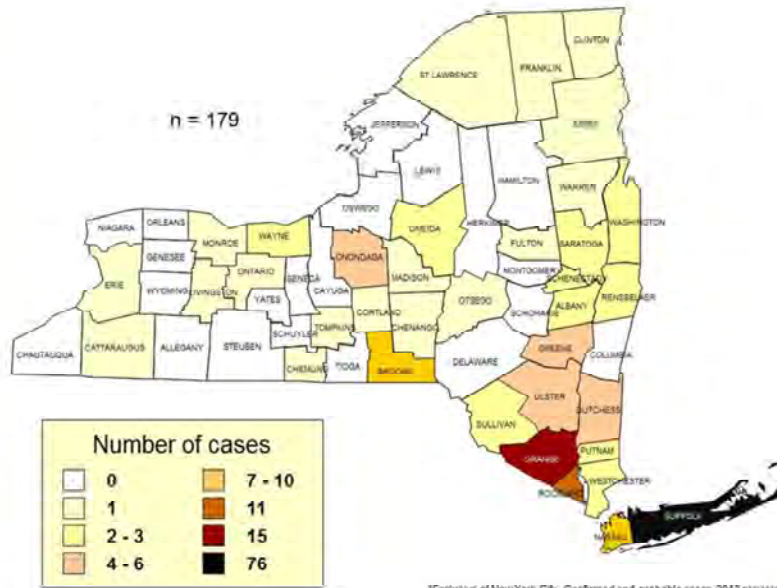


American dog tick



- NYSDOH: 240 reported cases in NYS between 2001-2015
- CDC - http://www.cdc.gov/ticks/diseases/rocky_mountain_spotted_fever/,
<http://www.cdc.gov/ticks/>:
- MedlinePlus: <http://www.nlm.nih.gov/medlineplus/ency/article/000654.htm>

Rocky Mountain Spotted Fever cases reported in New York State* 2001 - 2013



*Exclusive of New York City. Confirmed and probable cases, 2013 provisional data.

RMSF – Symptoms

Initial

- Fever (may last 2-3 weeks)
- Chills
- Nausea
- Deep muscle aches
- Fatigue
- Severe headache



Early rash on sole of foot

Later Stage

- Rash—starts on hands & feet, spreads to trunk
- Abdominal pain
- Joint pain
- Diarrhea
- Vomiting



Late rash



- NYSDOH: 240 reported cases in NYS between 2001-2015

Source: Original DEC notes

In patients with Rocky Mountain spotted fever, a rash first appears 2-5 days after the onset of fever, but may not present or may be very subtle when the patient is initially seen by a physician. Younger patients usually develop the rash earlier than older patients. Most often it begins as small, flat, pink, non-itchy spots (macules) on the wrists, forearms, and ankles. These spots turn pale when pressure is applied and eventually become raised on the skin. The red, spotted (petechial) rash of Rocky Mountain spotted fever is usually not seen until the sixth day or later after onset of symptoms and occurs in 35-60% of patients with the infection. The rash may involve the palms or soles of the feet.

Additional symptoms that may be associated with this disease:

- Abnormal sensitivity to light
- Excessive thirst
- Hallucinations
- Loss of appetite

RMSF Sources:

- CDC - http://www.cdc.gov/ticks/diseases/rocky_mountain_spotted_fever/,
<http://www.cdc.gov/ticks/>
- MedlinePlus: <http://www.nlm.nih.gov/medlineplus/ency/article/000654.htm>

RMSF – Diagnosis & Treatment

- Diagnosis: signs & symptoms and blood tests
- Antibiotics taken for 5-10 days cure most cases
- Complications are rare, but can occur
- Death from RMSF is rare
- No vaccine, but preventable



Late rash



Source: CDC:

http://www.cdc.gov/ticks/diseases/rocky_mountain_spotted_fever/faq.html

Outlook (Prognosis)

Treatment usually cures the infection. Complications are rare but can include paralysis, hearing loss, nerve damage, and, rarely, death.

Tick-borne Bacterial Diseases – continued

4. *Borrelia miyamotoi* infection



Deer tick

- Newly recognized pathogen (2011)
- Likely rare in NYS
- Symptoms:
 - Usually begin in 10 – 18 days
 - Fever (may relapse), fatigue, headache, muscle aches
 - May have cough, sore throat, abdominal pain, joint pain, stiff neck
- Treated with antibiotics
- No vaccine or commercial laboratory testing available, but preventable



Newly recognized pathogen. First cases described in Russia in 2011, few documented cases in the US. Symptoms similar to HGA. Likely occurs wherever Lyme disease is endemic.

Tick-borne Bacterial Diseases – continued

5. Tularemia

- Very rare in NYS: 4 cases between 2003-2009
- Transmitted by infected American dog and lone star ticks
- Also transmitted other ways
- Mild to life-threatening illness
- Symptoms vary based on way transmitted
- All cases include fever as high as 104°F
- Symptoms from infected tick transmission
 - Skin ulcer at site of bite
 - Swollen lymph nodes in region of bite
- Diagnosed by ulcer and laboratory tests
- Most infections successfully treated with antibiotics
- No vaccine, but preventable



American dog tick



Lone star tick



7 cases in NYS between 2003-2015: 4 in Suffolk Co., 2 in Clinton Co., and 1 in Westchester Co.

Very rare throughout the US & NYS

Other routes of transmission: infected deer fly bites, skin contact with infected animals, drinking contaminated water or inhaling contaminated dusts or aerosols

Source: CDC: <http://www.cdc.gov/Tularemia/>

“Tularemia is a disease of animals and humans caused by the bacterium *Francisella tularensis*. Rabbits, hares, and rodents are especially susceptible and often die in large numbers during outbreaks. Humans can [become infected](#) through several routes, including tick and deer fly bites, skin contact with infected animals, ingestion of contaminated water, or inhalation of contaminated dusts or aerosols. In addition, humans could be exposed as a result of bioterrorism. [Symptoms](#) vary depending upon the route of infection. Although tularemia can be life-threatening, most infections can be [treated](#) successfully with antibiotics. Steps to [prevent](#) tularemia include use of insect repellent, wearing gloves when handling sick or dead animals, and not mowing over dead animals. In the United States, naturally occurring infections have been reported from all States except Hawaii.”

Tick-borne Viral Disease – Powassan Encephalitis

- Very rare in NYS: 19 cases between 2001-2015
- Transmitted by infected deer ticks and woodchuck ticks
- No symptoms to serious illness or death
- Symptoms (7-14 days after bite):
 - Headache
 - Fever
 - Confusion
 - Muscle weakness or partial paralysis
 - Encephalitis (brain irritation & swelling)
 - Coma
- Permanent neurologic damage in about 50% of cases
- Fatal in about 10-15% of cases
- Diagnosed with lab testing
- No specific medicine to treat; supportive care
- No vaccine, but preventable



Deer tick



Woodchuck tick



Sources:

NYSDOH: Publication item # 2821 and 2823

CDC: <http://www.cdc.gov/niosh/topics/tick-borne/>

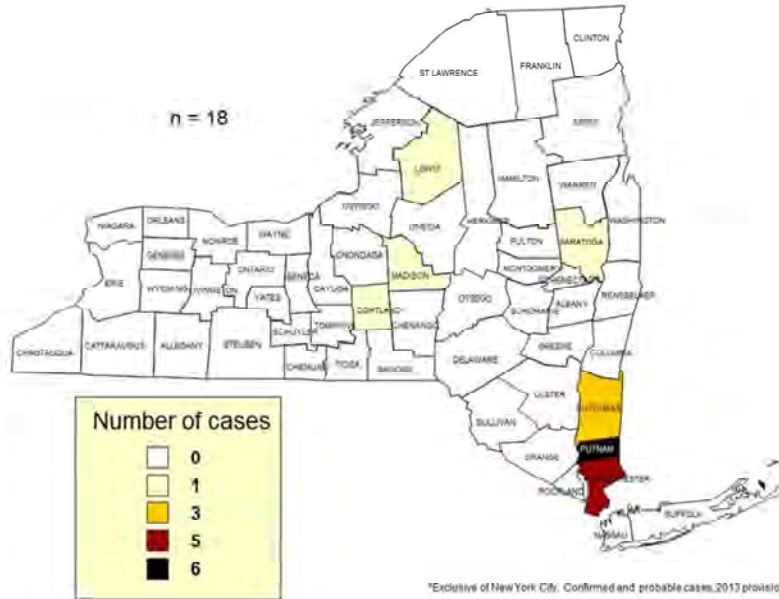
NIH:

http://www.ninds.nih.gov/disorders/encephalitis_meningitis/detail_encephalitis_meningitis.htm:

“Powassan encephalitis is the only well-documented tick-borne arbovirus in the United States and Canada. Symptoms are noticed 7-10 days following the bite and may include headache, fever, nausea, confusion, partial paralysis, and coma. Permanent neurologic damage occurs in about half of all cases and death in about 10-15 percent of all cases.”

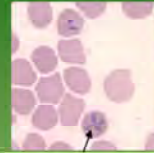
U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM),
Entomological Sciences Program: <http://chppm-www.apgea.army.mil/documents/FACT/18-005-0406Powassan-JusttheFactsApril2006.pdf>

Powassan cases reported in New York State* 2001 - 2013



Tick-borne Disease from Parasite - Babesiosis

- Caused by microscopic parasites called *Babesia microti*
- Parasites infect red blood cells
- Main route of transmission is from bite of infected deer tick (usually nymphs) that feeds for 24-36 hours
- Parasite may also be transmitted by receipt of contaminated blood transfusion or from infected mother to her baby during pregnancy or delivery
- Many infected people do not develop symptoms
- Parasites can live in the blood of an infected person (parasitemia) without symptoms for weeks to years



Babesia in RBC



Deer tick



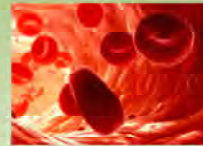
Sources:

•NYSDOH: Publication item # 2821 and 2823

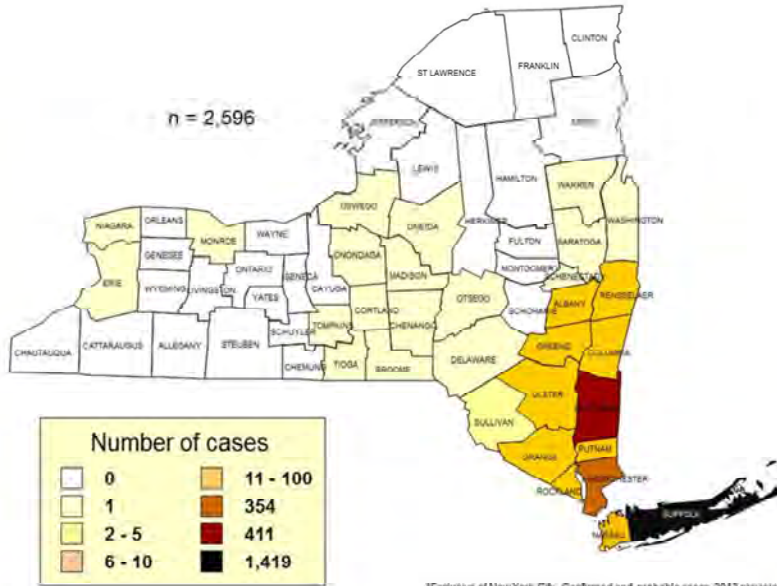
Data Source: NYSDOH BCDC: 3,650 human cases of Babesiosis reported in NYS between 2001-2015

Babesiosis – continued

- Symptoms may start between 1 week – 2 months or longer
- Symptoms include fever, chills, muscle pains, headache, fatigue and anemia
- Can be severe and life-threatening disease in people who:
 - Do not have spleens or whose spleens function poorly
 - Have weak immune systems
 - Have other serious health conditions
 - Are elderly
- Diagnosed by microscopic examination of blood for parasites and blood tests
- Treated with antibiotics
- More severe disease may require transfusions
- No vaccine, but preventable



Babesiosis cases reported in New York State* 2001 - 2013



*Exclusive of New York City. Confirmed and probable cases, 2013 provisional data.

Be on the Lookout!



**Infection with 2 or more
tick-borne pathogens
at the same time
IS NOT uncommon!**



Can you name the ticks...
and the diseases they can cause?



Upper left: woodchuck tick -> Powassan encephalitis

Lower left: lone star tick -> HME (erlichiosis)

Upper right: American dog tick -> RMSF

Lower right: deer tick -> Lyme disease, HGA, babesiosis, Powassan encephalitis,
Borrelia miyamotoi infection

Prevent Tick-Borne Disease!

- Avoid tick habitats, particularly in the spring & early summer
- Remove leaves & tall grass from around work areas
- Wear:
 - Light-colored clothing
 - Long-sleeved shirts
 - Long pants
 - Tuck pant legs into socks or boots
 - High boots or closed shoes
 - Hat
- Consider using an EPA-registered insect repellent (more on repellents later!)
- Thoroughly check your body for ticks—removing ticks as soon as possible lowers your risk of being infected
- Shower within 2 hours of working outdoors & wash clothes with hot water (even if you don't see or remove any ticks)



How to Remove an Attached Tick

- **DO** immediately remove attached ticks this way:
 - Using pointed tweezers, grasp tick as close to the skin as possible
 - Pull straight up
 - Disinfect site
 - Record date and location of the bite
 - If any symptoms appear, see your health care provider
- **DO NOT** try any other way:
 - Do not try to pull tick out with your fingers
 - Do not apply petroleum jelly, oil, gasoline, lit match or cigarette or nail polish to tick
 - These or any other method may increase your risk of acquiring a tick-borne disease



Insect Repellants – Preventing Mosquito and Tick-borne Diseases

- If you choose to use an insect repellent, use only EPA-registered products:
 - For exposed skin*, consider products that contain:
 - DEET
 - Picaridin
 - Oil of lemon eucalyptus (not on children under 3)
 - Oil of citronella
 - Permethrin is approved for clothing & other items:
 - Repellent and insecticide
 - Can apply to clothing, boots and outdoor gear that can remain protective through several washings; you can also buy clothing and gear that is pretreated
- Regardless of product, always follow the label instructions!



*If you are also using sunscreen, apply that 1st, then repellent



Updated EPA insect repellent info: <http://cfpub.epa.gov/oppref/insect/>
 CDC NIOSH: <http://www.cdc.gov/niosh/topics/tick-borne/> "...Permethrin kills ticks on contact. It can be used on clothing but not skin."

FDA: <http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm048022.htm>: **Beware of Bug Bites & Stings**

"It's okay to use insect repellent and sunscreen at the same time. The general recommendation is to apply sunscreen first, followed by repellent. There are also some combination products that contain both insect repellent and sunscreen. FDA regulates sunscreen as an over-the-counter (OTC) drug. The Environmental Protection Agency (EPA) regulates insect repellent products."

See CDC (http://www.cdc.gov/ncidod/dvbid/westnile/qa/insect_repellent.htm) for more info about using insect repellents to prevent West Nile Virus (mosquito-borne disease)

Per FDA (<http://www.drugs.com/ingredient/permethrin.html>), permethrin is also used to treat scabies and lice. Brand names for rx of scabies include Acticine, Elimite, Nix; for lice—Nix and Rid.

Slide Sources:

NYSDOH: <http://www.health.state.ny.us/publications/2749/>

CDC: http://www.cdc.gov/ncidod/dvbid/westnile/qa/insect_repellent.htm,

<http://www.cdc.gov/ncidod/dvbid/westnile/RepellentUpdates.htm>

EPA: <http://epa.gov/pesticides/insect/safe.htm>

EPA recommends the following precautions when using insect repellents:

- Apply repellents only to exposed skin and/or clothing (as directed on the product label.) Do not use repellents under clothing.
- Never use repellents over cuts, wounds or irritated skin.
- Do not apply to eyes or mouth, and apply sparingly around ears. When using sprays, do not spray directly on face—spray on hands first and then apply to face.
- Do not allow children to handle the product. When using on children, apply to your own hands first and then put it on the child. You may not want to apply to children's hands.
- Use just enough repellent to cover exposed skin and/or clothing. Heavy application and saturation are generally unnecessary for effectiveness. If biting insects do not respond to a thin film of repellent, then apply a bit more.
- After returning indoors, wash treated skin with soap and water or bathe. This is particularly important when repellents are used repeatedly in a day or on consecutive days. Also, wash treated clothing before wearing it again. (This precaution may vary with different repellents—check the product label.)
- If you or your child get a rash or other bad reaction from an insect repellent, stop using the repellent, wash the repellent off with mild soap and water, and call a local poison control center for further guidance. If you go to a doctor because of the repellent, take the repellent with you to show the doctor.
- Note that the label for products containing oil of lemon eucalyptus specifies that they should not to be used on children under the age of three years
- Other than those listed above, EPA does not recommend any additional precautions for using registered repellents on children or on pregnant or lactating women,. For additional information regarding the use of repellent on children, please see CDC's Frequently Asked Questions about Repellent Use. [http://www.cdc.gov/ncidod/dvbid/westnile/qa/insect_repellent.htm]

Choosing an Insect Repellent that is Right for You

- Consider:
 - Which insects you want protection from
 - Length of time you need protection
 - Active ingredient and % of it listed on product label
- Match product with the time you need protection and:
 - Your level of physical activity and how much you perspire
 - Whether you will have exposure to water
 - What the air temperature is
 - How attractive you are to mosquitoes and ticks (everyone is different!)
- Use EPA's search tool to help you choose skin-applied repellent products that will give you the protection you need:

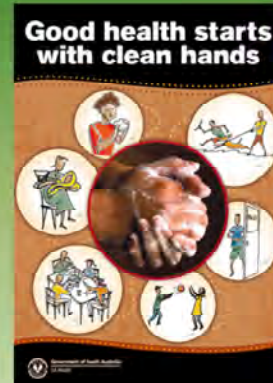
<http://cfpub.epa.gov/oppref/insect/index.cfm>



Slide Source: EPA (<http://epa.gov/pesticides/insect/choose.htm>)

Best Protection- Best Practice Hand Hygiene (Hand Washing)

- Hand hygiene is the #1 way to prevent the spread of infections
- Clean hands help prevent you from getting sick and spreading germs to others
- When soap and clean water are not available, use an alcohol-based hand sanitizer
- Get in the habit of frequently washing your hands or using a hand sanitizer every day!



Sources:

- NYSDOH:

http://www.nyhealth.gov/diseases/communicable/influenza/h1n1/frequently_asked_questions/definitions_and_terminology.htm

- CDC:

- <http://www.cdc.gov/cleanhands/>

- <http://www.bt.cdc.gov/disasters/pdf/flyer-wash-your-hands.pdf>

- <http://www.bt.cdc.gov/disasters/handhygienefacts.asp>

- Government of South Australia (image):

<http://dh.sa.gov.au/pehs/Immunisation/poster-Handwashing.jpg>

When to Wash Your Hands

- Before eating food
- After:
 - Touching or preparing raw foods (meats, vegetables and fruits)
 - Going to the bathroom
 - Blowing your nose, coughing or sneezing
 - Handling an animal (dead *or* alive) or animal waste
 - Handling garbage or trash
 - Changing diapers or cleaning someone after toilet use
- Before and after touching or taking care of:
 - A cut or wound on yourself or someone else
 - Someone who is sick



Sources:

- NYSDOH:

http://www.nyhealth.gov/diseases/communicable/influenza/h1n1/frequently_asked_questions/definitions_and_terminology.htm

- CDC:

- <http://www.cdc.gov/cleanhands/>
- <http://www.bt.cdc.gov/disasters/pdf/flyer-wash-your-hands.pdf>
- <http://www.bt.cdc.gov/disasters/handhygienefacts.asp>

How to...



Image: NYCDOHMH
www.nyc.gov/html/doh/flu/html/public/posters.shtml



After drying your hands, use the towel to turn off the faucets so you do not re-contaminate your clean hands.

Alcohol-based Hand Sanitizers

- When to use:
 - If soap and water are unavailable AND hands are not visibly dirty
- What to use:
 - An alcohol-based hand sanitizer (60% alcohol or greater)
- If alcohol-based hand sanitizers are unavailable or not allowed (for example, in a school):
 - Hand sanitizers that do not contain alcohol may be useful



Info source: NYSDOH at

http://www.nyhealth.gov/diseases/communicable/influenza/h1n1/frequently_asked_questions/definitions_and_terminology.htm

Image source: Tony Cenicola/The New York Times at

<http://www.nytimes.com/2006/03/21/health/21cons.html>

How to Use a Hand Sanitizer



Image: World Health Organization (WHO)
www.who.int/gpsc/5may/How_To_HandRub_Poster.pdf



Image Source: World Health Organization (WHO) --
www.who.int/gpsc/5may/How_To_HandRub_Poster.pdf

Additional info:

- NYSDOH:

www.nyhealth.gov/diseases/communicable/influenza/h1n1/frequently_asked_questions/definitions_and_terminology.htm

- Windsor-Essex Health Unit, Ontario, Canada:

- Home page: <http://www.wehealthunit.org/>
- Hand sanitizer use image at www.wehealthunit.org/inspect/emergency-preparedness/pandemic-flu/frequently-asked-questions-on-pandemic-influenza/how-do-i-use-hand-sanitizers-properly
- Workplace brochure: "Stop! Clean Your Hands--A Safe and Useful Guide to Proper Hand Cleaning Techniques at www.wehealthunit.org/workplace-health/initiatives/brochures/H1N1_STOPBook_WEB_RS.pdf

Attestation of Completion for employees required to view powerpoint

On the next slide, please **add your name and date** to the certificate of completion, **print, sign and forward to OHS** using one of the options below:

1. Scan and email to OHS mailbox – In the To: section of a Lotus note type OHS, or;
2. Fax to OHS at (518) 486-3680, or;
3. Send by inter-office mail to:
Occupational Health and Safety
ESP Corning Tower Room 2230
Albany, NY 12237

Give a copy to your Supervisor also

Your certificate will serve as document of your participation. Thank you!



Certification of Completion

This certifies that

NAME

Completed the Department of Health "Working Outdoors Training"

On DATE

Employee Signature





Presentation Sources



- **NYS Department of Environmental Conservation**
 - <http://www.dec.ny.gov/index.html>
- **NYS Department of Health: Diseases & Conditions**
 - <http://www.health.state.ny.us/diseases/>
- **NYS Department of Labor – Division of Safety & Health**
 - <http://www.labor.ny.gov/home>
- **CDC: Workplace Safety & Health**
 - <http://www.cdc.gov/workplace/>
- **NIOSH: Hazards to Outdoor Workers**
 - <http://www.cdc.gov/niosh/topics/outdoor/>



This list is not inclusive

Questions?

For questions or
comments on this
presentation
Contact Occupational
Health and Safety
(518) 474-8130
Or email
OHS



For questions or comments on this presentation , please contact Occupational Health and Safety (OHS) at 518-474-8130. OHS also has a mailbox called OHS.



**Department
of Health**

Vector Surveillance Fieldwork Personal Safety Training

NYSDOH Occupational Health and Safety Program

November 21, 2019

Overview

- General Personal Safety
 - Personal Safety While Driving
 - Personal Safety While Parking
 - If Followed by a Vehicle While Driving
- Duty Specific Personal Safety
 - 2-Way Radio Use
 - Potential Encounters



Personal Safety While Driving

- Plan your route ahead of time. Try to stay on main roads and highways.
- Tell someone your route, destination, and times of arrival and departure.
- Talk to co-workers or other teams to obtain information on conditions in the area where you are planning to go.
- Contact property managers (if applicable) and local police in the area you are traveling to identify problem spots.
- Always keep your seatbelt fastened.
- If your vehicle breaks down, raise the hood, stay in the vehicle with doors locked and windows up, and display a white cloth or other sign to signify the need for help.
- Do not stop for unmarked cars.

Personal Safety While Driving

- Keep your vehicle well-maintained and have enough gas to get you to your destination and back.
- Carry a flashlight and emergency equipment, such as a fire extinguisher and first aid kit.
- Keep windows closed enough to prevent entry when asking for directions or in stop-and-go traffic.
- Do not pick up hitchhikers under any circumstances. Do not open the door or window for strangers that may ask directions or approach your vehicle.
- Do not stop to aid a stranger in a stalled vehicle, report their location to the police.
- Take notice of stores that are open late, police barracks, and hospitals, etc.
Where could you get help if you needed it?

Personal Safety While Driving

- Always rent a vehicle from companies that provide 24-hour roadside assistance and write down the instructions for what to do if the vehicle breaks down.
 - OGS provides contracted roadside assistance and towing for NYS fleet vehicles, 24-hour contact information is located in the vehicle mileage binder.
- When stopping at a traffic light, try to leave space in front of you so you can drive away quickly if necessary.
- Notice people standing on corners as you approach a stop light or sign. If they approach your car and there is no danger of a collision, drive forward if necessary.
- Drive courteously. Unsafe, erratic, or aggressive driving may upset other motorists; they may want to get even with you. Don't get upset with other drivers, regardless of their behavior. You put yourself in danger when you lose your temper. Stay in control.

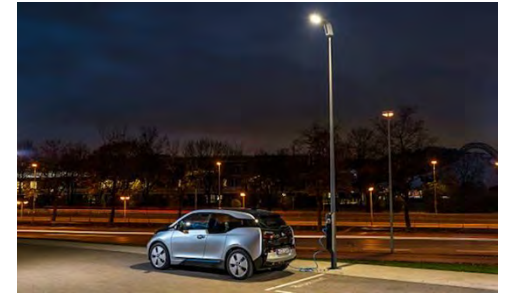
Personal Safety While Parking

- Park in an area as close as possible to your destination to limit the distance you have to walk.
- Remove ignition keys, roll windows up tightly, set parking brake and lock all doors when leaving vehicle. Do not park where you are required to leave your keys. If you must leave your keys, only leave the car door/ignition keys.
- Park in the direction in which you intend to leave. Avoid parking in driveways or tightly between other cars.
- Be cautious of vans or vehicles with dark tinted windows when parking in a lot or garage. Someone may be waiting inside.



Personal Safety While Parking

- Be alert whenever you are in a parking lot, covered garage, or side street. Look around before getting into or out of your car.
- Check under the vehicle and the back seat of the car before entering.
- Lock your doors immediately upon entry; always lock your doors when leaving your vehicle.
- Keep valuables in the trunk or out of sight, not on display.
- Park under a street light.
- Avoid dark parking lots.



If FOLLOWED BY A CAR While Driving

- Get the license plate number; dial 911 on your cell phone.
- Drive to a police station, firehouse, hospital or other public place that is open.
- If no safe areas are near, honk the horn repeatedly and turn on your emergency flashers.
- Get the attention of a police car if you should see one.
- Do not go home, the person following you will then know where you live.
- Do not pull into a driveway, you may get blocked in.
- Pull over to the side of the road, wait for the person to exit their car, and then drive off.
- If you are bumped by another car, think twice about getting out. If you are uncomfortable or suspicious, signal the other driver to follow you to the nearest police station or to a busy well-lighted area where it is safe to get out.

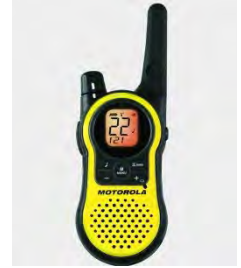
2-Way Radio Etiquette



- Think before you speak - Be brief and to the point.
- Stay off of the radio unless absolutely necessary.
- Avoid use of proper names and specific details of your location. 2-way radio communication can be received by other electronic devices such as scanners and CB radios. You never know who may be listening.
- Listen before you begin your transmission to make sure the channel is clear.
- Wait a full second AFTER you push-to-talk and BEFORE you begin to speak. This will insure the beginning of your message is heard.

2-Way Radio Tips

- Speak ACROSS the microphone rather than into it to improve intelligibility.
- DO NOT shout into the radio. It will distort your transmission.
- To overcome loud ambient noise, shield the microphone from the wind, point it away from the source of noise, or wait until the noise passes.
- Portable radios are much less effective when worn on your belt, because your body absorbs the radio signal. This is very noticeable with low powered radios.
- Unless you are within 1/4 mile of the person you are talking to, hold the radio vertically at face level, with its antenna in the clear. You will lose more than half of your range if you use the radio inside a metal vehicle or inside a steel reinforced building.
- DO NOT turn the volume all the way up. This drains the battery and causes distortion. It also has no effect on outgoing transmission quality.



2-Way Radio Use

Standard Communication Phrases:

- “Go Ahead” – Resume transmission.
- “Say Again” – Re-transmit your message.
- “Stand-by” – Transmission has been acknowledged, but I am unable to respond now.
- “Roger” – Message received and understood.
- “Affirmative” – Yes. (Avoid yup, nope, etc.)
- “Negative” – No.
- “Over” – Transmission finished.
- “Out” – Communication is over and the channel is available for others.



2-Way Radio Use

Standard NATO Alphabet:

A - Alpha

B - Bravo

C - Charlie

D - Delta

E - Echo

F - Foxtrot

G - Golf

H - Hotel

I - India

J - Juliet

K - Kilo

L - Lima

M - Mike

N - November

O - Oscar

P - Papa

Q - Quebec

R - Romeo

S - Sierra

T - Tango

U - Uniform

V - Victor

W - Whiskey

X - X-ray

Y - Yankee

Z - Zulu

2-Way Radio Use



Conversation Example:

Adam (Technician): “Student 1, this is Technician. Over.”

Mike (Student 1): “Technician, this is Student 1, Stand By. Over.”

Mike : “Technician, this is Student 1, Go Ahead. Over.”

Adam: “Student 1, sampling is concluded, meet at the vehicle. Over.”

Mike: “Technician, this is Student 1, confirming sampling is concluded. Meeting you at the vehicle. Over.”

Adam: “Student 1, this is Technician. Affirmative, see you there in about 5 minutes, thanks for the help. Over and Out.”

Potential Encounters

Hunters/General public: Acknowledge individual, briefly address any questions, refer them to the NYSDOH website for further information, and continue working on task.

Vegetation poachers: Stop activity. Scan area to ensure you are safe. Leave if you feel threatened. Report to DEC by dialing **1-844-DEC-ECOS**

Suspicious vehicle: Cautiously observe from your vehicle on arrival. Leave if you feel threatened and call 911.

Vagrants/Wanderers: Stop activity. Scan area to ensure you are safe. Leave the area if you feel threatened and call 911.



Potential Encounters

Cannabis crop: Stop activity. Scan area to ensure you are safe. Report to NY State Police non-emergency line.

Drug related activity: Stop activity. Scan area to ensure you are safe. Do not conduct work near discarded needles or syringes. Leave the area and call 911 if you feel threatened.

Overdosed individual/Medical emergency: Stop activity. Scan area to ensure you are safe. Call 911 to get help for the victim.



Questions?

Occupational Health and Safety Program
Corning Tower, Room 2283
Albany, NY 12237

Phone: 518-474-8130 or 518-473-4948
Email: OHS@health.ny.gov

Certificate of Completion

This certifies that

NAME

Completed the NYSDOH “Vector Surveillance Fieldwork Personal Safety Training”

On DATE

Employee Signature



Laboratory Supplies and Equipment for Testing - Start-up Costs

Vendor	Qty	Unit	Description	Price	Ext. Price	Justification
Applied Biosystems	1	ea	7500 Fast Real-Time PCR System	\$ 50,000.00	\$ 50,000.00	Laboratory tick testing supplies. PCR machine.
Miscellaneous	2	ea	Microcentrifuge	\$ 5,000.00	\$ 5,000.00	Laboratory tick testing supplies. Used during extraction and PCR process to consolidate particulates at bottom of tube.
Barnstead	1	ea	Reverse osmosis water purification system	\$ 10,000.00	\$ 100,000.00	Laboratory tick testing supplies. Ultra-pure R.O. water system.
Retsch	1	ea	MM300 Mixer Mill	\$ 20,000.00	\$ 20,000.00	Tick testing supplies. Used during extraction process to pulverize tick specimen and release pathogen DNA from inside ticks.
Qiagen	1	ea	Qiacube HT Robot	\$ 50,000.00	\$ 50,000.00	Tick testing supplies. Used to extract tick DNA from ticks and put into elution plates for storage and subsequent PCR testing. Automated robotic system.
Miscellaneous	1	ea	Vortex mixer	\$ 500.00	\$ 500.00	Tick testing supplies. Used to homogenize samples for PCR.
Amazon	2	ea	Safety goggles	\$ 6.99	\$ 13.98	Tick testing supplies. Worn during tick grinding process in Mixer Mill. Eye protection.
Baker	2	ea	SterilGaurd Biosafety cabinet	\$ 15,000.00	\$ 15,000.00	Laboratory tick testing supplies. Used for extraction process and PCR to reduce airborne contaminants and provide a clean, controlled environment. Need two separate units.
Grainger	1	ea	Flammable liquids storage cabinet, 60 gallon	\$ 1,000.00	\$ 1,000.00	Used to store Isopropanol and Ethanol bottles. Flame resistant.
Fischer Scientific	2	ea	JustRite Type 1 Steel Safety Can, liquid waste disposal	\$ 91.30	\$ 182.60	Tick testing supplies. Used for disposal of ethanol waste and reagents used during extraction process.
Fischer Scientific	2	ea	Gilson Pipetman Classic Pipets, P1000	\$ 412.50	\$ 825.00	Tick testing supplies. Used during extraction and PCR processes.
Fischer Scientific	2	ea	Gilson Pipetman Classic Pipets, P200	\$ 412.50	\$ 825.00	Tick testing supplies. Used during extraction and PCR processes.
Fischer Scientific	1	ea	Gilson Pipetman Classic Pipets, P20	\$ 412.50	\$ 412.50	Tick testing supplies. Used during PCR process.
Fischer Scientific	1	ea	Gilson Pipetman Classic Pipets, P2	\$ 412.50	\$ 412.50	Tick testing supplies. Used during PCR process.
Grainger	1	ea	Various glass graduated cylinders, 5 pk	\$ 169.10	\$ 169.10	Tick testing supplies. Used to measure additives for reagent creation and mixing.
Grainger	10	ea	Glass beakers, set of 4, 2000mL	\$ 85.58	\$ 85.58	Tick testing supplies. Used to store 2mL eppendorf snap cap tubes and sterilized prior to tubes use in tick extraction process.
Amazon	10	ea	Pyrex 1000mL glass storage bottle, screw cap, 2pk	\$ 28.94	\$ 28.94	Tick testing supplies. Used to store ultra pure water (PCR water) for mixtures with reagents and ethanol. Can be autoclaved.
Amazon	6	ea	Pyrex 100mL glass storage bottle, screw cap	\$ 10.72	\$ 10.72	Tick testing supplies. Used to mix and store PBS solution.
Fischer Scientific	1	ea	Negative 20C Upright laboratory freezers	\$ 1,500.00	\$ 1,500.00	Stores ticks pre and post extraction, PCR reagents, PCR machine calibration kits, and other biological supplies.
Miscellaneous	1	ea	Laboratory refrigerator	\$ 1,500.00	\$ 1,500.00	
Miscellaneous	1	ea	Negative 80C Ultra Low temp freezers	\$ 10,000.00	\$ 10,000.00	Stores ticks post extraction and allows samples to be stored without degradation of DNA, in case further tests need to be performed later.
Amazon	4	ea	White lab coats, various sizes	\$ 20.00	\$ 80.00	PPE for laboratory. Separate coats needed for PCR and DNA extractions.
Fischer Scientific	2	ea	Corning Round Ice Bucket with Lid, 2.5L	\$ 104.00	\$ 208.00	Tick testing supplies. Used in PCR biosafety cabinet during PCR process. Need two separate buckets.
Miscellaneous	1	ea	Drummond Pipette Aid	\$ 280.97	\$ 280.97	Tick testing supplies. Used for reagents that require measurements to a decimal place.

\$ 258,034.89

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Laboratory Supplies - Testing Consumables

Vendor	Qty	Unit	Description	Price	Ext. Price	Justification
Fisher	12	pk	BestRack*96-place reversible tube rack with lid, green, 5 per pack	\$68.75	\$825.00	Tick testing supplies. Racks needed to store tick DNA samples in freezer before and after molecular testing.
Fisher	2	cs	Fisherbrand SureOne aerosol resistant pipette tips 2 - 20 ul (5 per case)	\$199.70	\$399.40	Tick testing supplies. Sterile, disposable micropipette tips used during the testing process to transfer samples and chemicals using micropipettors. 2-20 ul size.
Fisher	3	cs	Fisherbrand SureOne aerosol resistant pipette tips 20 - 200 ul (5 per case)	\$194.60	\$583.80	Tick testing supplies. Sterile, disposable micropipette tips used during the testing process to transfer samples and chemicals using micropipettors. 20 - 200 ul size.
Fisher	20	cs	Microcentrifuge Safe-Lock Tubes, 2.0 mL, Natural, case of 500 tubes	\$46.31	\$926.20	Tick testing supplies. Disposable tubes used during the DNA extraction process to hold ticks while grinding in specialized grinding machine prior to molecular testing. Tubes can only be used once, then discarded due to DNA and pathogen contamination.
Fisher	1	cs	Falcon™ 15mL Conical Centrifuge Tubes	\$131.96	\$131.96	Tick testing supplies. Disposable tubes used during the DNA extraction and tick testing process to hold reagents and chemicals.
Fisher	3	cs	Fisherbrand™ Polypropylene Biohazard Autoclave Bags	\$27.41	\$82.23	Tick testing supplies. Required for disposal of consumable supplies (pipette tips, tubes, etc.) exposed to tick specimen homogenates during tick testing process.
Fisher	10	ea	Fisherbrand™ White Autoclave Tapes, 1 in wide	\$9.00	\$90.00	Tick testing supplies. Indicator for steam sterilization of tick testing equipment and supplies.
Fisher	1	cs	Fisherbrand™ 1in. Colored Label Tapes	\$45.00	\$45.00	Tick testing supplies. Colored laboratory tape used to label specimen boxes, contents of laboratory storage, adhere absorbent bench pad to benchtop, etc.
Fisher	2	cs	Fisherbrand™ Lab Wipes	\$58.41	\$116.82	Tick testing supplies. Highly absorbent and low-lint general purpose wipe for use throughout the lab setting (cleaning equipment, spill response, contamination control, etc.)
Fisher	1	cs	Isopropanol, Molecular Biology Grade, Fisher BioReagents, case of 6 bottles	\$354.56	\$354.56	Tick testing supplies. Chemical used to extract specimens DNA in preparation of tick testing.
Fisher	3	cs	Ethyl alcohol, absolute, 200 proof, case of 6 bottles	\$414.89	\$1,244.67	Tick testing supplies. Chemical used to preserve ticks and during the tick testing process.
Fisher	10	cs	Fisherbrand* Powder-Free Nitrile Exam Gloves - case of 10 pk, various sizes	\$48.81	\$488.10	Laboratory supplies. Personal protective equipment for staff working in the laboratory with chemicals while identifying ticks.
Fisher	1	cs	Thermo Scientific™ DNA AWAY™ Surface Decontaminant	\$240.42	\$240.42	Laboratory supplies. Product removes DNA contamination from equipment and surfaces to prevent cross-contamination of samples during the testing process.
Fisher	1	cs	Thermo Scientific™ SoftCIDE™ Extra-Mild Antimicrobial Handwash - 32 oz pump (case of 6)	\$115.66	\$115.66	Laboratory supplies. Product effectively eliminates bacteria and viruses on hands without harsh drying from repeated washing.
Fisher	8	pk	Thermo Scientific™ 96-Well Semi-Skirted Plates, Raised Deck. 25/pk	\$69.02	\$552.16	Laboratory supplies. Disposable tubes/plates used during the qPCR testing process to hold samples. Plates can only be used once each, then discarded due to DNA contamination. Used with AB 7500 machine.
Fisher	1	cs	Applied Biosystems™ MicroAmp™ Fast Optical 96-Well Reaction Plate, 0.1mL (200 plates)	\$907.41	\$907.41	Laboratory supplies. Disposable tubes/plates used during the qPCR testing process to hold samples. Plates can only be used once each, then discarded due to DNA contamination. Used with AB 7500 Fast machine.
Fisher	8	pk	ABsolute QPCR Seal. 50/pk	\$79.03	\$632.24	Laboratory supplies. Disposable adhesive film used during the qPCR testing process to seal sample plates (above). Can only be used once each, then discarded due to DNA contamination.

Vendor	Qty	Unit	Description	Price	Ext. Price	Justification
Fisher	3	pk	Thermo Scientific™ Nalgene™ Unitary™ LDPE Wash Bottles - 1000 mL (pack of 2)	\$22.93	\$68.79	Field and laboratory supplies. Used to transfer and store fluids in the laboratory for tick-borne pathogen surveillance.
Fisher	2	cs	Kimberly-Clark™ Professional Kimtech Science™ Kimwipes™ Delicate Task Wipers, 1-Ply, case od 30 pk	\$121.25	\$242.50	Tick testing supplies. low-lint general purpose wipe for use throughout the lab setting (cleaning equipment, spill response, contamination control, etc.)
Fisher	4	pk	Grinding balls stainless steel 5000 per pack	\$673.53	\$2,694.12	Laboratory supplies. Necessary to physically grind individual ticks to extract specimen DNA as part of molecular testing process to screen ticks collected as part of statewide tick-borne disease surveillance project for pathogens.
Fisher	1	pk	Standard Disposable Transfer Pipettes	\$25.03	\$25.03	Field and laboratory supplies. Used to transfer fluids in the field and laboratory for tick-borne pathogen surveillance.
IDT	2	ea	Custom DNA product, Anaplasma probe, 1 um PrimeTime® 5' JOE NHS / 3' BHQ-1	\$575.00	\$1,150.00	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Babesia probe, 1 um PrimeTime® 5' Cy5 / 3' BHQ-2	\$600.00	\$1,200.00	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Anaplasma forward primer, 1 umole DNA Oligo	\$56.70	\$113.40	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Anaplasma reverse primer, 1 umole DNA Oligo	\$42.00	\$84.00	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Borrelia reverse primer, 1 umole DNA Oligo	\$46.20	\$92.40	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Borrelia forward primer, 1 umole DNA Oligo	\$48.30	\$96.60	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Babesia forward primer, 1 umole DNA Oligo	\$44.10	\$88.20	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	2	ea	Custom DNA product, Babesia reverse primer, 1 umole DNA Oligo	\$46.20	\$92.40	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
IDT	1	ea		Shipping	\$16.00	16
Life Technologies	4	ea	Custom TaqMan probe - MGBNFQ, B. burgdorferi probe Bb16SrDNAp, 20000 pmol	\$ 562.00	\$ 2,248.00	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
Life Technologies	4	ea	Custom TaqMan probe - MGBNFQ, B. miyamotoi probe Bmiy16SrDNAp, 20000 pmol	\$ 562.00	\$ 2,248.00	Laboratory tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
Life Technologies	1	ea	shipping	\$ 85.95	\$ 85.95	S+H charges
Qiagen	18	ea	QIAamp 96 DNA QIAcube HT Kit (5)	\$ 671.40	\$ 12,085.20	Tick testing supplies. Used to extract tick DNA on an automated robotic system (QiacubeHT) as part of testing process to screen ticks for pathogens. Product classified as "molecular biology consumables", used up during the testing process. Vendor provided sole source justification.
Qiagen	18	ea	QIAcube HT Plasticware	\$ 272.70	\$ 4,908.60	Tick testing supplies. Used to extract tick DNA on an automated robotic system (QiacubeHT) as part of testing process to screen ticks for pathogens. Product classified as "molecular biology consumables", used up during the testing process. Vendor provided sole source justification.
Qiagen	4	ea	Elution Microtubes RS 24 x 96	\$ 357.30	\$ 1,429.20	Tick testing supplies. Used to store individual tick DNA extracts processed by the Qiacube HT before and after testing.

Vendor	Qty	Unit	Description	Price	Ext. Price	Justification
VWR	2	ea	PerfeCta® MultiPlex qPCR ToughMix, Quanta Biosciences, ToughMix®, Low ROX™, 5000 25ul reactions	\$ 6,473.20	\$ 12,946.40	Tick testing supplies. Chemical needed to test ticks for pathogens by real-time PCR.
Fischer Scientific	1	ea	Phosphate Buffered Saline (PBS) Tablets, 100ct	\$ 114.50	\$ 114.50	Tick testing supplies. Used to create solution in which to grind ticks in.
Fischer Scientific	1	cs	Thermoscientific Nalgene Versi-Dry Surface Protectors, 2pk	\$ 249.50	\$ 249.50	Tick testing supplies. Covers bench tops to reduce contamination, absorb spills, and cushion lab ware.
Fischer Scientific	1	cs	Therapak Aquei-pad Benchtop Absorbent Mat	\$ 149.70	\$ 149.70	Tick testing supplies. Covers bench top and allows clean spot to dry lab ware used during extraction process. Cushions glassware.
Fischer Scientific	10	ea	Cryo Freezer boxes, cardboard	\$ 12.00	\$ 120.00	Tick testing supplies. Used to store ticks in -20 freezers once sorted and prior to extraction process.
Miscellaneous	1	ea	Serological pipettes with filter, various sizes	\$ 100.00	\$ 100.00	Tick testing supplies. Used for reagents that require measurements to a decimal place.

\$ 50,384.12

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Collection and Identification Equipment and Supplies

Vendor	Qty	Unit	Description	Price	Ext. Price	Justification
Miscellaneous	10	ea	White painters long sleeve cotton coveralls, various sizes	\$ 40.00	\$ 400.00	PPE for staff conducting tick collections
Grainger	10	ea	Insulated coveralls, various sizes	\$ 133.32	\$ 1,333.20	PPE for staff conducting tick collections in autumn months and during hunter-killed deer survey (ticks and blood samples collected in mid-November).
Grainger	10	pk	Women's 8" Socks, White, 10 PK	\$ 8.13	\$ 81.30	PPE for staff conducting tick collections.
Grainger	10	pk	Men's 10" Socks, White, 6 PK Sz 6-12	\$ 10.46	\$ 104.60	PPE for staff conducting tick collections.
Forestry Suppliers	10	ea	Bug Cap®	\$ 25.03	\$ 250.30	Tick collections supplies. PPE for staff collecting ticks to prevent mosquito and fly bites to the head and neck.
Forestry Suppliers	10	ea	Hi-Vis Orange 10 pocket cruiser vest	\$ 64.95	\$ 64.95	PPE for staff conducting tick collections. Allows for high visibility in wooded environments and storage of collecting supplies while in the field.
Staples	1	cs	3M Paper Masking Tape, 2" x60 yds/ 24 case	\$ 91.74	\$ 91.74	junction between socks and suits.
Forestry Suppliers	5	ea	Digital Hygro-thermometer	\$ 27.94	\$ 139.70	Tick collections supplies. Measure weather conditions (temperature/relative humidity) when making field collections.
BioQuip	50	ea	Forceps, #4, 4-3/8"	\$ 5.57	\$ 278.50	Tick collecting and testing supplies. Fine pointed forceps used to handle tick specimens in the field and laboratory, prior to testing.
Amazon	5	pk	Motorolla T600 Talkabout Radio	\$ 69.98	\$ 349.90	Tick collection supplies. Used to keep in contact with coworkers in field. Important for personal safety.
Amazon	10	ea	Foraineam 6 Pack Metal Hand Tally Counter	\$ 11.99	\$ 11.99	Tick collection supplies. Used to keep track of steps for proper totaling of distance sampled.
Fisher	1	cs	Falcon™ 50mL Conical Centrifuge Tubes	\$ 129.45	\$ 129.45	Tick collecting supplies. Disposable tubes used during tick specimen collection, DNA extraction, and tick testing process to hold reagents and chemicals.
Amazon	3	ea	Crosstex 19300 Dental Dam, Latex, Unflavored, Medium Gauge, 6" x 6" Size, Blue (Pack of 36)	\$ 22.76	\$ 68.28	Tick collection supplies. Used to cap tick vials for easy transfer of ticks from forceps to vial in the field.
Amazon	3	ea	Crosstex 19301 Dental Dam, Latex, Unflavored, Heavy Gauge, 6" x 6" Size, Blue (Pack of 36)	\$ 26.31	\$ 78.93	Tick collection supplies. Used to cap tick vials for easy transfer of ticks from forceps to vial in the field.
Forestry Suppliers	5	ea	Garmin® Drive™ 61 LM	\$ 149.99	\$ 749.95	Tick collection supplies. GPS navigation to assist staff in navigating routes between tick collection sites, especially in areas without cell phone service. Currently using employee's personal
Amazon	5	ea	2pk Purell hand sanitizer	\$ 12.16	\$ 12.16	Tick collection supplies. Used to clean hands after field work to remove dirt and irritants.
Forestry Suppliers	5	ea	Tecnu® Cleanser	\$ 18.58	\$ 92.90	Tick collections supplies. PPE for staff collecting ticks. Removes oils from poison ivy, oak and sumac, and prevents irritant from spreading on skin, boots and equipment.
Staples	5	ea	Lint Roller w/ 3 refill rolls	\$ 9.99	\$ 49.95	Tick collection supplies. Used to collect tick larvae from drag cloths, removing tick nymphs and larvae from clothes/tick suits
Staples	4	ea	Duracell Coppertop AAA Alkaline Batteries, 24/Pack	\$ 16.99	\$ 67.96	Tick collection supplies. To power handheld temperature and RH gauges.

Vendor	Qty	Unit	Description	Price	Ext. Price	Justification
Amazon	3	ea	Cotton Flannel Fabric 45" Wide Soft Warm Comfy 10+ Colors By The Yard (White, 10 YARD)	\$ 42.50	\$ 127.50	Tick collection supplies. Used to construct tick drags to collect immature ticks (larvae and nymphs)
Amazon	6	ea	Galaxy Products HW69 Paintessentials Canvas Drop Cloth, 6 x 9-Foot, Natural	\$ 11.95	\$ 71.70	Tick collection supplies. Used to construct tick flags to collect adult ticks.
Amazon	2	ea	Natural Twisted Cotton Rope Bohemia Macrame DIY Wall Hanging Plant Hanger Cotton Clothesline Rope Craft Making Knitting Cord Rope 200M	\$ 14.49	\$ 28.98	Tick collection supplies. Used to construct tick drags to collect immature ticks (larvae and nymphs)
Amazon	2	ea	L.H. Dottie CH1414 Jack Chain, No.14 Gauge, Bright Galvanized, 100 ft	\$ 35.00	\$ 70.00	Tick collection supplies. Used to construct tick drags to collect immature ticks (larvae and nymphs)
Amazon	5	ea	Coats & Clark All Purpose Thread 400 Yards White (ONE spool of yarn)	\$ 5.58	\$ 27.90	Tick collection supplies. Used to construct tick flags and drags to collect ticks.
Amazon	2	ea	HEVERP 20Pcs 7/8 x 2 inch Stainless Steel Screw Eyes/Tapping Screws/Hanging Hooks	\$ 11.49	\$ 22.98	Tick collection supplies. Used to construct tick drags to collect immature ticks (larvae and nymphs)
Amazon	1	ea	BENECREAT 1 Box(100pcs) 2 Inch Assorted Color Plastic Head Safety Pins Baby Safety Pins Diaper Pins Plastic Head Cloth Diaper Nappy Pins	\$ 11.99	\$ 11.99	Tick collection supplies. Used to construct tick drags to collect immature ticks (larvae and nymphs)
Amazon	1	ea	1/2" Inch x 48" Inch Wooden Dowel Rods Bag of 50 Unfinished Hardwood Dowels Sticks for Crafts & Woodworking - by Woodpeckers	\$ 49.99	\$ 49.99	Tick collection supplies. Used to construct tick flags and drags to collect ticks.
Fisher	1	cs	Fisherbrand™ Premium Microcentrifuge Tubes: 1.5mL	\$ 157.93	\$ 157.93	Tick testing supplies. Disposable tubes used to store tick specimens and during the DNA extraction process.
Fisher	1	cs	Fisherbrand™ Petri Dishes with Clear Lid, 60 x 15 mm, case of 500	\$ 49.61	\$ 49.61	Tick testing supplies. Used to sort and identify tick specimens prior to molecular testing.
Fisher	1	cs	Fisherbrand™ Petri Dishes with Clear Lid, 100 x 15 mm, case of 500	\$ 58.60	\$ 58.60	Tick testing supplies. Used to sort and identify tick specimens prior to molecular testing.
Miscellaneous	1	ea	Stereo microscope	\$10,000.00	\$10,000.00	Tick Iding supplies. Used to view ticks under high magnification for proper identification and recognition of identifying features.
Bioquip	1	ea	Laboratory chill table	\$ 1,790.46	\$ 1,790.46	Tick Iding supplies. Used for immobilizing insects during sorting and Iding process. Also helps maintain cold chain.
Miscellaneous	n/a	n/a	Miscellaneous office supplies (pens, pencils, sharpies, scissors)	\$ 100.00	\$ 100.00	Used in lab and field.

\$16,923.40

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NSF- EID: Lyme Disease Gradient Project

Safety Manual

Purpose: This document is to serve as a general guide for possible biological and environmental safety issues that may arise when participating in this project. It is not an all inclusive document to replace first aid training or hands on training.

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June 17, 2006

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Avoiding Lyme disease and other tick-borne infections

Ticks do not jump, fly, or drop from trees, but grasp passing hosts from various sources such as the leaf litter and tips of grass. Ticks are usually picked up on the lower legs and then crawl up the body seeking a place to feed.

What is Lyme Disease?

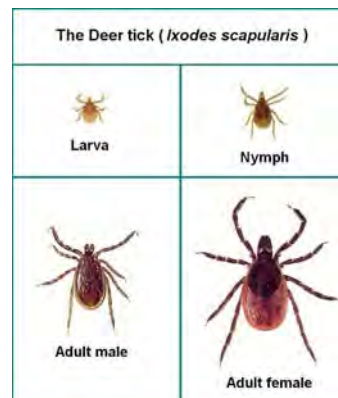
Lyme disease is caused by a bacterial infection (*Borrelia burgdorferi*), which can be transmitted to humans by the bite of *Ixodes scapularis*, the blacklegged tick, also known as the deer tick in the Eastern U.S.

Know the Symptoms!

While some people show no reaction to Lyme disease, others are seriously affected by it. About 70% of infected people develop a rash called *erythema migrans* (EM) a few days to weeks after the bite. This rash usually resembles a reddish “bull’s-eye” or an expanding red ring and is often accompanied by flu-like symptoms. These early symptoms generally subside on their own, but untreated patients can later develop more serious health complications. However, it can be easily treated with antibiotics.

Common Signs of Infection:

- “Bull’s-eye” rash
- Flu-like Symptoms
- Headaches
- Stiff Neck and/ or Joints
- Fever
- Muscle Aches
- Numbness/ Tingling
- Loss of Concentration



How to Avoid Tick Bites:

- Personal Protective Clothing:
 - Wear light colored clothes to easily spot ticks or PPE such as Tyvek suits
 - Wear long sleeved shirts and closed toed shoes
 - Tuck your shirt into your pants and your pants into your socks.
- Apply bug repellent on your clothes. DEET, picaridin, and permethrin are good options. Carefully follow directions on label. CDC recommends products containing 30-50% DEET.
- Thoroughly inspect your head and body when you get back from the field!

What To Do if Bitten:

- DO NOT squeeze the body of the tick! Grasp it as near to your skin as you can with fine tweezers or tick remover, and GENTLY pull it out.
- Clean the bite with soap and water; and sterilize the area using rubbing alcohol or hydrogen peroxide.
- If you accidentally break off the mouthparts, seek medical attention to remove them to avoid infection.
- SAVE THE TICK. This is important to identification which tick-borne pathogens you were possibly exposed to. Either, place the tick in your freezer or in a vial of 70% alcohol. Always include information like where and when the tick may have been acquired and when it was removed.

For an excellent guide to common tick identification, please visit:

http://tickencounter.org/education/tick_identification/

Other Tick-borne Diseases:

Rocky Mountain spotted fever (RMSF) (caused by *Rickettsia rickettsii*).

Vector Ticks: American dog tick and Rocky Mountain wood tick.

Symptoms: Usually 2 to 14 days: fever, spotted rash, nausea, vomiting, severe headache, abdominal pain, joint pain, diarrhea, muscle pain and lack of appetite.

Babesiosis (caused by *Babesia microti*)

Vector ticks: Deer ticks and possibly other related Ixodid ticks.

Symptoms: Malaria-like illness normally begins about a week after a tick bite with a gradual onset of malaise, anorexia and fatigue. This is followed several days later by high fever, drenching sweats, muscle pain and headaches. As with malaria, these symptoms can continue over a protracted period or can abate, then recur.

Ehrlichiosis, Anaplasmosis (caused by rickettsial bacteria)

Nonspecific symptoms include fever, headache, nausea, vomiting, and malaise. Most cases occur April through October.

Tick-borne diseases are easily treatable if caught early so check for ticks daily and use preventative practices!

For more information on these and other **tick-borne diseases and prevention measures** visit:

<http://www.aldf.com/majorTick.shtml>

<http://www.cdc.gov/ticks/diseases/>

<http://www.tickencounter.org/>

<http://wwwnc.cdc.gov/travel/yellowbook/2010/chapter-2/protection-against-mosquitoes-ticks-insects-arthropods.aspx>

Biting and Stinging Insects

Preparing for the Field:

Before venturing outdoors, anyone who is allergic to insect stings or bites should inform their supervisor and coworkers about their condition and the possible danger if they were to be stung.

It's important to distinguish an allergic reaction from the normal reaction to insect stings and bites. Swelling, redness, and itching around the sting or bite are normal. Itching and hives far from the sting or bite are signs of an allergic reaction.

Biting Insects:



Midges: Also known as "no-see-ums" and "punkies", biting Midges are so small that they can pass through ordinary mosquito netting. Bites cause a burning sensation, and subsequent welts can itch for days.



Deer and Horse Flies: Most prefer warm seasons and the warmth of the day, but some species are most active at dawn or dusk. Females bite which can be deep and painful, but unless one is allergic the effects will soon pass.



Black Flies: Spring and early summer, swarms of small female black flies bite mostly during the day, particularly early morning and toward evening and mostly near rivers or streams. Threatening weather, as before a thunderstorm, intensifies biting.



Chiggers: Chiggers are the larval stage of a mite. They do not burrow into skin but rather inject saliva into the wound which causes an allergic reaction and an

intensely itchy area and dermatitis. Chigger mites are very small (0.2-0.4 mm ~ 1/100") and not easily seen.



Mosquitoes: Most species are active in the early morning and dusk hours. Mosquito bites affect each person differently and can result in no reaction to severe swelling and itching. Only female mosquitoes bite. The **West Nile virus (WNV)** is most often spread to humans from the bite of an infected mosquito.

Most human infections with WNV (about 80%) cause no symptoms, and about 20% cause flu-like symptoms, including fever, fatigue, headache, and muscle or joint pain. Fewer than 1% of humans infected with WNV become severely ill. Severe symptoms include high fever, stiff neck, disorientation, tremors, muscle weakness, and paralysis. Severely affected persons may develop encephalitis (inflammation of the brain) or meningitis (inflammation of the membranes of the brain or spinal cord). Severe cases may be fatal. People of all ages and conditions may be affected. However, those who are above age 50 or who have had an organ transplant are at increased risk of severe illness.

Protecting yourself from biting insects:

- Use insect repellent if you work outdoors with areas of biting insects. DEET and non-DEET repellents work. Use as directed.
- Use permethrin on clothing only.
- Use protective clothing if you work outdoors, including long-sleeved shirts, long pants, and socks.
- If necessary, bug-jackets, head-nets, gloves, and Tyvek suits can be used to avoid biting insects.
- Wash skin treated with insect repellent with soap and water after returning indoors.

Stinging Insects

Recognizing Stinging Insects:

The insects that are most likely to trigger an allergic reaction are:

1. **Wasps** (such as yellow jackets and bald-faced hornets) have a straight stinger that they can use again and again.
2. **Honey bee workers** have barbed stingers that become embedded in the skin, preventing them from stinging more than once. Other bees (e.g., bumble bees, sweat bees) have straight stingers and can sting multiple times.
3. **Fire ants** can pivot as they sting, leaving a circular cluster of stings.

If you're attacked by a swarm of stinging insects, move away quickly! Insects are probably protecting their nest and view you as an intruder. The longer you stay, the more likely you are to be stung. Pull your shirt or jacket over your head to protect your face and airways. Keep moving until the insects stop chasing you or you reach a safe area, such as a vehicle or building. Check for stings and remove any venom sacs and stingers. Monitor yourself for signs of an allergic reaction and seek medical attention if necessary.

The color and size of individual insects may vary widely; when possible bring the insect with you for identification if you're seeking treatment.

Some tips to avoid stinging insects include:

- Avoid wearing brightly colored clothes or perfumes, lotions, or other scented products that may attract insects.

- Be alert for insects when you are eating, drinking, or cooking; the scent of food attracts insects.
- Wear pants that seal at the ankle and shirts that seal at the wrist to prevent insects from getting inside your clothing.
- Do not swat or crush insects; when some insects are injured, they send chemical signals that incite other insects to attack.

General Treatment for Insect Stings and Bites:

- If you've been stung by a bee, look for the barbed stinger and venom sac that may be embedded in your skin. The stinger will look like a little black dot in the center of the wound. Do not use your fingers or tweezers to remove it. Doing so might pinch the venom sac, forcing venom into the wound. It's best to remove the venom sac and stinger by scraping the area with a straight-edged object, such as a credit card or driver's license. If you've been attacked by fire ants, brush them off and take off any rings and tight-fitting jewelry.
- Wash the area of the sting or bite with soap and water or with an antiseptic wipe.
- Elevate the affected area and use ice or a cold compress to reduce swelling and pain.
- If needed, apply a topical steroid ointment or take an over-the-counter oral antihistamine, such as Benadryl or Chlor-Trimeton to help reduce swelling, itching, and redness. An anesthetic spray containing benzocaine, such as Solarcaine, may provide some pain relief. Hydrocortisone cream or calamine lotion applied to the skin may help relieve itching and swelling. Be sure to follow all labels and instructions on the medications. If you've been stung by fire ants, do not break the pustules.

Anaphylaxis

Anaphylaxis is a serious and potentially life-threatening medical situation that requires immediate emergency treatment. Someone with allergies usually will begin to show signs of a reaction within 1 to 15 minutes after an insect sting or bite. Sometimes a reaction may not begin for up to 4 hours.

The normal reactions to a sting or bite include pain, swelling, and redness around the bite. Stings or bites near the mouth or nose may cause swelling that interferes with breathing, even in individuals who are not suffering an allergic reaction.

Allergic reactions can vary from mild to severe and from individual to individual.

- Itching and hives far from the bite
- Red, itchy, watery eyes
- Swelling of the throat or tongue/difficulty swallowing
- Difficulty breathing
- Dizziness
- Severe headache
- Stomach cramps
- Diarrhea
- Nausea
- A sharp drop in blood pressure
- Loss of consciousness or shock
- Anxiety, feeling of "impending doom"

If You're Allergic to Insect Stings or Bites:

If you've been stung or bitten and know you are allergic, seek immediate medical treatment.

- Speak to your physician ahead of time. He/she can offer suggestions and possibly provide medications or kits that can be taken to the field for use in case of a severe reaction.
- Make sure your coworkers know that you've been stung or bitten and that you may suffer an allergic reaction.
- Have your coworkers contact emergency services or your dispatch center immediately to make them aware of the potentially life-threatening situation.
- If you have been prescribed epinephrine by your doctor, administer the proper dose. Antihistamines may provide some relief, but they are no substitute for epinephrine.

- Remain calm; anxiety increases blood flow and can worsen the situation.
- Take steps to prevent shock. Lie flat with your feet about 12 inches above your head. You may need a blanket or coat to keep warm.
- Go to an emergency room in case additional treatment is necessary, especially if you've administered epinephrine to yourself.

For more comprehensive information about **biting and stinging insects and WNV** see:

<http://www.cdc.gov/westnile>

<http://www.cdc.gov/niosh/docs/2005-155/>

http://edis.ifas.ufl.edu/topic_biting_flies

<http://bitinginsects.siteideas.net>

<http://www.epipen.com>

<http://www.fhwa.dot.gov/environment/fspubs/08672331/index.htm>

Poison ivy, oak, and sumac

Poison ivy, poison oak, and poison sumac release an oil, urushiol, when the leaf or other plant parts are bruised, damaged, or burned. When the oil gets on the skin an allergic reaction, referred to as *contact dermatitis*, occurs in most exposed people as an itchy red rash with bumps or blisters.

The old saying "*Leaves of three, Let it be!*" is a helpful reminder for identifying poison ivy and oak, but not poison sumac which usually has clusters of 7-13 leaves. Even poison ivy and poison oak may have more than three leaves and their form may vary greatly depending upon the exact species encountered, the local environment, and the season. Being able to identify local varieties of these poisonous plants throughout the seasons and differentiating them from common nonpoisonous look-a-likes are the major keys to avoiding exposure.

Poison Ivy



- Eastern poison ivy is typically a hairy, ropelike vine with three shiny green (or red in the fall) leaves budding from one small stem.
- Western poison ivy is typically a low shrub with three leaves that does not form a climbing vine.
- May have yellow or green flowers and white to green-yellow or amber berries.

Poison Oak



- Typically a shrub with leaves of three, similar to poison ivy.
- Pacific poison oak may be vine-like.
- May have yellow or green flowers and clusters of green-yellow or white berries.

Poison Sumac



- Woody shrub that has stems that contain 7-13 leaves arranged in pairs.
- May have glossy, pale yellow, or cream-colored berries.

Tips to avoid Poison Ivy:

1. *Learn to identify poison ivy, poison oak, and poison sumac, and when you see them, avoid them.*
2. *Wear long pants, long-sleeve shirts, socks, and fully-enclosed footwear when walking in poison-ivy infested areas.*
3. *Wear gloves when working where poison ivy may be present.*
4. *Apply a barrier cream (Ivy Block or Stokoguard), if you know you have a good chance of exposure to poison ivy. (While no vaccine or medicine has been shown to prevent reactions to poison ivy, barrier creams containing bentoquatam seem to be effective in slowing the absorption of urushiol into the skin. Apply the cream as directed, usually about an hour before potential exposure, and thoroughly wash it off within four hours, reapplying as necessary).*
5. *Exercise caution not to touch your face or eyes (or other exposed skin) with hands or gloves that may have come in contact with poison ivy.*
6. *Beware of latent resin.* Urushiol resin can remain active for a long time! Thoroughly wash or dispose of clothes, tools, or other objects which may have come into contact with poison ivy. To wash objects, use hot, soapy water and let the clothing or object dry outside for several days.
7. *Wash exposed skin immediately.* It takes about 10-30 minutes after contact for urushiol to bind with skin, so fast cleaning may prevent a reaction. If you think your skin may have been exposed to poison ivy, clean the affected area with rubbing alcohol, and then wash it with cool water. Commercially-available products (e.g., Tecnu soap) can be used to wash urushiol from exposed skin and to minimize the likelihood of a reaction.

Tips to treat poison ivy:

1. *Clean your skin immediately.* If you do this within 10 minutes, you may be able to get the urushiol off before it penetrates your skin. Clean the skin with rubbing alcohol first, then rinse thoroughly with cold water. However, the alcohol will make your skin extra sensitive to urushiol-containing plants that day.
 - a. *Don't scrub or use hot water on your skin.* This can draw the urushiol deeper into your pores.
 - b. *Don't use regular soap until after you've rinsed off your skin with just water or with another product to remove the urushiol.* Soap can pick up the urushiol and

move it around to other parts of your body. Considering purchasing Technu for people highly sensitive to poison ivy.

- c. *Don't forget to clean under your fingernails*; you may have scratched off some urushiol and could redeposit it on other objects or areas of your skin by accident.
 - d. *There are products designed to break down urushiol* and help with removing it from skin; because it is an oily sap, it can be difficult to remove.
2. *Recognize the symptoms.* An allergic reaction may follow within 48 hours. First, your skin gets red and itchy. Then a rash follows, usually in a pattern of streaks of patches. Eventually the rash turns into red bumps or large oozing blisters. The rash will appear wherever you came in contact with urushiol, although it may take longer for the rash to appear on parts of your body where your skin is thicker. It doesn't spread, however, because there's no urushiol in the blisters. Once the urushiol is gone, the rash will go away.
 3. *Stop scratching.* Even though the rash is not contagious, it's best to avoid damaging the skin, or else you run the risk of getting an infection.
 4. *Wash clothes and anything else that may have come in contact with it.*
 5. *Cool off.* Apply cold compresses, and/or massage the affected area with an ice cube. The cooling sensation will provide temporary relief.
 6. *Dry off.* Always let the area air dry--this reduces the itching and oozing of blisters.
 7. *Use antihistamines.* They can be taken orally or applied topically, or both. Unfortunately, these types of products only treat the symptom--which is the rash. That's why they should be used after you have used a product to remove the urushiol. Calamine lotion can ease the itching and soothe blistered skin. Apply regularly and liberally.

More reading can be found at:

<http://www.cdc.gov/niosh/topics/plants/>

<http://www.fda.gov/downloads/ForConsumers/ConsumerUpdates/UCM143611.pdf>

Hypothermia

Hypothermia is dangerously low body temperature, below 95 °F (35 °C). Hypothermia occurs when more heat is lost than the body can generate. It is usually caused by extended exposure to the cold.

Common causes:

- Being outside without enough protective clothing in winter.
- Wearing wet clothing in windy or cold weather.
- Heavy exertion, not drinking enough fluids, or not eating enough in cold weather.

As people develop hypothermia, their abilities to think and move are often lost slowly. In fact, they may even be unaware that they need emergency treatment.

Symptoms:

- Drowsiness
- Weakness and loss of coordination
- Pale and cold skin
- Confusion
- Uncontrollable shivering (although at extremely low body temperatures, shivering may stop)
- Slowed breathing or heart rate

Prevention:

1. Wear proper clothing in cold temperatures to protect your body. These include:

- a. Mittens (better than gloves).
 - b. Wind-proof, water-resistant, many-layered clothing.
 - c. Two pairs of socks (avoid cotton, wool is best).
 - d. Scarf and hat that cover the ears (to avoid major heat loss through the top of your head).
2. Avoid: Extremely cold temperature, especially with high winds and wet cloths.
 3. Poor circulation; tight clothing or boots, cramped positions, fatigue.

Before you spend time outside in the cold, do NOT drink alcohol or smoke. Drink plenty of fluids and get adequate food and rest.

Treatment:

- If any symptoms of hypothermia are present, especially confusion or changes in mental status, immediately call 911.
- If the person is unconscious, check airway, breathing, and circulation. If necessary, begin rescue breathing or CPR. If the victim is breathing fewer than 6 breaths per minute, begin rescue breathing.
- Take the person inside to room temperature and cover him or her with warm blankets. If going indoors is not possible, get the person out of the wind and use a blanket to provide insulation from the cold ground. Cover the person's head and neck to help retain body heat.
- Once inside, remove any wet or constricting clothes and replace them with dry clothing.
- Warm the person. If necessary, use your own body heat to aid the warming. Apply warm compresses to the neck, chest wall, and groin. If the person is alert and can easily swallow, give warm, sweetened, nonalcoholic fluids to aid the warming.
- Stay with the person until medical help arrives.

More information on Hypothermia can be found at:

<http://health.nytimes.com/health/guides/injury/hypothermia/overview.html>

Hot Weather Health Emergencies

Heat Stroke: Heat stroke occurs when the body is unable to regulate its temperature. The body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. Body temperature may rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not provided.

Warning signs of heat stroke vary but may include the following:

- An extremely high body temperature (above 103°F, orally)
- Red, hot, and dry skin (no sweating)
- Rapid, strong pulse
- Throbbing headache
- Dizziness
- Nausea
- Confusion
- Unconsciousness

Treatment:

1. Move to a shady area.
2. Cool the person rapidly using whatever methods you can.
3. Monitor body temperature, and continue cooling efforts until the body temperature drops to 101-102°F.
4. If emergency medical personnel are delayed, call the hospital emergency room for further instructions.

5. Do not give the victim fluids to drink.
6. Get medical assistance as soon as possible.

Heat Exhaustion: Heat exhaustion is a milder form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids. It is the body's response to an excessive loss of the water and salt contained in sweat.

Warning signs of heat exhaustion:

- Heavy sweating
- Paleness
- Muscle cramps
- Tiredness
- Weakness
- Dizziness
- Headache
- Nausea or vomiting
- Fainting

Treatment:

1. Cool, nonalcoholic beverages
2. Rest
3. Cool shower, bath, or sponge bath
4. If available move to an air-conditioned environment
5. Lightweight clothing

Heat Cramps: Heat cramps usually affect people who sweat a lot during strenuous activity. Heat cramps are muscle pains or spasms—usually in the abdomen, arms, or legs—that may occur in association with strenuous activity.

Treatment:

1. Stop activity, and sit quietly in a cool place.
2. Drink clear juice or a sports beverage.
3. Do not return to strenuous activity for a few hours after the cramps subside, because further exertion may lead to heat exhaustion or heat stroke.

Sunburn: Although the discomfort is usually minor and healing often occurs in about a week, a more severe sunburn may require medical attention. Skin becomes red, painful, and abnormally warm after sun exposure. Sunburn can be easily avoided by wearing sunscreen with proper SPF for your skin.

Treatment:

1. Avoid repeated sun exposure.
2. Apply cold compresses or immerse the sunburned area in cool water.
3. Apply Aloe or other sunburn specific product.
4. Apply moisturizing lotion to affected areas (only after initial burn cooled). Do not use salve, butter, or ointment.
5. Do not break blisters.

Heat Rash: Heat rash is a skin irritation caused by excessive sweating during hot, humid weather. Heat rash looks like a red cluster of pimples or small blisters. It is more likely to occur on the neck and upper chest, in the groin, under the breasts, and in elbow creases.

Treatment:

The best treatment for heat rash is to provide a cooler, less humid environment. Keep the affected area dry. Dusting powder may be used to increase comfort.

Dehydration: Dehydration occurs when a person's body loses more fluids (like sweat or urine) than he or she consumes.

Warning signs of dehydration:

- Frequent thirst
- Dry lips and tongue
- Muscle cramping
- Bright-colored or dark urine

Treatment::

If you think you are dehydrated, drink plenty of water and sports drinks that have added salts, and rest.

Avoiding Heat-related Illnesses:

1. *Drink plenty of fluids!* In hot weather, you need to drink more fluid than you would normally. Drink two to four glasses of cool fluids each hour and ones that do not contain alcohol, or large amounts of sugar--these actually cause you to lose more body fluid. Also avoid very cold drinks, because they can cause stomach cramps.
2. *Replace salts and minerals.* Heavy sweating removes salt and minerals from the body. A sports beverage can replace the salt and minerals you lose in sweat.
3. *Wear appropriate clothing and sunscreen.* Choose lightweight, light-colored, loose-fitting clothing that will cover most of your body. Wear a wide-brimmed hat along with sunglasses, and by putting on sunscreen of SPF 15 or higher (the most effective products say "broad spectrum" or "UVA/UVB protection" on their labels) 30 minutes prior to going out. Continue to reapply it according to the package directions.
4. *Pace yourself!* If you are not accustomed to working in a hot environment, start slowly and pick up the pace gradually. If exertion in the heat makes your heart pound and leaves you gasping for breath, STOP all activity. Get into a cool area or at least into the shade, and rest, especially if you become lightheaded, confused, weak, or faint.
5. *Use a buddy system.* When working in the heat, monitor the condition of your co-workers and have someone do the same for you. Heat-induced illness can cause a person to become confused or lose consciousness.
6. *Adjust to the environment.* Be aware that any sudden change in temperature, such as an early summer heat wave, will be stressful to your body. You will have a greater tolerance for heat if you limit your physical activity until you become accustomed to the heat. If you travel to a hotter climate, allow several days to become acclimated before attempting any vigorous exercise, and work up to it gradually.

More information on heat related illnesses can be found at:

http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp

<http://www.fayettehospital.org/oth/Page.asp?PageID=OTH000044>

http://www.orcbs.msu.edu/occupational/programs_guidelines/heat_stress/heatstressguide.pdf

Thunderstorms and Lightning

Stay Alert

Monitor local weather conditions regularly with a special weather radio or AM/FM radio.

- Recognize the signs of an oncoming thunder and lightning storm - towering clouds with a "cauliflower" shape, dark skies and distant rumbles of thunder or flashes of lightning. Do not wait for lightning to strike nearby before taking cover.

Seek Shelter

- Look for a large, enclosed building when a thunder or lightning storm threatens. That's the best choice.
- If you are in a car and it has a hard top, stay inside and keep the windows rolled up.
- Avoid small sheds and lean-tos or partial shelters, like pavilions.
- Stay at least a few feet away from open windows, sinks, toilets, tubs, showers, electric boxes and outlets, and appliances. Lightning can flow through these symptoms and "jump" to a person.
- Do not shower or take a bath during a thunder or lightning storm
- Avoid using regular telephones, except in an emergency. If lightning hits the telephone lines, it could flow to the phone. Cell or cordless phones, not connected to the building's wiring, are safe to use.
- If your skin tingles or your hair stands on the end, a lightning strike may be about to happen. Crouch down on the balls of your feet with your feet close together. Keep your hands on your knees and lower your head. Get as low as possible without touching your hands or knees to the ground. **DO NOT LIE DOWN!**
- If you are swimming, fishing or boating and there are clouds, dark skies and distant rumbles of thunder or flashes of lightning, get to land immediately and seek shelter.
- If you are on land, find a low spot away from trees, metal fences, pipes, tall or long objects.
- If you are in the woods, look for an area of shorter trees. Crouch down away from tree trunks.

Helping someone struck by lightning

When someone is struck by lightning, get emergency medical help as soon as possible. If more than one person is struck by lightning, treat those who are unconscious first. They are at greatest risk of dying. A person struck by lightning may appear dead, with no pulse or breath. Often the person can be revived with cardiopulmonary resuscitation (CPR). There is no danger to anyone helping a person who has been struck by lightning - no electric charge remains. CPR should be attempted immediately.

More information about Thunderstorms and Lightning:

<http://www.health.state.ny.us/environmental/emergency/weather/lightning/>

Wildlife Encounters and Handling Protocols

All personnel should be trained in proper techniques for wildlife handling before working with animals in the field. Protective clothing should be worn as appropriate for the species being handled (e.g., gloves to prevent exposure to bodily fluids, thick gloves to protect against bites and scratches, tyvek suits or respiratory protection when needed). Wash hands often (using soap and water or hand sanitizer) and do not eat, drink, or smoke while working with animals. Disinfect work areas after use. Certain precautions are recommended for specific wildlife groups.

Small mammals: Exposure to hantavirus (and potentially Hantavirus Pulmonary Syndrome) can result from handling mice. Field workers should wear gloves to prevent exposure to feces and urine, and work with the mouse downwind and/or wear respiratory protection if desired. Most exposure to hantavirus occurs in enclosed areas with large amounts of dried mouse

fecal material. Respiratory protection should be worn in such locations. Detailed information is available at the CDC web site (<http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5109a1.htm>).

Medium mammals: Medium sized mammals (especially raccoons) can carry rabies in the study area (also bats). All personnel who handle these animals should have pre-exposure vaccination against rabies before working with the animals in the field. In case of possible exposure, post-exposure vaccination is also needed. Additional information and updates are available on the CDC website (<http://198.246.98.21/rabies/>).

Amphibians: This project does not specifically involve amphibians, so there is no need for you to handle any amphibians. However, because some people will anyway, assume that anytime you touch a toad that your hands have been exposed to bufotoxins and therefore wash your hands thoroughly before touching food or any part of your face. Also, many insect repellants and other chemicals are fatal to amphibians, so do not touch them unless they are protected from you.

Reptiles: Remember that birds are reptiles, and assume that all reptiles have *Salmonella*. Wash your hands with disinfectant after handling any animal. Many reptiles will defecate on you when captured.

Turtles: This project does not specifically involve turtles, so there is no need for you to handle any turtles. You might check box turtles for ticks if you have time. Turtles can give a nasty bite and can scratch. If you must, handle small turtles carefully, but do not handle large turtles at all unless you have been trained in proper procedures. Wash your hands with disinfectant after handling any animal, paying special attention to any wounds you have received.

Snakes: This project does not specifically involve snakes, so there is no need for you to handle any snakes. Nevertheless, you should familiarize yourself with the snake species where you are working, and be able to identify venomous species quickly. If you work in an area where venomous snake occur, you should always be wearing closed shoes, socks, and long pants. Look carefully before putting your hands into a bucket trap. You may encounter snakes under cover boards, in pit fall traps, on roads, or by chance in the field. Under no circumstances should you attempt to contact, touch, handle, or move a snake unless you know it is safe. Under cover boards and in chance encounters, you can just leave snakes undisturbed. In pit fall traps, they must be removed, but under most circumstances they can remain in the buckets overnight if you do not have appropriate equipment with you at the time. It is recommend that each team working in an area with rattlesnakes, cottonmouths, and/or copperheads keep a 40 inch snake hook in their field gear, and a second, smaller snake hook if they are working where there are coral snakes. With a hook it is easy and safe to remove snakes from pit falls. Release snakes outside the grid.

Snake bite: Even a bite from a "harmless" snake can cause infection or allergic reaction in some people. While each individual may experience symptoms differently, common venomous snake bites symptoms are bloody wound discharge, fang marks in the skin and swelling at the site of the bite, severe localized pain, diarrhea, fainting, dizziness, blurred vision, excessive sweating, fever, thirst, nausea and vomiting, rapid pulse.

The majority of snake bites, even venomous snake bites, have few complications. Nevertheless, call for emergency assistance immediately if someone has been bitten by a snake that might be venomous. Responding quickly is crucial. While waiting for emergency assistance: Wash the bite with soap and water, immobilize the bitten area and keep it lower than the heart, cover the area with a clean, cool compress or a moist dressing to minimize swelling and discomfort, and monitor vital signs.

If you are unable to get the victim to medical care within 30 minutes, the American Red Cross recommends:

- Apply a bandage, wrapped two to four inches above the bite, to help slow the venom. This should not cut off the flow of blood from a vein or artery - the band should be loose enough to slip a finger under it.
- A suction device can be placed over the bite to help draw venom out of the wound without making cuts. These devices are often included in commercial snake bite kits.
- Do not use ice, alcohol (internal or external), a tourniquet, or attempt to suck venom by mouth, or cut the skin.

Lizards: Lizards can bite and scratch enough to draw blood but none of those we will encounter are dangerous. Usually it is more important to capture the lizard than to worry about a minor scratch. Wash your hands with disinfectant after handling any animal, paying special attention to any wounds you have received.

Birds: Highly pathogenic avian influenza (HPAI, e.g., H5N1) has not been reported in the study area, but it could appear during the study. Birds should be handled with care, with the bird downwind if possible, and examination gloves should be worn when collecting blood or other body fluids. Respiratory protection (e.g., N95 face masks) is also recommended for close work with wild birds. Additional information is available online from the USGS National Wildlife Health Center (http://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_05_03.jsp).

More information on safe handling of animals can be found at:
<http://safetyservices.ucdavis.edu/occupational-health-services/acu/educational-materials/zoonosis-information>

Working alone

A person is considered “working alone” if the individual is working by his/herself such that assistance is not readily available should some injury, illness, or emergency arises.

Please be aware of the potential hazards of working alone.

- Always carry some sort of communication when working alone (i.e. cell phone or “walkie-talkie”)
- Always let someone know where you are going and when you will be back.
- Know where the first aid kit is.
- Know take proper safety precautions and bring PPE

Allergies, Asthma, and other Medications

It is important to let your supervisors know if you have any serious medical conditions requiring certain medications or care. Let your supervisors know of any allergies (food and insect bite/stings) you have, medications you make take, and where they can find them if needed.

Sharing this information is important for your safety and for the safety of all people working on this project.

Health Care Facility Locations

First aid kits

First aid kits will be available at every field site and you should always know where to find it. Please check with your supervisor to find out its location at your study site.

Hospitals, Urgent Care, and Doctors

Each institution involved with this study will have its own set of protocols and locations for seeking medical attention. Known where the closest emergency facilities are located BEFORE you begin field work and where to seek medical attention for non-life threatening medical situations. Please check with your supervisor for this information.

Safety Training

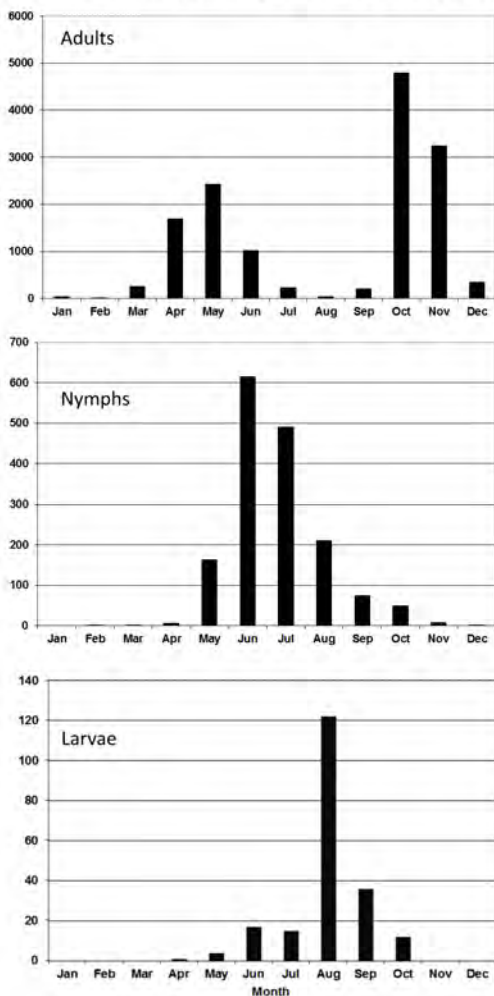
Each institution will also have a set of safety training courses (blood borne pathogens, respirator fit, first aid, CPR, etc...) needed to be completed before field work begins. Please check with your supervisor to find what courses you need to complete.

Protocol for Questing Tick Surveys April 2019

Materials

This method of surveying for ticks, at its most basic, does not require much in the way of technology. A tick flag or drag is a piece of cloth attached to a pole that is spread over the ground as the surveyor walks. Many studies record the use of either a heavy flannel or corduroy as the material to construct flags with. These two fabrics in many ways mimic the hair of a mammalian host that the tick might be seeking (flannel because of the fine hairs, corduroy because of the ribbing). In our studies, although we do occasionally use flannel, corduroy has proven to be more effective simply because it seems more durable in the field, especially after the fabric gets wet.

Seasonality of *Ixodes scapularis* (the 'deer' or black-legged tick)



The size of the flag is ~ 1 meter square.

Other items that are handy to have are a GPS unit for marking collections and a thermometer, which should be kept nearby for recording temperature while surveying.

Methods

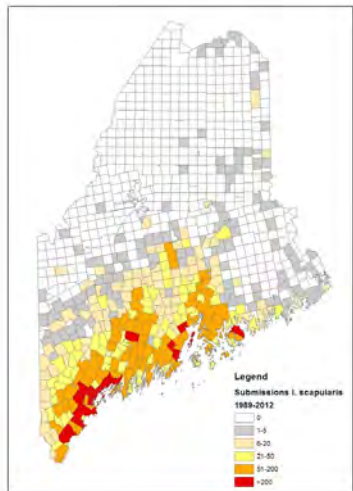
To flag for ticks, aim to conduct collections on a day of good weather. Although the particulars for each tick species are different, these instructions will focus on deer ticks, the vector of Lyme disease. Flagging for ticks is not reliable during the rain or when temperatures are above 35°C or below 10°C. Likewise, days with lower wind produce better results. Higher winds desiccate ticks and lift the flag from the ground, where ticks might be found. Be sure to maximize the season to your advantage as well. Figure 1 illustrates the seasons of deer ticks in Maine but generally, nymphs have a seasonal peak of late June to mid- July while adult ticks peak in mid- to later October.

Dragging vs. Flagging?

Dragging is essentially pulling the cloth behind you, and is used in parts of the northeast where open or park-like vegetation is present. Dragging becomes problematical if shrubs appear in the understory. Flagging allows more flexibility in these circumstances, with the flag able to get around or underneath shrubs. Because many of our sampling sites have dense vegetation, tick flagging has been the preferred method.

Begin flagging by placing the flag behind you and on vegetation. It is important to pull the flag alongside with the full flag on the ground. Tick flagging may be used to measure tick abundance in two ways, either spatially or temporally. Spatial abundance for ticks will occur along a measured distance (ticks per square meter, linear meter, etc). In this instance, a study grid or transect is usually measured out. Common distances used are 10-meter or 100-meter transects. In our studies, we have frequently employed the method of flagging for one full minute, then examining the flag for ticks, along a transect. Many investigators employ the nebulous phrase of “walking at a leisurely pace” but generally this comes out to 10-20 meters in a minute of flagging.

Temporally, ticks are usually measured on a basis of allotted time (ticks/hour). In this case, surveyors may take one full minute of flagging, examine the flag, remove ticks, then flag for another full minute etc. Unlike transect surveys, this type of sampling is useful when exploring new areas for ticks and can be done along paths, roads, etc. Two sample datasheets are provided that we use for both types of flagging.



Where to flag?

Deer ticks are often found in association with second-growth deciduous forest (successional fields, abandoned orchards, oak forests, etc). In general, the presence of a moderate to dense shrub layer indicates better habitat for deer ticks. Too, moisture plays a factor. Deer ticks desiccate easily, so a mesic habitat is best, although areas adjacent to wetlands might also be productive (alder swamps) if standing water *is not* present. In short, habitat that is good for the tick’s hosts (mice, birds, & deer) is also good for the ticks. It will generally be harder to collect ticks in areas where they are just emerging as opposed to regions of the state where they are well-established (Fig.2).

Containing the ticks

These ticks are being collected for identification and the detection of DNA based pathogens (Lyme, Anaplasma, etc). As such, these ticks will be collected in vials containing 90% HPLC ethanol. Kept in alcohol, ticks will not break up into pieces, and may stay whole for years.

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Maine has many species of ticks. Some you might encounter in the field include:

Ixodes scapularis (previously *Ixodes dammini*), the “deer tick”, also called the “black-legged tick”, is the principal vector of the Lyme disease spirochete in the northeastern United States. At some sites in Maine, particularly in southern coastal areas, over half of the adult ticks contain spirochetes, although infection rates vary considerably, even in adjacent areas. Infection rates of questing nymphs are typically somewhat lower. Immature stages feed on small mammals such as mice, while adult ticks prefer deer, but all stages may feed on humans and domestic animals. Although rare in Maine, the agents of two other infectious diseases, human granulocytic anaplasmosis and babesiosis, may also be found in this species of tick. Although male deer ticks can be infected, they do not engorge with blood and are therefore not thought to be vectors of Lyme disease.

Ixodes cookei, the "woodchuck tick" is widely distributed in Maine and is the second most common species of *Ixodes* found. It has not been associated with Lyme disease transmission. *Ixodes cookei* usually feeds on wild animals, such as woodchucks and raccoons, but will also feed readily on humans and domestic animals. This tick is known to be a vector of Powassan virus. Rare cases of encephalitis have occurred in Maine in people infected with Powassan virus.

Ixodes marxi, the "squirrel tick", has not been associated with Lyme disease. It is commonly found on squirrels but will occasionally bite humans.

Ixodes muris is occasionally found in Maine. Usually it is found only on voles and mice, but it may bite humans, cats, dogs, and birds. A recent report indicates that *I. muris* is a weak vector of Lyme disease. We have associated its bite with a reaction in dogs, cats and other domestic animals characterized by pain, swelling, fever, lethargy and loss of appetite. If this reaction is observed we are very interested in receiving the tick alive and with relevant information.

Ixodes angustus is usually found only on voles and mice and is common in many parts of Maine, but it is very rarely found on humans or domestic animals

Dermacentor variabilis, the "American dog tick", is not a vector of Lyme disease. This tick is particularly abundant in southwestern Maine but its range has been expanding in recent years. Immature stages feed on voles and other small rodents, but adults are often found on humans, dogs, and other domestic animals. The adults, found from May through July and rarely later in the season, are larger than *Ixodes* ticks and can be distinguished by characteristic white markings. This tick is the vector of Rocky Mountain spotted fever in the eastern United States. There have not been cases of Rocky Mountain spotted fever reported from Maine.

Dermacentor albipictus, the "winter tick" or “moose tick”, is found on moose and deer and occasionally on horses, cows, dogs and humans, particularly in central and northern Maine. Large numbers of the tiny larvae may be encountered in the fall, particularly in habitat where moose are found. This tick has not been associated with Lyme disease.

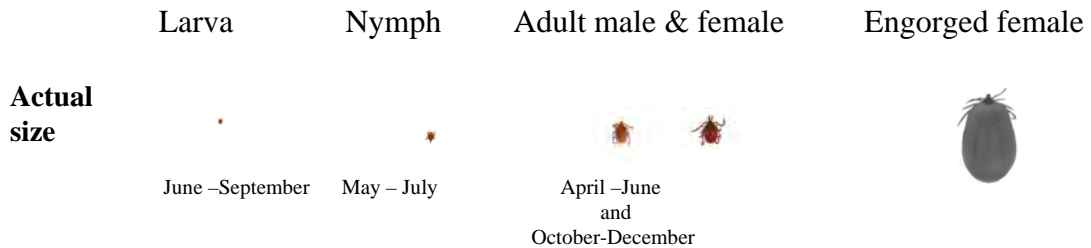
Haemaphysalis leporispalustris, the "rabbit tick", is usually found only on rabbits and birds. Although it has rarely been reported to be infected with the Lyme disease bacteria, it has not been associated with Lyme disease in humans.

Amblyomma americanum, the "Lone Star tick", is most often found on people traveling from states to the south where it is very common, but is becoming more frequently acquired in Maine. It has been shown to carry a different spirochete, which in humans may produce a rash and some symptoms similar to Lyme disease.

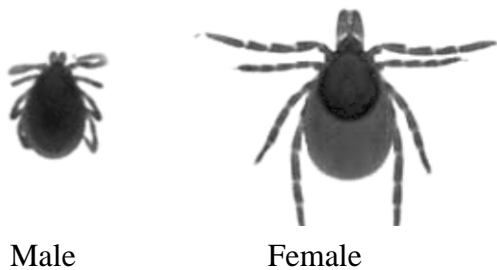
Other species of *Ixodes*, *I. brunneus*, (found on migratory birds), *I. dentatus*, (found on rabbits and hares), *I. uriae*, (found on marine birds) and *Ixodes gregsoni* (found on mink, weasel and marten) have occurred in Maine. The “bird tick” *Haemaphysalis chordeilis*, *Ixodes banksi* (found on beaver and muskrat) have not yet been found in Maine but may occur here. There is no record of soft ticks, Family Argasidae, in Maine.

THE DEER TICK

Ixodes scapularis



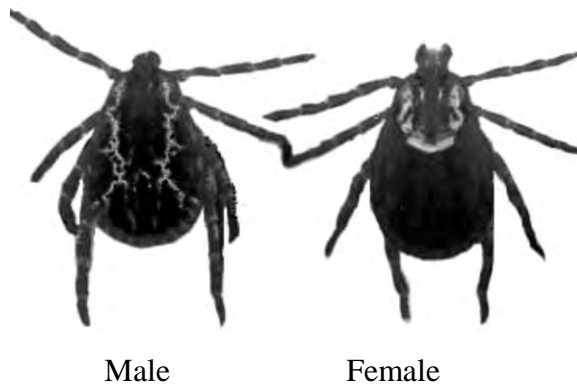
Enlarged adult deer ticks



THE DOG TICK

Dermacentor variabilis, the American dog tick, **which does not transmit Lyme disease**, is commonly found in spring and early summer. Adult stages have **characteristic whitish markings** that can usually be seen in bright light even on engorged females.

Enlarged adult dog ticks



Actual size



Collector: _____

Collection Date: _____

Town: _____

Acc.# _____

Date: _____

MMC Lab Only

This number will be assigned at MMCRI. Please leave blank.

Unique for each vial. Include initials, site name, vial letter. Ex. EFH Sprauge Prop. A

Any additional relevant information

Lab Results				Vial Letter
♀	♂	Nymphs	Larvae	Identification

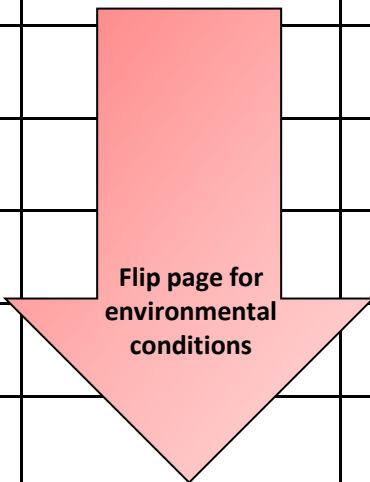
Site Name	** Field ID # (code on vials)	Time Sampling (Total Time [min])	Remarks	# Field Ticks
-----------	-------------------------------	----------------------------------	---------	---------------

Assign each site a unique name during first visit. Keep consistent

Record time spent collecting for each vial in minutes.

Number of ticks collected per vial (10 ticks/vial MAX)

DO NOT write in this section!
This is intended for lab identification at MMCRI



Conditions

Cloud Cover: Clear ____ Overcast ____ Partial ____

Live vials: Y N

Wet Soils: Y N

Record temperature in Celsius

Temp: _____

Wind Speed: _____

Wind Direction: _____

Geocode Information

Latitude

Record latitude and longitude of the site on your first collection date.

Longitude

Notes:

Collector: _____

Collection Date: _____

Town: _____

Acc.# _____

Date: _____

MMC Lab Only

Site Name	** Field ID # (code on vials)	Time Sampling (Total Time [min])	Remarks	# Field Ticks	Lab Results				Vial Letter
					♀	♂	N y m p h s	L a r v a e	Identification

Conditions

Live vials: Y N

Cloud Cover: Clear ____ Overcast ____ Partial ____

Wet Soils: Y N

Wind Speed: _____

Temp: _____

Wind Direction: _____

Geocode Information

Latitude

Longitude

Notes:

Surveillance for *Ixodes scapularis* and pathogens found in this tick species in the United States

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Intended Audience and Objectives

Public health entomologists/biologists are the intended audience for this document.

The geographic distributions of *Ixodes scapularis* (the blacklegged tick or deer tick) and its associated pathogens are expanding, putting an increasing number of Americans at risk for acquiring Lyme disease, anaplasmosis, babesiosis, *Borrelia miyamotoi* disease and other, less common *I. scapularis*-associated illnesses. The primary objective of this document is to provide guidance for surveillance of *I. scapularis* and pathogens found in this tick species in order to provide health care providers and the public with current and accurate information on where this tick occurs, when the different life stages are most active during the year, and which human pathogens are of greatest local concern.

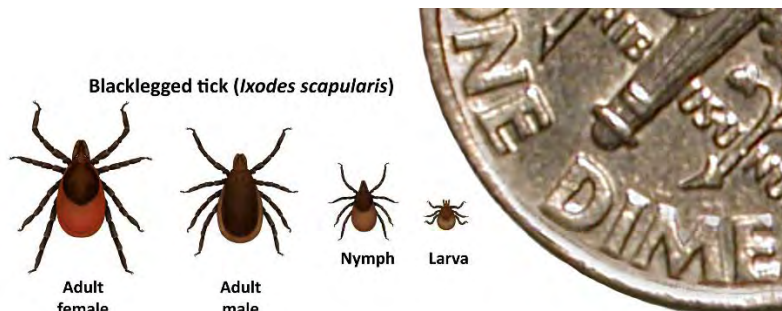
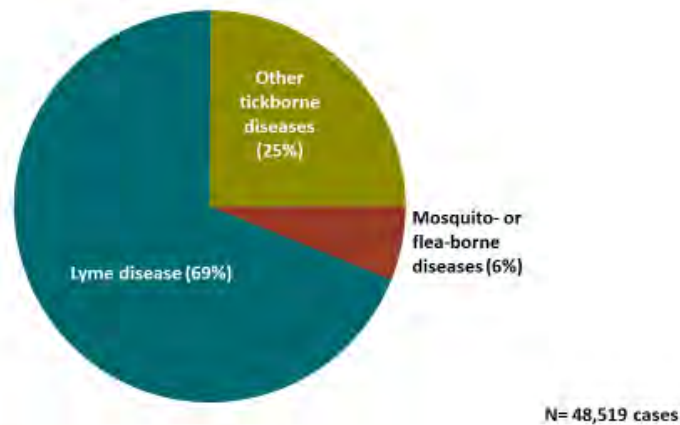


Figure 1. Active life stages of the blacklegged tick, *Ixodes scapularis*.

Public Health Importance of *Ixodes scapularis*

Of the nearly 50,000 cases of locally-acquired vector-borne disease cases reported annually from states and the District of Columbia to the Centers for Disease Control and Prevention, nearly 95% are caused by pathogens spread by ticks ((Adams et al. 2016); Figure 2). The majority are Lyme disease cases, with approximately 30,000 cases reported annually, which is an approximately 10-fold under-estimate of the nearly 300,000 Lyme disease cases diagnosed annually (Hinckley et al. 2014, Nelson et al. 2015). Since becoming a notifiable condition in 1991, the number of Lyme disease cases reported annually has roughly tripled and cases have been reported over an expanding geographical region (Kugeler et al. 2015, Mead 2015) (Figure 3).



Cases of Nationally Notifiable Vector-borne Diseases Reported in the U.S., 2014

Figure 2. Reported vector-borne diseases, United States, 2014.

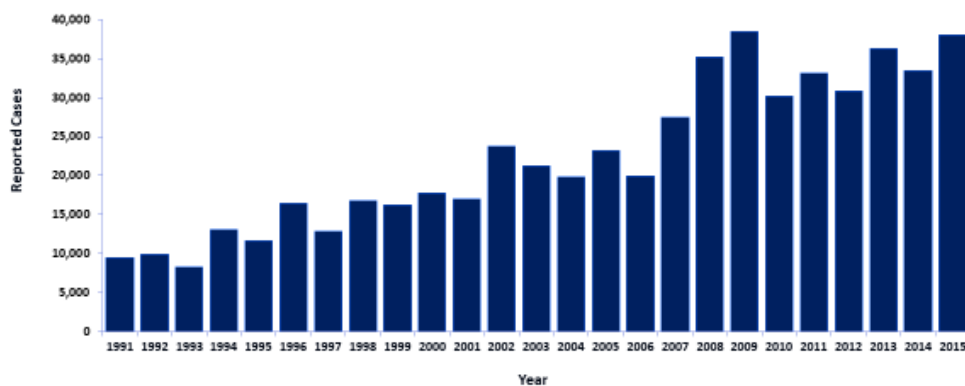


Figure 3. Number of Lyme disease cases reported per year.

Since 1970, when *Babesia microti* was first reported to be a human pathogen, six additional *I. scapularis*-borne human pathogens have been described (Eisen and Eisen 2018) (Table 1; Figure 4). Moreover, annual case counts have increased over time for notifiable *I. scapularis*-associated diseases, including Lyme disease, anaplasmosis and babesiosis (Eisen et al. 2017). In the northern parts of the tick's range, *I. scapularis* nymphs are considered the primary vectors of the agents causing Lyme disease, anaplasmosis and babesiosis.

Table 1. Pathogens transmitted by *Ixodes scapularis*, life stages that can be infected, and the human diseases caused by infection with these pathogens.

Disease	Pathogen(s)	Life stages infected
Anaplasmosis	<i>Anaplasma phagocytophilum</i>	Nymphs, Adults
Babesiosis	<i>Babesia microti</i>	Nymphs, Adults
<i>Borrelia miyamotoi</i> disease	<i>Borrelia miyamotoi</i>	Larvae, Nymphs, Adults
Ehrlichiosis	<i>Ehrlichia muris euclairensis</i>	Nymphs, Adults
Lyme disease	<i>Borrelia burgdorferi sensu stricto</i> , <i>Borrelia mayonii</i>	Nymphs, Adults
Powassan virus disease	Powassan virus (lineage II/deer tick lineage)	Larvae, Nymphs, Adults

Ixodes scapularis: an increasing public health concern



Eisen, RU and Eisen, L. Trends in Parasitology, 2018, 34:295-309.

Figure 4. Timeline showing when various *I. scapularis*-borne agents were demonstrated to be human pathogens.

Tick surveillance is not standardized or routine. Nonetheless, available collection records indicate that the geographic distribution of *I. scapularis* has expanded markedly over the past two decades. Specifically, from 1996 through 2015 the number of counties in which *I. scapularis* is considered to be established has more than doubled (Eisen et al. 2016) (Figure 5). Moreover, recent models indicate that potentially suitable habitat for the blacklegged tick is wide-spread in the eastern United States, suggesting that either the distribution of the tick is currently under-reported or there is potential for additional range expansion (Hahn et al. 2016, 2017) (Figure 6).

Reported Distribution of *I. scapularis* has expanded

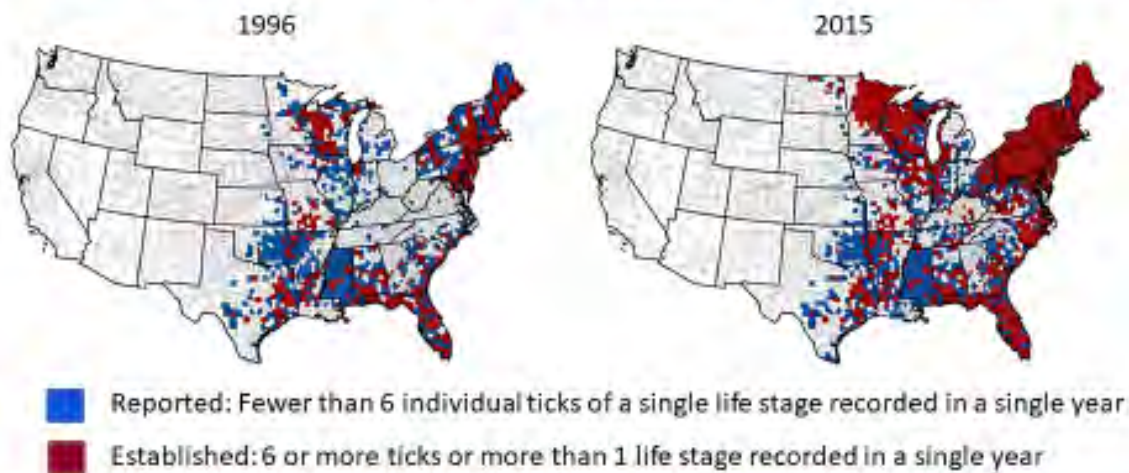
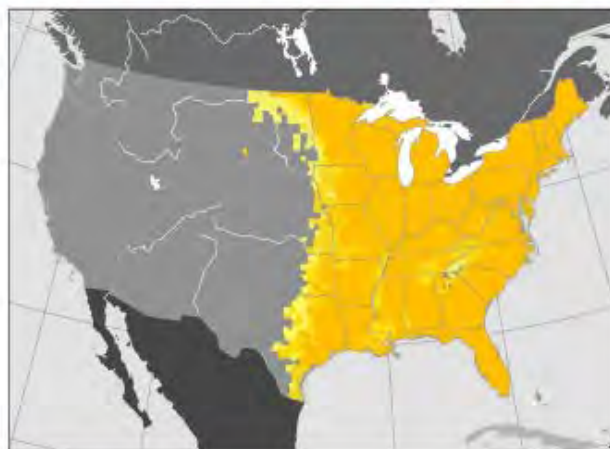


Figure 5. Distribution of counties with reported or established populations of *I. scapularis* in 1996 (Dennis et al. 1998) and 2015 (Eisen et al. 2016).

Distribution of suitable habitat, *Ixodes scapularis*



Hahn MB et al. J Med Entomol 2017;54:1104-1106.

Figure 6. Distribution of potentially suitable habitat for *I. scapularis* (Hahn et al. 2016, 2017).

Because the distributions of ticks and tick-borne pathogens change over time, human risk of exposure to ticks and their associated pathogens also change. Tick surveillance is intended to monitor changes in the distribution and abundance of ticks and the presence and prevalence of tick-borne pathogens in order to provide actionable, evidence-based information to clinicians, the public and public health policy makers. Key questions address when and where humans are at risk for exposure to ticks and tick-borne pathogens.

Life Cycle of *Ixodes scapularis*

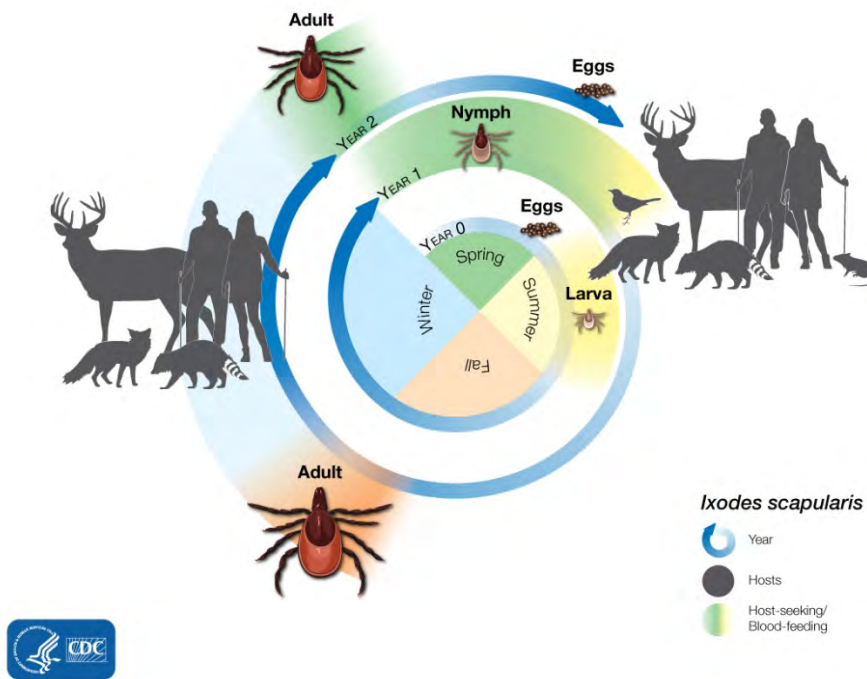


Figure 6. Generalized life cycle of *Ixodes scapularis*.

Ixodes scapularis is a primarily woodland-associated tick. It has a 2-3 year life cycle consisting of four life stages: egg, larva, nymph, and adult (Yuval and Spielman 1990). Larval and nymphal ticks each take a single bloodmeal before molting to the next life stage and may acquire human pathogens through blood-feeding on infectious hosts or by co-feeding transmission (infected and uninfected ticks feeding in close proximity; pathogen transmission can occur in the absence of a systemic host infection). Larvae and nymphs feed primarily on small and medium-sized mammals including, but not limited to, white-footed mice, chipmunks, voles, and shrews. However, they can also infest birds, lizards and larger mammals including deer. Female ticks take a single bloodmeal (most commonly from deer but also from other medium-sized and large mammals), lay a large batch of eggs and then die. Male ticks do not blood-feed. With the exception of Powassan virus and the relapsing fever spirochete *Borrelia miyamotoi*, *I. scapularis*-borne human pathogens have not been demonstrated to be transmitted transovarially (vertical transmission from infected females to their offspring) (Costero and Grayson 1996, Rollend et al. 2013). The other *I. scapularis*-borne pathogens are maintained via horizontal transmission, where infected nymphal or female ticks transmit the agents to vertebrate hosts, and naïve larval or nymphal ticks then acquire pathogens while feeding on the infectious hosts.

Adults are active mainly in the fall and spring, but can be active also in the winter months in settings where daytime temperatures are above freezing and there is little to no snow cover, allowing for tick activity. Females

typically lay eggs in the late spring but hatched larvae do not seek hosts actively until months later, in summer. After blood-feeding, larvae over-winter and molt to nymphs. Nymphs begin host-seeking in the spring with peak activity typically observed from May through July, depending on location. After blood-feeding, nymphs molt to adults and seek hosts in the fall (Figure 6). In some localities, particularly in colder-regions, the life cycle may be extended to 3-4 years (Hamer et al. 2012a).

Tick Surveillance Objectives

Tick surveillance is intended to monitor changes in the distribution and abundance of ticks and the presence and prevalence of tickborne pathogens in order to provide actionable, evidence-based information to clinicians, the public and public health policy makers. Key questions address when and where humans are at risk for exposure to ticks and tickborne pathogens.

Specifically, at the spatial scale of U.S. counties, CDC aims to:

- 1) classify county status for *I. scapularis*: established, reported, or no data available
- 2) classify county status for presence of specific pathogens in *I. scapularis* ticks: present or no data available

Additional objectives include the following: (3) generate estimates for local prevalence of specific pathogens in relevant *I. scapularis* life stages and local density of host-seeking (infected) nymphs or adults, which then can be aggregated and displayed at county scale; and (4) document host-seeking phenology of all *I. scapularis* life stages in strategic locations across the tick's range and display this information at state or regional spatial scales. For more details on tick sampling methods, please see the "Tick Collection Methods" section of this document.

Objective 1 provides the most basic information for risk assessment (i.e., is the tick known to be reported or established in the county of interest?). Presence of a vector tick species does not necessarily indicate presence of human pathogens, and therefore, Objective 2 provides additional information about potential exposure to *I. scapularis*-borne human pathogens. While documenting the presence of a human pathogen in a county is useful, estimates of infection prevalence in host-seeking ticks (the percentage of ticks tested that are infected) provides a better indication of the likelihood that ticks encountered by humans may be infected with the pathogen of interest.

Tick-borne infections in humans arise following the bite of infected ticks. Therefore, a measure that captures the abundance of host-seeking ticks, often referred to as density of host-seeking nymphs (DON) or females (DOF), provides better information on the likelihood of human encounters than simple measures of tick presence or establishment. That is, although human behavior affects the likelihood of human-tick encounters, assuming similar human behavior across tick habitats, human-tick encounters are likely to increase with increasing DON or DOF. Overall, acarological risk measures such as pursued in Objective 3 that combine the density of host-seeking nymphs and local estimates of infection prevalence (often referred to as the density of host-seeking infected nymphs or DIN) provide better estimates of human encounters with infected host-seeking nymphs than simple measures of tick/pathogen presence or abundance (Mather et al. 1996, Pepin et al. 2012, Eisen and Eisen 2016). Similar arguments can be made for the relative value of estimating infection prevalence in and abundance of female ticks, particularly in areas of the eastern United States where host-seeking behavior of nymphs limits human-tick contact and where human encounters with female ticks are more common than nymphal tick encounters (Stromdahl and Hickling 2012, Arsnoe et al. 2015, Hickling et al. 2018).

Finally, recognizing that acarological risk measures often differ by life stage, documenting when each life stage is actively host-seeking aids in identifying when humans are at greatest risk for exposure to tick bites and tick-borne pathogens. Therefore, Objective 4 aims to document host-seeking phenology of larval, nymphal and adult *I. scapularis* ticks.

Criteria for classifying county establishment status for *I. scapularis* and estimating infection prevalence, densities of host-seeking (infected) ticks and documenting host-seeking phenology are summarized below. CDC aims to collate tick surveillance data to make county-level data available to the public on national-scale maps that will be displayed on the CDC website. State health departments and other CDC public health partners may submit data through ArboNET. For additional information on ArboNET submissions, please see <https://www.cdc.gov/arboNET> or contact us at ticksurveillance@cdc.gov. Additional information can be found in subsequent sections of this document.

Classify County Status for *Ixodes scapularis*

- **Objective: Update the *I. scapularis* distribution map based on county level establishment criteria** (Dennis et al. 1998). Data will be displayed at: <https://www.cdc.gov/ticks/surveillance/>
- County status classification criteria are as follows:
 - Established: ≥ 6 *I. scapularis* of a single life stage or > 1 life stage collected per county within a 12-month period
 - Reported: < 6 *I. scapularis* of a single life stage collected per county within a 12-month period
 - No records
- For this objective and all others, ticks should be identified to species and life stage using published taxonomic keys (e.g., Keirans and Clifford 1978, Durden and Keirans 1996)
- For counties reporting new records, voucher specimens supporting the status change should be archived.
- Because we have greater confidence in presence than absence data, after a county is classified as “established,” it will remain so and will not regress to “reported” or “no records” status. Counties classified as “reported” may progress to “established” and counties classified as “no records” may progress to “reported” or “established” when criteria for those classifications have been met. After a county is classified as “established” surveillance efforts should focus instead on pathogen presence and prevalence and assessments of acarological risk of human exposure to *I. scapularis*-borne pathogens.

Identify Presence and Prevalence of Human Pathogens in *Ixodes scapularis* Ticks

- **Objective: Map the county level distribution of human pathogens in *I. scapularis* ticks or in natural hosts for this tick.** Data will be displayed at: <https://www.cdc.gov/ticks/surveillance/>
- Data to be mapped include:
 - Shading counties where the *I. scapularis*-borne pathogen of interest has been detected in *I. scapularis* ticks or in natural hosts of *I. scapularis*. This is a simple binary response (pathogen detected or not). Pathogen detection assays must meet minimal assay requirements described in “Minimum Criteria for Acceptability of Pathogen Detection Assay.” Samples from which potential exposure could have occurred in other counties will not be included (ticks from people or pets are not acceptable unless travel outside of the county within 10 days prior to detection of the tick can be ruled out) but infection in ticks collected from the environment (by dragging, flagging, walking, or trapping) or infection in ticks collected from trapped mammals (provided

- their home ranges are limited enough to infer exposure occurred in the county of interest) are acceptable for documenting presence of pathogens in a county.
- For counties where the pathogen of interest already has been detected in *I. scapularis* ticks (this information will be updated annually on <https://www.cdc.gov/ticks/surveillance/>), pathogen prevalence and 95% confidence intervals can be estimated per relevant tick life stage and per collection site in Excel using the [Pooled Infection Rate Add-In](#). Inclusion of confidence intervals is recommended in addition to point estimates in order to convey the level of uncertainty in point estimates. Confidence intervals can be interpreted as “there is a 95% probability that the true infection prevalence is between [insert lower confidence limit] and [insert upper confidence limit].” As sample sizes increase, the width of the confidence intervals decreases. Typically, testing 50 nymphal or adult ticks per site gives reasonable confidence limits for most *I. scapularis*-borne pathogens. For example, when 10 of 50 tested ticks are positive, infection prevalence is estimated as 20% (95%CI: 11-33%). Likewise, if no ticks are infected in a sample of 25 or 50 ticks, infection prevalence could be as high as 13% or 7%, respectively. Although infection prevalence can be calculated for smaller sample sizes, uncertainty in estimates is high; pathogen prevalence will not be displayed unless a minimum of 25 ticks have been tested within a given county for a given life stage. Infection prevalence and associated 95% confidence intervals will be calculated by CDC for data submitted to ArboNET.

Estimate the Density of Host-Seeking (Infected) *Ixodes scapularis* Ticks

For each of the objectives listed below, when sufficient data have been submitted to ArboNET, CDC will post annual surveillance reports at <https://www.cdc.gov/ticks/surveillance/>.

- **Objective: Map the county level density of host-seeking *I. scapularis* nymphs.**
 - Data display and minimal sampling requirements include:
 - Displayed in categories based on number of host-seeking nymphs collected per 100 m² or displayed as the inverse showing the distance covered before expected encounter with a nymph.
 - Requires at least 750 m² drag sampled per site for density estimate; drags should be inspected for ticks at least every 10-20 m; sampling should be timed to coincide with the peak in nymphal host-seeking activity; ideally, estimates of nymphal density should be based on at least 2-3 visits to the site within the perceived seasonal peak in host-seeking (Dobson 2013). For more information on sampling, please see: “Estimating the Density of Host-seeking (Infected) *Ixodes scapularis* ticks.”
 - Requires at least 1 site sampled per county, otherwise county will be displayed as “no records.”
 - In ecologically diverse counties, sampling at multiple sites representing the range in suitable habitat for the tick is recommended; when multiple sites are sampled per county, average and range will be accessible.
 - Although timed sampling (e.g., dragging for fixed amounts of time, rather than fixed distances) is a valid sampling approach, in the interest of comparability among localities, we will only accept distance-based assessments of DON and DIN for ArboNET.
- **Objective: Map the county level density of host-seeking infected *I. scapularis* nymphs.**
 - Data display and minimal sampling requirements include:

- Displayed in categories based on number of host-seeking infected nymphs collected per 100 m² or displayed as the inverse showing the distance covered before expected encounter with an infected nymph.
 - Calculated by multiplying the estimated density of nymphs by infection prevalence (both described above).
 - When multiple sites are sampled per county, average and range will be accessible.
- **Objective: Map the county level density of host-seeking *I. scapularis* females.**
 - Data display and minimal sampling requirements include:
 - Displayed in categories based on number of host-seeking females collected per 100 m² (DOF) or displayed as the inverse showing the distance covered before expected encounter with a female tick.
 - Requires at least 750 m² drag sampled or flagged per site for density estimate; because adults drop off more readily than nymphs, drags or flags should be inspected for ticks every 10 m; sampling should be timed to coincide with the peak in adult host-seeking activity; ideally, estimates of female density should be based on at least 2-3 visits to the site within the perceived seasonal peak in host-seeking.
 - Requires at least 1 site sampled per county, otherwise county will be displayed as “no records.”
 - Sampling at three or more sites per county is recommended; when multiple sites are sampled per county, average and range will be accessible.
 - In ecologically diverse counties, sampling at multiple sites representing the range in suitable habitat for the tick is recommended; when multiple sites are sampled per county, average and range will be accessible.
 - Although timed sampling (e.g., dragging for fixed amounts of time, rather than fixed distances) is a valid sampling approach, in the interest of comparability among localities, we will only accept distance-based assessments of DOF and DIF for ArboNET.
- **Objective: Map the county level density of infected host-seeking *I. scapularis* females.**
 - Data display and minimal sampling requirements include:
 - Displayed in categories based on number of host-seeking infected females collected per 100 m² or displayed as the inverse showing the distance covered before expected encounter with an infected female tick.
 - Calculated by multiplying the estimated density of females by infection prevalence in tested adult ticks (both described above).
 - When multiple sites are sampled per county, average and range will be accessible

Document Host-Seeking Phenology of *Ixodes scapularis* Ticks

- **Objective: Describe when *I. scapularis* ticks are actively host-seeking (phenology).**
- Data display and minimal sampling requirements include:
 - Displayed as state (or neighboring state) records of tick activity by life stage. This will be a categorical response (records of the tick being active for a particular month of the year or not, or no records if phenology studies were not reported from a particular state or its neighbor).
 - Based on weekly, bi-weekly, or monthly non-removal sampling over a 12-month period, excluding winter months too cold for tick activity in colder parts of the tick’s range. For more information, see “Describing Host-Seeking Phenology of *Ixodes scapularis* Ticks.”

Tick Collection Methods

Several methods can be used to collect *I. scapularis* ticks, however, some are better suited than others for addressing specific surveillance objectives (Table 2). For example, all of the methods described below can be used to demonstrate the presence of *I. scapularis* or *I. scapularis*-borne pathogens in a county of interest. Demonstrating that both the vector and pathogen are present within a county provides fundamental data for assessing the risk of human encounters with infected ticks. However, for Lyme disease, which is most commonly acquired through the bite of infected nymphs, estimates of the density of *Borrelia burgdorferi* sensu stricto (s.s.)-infected host-seeking nymphs are a better predictor of human Lyme disease occurrence than simple measures of the presence of the tick or pathogen, or quantitative measures of the density of host-seeking nymphs or the infection prevalence in the nymphs alone (Mather et al. 1996, Stafford et al. 1998, Pepin et al. 2012, Eisen and Eisen 2016)) Drag sampling is the single most reliable method for quantifying the density of host-seeking (infected) *I. scapularis* nymphs (Falco and Fish 1992).

Table 2. Summary of tick collection methods that are acceptable or unacceptable for each surveillance objective.

Collection Method	Objective: Classify county status	Objective: Presence/Prevalence of pathogens in ticks	Objective: DON/DIN or DOF/DIF	Objective: Phenology
Dragging/Flagging	Acceptable	Acceptable	Acceptable	Acceptable
Walking	Acceptable	Acceptable	Not Acceptable	Acceptable
CO2 traps	Acceptable	Acceptable for presence, but not prevalence	Not Acceptable	Not Acceptable
Ticks collected from deer	Acceptable	Acceptable for presence, but not prevalence	Not Acceptable	Not Acceptable
Ticks collected from small- or medium-sized mammals, birds, lizards	Acceptable	Acceptable for presence, but not prevalence	Not Acceptable	Acceptable
Ticks from people/pets	Acceptable, if travel history is accounted for	Acceptable for presence, but not prevalence	Not Acceptable	Not Acceptable

Drag Sampling or Flagging

Background and methods

Drag sampling and flagging are similar methods used to collect host-seeking ticks (Daniels and Fish 1990, Carroll and Schmidtman 1992, Falco and Fish 1992). Both typically use a 1 m wide by 1 m long flannel, denim or other sturdy white fabric with sufficient texture for ticks to grip. To increase contact between the fabric and vegetation, weights (e.g., metal washers or chains) may be sewn into the trailing edge and/or the trailing edge may be cut into “fingers” or “strips” rather than using a solid cloth. Modified handles (e.g. wooden dowel or rope) may be used to increase maneuverability. For additional details on how to make tick drags, please see the

“How to Make Tick Drags” supplemental information. The tick drag or flag is moved horizontally across vegetation or leaf litter (drag) or more vertically (flag). This method of sampling provides good spatial precision for documenting the occurrence and/or abundance of ticks in a county.

Acceptable to use to address the following key surveillance objectives:

- Classifying county status for *Ixodes scapularis*
- Identifying presence and prevalence of pathogens in ticks (all active life stages)
- Estimating the density of host-seeking (infected) nymphs or females; although either dragging or flagging can be used, horizontal distance sampled should be reported to ArboNET
- Documenting host-seeking phenology

Walking Sampling

Background and methods

Walking sampling entails an investigator walking through tick habitat and checking his/her clothing and body for crawling ticks (Carey et al. 1980, Schulze et al. 1986). The distance walked and the number of ticks encountered per distance should be recorded. Investigators typically wear light-colored clothing to more easily detect ticks on clothing. Long sleeves and long pants, tucked into socks, are required to reduce the risk for tick bites. This method of collection may be more accurate for assessing human-tick encounters than drag sampling, flagging or collection from hosts or carbon dioxide baited traps, but more so in areas with emergent vegetation for ticks to ascend than in leaf litter where tick exposures more commonly may be related to human behaviors exposing legs or hands/arms directly to the substrate (e.g., when playing or doing yardwork). Walking sampling is similar in efficiency to flagging or dragging for adult ticks, but apparently yields fewer nymphs than drag sampling or flagging (Ginsberg and Ewing 1989). This method of sampling provides good spatial precision for documenting the occurrence and/or abundance of ticks in a county.

Acceptable to use to address the following key surveillance objectives:

- Classifying county status for *Ixodes scapularis*
- Identifying presence and prevalence of pathogens in ticks (all active life stages)
- Documenting host-seeking phenology

Carbon Dioxide–Baited Tick Traps

Background and methods

Carbon dioxide traps work on the premise that ticks have well-developed chemo-receptors and are attracted to carbon dioxide to find a host. Traps consist of a solid base to hold dry ice (a solid form of carbon dioxide) within an insulating material that is surrounded by a sticky tape to capture ticks attracted to the carbon dioxide released as the dry ice sublimates (Wilson et al. 1972). Developed originally for collection of lone star ticks (*Amblyomma americanum*) which display a more aggressive and mobile host-seeking behavior compared with *I. scapularis*, carbon dioxide traps capture *I. scapularis*, but appear to be less effective than drag sampling or flagging (Ginsberg and Ewing 1989, Falco and Fish 1992). Carbon dioxide trapping is generally less labor-intensive than several other tick collection methods, but because of its inefficiency at collecting *I. scapularis*, it is not recommended for assessments of host-seeking densities for this tick species. However, this method of

sampling provides good spatial precision for documenting the occurrence and/or presence or prevalence of pathogens in a county.

Acceptable to use to address the following key surveillance objectives:

- Classifying county status for *Ixodes scapularis*
- Identifying presence and prevalence of pathogens in ticks (all active life stages)

Tick Collection from Deer

Background and methods

White-tailed deer serve as important hosts for adult *I. scapularis* ticks. Inspection of hunter-killed deer brought into check stations is a cost-effective means of detecting changes in the distribution of *I. scapularis*, particularly in areas where the tick is emerging. However, owing to the home range of deer, it is spatially non-specific and may not correlate well with estimates of host-seeking tick densities obtained from drag sampling (French et al. 1992, Bouchard et al. 2013, Lee et al. 2013, Raizman et al. 2013). Because infection rates derived from blood-fed ticks is not representative of infection rates in host-seeking ticks, we do not recommend assessing infection prevalence in ticks collected from deer to infer infection prevalence in host-seeking ticks.

Acceptable to use to address the following key surveillance objectives:

- Classifying county status for *Ixodes scapularis*
- Identifying presence but not prevalence of pathogens in ticks (all active life stages)

Tick Collection from Small- or Medium-Sized Mammals, Birds and Lizards

Background and methods

Small- and medium-sized mammals, birds and lizards often serve as hosts of larval and nymphal *I. scapularis* ticks. Trapping and inspecting these animals for ticks can provide useful information on the presence and abundance of ticks and presence of associated pathogens in the collected ticks, as well as data on host-seeking phenology of immature life stages, in a county of interest. Spatial precision of estimates is associated with the home-range of the target animals, with migratory birds having the greatest home-range and providing low spatial precision in estimating exposure sites to ticks. Host trapping is generally more labor-intensive than drag sampling, however, in areas where *I. scapularis* immatures are seldom collected on drags, host sampling may be an effective means of demonstrating establishment of *I. scapularis* populations and documenting host-seeking phenology.

Acceptable to use to address the following key surveillance objectives:

- Classifying county status for *Ixodes scapularis*
- Identifying presence but not prevalence of pathogens in ticks (all active life stages)
- Documenting host-seeking phenology

Ticks Found on People and Pets

Background and methods

Identification of ticks collected from people or pets can be a useful means of assessing human- or pet-tick encounters. However, because people and their pets often travel long distances, ticks collected from these hosts should only be included in assessments of county status when travel history is considered. Specifically, because ticks can remain attached to a host for 7-10 days, samples obtained from persons or pets who traveled outside the county of residence within 10 d of tick encounter should be excluded. Likewise, records with more than one possible exposure site should not be reported. [CDC does not recommend testing ticks from people for human diagnostic purposes.](#)

Acceptable to use to address the following key surveillance objectives:

- Classifying county status for *Ixodes scapularis* (if travel history is considered)
- Identifying presence but not prevalence of pathogens in ticks (all active life stages; if travel history is considered)

Estimating the Density of Host-seeking (Infected) *Ixodes scapularis* Ticks

Where to Sample

Ixodes scapularis is primarily a woodland-associated tick. Therefore, sampling will typically focus on forested or wooded settings, including their edges. Specific sampling sites should focus on areas considered to be a public health concern and might include, but not limited to, the following:

- novel areas of potential human exposure to *I. scapularis*
- counties where *I. scapularis* is newly established
- counties (or counties neighboring areas) where incidence of *I. scapularis*-borne illnesses have changed over time
- heavily used recreational areas, including those bordering on neighborhoods
- areas where novel pathogens are suspected to be circulating
- representative habitat types within counties where *I. scapularis*-borne infections are prevalent

Size of Area to Sample

The density of host-seeking nymphal or female ticks varies spatially and temporally. To get a representative sample of the density of host-seeking (infected) nymphs or females, the sampling area should be expansive (spanning at least 750 m of linear transects, or 50 transects of 15 m dragged with a cloth measuring 1 m wide). Distance sampled can be assessed using several methods including: 1) setting fixed sampling grids where flags, stakes or other objects are used to mark the start and end points of each measured length of the transect, 2) using a measured rope or cable and dragging or flagging its full length, or 3) measuring the collectors stride length and walking a fixed number of strides prior to checking the flag or drag. Because ticks can drop off from the drag or flag easily, inspecting the cloth at regular intervals is important (typically between 10-20 m; adults detach more readily than nymphs and therefore the drag or flag should be checked minimally every 10-15 m)

(Diuk-Wasser et al. 2006, Diuk-Wasser et al. 2010, Diuk-Wasser et al. 2012, Johnson et al. 2017, Johnson et al. 2018a, Johnson et al. 2018b). Drags/Flags should be checked systematically and all parts of the cloth should be examined, including the leading edge, ropes, and seams. Samplers should also inspect their hands at each cloth check and include any ticks recorded on their person. Wearing white or other light-colored clothing is recommended to more easily detect ticks on the tick collector.

When to Sample

- Sampling should be conducted during the perceived peak of nymphal or adult tick activity. This information could be gleaned from previous phenology studies conducted in the region, timing of onset of human Lyme disease cases or data obtained from passive surveillance (submission of ticks from people or pets, etc.).
- Sampling each site 3 or more times within the perceived peak of host-seeking activity provides the most accurate density estimates, but this may not always be feasible; sampling twice improves precision over a single sample (Dobson 2013).
- Sampling should NOT be conducted when it is raining, when the vegetation is wet enough to saturate the tick drag or when it is unseasonably cold or extremely windy.

How Many Sites to Sample

Sampling numerous sites per county provides better estimates of spatial variation in the density of host-seeking (infected) ticks within a county. Sampling multiple sites is strongly encouraged, particularly within ecologically-diverse counties. However, data will be displayed if minimum sampling requirements are met for only a single site per county.

How to Estimate Infection Prevalence in Host-Seeking Ticks

In some situations, particularly where the densities of host-seeking ticks are low, it will not be possible to collect a reasonable sample size for pathogen testing within the defined 750 m² sampling area even when combining ticks collected over multiple sampling sessions. In this case, it is recommended to collect additional ticks through drag sampling or flagging in the area surrounding the sampling plot. These ticks should not be included in estimates of nymphal or females densities, but can be included in assessing site-specific estimates of pathogen prevalence.

Pathogen detection assays should meet the minimal requirements described above (“Minimum criteria for acceptability of pathogen detection assay”). Pathogen prevalence and 95% confidence intervals can be estimated per tick life stage and per site in Excel using the [Pooled Infection Rate Add-In](#). Inclusion of confidence intervals is recommended in addition to point estimates in order to convey the level of uncertainty in point estimates. Confidence intervals can be interpreted as “there is a 95% probability that the true infection prevalence is between [insert lower confidence limit] and [insert upper confidence limit].” As sample sizes increase, the width of the confidence intervals decreases. Typically testing 50 ticks per site gives reasonable confidence limits. However, the number of ticks that need to be tested is dependent on how infection prevalence estimates will translate to public health action. Pathogen prevalence will not be displayed unless a minimum of 25 *I. scapularis* ticks of a given life stage have been tested within a given county. NOTE: infection prevalence and confidence intervals will be calculated per site upon submission of data to the ArboNET Tick Module (described below: ArboNET Tick Module).

How to Calculate the Density of Host-Seeking (Infected) Ticks with Confidence Intervals

- Density of host-seeking nymphs (DON) is estimated as the total number of *I. scapularis* nymphs collected per total area sampled. DON can be scaled per 100 m² by multiplying the total number of *I. scapularis* nymphs collected per sampling session by 100 m², then dividing the product by the total area sampled.
- Density of host-seeking infected nymphs (DIN) is estimated by multiplying DON by the local infection prevalence (% of ticks infected or the point estimate derived using the [Pooled Infection Rate Add-In](#)). To include a confidence interval, DON should be multiplied by the lower infection prevalence confidence limit and then by the upper infection prevalence confidence limit.
- Density of host-seeking females (DOF) is estimated as the total number of *I. scapularis* females collected per total area sampled. DOF can be scaled per 100 m² by multiplying the total number of *I. scapularis* females collected per sampling session by 100 m², then dividing the product by the total area sampled.
- Density of host-seeking infected adults (DIF) is estimated by multiplying DOF by the local infection prevalence (% of ticks infected or the point estimate derived using the [Pooled Infection Rate Add-In](#)). To include a confidence interval, DOF should be multiplied by the lower infection prevalence confidence limit and then by the upper infection prevalence confidence limit.

Describing Host-Seeking Phenology of *Ixodes scapularis* Ticks

Where to Sample

Because *I. scapularis* is a primarily woodland-associated tick, phenology study sites should be situated in woodlands, ideally in an area where the tick is abundant in order to accurately assess temporal changes in density. Sites with low tick density are susceptible to stochastic variation. Typically, significant differences in host-seeking phenology are not expected over short-distances. Therefore, this labor-intensive sampling should be conducted in strategic locations to identify regional differences in host-seeking phenology, such as in 1-2 sites per State.

How to Sample

Drag sampling, flagging or collection of ticks from hosts trapped within a fixed area provide suitable samples for documenting when ticks are actively host-seeking.

When to Sample

Sampling should be conducted at the same site, using the same standardized methods across sampling session. Sites should be sampled weekly or every two weeks to assess either the presence or abundance of ticks collected by life stage per visit. For drag sampling or flagging, ticks should be returned to the transect from which they were collected (non-removal sampling) to avoid artificial depletion of ticks over time in the study area due to intensive sampling.

Pathogen Detection

Recommended Tick Samples and Preservation for Pathogen Testing

Pathogen testing in host-seeking, unfed ticks is recommended for the following surveillance objectives:

- Identifying presence and prevalence of pathogens
- Calculating DIN and DIF

Results from pathogen testing in fed ticks, or from vertebrate host blood or tissue, should be considered with caution because: 1) in some cases ticks can acquire pathogens from hosts while feeding and become infected, but not be able to maintain infection through the molt to the next life stage, and 2) infection rates derived from blood-fed ticks or from hosts is not representative of infection rates in host-seeking ticks. Pathogen testing in fed ticks, or from vertebrate host blood or tissue, is acceptable for the following surveillance objectives:

- Documenting presence of pathogens in a county

Prior to testing, ticks or tissue samples should be preserved in one of the following:

- 70-95% ethanol (denatured ethanol should be avoided as it contains additives that may inhibit PCR)
- RNALater
- Frozen at -80°C without preservatives

Minimum Criteria for Acceptability of Pathogen Detection Assay

To improve accuracy in estimates of infection prevalence and to enable detection of co-infections, ticks should be tested individually, rather than in pools. However, testing pools of ticks can be useful in some situations, including 1) when prevalence of infection is expected to be very low and testing resources are limited, or 2) when simply noting the presence, rather than prevalence, of pathogens is the goal.

In order to report that an *I. scapularis* or pool of *I. scapularis* is positive for *Borrelia burgdorferi* s.s., *Borrelia mayonii*, *Borrelia miyamotoi*, *Anaplasma phagocytophilum*, *Babesia microti*, *Ehrlichia muris eauclairensis*, or Powassan virus based on the results of molecular testing of a nucleic acid extract, that testing must include:

- A detection assay or assays (e.g., real-time PCR or standard PCR) specific to the target pathogen. To demonstrate that an assay is pathogen species-specific, it should be tested against a panel comprising genetically-similar species, ideally including any genetically-similar species that might also be found in *I. scapularis* ticks (see the specific considerations for each pathogen below). A published assay that has previously been shown not to detect genetically-similar species meets this requirement.

OR

- An assay or assays that detect a genus (bacteria and hemoprotozoan parasites) or family (viruses) followed by sequencing to identify the pathogen to species or to at least confirm or rule out the target species. If a molecular target sequence is similar to homologous sequences from multiple species such that it is impossible to confirm or rule out the presence of the target species, testing must incorporate sequencing of at least one additional molecular target.

In addition to the minimum requirements listed above, we highly recommend using a molecular testing scheme that has been published in a peer-reviewed journal and includes:

- Multiple targets for each pathogen.
- Established limits of detection for each real-time and/or standard PCR target in the presence of tick DNA. If the testing scheme includes a multiplex assay designed to detect multiple pathogens, the limit of detection for each pathogen target should also be confirmed in the presence of more abundant DNA from other pathogens targeted by the same assay.
- An internal control (e.g., a segment of the tick actin gene) that can be used to confirm the presence of amplifiable DNA in each specimen. A specimen that does not contain amplifiable DNA should not be included in infection prevalence calculations.

See, for example, Graham et al. (2018).

All real-time or standard PCR testing should include no-template controls and, if possible, negative extraction controls (extracts from DNA-free water or buffer taken through the entire DNA extraction process alongside tick specimens). To limit the risk of contaminating field-collected samples with amplicons from previously processed samples, nucleic acid extraction, PCR reaction set-up, and any work with amplicons (e.g., setting up sequencing reactions) should be conducted in separate work areas, ideally with dedicated pipets.

Important considerations for *Borrelia* testing

The *Borrelia* genus comprises two major clades: a relapsing fever (RF) group and a distinct *Borrelia burgdorferi* sensu lato (s.l.) complex. Phylogenetic analyses place *B. miyamotoi* within the RF group. To date, *B. miyamotoi* is the only RF group *Borrelia* associated with *I. scapularis* (Barbour 2014). *Borrelia miyamotoi* is known to cause human disease in the United States (Krause et al. 2015).

There are at least 9 recognized (named) species within the *B. burgdorferi* s.l. complex occurring in the United States (Schotthoefer and Frost 2015, Pritt et al. 2016, Margos et al. 2017a). At least 4 of those have been detected in field-collected *I. scapularis*: *B. burgdorferi* s.s., *B. mayonii*, *B. kurtenbachii*, and *B. andersonii* (Margos et al. 2010, Hamer et al. 2012b, Eisen et al. 2017). Of the *I. scapularis*-associated *B. burgdorferi* s.l. species, only *B. burgdorferi* s.s. and *B. mayonii* have been culture-confirmed as human pathogens in the United States (Stanek and Reiter 2011, Pritt et al. 2016).

Notes on nomenclature:

- Publications may use “*Borrelia burgdorferi*” to refer to *B. burgdorferi* s.s. and/or *B. burgdorferi* s.l. If you are using a published assay that is reported to be *B. burgdorferi*-specific, it is important to determine whether it is truly specific to *B. burgdorferi* s.s., which causes human disease, or to *B. burgdorferi* s.l., which includes a number of species that are not known to cause human disease.
- Some have proposed dividing the genus *Borrelia* into two genera, with *Borrelia* continuing to encompass species in the RF group, and a new genus, *Borrelia*, to encompass species previously included in the *Borrelia burgdorferi* s.l. group (Adeolu and Gupta 2014). Investigators continue to debate this proposal (Barbour et al. 2017, Margos et al. 2017b). Those querying databases to identify specimens to species should be aware, however, that *Borrelia* was included in a validation list (no. 163: list of new names and new combinations previously effectively, but not validly, published (Oren and Garrity 2015)), and that *B. burgdorferi* s.l. species in the National Center for Biotechnology (NCBI) nucleotide databases may be identified as *Borrelia* species or *Borrelia* species.

To demonstrate that an assay is ***B. miyamotoi* specific**, it should be tested against at least one *B. burgdorferi* s.l. species (e.g., *B. burgdorferi* s.s.). Ideally, it should also be shown not to detect other RF *Borrelia* species.

To demonstrate that an assay is ***B. burgdorferi* s.s. specific**, it should be tested against a panel including non-target *B. burgdorferi* s.l. species, ideally including *B. kurtenbachii* and *B. andersonii*. If you will be testing ticks from the upper Midwestern United States, testing should also demonstrate that the assay does not detect *B. mayonii*.

To demonstrate that an assay is ***B. mayonii* specific**, it should be tested against a panel that includes *B. burgdorferi* s.s. and other non-target *B. burgdorferi* s.l. species, ideally including *B. kurtenbachii* and *B. andersonii*.

There are a number of published assays for amplifying and sequencing *Borrelia* targets to identify *Borrelia* to species. Assays including nested PCR protocols are useful for amplifying the often scarce pathogen DNA in ticks. See (Wang et al. 2014) for descriptions of and references to several approaches for molecular typing of *B. burgdorferi* s.l. Note that protocols for PCR-based RFLP can also be used to generate amplicons for sequencing.

Important considerations for *Anaplasma phagocytophilum* testing

To demonstrate that an assay is specific to *A. phagocytophilum*, it is important to confirm that *A. phagocytophilum* primer and probe target sites are not conserved across Anaplasmataceae or Rickettsiaceae, as *I. scapularis* can harbor at least one rickettsial endosymbiont and at least one *Ehrlichia* species (Kurtti et al. 2015, Pritt et al. 2017). Assays should be tested for specificity against *Rickettsia* and *Ehrlichia* spp. as well as against other *Anaplasma* spp., ideally including *A. bovis* and *A. marginale*.

Molecular assays designed to detect *A. phagocytophilum* usually cannot differentiate the *A. phagocytophilum* human-active strain (*A. phagocytophilum*-ha), which causes disease in humans, from other variants that are not known to infect humans, including *A. phagocytophilum* variant 1 (*A. phagocytophilum*-v1) (Keesing et al. 2014). *Ixodes scapularis* may be infected with either *A. phagocytophilum*-ha, variant 1, or both, but the relative abundance of the two strains can vary dramatically between sites and years (Keesing et al. 2014). The relative abundance of *A. phagocytophilum*-v1 also tends to be higher among female ticks that have fed on deer than among males collected from deer, consistent with findings that white-tailed deer are likely a reservoir for *A. phagocytophilum*-v1 but not for *A. phagocytophilum*-ha (Courtney et al. 2003). You should interpret PCR-based *A. phagocytophilum* testing results with this in mind. It is possible to differentiate the two strains by amplifying and sequencing select targets (i.e., the *msp4* gene (de la Fuente et al., 2005), the *ank* gene (Massung et al. 2007), or a segment of the 16S rRNA gene (Massung et al., 2003). This is advisable when reporting an *A. phagocytophilum*-positive tick from a county that has never reported a human anaplasmosis case and/or has never reported an *A. phagocytophilum* ha-positive tick.

Important considerations for *Ehrlichia muris eauclairensis* testing

To demonstrate that an assay is specific to *Ehrlichia muris eauclairensis*:

- At a minimum, BLAST analysis should be used to confirm that primer and probe target sites are not conserved across Anaplasmataceae or Rickettsiaceae, as *I. scapularis* can harbor *A. phagocytophilum* and at least one rickettsial endosymbiont (Kurtti et al. 2015).
- Ideally, the assay should be tested against a panel including other ehrlichial species as well as Rickettsiales. See, for example, (Allerdice et al. 2016).

Important considerations for *Babesia microti* testing

In the United States, *I. scapularis* is the vector of the parasite *B. microti*, which is the most common etiologic agent of human cases of babesiosis in this country. To date, *I. scapularis* has not been established to be the vector of any of the other pathogens that have caused documented U.S. zoonotic cases of babesiosis. However, the tick vectors have not been identified for all such agents, let alone for all of the many other *Babesia* species that infect non-human animals and that might be found to have zoonotic potential.

Ixodes scapularis may be infected with *B. odocoilei*, a parasite of white-tailed deer and other cervids, and *Theileria cervi*, another parasite in the same order as *Babesia* spp. (Prioplasmida) (Steiner et al. 2006, Fritzen et al. 2014). Neither of these has been documented to cause infection in humans.

To demonstrate that an assay is ***B. microti*-specific**, it should be tested – at a minimum – against *B. odocoilei*, and ideally against a panel comprising other *Babesia* species as well as *T. cervi*.

Important considerations for Powassan virus testing

Powassan virus comprises 2 lineages: Powassan virus (POWV) lineage I, for which *Ixodes cookei* serves as the vector, and Powassan virus lineage II, or deer tick virus (DTV), for which *I. scapularis* serves as the vector (Telford et al. 1997, Kuno et al. 2001).

Powassan virus is a positive-sense RNA virus.

- Sample preservation, nucleic acid extraction, and nucleic acid storage requirements for RNA are generally more stringent than those for bacterial or protozoan DNA. If you want to include Powassan virus testing in your tick surveillance plan, you may need to collect and store one set of ticks for DNA testing and a second set for RNA testing. Alternatively, you may optimize your sample preservation, nucleic acid extraction, and nucleic acid storage protocols to allow for both DNA and RNA testing. In this case, it is important to ensure that your preservation, extraction, and storage procedures do not compromise assay sensitivity to any of your RNA or DNA pathogen targets.
- PCR-based assays designed to detect or identify this virus must incorporate a reverse transcription step.

Samples CDC will Test for Pathogens

In support of tick surveillance efforts, CDC has limited resources available to support pathogen detection in ticks submitted by public health partners. Samples will not be accepted for testing from the general public. We offer tick testing for the following pathogens: *Borrelia burgdorferi* s.s., *Borrelia mayonii*, *Borrelia miyamotoi*, *Anaplasma phagocytophilum* and *Babesia microti*. By submitting ticks to CDC for testing, submitters agree to allow CDC to retain the DNA extract for our reference collection. Limited resources typically preclude us from returning aliquots from ticks for which we perform DNA extractions. For submitters wishing to retain DNA from their ticks, we ask that you extract the DNA and submit an aliquot to CDC for pathogen testing. Prior to submitting ticks or DNA for testing, public health entities should contact CDC at: ticksurveillance@cdc.gov.

In Counties Where the Pathogen of Interest has Never Been Identified

In counties where *Borrelia burgdorferi* s.s., *Borrelia mayonii*, *Borrelia miyamotoi*, *Anaplasma phagocytophilum* or *Babesia microti* have not been identified previously in ticks or hosts, CDC will test the following samples submitted by collaborating public health partners for **presence of pathogens**:

- Host-seeking nymphs (collected from vegetation, walking samples or tick traps); pathogen prevalence will be estimated if sample size is ≥ 25 individuals per site per county.
- Host-seeking females (collected from vegetation, walking samples or tick traps); pathogen prevalence will be estimated if sample size is ≥ 25 individuals per site per county.
- Ticks collected from hosts; ticks will be tested for pathogen presence only, but prevalence will not be estimated. Blood-fed adults will not be tested due to assays not being optimized for that purpose.

In Counties Where the Pathogen of Interest has Been Identified

In counties where *Borrelia burgdorferi* s.s., *Borrelia mayonii*, *Borrelia miyamotoi*, *Anaplasma phagocytophilum* or *Babesia microti* have been identified previously in ticks or hosts, CDC will test the following samples submitted by collaborating public health partners for **prevalence of pathogens**:

- Host-seeking nymphs (collected from vegetation, walking samples or tick traps) where ≥ 25 individuals are submitted per site per county.
- Host-seeking females (collected from vegetation, walking samples or tick traps) where ≥ 25 individuals are submitted per site per county.
- In areas where drag sampling/flagging was conducted to assess DIN or DIF, we will test ticks from low density sites, even if the total sample size is less than 25 individuals. Collection of additional ticks from area surrounding the density sampling site should be attempted, but in some cases, collection of 25 individuals will not be feasible.

Limitations to Tick Surveillance

- Presence of *I. scapularis* within a county may be a poor indicator of human disease risk. For example, *I. scapularis* has been reported in many counties in the southeastern United States, but *Borrelia burgdorferi* s.s. infection rates are typically low and nymphs do not commonly ascend vegetation when host-seeking, thus limiting contact between people and nymphs.
- Although county estimates of the density of host-seeking infected nymphs is a better predictor of human disease occurrence compared with simple measures of tick presence or density of host-seeking nymphs, DIN and DON do not always accurately estimate risk of tick-borne diseases in humans. This may relate to spatial heterogeneity in where ticks are found and where people spend time outdoors, human behaviors that may increase or decrease risk of exposure to infected ticks, or other factors.

References

- Adams, D. A., K. R. Thomas, R. Jajosky, P. Sharp, D. Onweh, A. Schley, W. Anderson, A. Faulkner, and K. Kugeler. 2016. Summary of notifiable infectious disease conditions - United States, 2014. *Morbid. Mortal. Wkly Rep.* 63: 1-52.
- Adeolu, M., and R. S. Gupta. 2014. A phylogenomic and molecular marker based proposal for the division of the genus *Borrelia* into two genera: the emended genus *Borrelia* containing only the members of the relapsing fever *Borrelia*, and the genus *Borrelia* gen. nov. containing the members of the Lyme disease *Borrelia* (*Borrelia burgdorferi* sensu lato complex). *Antonie Van Leeuwenhoek* 105: 1049-1072.
- Allerdice, M. E. J., B. S. Pritt, L. M. Sloan, C. D. Paddock, and S. E. Karpathy. 2016. A real-time PCR assay for detection of the *Ehrlichia muris*-like agent, a newly recognized pathogen of humans in the upper Midwestern United States. *Ticks Tick-Borne Dis.* 7: 146-149.
- Arsnoe, I. M., G. J. Hickling, H. S. Ginsberg, R. McElreath, and J. I. Tsao. 2015. Different populations of blacklegged tick nymphs exhibit differences in questing behavior that have implications for human Lyme disease risk. *PLoS One* 10: e0127450.
- Barbour, A. G. 2014. Phylogeny of a relapsing fever *Borrelia* species transmitted by the hard tick *Ixodes scapularis*. *Infect. Genet. Evol.* 27: 551-558.
- Barbour, A. G., M. Adeolu, and R. S. Gupta. 2017. Division of the genus *Borrelia* into two genera (corresponding to Lyme disease and relapsing fever groups) reflects their genetic and phenotypic distinctiveness and will lead to a better understanding of these two groups of microbes. *Int. J. Syst. Evol. Microbiol.* 67: 2058-2067.
- Bouchard, C., P. A. Leighton, G. Beauchamp, S. Nguon, L. Trudel, F. Milord, L. R. Lindsay, D. Belanger, and N. H. Ogden. 2013. Harvested white-tailed deer as sentinel hosts for early establishing *Ixodes scapularis* populations and risk from vector-borne zoonoses in southeastern Canada. *J. Med. Entomol.* 50: 384-393.
- Carey, A. B., W. L. Krinsky, and A. J. Main. 1980. *Ixodes dammini* (Acari: Ixodidae) and associated ixodid ticks in South-central Connecticut, USA. *J. Med. Entomol.* 17: 89-99.
- Carroll, J. F., and E. T. Schmidtman. 1992. Tick sweep: modification of the tick drag-flag method for sampling nymphs of the deer tick (Acari: Ixodidae). *J. Med. Entomol.* 29: 352-355.
- Costero, A., and M. A. Grayson. 1996. Experimental transmission of Powassan virus (Flaviviridae) by *Ixodes scapularis* ticks (Acari: Ixodidae). *Am. J. Trop. Med. Hyg.* 55: 536-546.
- Courtney, J. W., R. L. Dryden, J. Montgomery, B. S. Schneider, G. Smith, and R. F. Massung. 2003. Molecular characterization of *Anaplasma phagocytophilum* and *Borrelia burgdorferi* in *Ixodes scapularis* ticks from Pennsylvania. *J. Clin. Microbiol.* 41: 1569-1573.
- Daniels, T. J., and D. Fish. 1990. Spatial distribution and dispersal of unfed larval *Ixodes dammini* (Acari: Ixodidae) in southern New York. *Environ. Entomol.* 19: 1029-1033.
- Dennis, D. T., T. S. Nekomoto, J. C. Victor, W. S. Paul, and J. Piesman. 1998. Reported distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the United States. *J. Med. Entomol.* 35: 629-638.
- de la Fuente, J. R.F. Massung, S. J. Wong, F.K. Chu, H. Lutz, M. Meli, F. D. Loewenich, A. Grzeszczuk, A. Torina, S. Caracappa, A.J. Mangold, V. Naranjo, S. Stuen, and K. M. Kocan. 2005. Sequence analysis of the msp4 gene of *Anaplasma phagocytophilum* strains. *J. Clin. Microbiol.* 43: 1309-1317.
- Diuk-Wasser, M. A., A. G. Gatewood, M. R. Cortinas, S. Yaremych-Hamer, J. Tsao, U. Kitron, G. Hickling, J. S. Brownstein, E. D. Walker, J. Piesman, and D. Fish. 2006. Spatiotemporal patterns of host-seeking *Ixodes scapularis* nymphs (Acari: Ixodidae) in the United States. *J. Med. Entomol.* 43: 166-176.
- Diuk-Wasser, M. A., G. Vourc'h, P. Cislo, A. G. Hoen, F. Melton, S. Hamer, M. Rowland, R. Cortinas, G. J. Hickling, J. I. Tsao, A. G. Barbour, U. Kitron, J. Piesman, and D. Fish. 2010. Field and climate-based model for predicting the density of host-seeking nymphal *Ixodes scapularis*, an important vector of tick-borne disease agents in the eastern United States. *Global Ecol. Biogeogr.* 19: 504-514.
- Diuk-Wasser, M. A., A. G. Hoen, P. Cislo, R. Brinkerhoff, S. A. Hamer, M. Rowland, R. Cortinas, G. Vourc'h, F. Melton, G. J. Hickling, J. I. Tsao, J. Bunikis, A. G. Barbour, U. Kitron, J. Piesman, and D. Fish. 2012. Human risk of infection with *Borrelia burgdorferi*, the Lyme disease agent, in eastern United States. *Am. J. Trop. Med. Hyg.* 86: 320-327.
- Dobson, A. D. 2013. Ticks in the wrong boxes: assessing error in blanket-drag studies due to occasional sampling. *Parasit. Vectors* 6: 344.
- Durden, L.A. and J.E. Keirans. 1996. Nymphs of the genus *Ixodes* (Acari: Ixodidae) of the United States: Taxonomy, identification key, distribution, hosts, and medical/veterinary importance. Thomas Say Publications in Entomology: Monographs, Entomological Society of America, Lanham, MD, 95p.

- Eisen, L., and R. J. Eisen. 2016.** Critical evaluation of the linkage between tick-based risk measures and the occurrence of Lyme disease cases. *J. Med. Entomol.* 53: 1050-1062.
- Eisen, R. J., and L. Eisen. 2018.** The blacklegged tick, *Ixodes scapularis*: An increasing public health concern. *Trends Parasitol.* 34: 295-309.
- Eisen, R. J., L. Eisen, and C. B. Beard. 2016.** County-scale distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the Continental United States. *J. Med. Entomol.* 53: 349-386.
- Eisen, R. J., K. J. Kugeler, L. Eisen, C. B. Beard, and C. D. Paddock. 2017.** Tick-Borne zoonoses in the United States: Persistent and emerging threats to human health. *ILAR J.*: 1-17.
- Falco, R. C., and D. Fish. 1992.** A comparison of methods for sampling the deer tick, *Ixodes dammini*, in a Lyme disease endemic area. *Exp. Appl. Acarol.* 14: 165-173.
- French, J. B., Jr., W. L. Schell, J. J. Kazmierczak, and J. P. Davis. 1992.** Changes in population density and distribution of *Ixodes dammini* (Acari: Ixodidae) in Wisconsin during the 1980s. *J. Med. Entomol.* 29: 723-728.
- Fritzen, C., E. Mosites, R. D. Applegate, S. R. Telford, 3rd, J. Huang, M. J. Yabsley, L. R. Carpenter, J. R. Dunn, and A. C. Moncayo. 2014.** Environmental investigation following the first human case of babesiosis in Tennessee. *J. Parasitol.* 100: 106-109.
- Ginsberg, H. S., and C. P. Ewing. 1989.** Comparison of flagging, walking, trapping, and collecting from hosts as sampling methods for northern deer ticks, *Ixodes dammini*, and lone-star ticks, *Amblyomma americanum* (Acari: Ixodidae). *Exp. Appl. Acarol.* 7: 313-322.
- Goethert, H. K., and S. R. Telford, 3rd. 2003.** Enzootic transmission of *Babesia divergens* among cottontail rabbits on Nantucket Island, Massachusetts. *Am. J. Trop. Med. Hyg.* 69: 455-460.
- Graham, C. B., S. E. Maes, A. Hojgaard, A. C. Fleshman, S. W. Sheldon, and R. J. Eisen. 2018.** A molecular algorithm to detect and differentiate human pathogens infecting *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae). *Ticks Tick Borne Dis.* 9: 390-403.
- Hahn, M. B., C. S. Jarnevich, A. J. Monaghan, and R. J. Eisen. 2016.** Modeling the geographic distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the contiguous United States. *J. Med. Entomol.* 53: 1176-1191.
- Hahn, M. B., C. S. Jarnevich, A. J. Monaghan, and R. J. Eisen. 2017.** Response: The geographic distribution of *Ixodes scapularis* (Acari: Ixodidae) revisited: The importance of assumptions about error balance. *J. Med. Entomol.* 54: 1104-1106.
- Hamer, S. A., G. J. Hickling, J. L. Sidge, E. D. Walker, and J. I. Tsao. 2012a.** Synchronous phenology of juvenile *Ixodes scapularis*, vertebrate host relationships, and associated patterns of *Borrelia burgdorferi* ribotypes in the midwestern United States. *Ticks Tick Borne Dis.* 3: 65-74.
- Hamer, S. A., G. J. Hickling, R. Keith, J. L. Sidge, E. D. Walker, and J. I. Tsao. 2012b.** Associations of passerine birds, rabbits, and ticks with *Borrelia miyamotoi* and *Borrelia andersonii* in Michigan, U.S.A. *Parasit. Vectors* 5: 231.
- Herwaldt, B. L., G. de Bruyn, N. J. Pieniazek, M. Homer, K. H. Lofy, S. B. Slemenda, T. R. Fritzsche, D. H. Persing, and A. P. Limaye. 2004.** *Babesia divergens*-like infection, Washington State. *Emerg. Infect. Dis.* 10: 622-629.
- Hickling, G. J., J. R. Kelly, L. D. Auckland, and S. A. Hamer. 2018.** Increasing prevalence of *Borrelia burgdorferi* sensu stricto-infected blacklegged ticks in Tennessee Valley, Tennessee, USA. *Emerg. Infect. Dis.* 24: in press.
- Hinckley, A. F., N. P. Connally, J. I. Meek, B. J. Johnson, M. M. Kemperman, K. A. Feldman, J. L. White, and P. S. Mead. 2014.** Lyme disease testing by large commercial laboratories in the United States. *Clin. Infect. Dis.* 59: 676-681.
- Johnson, T. L., C. B. Graham, K. A. Boegler, C. C. Cherry, S. E. Maes, M. A. Pilgard, A. Hojgaard, D. E. Buttke, and R. J. Eisen. 2017.** Prevalence and diversity of tick-borne pathogens in nymphal *Ixodes scapularis* (Acari: Ixodidae) in eastern national parks. *J. Med. Entomol.* 54: 742-751.
- Johnson, T. L., K. A. Boegler, R. J. Clark, M. J. Delorey, J. K. H. Bjork, F. M. Dorr, E. K. Schiffman, D. F. Neitzel, A. J. Monaghan, and R. J. Eisen. 2018a.** An acarological risk model predicting the density and distribution of host-seeking *Ixodes scapularis* nymphs in Minnesota. *Am. J. Trop. Med. Hyg.* 98: 1671-1682.
- Johnson, T. L., C. B. Graham, S. E. Maes, A. Hojgaard, A. Fleshman, K. A. Boegler, M. J. Delory, K. S. Slater, S. E. Karpathy, J. K. Bjork, D. F. Neitzel, E. K. Schiffman, and R. J. Eisen. 2018b.** Prevalence and distribution of seven human pathogens in host-seeking *Ixodes scapularis* (Acari: Ixodidae) nymphs in Minnesota, USA. *Ticks Tick Borne Dis.*
- Keesing, F., D. J. McHenry, M. Hersh, M. Tibbetts, J. L. Brunner, M. Killilea, K. LoGiudice, K. A. Schmidt, and R. S. Ostfeld. 2014.** Prevalence of human-active and variant 1 strains of the tick-borne pathogen *Anaplasma phagocytophilum* in hosts and forests of eastern North America. *Am. J. Trop. Med. Hyg.* 91: 302-309.
- Keirans, J.E. and C.M. Clifford. 1978.** The genus *Ixodes* in the United States: A scanning electron microscope study and key to the adults. *J. Med. Entomol. Suppl.* 2: 1-149.
- Krause, P. J., D. Fish, S. Narasimhan, and A. G. Barbour. 2015.** *Borrelia miyamotoi* infection in nature and in humans. *Clin. Microbiol. Infect.* 21: 631-639.

- Kugeler, K. J., G. M. Farley, J. D. Forrester, and P. S. Mead. 2015.** Geographic distribution and expansion of human Lyme disease, United States. *Emerg. Infect. Dis.* 21: 1455-1457.
- Kuno, G., H. Artsob, N. Karabatsos, K. R. Tsuchiya, and G. J. Chang. 2001.** Genomic sequencing of deer tick virus and phylogeny of Powassan-related viruses of North America. *Am. J. Trop. Med. Hyg.* 65: 671-676.
- Kurtti, T. J., R. F. Felsheim, N. Y. Burkhardt, J. D. Oliver, C. C. Heu, and U. G. Munderloh. 2015.** *Rickettsia buchneri* sp. nov., a rickettsial endosymbiont of the blacklegged tick *Ixodes scapularis*. *Int. J. Syst. Evol. Microbiol.* 65: 965-970.
- Lee, X., K. Hardy, D. H. Johnson, and S. M. Paskewitz. 2013.** Hunter-killed deer surveillance to assess changes in the prevalence and distribution of *Ixodes scapularis* (Acari: Ixodidae) in Wisconsin. *J. Med. Entomol.* 50: 632-639.
- Margos, G., N. Fedorova, J. E. Kleinjan, C. Hartberger, T. G. Schwan, A. Sing, and V. Fingerle. 2017a.** *Borrelia lanei* sp. nov. extends the diversity of *Borrelia* species in California. *Int. J. Syst. Evol. Microbiol.* 67: 3872-3876.
- Margos, G., A. Hojgaard, R. S. Lane, M. Cornet, V. Fingerle, N. Rudenko, N. Ogden, D. M. Aanensen, D. Fish, and J. Piesman. 2010.** Multilocus sequence analysis of *Borrelia bissettii* strains from North America reveals a new *Borrelia* species, *Borrelia kurtenbachii*. *Ticks Tick Borne Dis.* 1: 151-158.
- Margos, G., D. Marosevic, S. Cutler, M. Derdakova, M. Diuk-Wasser, S. Emler, D. Fish, J. Gray, K. P. Hunfeldt, B. Jaulhac, O. Kahl, S. Kovalev, P. Kraiczy, R. S. Lane, R. Lienhard, P. E. Lindgren, N. Ogden, K. Ornstein, T. Rupprecht, I. Schwartz, A. Sing, R. K. Straubinger, F. Strle, M. Voordouw, A. Rizzoli, B. Stevenson, and V. Fingerle. 2017b.** There is inadequate evidence to support the division of the genus *Borrelia*. *Int. J. Syst. Evol. Microbiol.* 67: 1081-1084.
- Massung, R. F., R. A. Priestley, N. J. Miller, T. N. Mather, and M.L. Levin. 2003.** Inability of a variant strain of *Anaplasma phagocytophilum* to infect mice. *J. Infect. Dis.* 188: 1757-1763.
- Massung, R. F., M. L. Levin, U. G. Munderloh, D. J. Silverman, M. J. Lynch, J. K. Gaywee, and T. J. Kurtti. 2007.** Isolation and propagation of the Ap-variant 1 strain of *Anaplasma phagocytophilum* in a tick cell line. *J. Clin. Microbiol.* 45: 2138-2143.
- Mather, T. N., M. C. Nicholson, E. F. Donnelly, and B. T. Matyas. 1996.** Entomologic index for human risk of Lyme disease. *Am. J. Epidemiol.* 144: 1066-1069.
- Mead, P. S. 2015.** Epidemiology of Lyme disease. *Infect. Dis. Clin. North Am.* 29: 187-210.
- Nelson, C. A., S. Saha, K. J. Kugeler, M. J. Delorey, M. B. Shankar, A. F. Hinckley, and P. S. Mead. 2015.** Incidence of clinician-diagnosed Lyme disease, United States, 2005-2010. *Emerg. Infect. Dis.* 21: 1625-1631.
- Oren, A., and G. M. Garrity. 2015.** Notification that new names of prokaryotes, new combinations, and new taxonomic opinions have appeared in volume 65, part 3, of the IJSEM. *Int. J. Syst. Evol. Microbiol.* 65: 1701-1702.
- Pepin, K. M., R. J. Eisen, P. S. Mead, J. Piesman, D. Fish, A. G. Hoen, A. G. Barbour, S. Hamer, and M. A. Diuk-Wasser. 2012.** Geographic variation in the relationship between human Lyme disease incidence and density of infected host-seeking *Ixodes scapularis* nymphs in the Eastern United States. *Am. J. Trop. Med. Hyg.* 86: 1062-1071.
- Pritt, B. S., M. E. J. Allerdice, L. M. Sloan, C. D. Paddock, U. G. Munderloh, Y. Rikihisa, T. Tajima, S. M. Paskewitz, D. F. Neitzel, D. K. Hoang Johnson, E. Schiffman, J. P. Davis, C. S. Goldsmith, C. M. Nelson, and S. E. Karpathy. 2017.** Proposal to reclassify *Ehrlichia muris* as *Ehrlichia muris subsp. muris subsp. nov.* and description of *Ehrlichia muris subsp. eaucloirensis subsp. nov.*, a newly recognized tick-borne pathogen of humans. *Int. J. Syst. Evol. Microbiol.* 67: 2121-2126.
- Pritt, B. S., L. B. Respicio-Kingry, L. M. Sloan, M. E. Schriefer, A. J. Replogle, J. Bjork, G. Liu, L. C. Kingry, P. S. Mead, D. F. Neitzel, E. Schiffman, D. K. Hoang Johnson, J. P. Davis, S. M. Paskewitz, D. Boxrud, A. Deedon, X. Lee, T. K. Miller, M. A. Feist, C. R. Steward, E. S. Theel, R. Patel, C. L. Irish, and J. M. Petersen. 2016.** *Borrelia mayonii* sp. nov., a member of the *Borrelia burgdorferi* sensu lato complex, detected in patients and ticks in the upper midwestern United States. *Int. J. Syst. Evol. Microbiol.* 66: 4878-4880.
- Raizman, E. A., J. D. Holland, and J. T. Shukle. 2013.** White-tailed deer (*Odocoileus virginianus*) as a potential sentinel for human Lyme disease in Indiana. *Zoonoses Publ. Hlth.* 60: 227-233.
- Rollend, L., D. Fish, and J. E. Childs. 2013.** Transovarial transmission of *Borrelia* spirochetes by *Ixodes scapularis*: a summary of the literature and recent observations. *Ticks Tick Borne Dis.* 4: 46-51.
- Schotthoefer, A. M., and H. M. Frost. 2015.** Ecology and epidemiology of Lyme borreliosis. *Clin. Lab. Med.* 35: 723-743.
- Schulze, T. L., G. S. Bowen, M. F. Lakat, W. E. Parkin, and J. K. Shisler. 1986.** Seasonal abundance and hosts of *Ixodes dammini* (Acari: Ixodidae) and other ixodid ticks from an endemic Lyme disease focus in New Jersey, USA. *J. Med. Entomol.* 23: 105-109.
- Stafford, K. C., 3rd, M. L. Cartter, L. A. Magnarelli, S. H. Ertel, and P. A. Mshar. 1998.** Temporal correlations between tick abundance and prevalence of ticks infected with *Borrelia burgdorferi* and increasing incidence of Lyme disease. *J. Clin. Microbiol.* 36: 1240-1244.
- Stanek, G., and M. Reiter. 2011.** The expanding Lyme *Borrelia* complex--clinical significance of genomic species? *Clin. Microbiol. Infect.* 17: 487-493.

- Steiner, F. E., R. R. Pinger, C. N. Vann, M. J. Abley, B. Sullivan, N. Grindle, K. Clay, and C. Fuqua. 2006.** Detection of *Anaplasma phagocytophilum* and *Babesia odocoilei* DNA in *Ixodes scapularis* (Acari: Ixodidae) collected in Indiana. *J. Med. Entomol.* 43: 437-442.
- Stromdahl, E. Y., and G. J. Hickling. 2012.** Beyond Lyme: aetiology of tick-borne human diseases with emphasis on the south-eastern United States. *Zoonoses Publ. Hlth.* 59 Suppl 2: 48-64.
- Telford, S. R., 3rd, P. M. Armstrong, P. Katavolos, I. Foppa, A. S. Garcia, M. L. Wilson, and A. Spielman. 1997.** A new tick-borne encephalitis-like virus infecting New England deer ticks, *Ixodes dammini*. *Emerg. Infect. Dis.* 3: 165-170.
- Wang, G., D. Liveris, P. Mukherjee, S. Jungnick, G. Margos, and I. Schwartz. 2014.** Molecular typing of *Borrelia burgdorferi*. *Curr. Protoc. Microbiol.* 34: 12C 15 11-31.
- Wilson, J. G., D. R. Kinzer, J. R. Sauer, and J. A. Hair. 1972.** Chemo-attraction in the lone star tick (Acarina: Ixodidae). I. Response of different developmental stages to carbon dioxide administered via traps. *J. Med. Entomol.* 9: 245-252.
- Yuval, B., and A. Spielman. 1990.** Duration and regulation of the developmental cycle of *Ixodes dammini* (Acari: Ixodidae). *J. Med. Entomol.* 27: 196-201.

Supplemental Material

Avoiding Tick Bites

The best way to prevent tick-borne diseases is to prevent tick bites. To do so, [CDC recommends](#):

While You Are Outdoors

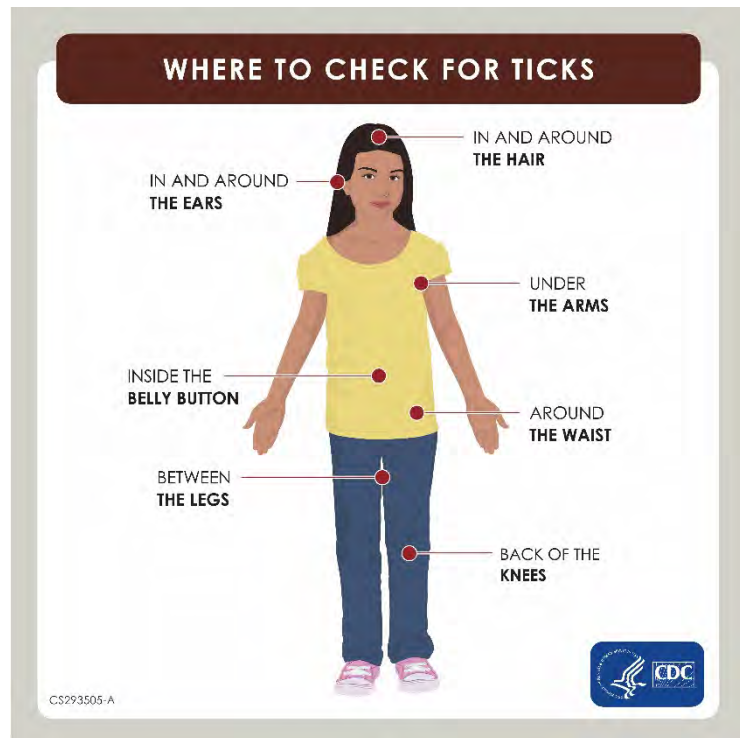
- **Know where to expect *I. scapularis* ticks.** Spending time outside playing in the yard, gardening or doing yard work, walking your dog in the neighborhood, camping, or hunting could bring you in contact with ticks seeking a host. Many people get bites by *I. scapularis* ticks in their own yard or neighborhood, where the ticks occur commonly in wooded portions and along wooded ecotones in yards or greenbelts (shaded, moister microhabitats), but less commonly on open, sunny and drier lawns.
- **Use [Environmental Protection Agency \(EPA\)-registered tick repellents](#)** containing DEET, picaridin, IR3535, Oil of Lemon Eucalyptus (OLE), para-menthane-diol (PMD), or 2-undecanone. EPA's helpful [search tool](#) can help you find the product that best suits your needs. Always follow product instructions.
 - Do not use repellent on babies younger than 2 months old.
 - Do not use products containing OLE or PMD on children under 3 years old.
- **Treat clothing and gear** with products containing 0.5% permethrin. Permethrin can be used to treat boots, clothing and camping gear and remain protective through several washings.
- **Minimize the risk of contact with *I. scapularis* ticks**
 - Avoid wooded and brushy areas with high grass and leaf litter when possible.
 - Walk in the center of trails.
- **Check your clothing for crawling ticks** frequently and remove them before they can attach and blood-feed.

After You Come Indoors

- **Check your clothing for ticks.** Ticks may be carried into the house on your clothing. Any ticks that are found should be removed. Tumble dry clothes in a dryer on high heat for 10 minutes to kill ticks on dry clothing after you come indoors. If the clothes are damp, additional time may be needed. If the clothes require washing first, hot water is recommended. Cold and medium temperature water will not kill ticks.
- **Shower soon after being outdoors.** Showering within two hours of coming indoors has been shown to reduce your risk of getting Lyme disease and may be effective in reducing the risk of other tick-borne diseases. Showering ensures that you remove (and then presumably change into clean) clothing and also provides an opportunity to spot ticks that were crawling or attached under the clothing. Showering may help wash off unattached ticks and it is a good opportunity to do your daily tick check.

- **Even if not showering, check your body for ticks after being outdoors.** Conduct a full body check upon return from potentially tick-infested areas, including your own backyard. Use a hand-held or full-length mirror to view all parts of your body. Tick can attach anywhere on the body, but especially check these parts of your body and your child's body for ticks:

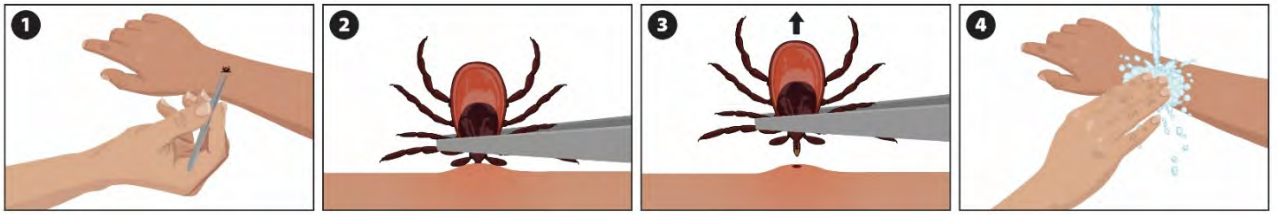
- Under the arms
- In and around the ears
- Inside belly button
- Back of the knees
- In and around the hair
- Between the legs
- Around the waist



- **Examine gear and pets.** Ticks can be transported into the home on clothing and pets, then attach to a person later, so carefully examine pets, coats, and daypacks.

How to Remove a Tick

- Use fine-tipped tweezers to grasp the tick as close to the skin's surface as possible.
- Pull upward with steady, even pressure. Don't twist or jerk the tick; this can cause the mouth-parts to break off and remain in the skin. If this happens, remove the mouth-parts with tweezers. If you are unable to remove the mouth-parts easily with clean tweezers, leave it alone and let the skin heal.
- After removing the tick, thoroughly clean the bite area and your hands with rubbing alcohol or soap and water.
- Never crush a tick with your fingers. Dispose of a live tick by putting it in alcohol, placing it in a sealed bag/container, wrapping it tightly in tape, or flushing it down the sink or toilet.



- If you develop a rash or fever within several weeks of removing a tick, see your doctor. Be sure to tell the doctor about your recent tick bite, when the bite occurred, and where you most likely acquired the tick.

How to Make Tick Drags

Blanket-Style Drag

Supplies

- 1-1/2 yd. rubberized cotton flannel sheeting, 45" wide
- 2 - zinc-plated screw eyes, size #12
- 3 - zinc-plated cut washers, 2" outer diameter, 3/4" inner diameter
- 1 - length of braided polyester clothesline, 3/16" thick
- 1 - dowel, 3/4" in diameter, 48" long
- Heavy-duty thread
- Heavy-duty sewing machine
- 20 small lead sinkers, used for weighting fishing lines, 1/4 oz. size

Sewing instructions

For each flag:

Step 1: *Preparing the materials*

From the rubberized cotton flannel material, cut:

- One (1) – 39.5" x 36" rectangle for the main panel of the tick drag.
- One (1) – 39.5" x 4" strip for the pocket that will hold the washers.

Step 2: *Sewing the loop for the dowel*

- Laying the main panel flat so that it measures 39.5" from left to right, fold the top of the panel down approximately 3" toward the front of the panel and pin or clip in place. (Diagram A)
- Sew along the bottom edge of the fabric, leaving the two sides open to form a "loop" for the dowel. (Diagram B)

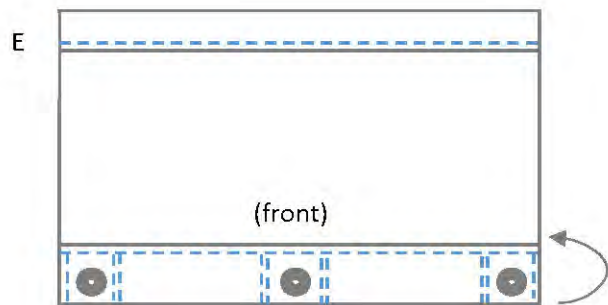
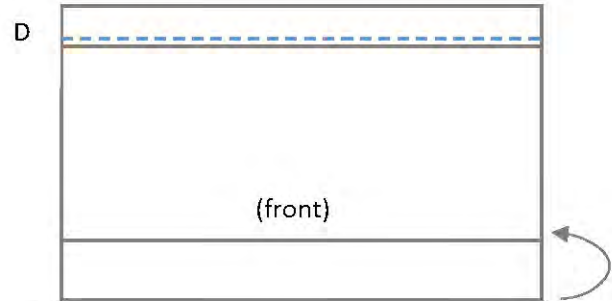
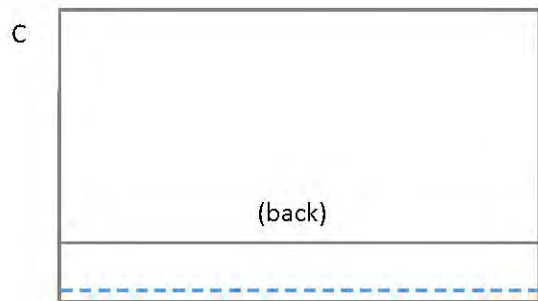
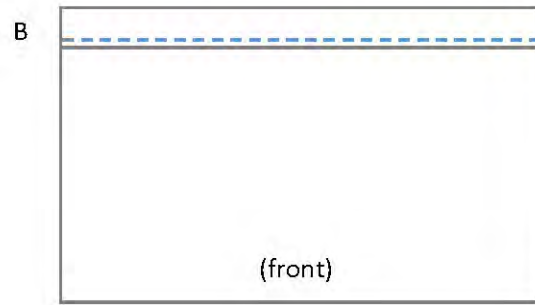
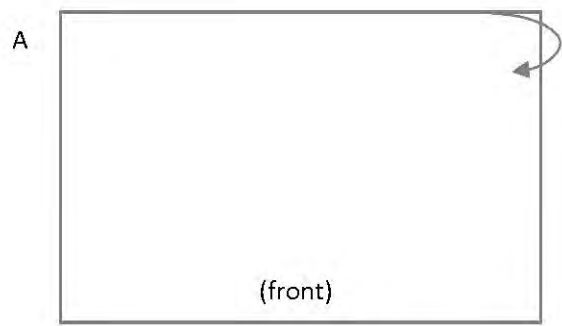
Step 3 (flat drag): *Adding the weights*

- a. Flip the panel over so that the seam from Step 2 is facing down. The panel should still be situated so that the loop is across the top of the panel.
- b. Next, pin or clip the 39.5" x 4" rectangle onto the bottom of the panel so that the long edges align. Sew the two pieces together along the bottom edge, using a generous seam allowance. (Diagram C)
- c. Flip the panel again so that the seam from Step 2 is again facing up. Turn the 39.5" x 4" strip from Step 3b to the front of the panel and pin or clip in place. (Diagram D)
- d. Following the diagram, sew the strip in place, adding the three washers as you work. (Diagram E)

Step 4: *Completing the drag*

- a. Affix one screw eye to each end of the dowel, and thread the dowel through the dowel loop from Step 2.
- b. Measure and cut a length of braided cord, and knot each end through the screw eyes to make the drag handle. The length of cord should be long enough for the front of the drag to reach the ground as the collector pulls it along the vegetation.

Sewing diagrams



Modified Drag with “Fingers”

Supplies

- 1-1/2 yd. rubberized cotton flannel sheeting, 36” wide
- 2 - zinc-plated screw eyes, size #12
- 3 - zinc-plated cut washers, 2” outer diameter, 3/4” inner diameter
- 1 - length of braided polyester clothesline, 3/16” thick
- 1 - dowel, 3/4” in diameter, 48” long
- 20 - small lead sinkers, ¼ oz. weight
- Heavy-duty thread
- Heavy-duty sewing machine

Sewing instructions

From the rubberized cotton flannel material, cut:

- a. One (1) – 39.5” x 23” rectangle for the main panel of the tick drag.
- b. Ten (10) – 23” x 2” strips for the fingers that will hold the lead weights.

Step 2: *Sewing the loop for the dowel*

- a. Laying the main panel flat so that it measures 39.5” from left to right, fold the top of the panel down approximately 3” toward the front of the panel and pin or clip in place. (Diagram A)
- b. Sew along the bottom edge of the fabric, leaving the two sides open to form a “loop” for the dowel. (Diagram B)

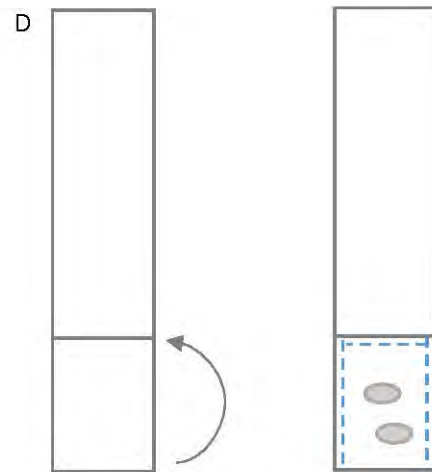
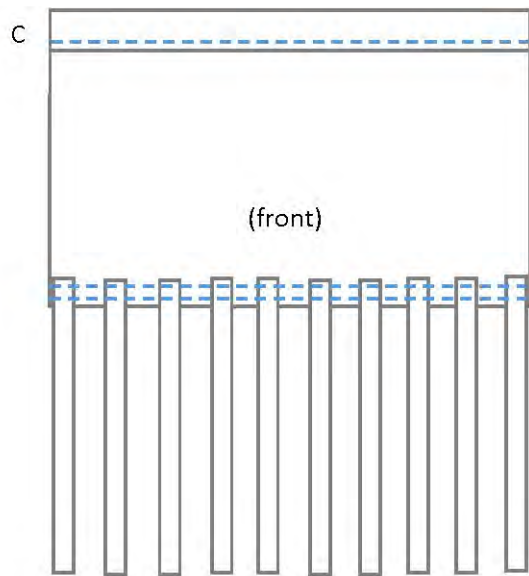
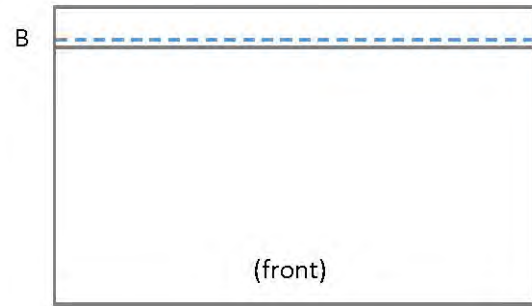
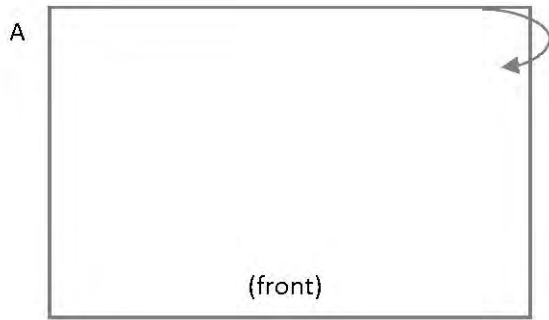
Step 3 (finger drag): *Adding the weights*

- a. Pin or clip the ten 23” x 2” fabric strips at even distances across the bottom of the rectangular piece so that each one overlaps the larger piece by approximately 1”.
- b. Sew a double line of stitches across all ten fingers, securing them to the back of the drag. (Diagram C)
- c. Fold approximately 2” of the bottom of each strip over and sew along two edges to form a pocket with an open side. (Diagram D)
- d. Insert two of the lead sinkers into this pocket and continue sewing the third side of the pocket to close. Repeat for all ten fingers. (Diagram D)

Step 4: *Completing the drag*


- a. Affix one screw eye to each end of the dowel, and thread the dowel through the dowel loop from Step 2.
- b. Measure and cut a length of braided cord, and knot each end through the screw eyes to make the drag handle. The length of cord should be long enough for the front of the drag to reach the ground as the collector pulls it along the vegetation.

Sewing diagrams



Article

Leveraging the Expertise of the New Jersey Mosquito Control Community to Jump Start Standardized Tick Surveillance

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Abstract: Despite the rising incidence of tick-borne diseases (TBD) in the northeastern United States (US), information and expertise needed to assess risk, inform the public and respond proactively is highly variable across states. Standardized and well-designed tick surveillance by trained personnel can facilitate the development of useful risk maps and help target resources, but requires nontrivial start-up costs. To address this challenge, we tested whether existing personnel in New Jersey's 21 county mosquito control agencies could be trained and interested to participate in a one-day collection of American dog ticks (*Dermacentor variabilis*), a presumably widespread species never before surveyed in this state. A workshop was held offering training in basic tick biology, identification, and standard operating procedures (SOPs) for surveillance, followed by a one-day simultaneous collection of *D. variabilis* across the state (the "NJ Tick Blitz"). In total, 498 *D. variabilis* were collected from 21 counties and follow-up participant surveys demonstrated an increase in knowledge and interest in ticks: 41.7% of respondents reported collecting ticks outside the Tick Blitz. We hope that the success of this initiative may provide a template for researchers and officials in other states with tick-borne disease concerns to obtain baseline tick surveillance data by training and partnering with existing personnel.

Keywords: integrated pest management; vector-borne diseases; vector surveillance; citizen science; American dog tick

1. Introduction

The northeastern United States currently have the largest burden of tick-borne diseases (TBDs) in the nation, due primarily to the concentration of Lyme disease within the region (~81% of 38,069 Lyme disease cases in the United States (US) in 2015 [1]) but also increasing prevalence of anaplasmosis, babesiosis, and spotted fever rickettsioses [2,3]. Ticks are both a threat to human health and to economic health: According to a recent estimate, healthcare costs associated with diagnosis and treatment of Lyme disease could total as much as \$1.3 billion per year [4] and tick-borne illnesses are a common drain on the labor force especially to those spending time outdoors, such as agricultural workers [5,6].

The number of tick-borne disease cases in the US have increased annually since ca. 2000 and new pathogens are continually emerging; in fact 40% of all known tick-borne pathogens were described in just the last 20 years [7,8]. The tick-borne disease landscape in the northeastern US has therefore undergone dramatic shifts since the emergence of Lyme disease in the 1980's including the northward expansion of lone star ticks (*Amblyomma americanum*) and associated pathogens [9] as well as growing

recognition of human infections with deer tick virus (DTV), a new lineage of Powassan virus vectored by *Ixodes scapularis* [10]. Furthermore, questions about the changing epidemiology of spotted fever rickettsioses in the US [11] are especially pertinent in the northeast, where human cases are increasing but the causative agent, *Rickettsia rickettsii*, is rare in the presumed vector, American dog ticks (*Dermacentor variabilis*) [12]. The southern Gulf coast tick, *A. maculatum*, is a vector of related pathogen *R. parkeri* and has recently expanded into Maryland and Delaware [13] but its penetration further north is unknown. As TBD incidence has been linked to climate, the situation is expected to worsen [14].

Against the backdrop of a high TBD burden, integrated tick and tick-borne disease management strategies in the Northeast region are broadly missing [15]. The first step to devising strategies to minimize disease burden is to assess which tick species are present, their abundance and their phenology [16,17]. Unfortunately, in much of the northeast there is currently very little funding/infrastructure available to conduct even basic tick surveillance. In particular, while some university, county or state programs test for pathogens in ticks submitted by residents and physicians (passive surveillance) this practice is discouraged by the US Centers for Disease Control and Prevention (CDC) in favor of active tick and tick-borne pathogen surveillance similar to existing programs that track mosquitoes and mosquito-borne pathogens (<https://www.cdc.gov/lyme/removal/index.html>).

The lack of information on ticks and tick-borne pathogens means that we are unlikely to notice changes until prevention is no longer feasible, i.e., after infestations have established or human disease cases have become common. Importantly, due to the potential for wide cross-reactivity among closely-related and/or emerging pathogens in standard serological testing, relying on human case reports as a proxy for pathogen/tick surveillance is suboptimal. For example, extensive cross-reactivity among *Rickettsia* bacteria in diagnostic testing of humans obscures large differences in pathogenicity [18,19]: The human disease-based surveillance cannot distinguish between potentially fatal *R. rickettsii*, the agent of Rocky Mountain Spotted Fever (thought to be transmitted by *D. variabilis* in the Eastern US), moderately pathogenic *R. parkeri* (transmitted by *A. maculatum*) or even apparently non-pathogenic *R. amblyommatis*, a common (>25% infection rates, [20]) bacterium found in the lone star tick, *A. americanum*. These three agents have widely varying degrees of pathogenicity and occur in three different tick species (all of which commonly parasitize humans, [21]) with overlapping distributions in the eastern United States, underscoring the epidemiological need for entomological surveillance.

Tick-borne disease surveillance and education in the northeast has centered on Lyme disease (LD) since the early 1980's when this emerging disease was first linked to the spirochete *Borrelia burgdorferi* found in ticks [22–24]. Dozens of studies have mapped LD cases and the distribution of its vector, the blacklegged or deer tick (*I. scapularis*) in a variety of northeast and north-central states (reviewed by [25], and updated by [26]). In those studies, ticks primarily came from surveys on deer associated with deer-check stations (30.1%), followed by public submissions (18.1%), while flagging/dragging made up just 7.5% of collections [25]. Many of these surveys were able to document significant changes in *I. scapularis* populations, such as local increases in abundance or geographic expansions into new areas [27–29]. As awareness of other TBDs began to increase in the northeast including anaplasmosis and babesiosis [30,31], new surveys began tracking the distribution of their causative agents (*Anaplasma phagocytophilum* and *Babesia microti*, respectively). However, because these pathogens are also vectored by *I. scapularis*, the singular focus on this species continued (e.g., [32–34], among many others). In fact, only a few studies within the northeast have specifically targeted other species such as *A. americanum* [35–37] and *D. variabilis* [38,39]. To the best of our knowledge, in many northeastern US states (including New Jersey) there has never been a systematic survey of *D. variabilis* or of the pathogens it may carry, as this tick species favors open fields such as grassy roadsides and meadows instead of the forests where *I. scapularis* thrives [40]. This is particularly a concern as some areas are seeing increasing numbers of encounters between humans and *D. variabilis* [41].

Concurrent with the early focus on LD in tick surveys, surveys examining public knowledge about ticks and evaluating the success of prevention education in the northeast US also focused on

I. scapularis. While most studies have found that public awareness of LD is high, the use of personal precautions is consistently low [42,43]. Overall, the public knows very little about tick-borne diseases other than LD [44,45].

The primary objective of our study was to assess the interest and proficiency of existing agencies in New Jersey (NJ) dedicated to pest management and public health to provide state-wide standardized tick surveillance. We targeted the NJ mosquito control community that has agencies in all 21 NJ counties (Figure 1), two professional organizations (the New Jersey Mosquito Control Association (NJMCA) and Associated Executives of Mosquito Control Work in NJ, Inc.) and a long history of science-based mosquito control research and practice [46]. A secondary objective was to obtain the first NJ statewide snapshot of the putative *Rickettsia* vector *Dermacentor variabilis*. We present our experience, results and lessons learned from trialing a “Tick Blitz” approach with this community, supported by a one-day workshop, where surveillance SOPs (standard operating procedures) and supplies were provided. Our aim was to evaluate if a Tick Blitz-like approach could act as a crucial first step towards developing a quorum of skilled personnel and statewide interest conducive to investment in a larger tick-surveillance program.



Figure 1. Map of New Jersey with 21 counties, each of which has a locally funded mosquito control program.

2. Materials and Methods

2.1. Recruitment and Training

Mosquito control agencies were recruited via an in-person announcement at a monthly meeting of the Associated Executives of Mosquito Control of New Jersey (“Associate Execs”) in the fall of 2017

requesting letters of support for a Northeast IPM Partnership Grant application. We received letters from 15 out of 21 counties plus the NJ State Office of Mosquito Control Coordination (OMCC; housed in the New Jersey Department of Environmental Protection). After the grant was awarded, we made a second announcement at one of the Associate Execs monthly meetings and sent a follow-up email to the organization's list-serve with additional details asking mosquito control professionals to sign up for a workshop that was held on 4 May 2018 and participate in a one-day "NJ Tick Blitz" that was held on 10 May 2018.

50 attendees from 24 agencies (20/21 county mosquito control agencies plus the OMCC, New Jersey Department of Health, Rutgers University and US Department of Agriculture—Animal and Plant Health Inspection Service) attended the training. At the workshop, speakers from Rutgers University and the Monmouth County Mosquito Control Division, Tick-borne Diseases Lab provided information about tick-borne pathogens and tick biology, identification and environmental collecting (including a hands-on demonstration). Detailed information about the Tick Blitz including site selection and additional information regarding surveillance for *D. variabilis*, the focal species, as well as surveillance supplies (below) were also provided.

2.2. Site Selection

In contrast to forest dwelling ticks such as *I. scapularis*, *D. variabilis* typically occupies old field habitats and ecotones adjacent to meadows [47,48]. Each participating county mosquito control agency was given a document with pictures and examples of *D. variabilis* habitat and they were instructed to choose at least two sites within their county that matched the description: One primary and one backup. Pictures and GPS coordinates of these sites were sent to Tick Blitz organizers to review and assess habitat suitability for *D. variabilis*. The organizers reviewed the landscape at each site using Google satellite maps and occasionally Google street view, and gave each agency feedback on whether the site would be suitable and which areas within the site would be ideal for sampling.

2.3. Tick Surveillance

Emphasis was placed on use of a standardized tick collection protocol at all sites. To facilitate this, tick collection kits were provided to each participating county mosquito control agency. Each kit placed inside a cloth drawstring bag contained: A collapsible "tick sweep" (modified from [49] by Benedict Pagac and James Butler, Army Public Health Command—Atlantic), a NJ Tick-Blitz t-shirt, a roll of masking tape, a box of ziploc bags, a permanent marker and sample collection sheets. The sample collection sheets instructed participants to record the date and time of the collection, collector's name, county, site number, and transect number; there was also a blank space for additional notes (e.g., weather conditions or issues encountered). We also provided a cardboard box for courier pickup: A courier service was hired to visit each county, pick up collected ticks and transport them to the Rutgers Center for Vector Biology (CVB) for processing. Tick sweeps (a sampling device with a long, bent handle allowing the cloth to contact the ground, [49]) were chosen both due to the type of habitat being targeted for American dog tick sampling (i.e., edge habitat between wooded areas and open grass) and because they were relatively easy to mass-produce. In contrast to Carroll and Schmidtman [49], who used the device to sweep back and forth in front of the investigator's path, we instructed participants to walk with the sweep at their side, allowing them to sample the taller grass/ecotone more likely to contain ticks while staying in shorter grass or along trails (Figure 2) thereby reducing their exposure to ticks. Thirty sweeps were manufactured using polyvinyl chloride (PVC) pipe and crib flannel (Buy Buy Baby, cat#14814620, Union Township, NJ, USA). The 0.25 m² flannel was folded around the pipe and sewn to allow easy removal for washing (see Figure 2).



Figure 2. New Jersey (NJ) Tick Blitz participant using provided tick sweep. Original design by [49] with modifications by Benedict Pagac and James Butler. Photo courtesy Jonathan Cassidy and Joe New, Burlington County, NJ.

Participants were instructed to measure out 300 m transects along edge habitat at sites selected earlier (one transect per site). Each transect was sampled with the tick sweep held to the side at a slow, steady pace and participants were told to stop every 20–30 m to inspect for ticks. Ticks were removed from the sweeps with masking tape and placed in Ziploc bags with a completed label. This removal methodology was chosen as opposed to forceps and vials to minimize handling time as most participants were first-time tick collectors with job responsibilities outside this project. Recorded length of sampling varied across teams from under 1 h excluding travel time to over 3 h with additional (i.e., more than the 2 requested) sites visited.

On “Tick Blitz Day,” 50 participants collected ticks in 21 counties. They were instructed to begin collecting simultaneously throughout the state at 10 am Eastern Standard Time (EST). Collected ticks were kept refrigerated until they were picked up by the courier service and brought to the CVB, where they were removed from the tape and identified to species and stage by experienced tick researchers using established keys (e.g., [50]). Due to the recent detection of *Haemaphysalis longicornis* in New Jersey [51] and at the time lack of available keys to distinguish them from native species (but see [52]) ticks in the genus *Haemaphysalis* were identified by DNA sequencing of the barcode locus in the mitochondrial cytochrome c oxidase gene [53]. Very occasionally, non-tick arthropods were picked up along with ticks on the tape, but that bycatch was ignored.

Statewide maps of tick collections were created in QGIS (<https://qgis.org/>). *D. variabilis* and *A. americanum* were set aside for *Rickettsia* spp. testing [54].

2.4. Participant Surveys

Pre- and post-tests were administered to participants during the 4 May training. Each paper survey contained five questions (4 multiple choice and 1 open-ended) designed to quickly evaluate the participants' level of knowledge about ticks and tick-borne diseases before and after the training. Pre- and post-test questions were different but judged to be similar in difficulty by a panel of three researchers.

After the conclusion of the project in December 2018, a final survey was administered through Qualtrics (Qualtrics, Provo, UT, USA) to examine the participants' overall experience with the NJ Tick Blitz. This survey consisted of 15 questions on topics such as their knowledge/comfort level with ticks before and after the Tick Blitz, whether or not they had done additional tick collecting outside the Tick Blitz, and what could be improved if the Tick Blitz were repeated. The link was sent by email, participants were given 30 days to respond and responses were collected anonymously. Data was analyzed using the "Data and Analysis" tab in Qualtrics.

3. Results

3.1. Tick Surveillance

Fifty sites in all 21 New Jersey counties were sampled for ticks on the morning of 10 May 2018 between approximately 10 am and 12 pm (Figure 3A). An *a posteriori* evaluation of the site sampled in Essex County, where no ticks were collected, indicated the habitat did not match the guidelines therefore a second site in Essex was sampled on 16 May bringing the total sites sampled to 51. Ultimately, *D. variabilis* ticks ($N = 498$) were collected from all 21 NJ counties (Figure 3B). Other species collected were *A. americanum* ($N = 238$, Figure 3C), *I. scapularis* ($N = 37$, Figure 3D), *H. longicornis* ($N = 36$, Figure 3E), and *H. leporispalustris* ($N = 2$, Figure 3F) (Supplementary Table S1). In general, these incidental collections reflected known distributions of these species in NJ, i.e., a primarily southern distribution of *A. americanum* and a statewide distribution of *I. scapularis*. Specimens of *H. longicornis* were collected from both counties with known populations of this species prior to 10 May 2018 (Hunterdon and Union counties) as well as in two new counties with no prior detections (Middlesex and Mercer). Both specimens of the rabbit tick *H. leporispalustris* were immatures: A larva from Camden County and a nymph from Ocean County.



Figure 3. Cont.



Figure 3. Map of New Jersey plotted with (A) all 51 sites sampled for the 2018 Tick Blitz; and (B–F) Sites where each tick species was collected: (B) *Dermacentor variabilis* (Total of 498 ticks); (C) *Amblyomma americanum* (238 ticks); (D) *Ixodes scapularis* (37 ticks); (E) *Haemaphysalis longicornis* (36 ticks); (F) *Haemaphysalis leporispalustris* (2 ticks).

3.2. Participant Surveys: Pre- and Post-Tests

Forty-eight attendees to the Tick Blitz Workshop completed both a pre-and post-test. Most respondents answered the questions correctly (Table 1). The lowest scoring question was pre-test question #1, where many respondents remembered three medically important tick species yet did not realize there are actually more than 10 species in New Jersey (including several that do not bite humans [55]), and post-test question #2, where many accurately remembered that adults have taken a second bloodmeal and thus likelihood of carrying a pathogen is higher, but did not recall from our lecture that nymphs are more likely to transmit a pathogen to humans because they are easier to miss during tick checks (55.3% of respondents answered “adults,” vs. 42.6% “nymphs”) (Table 1).

Table 1. Graded responses to pre- and post-tests taken at Tick Blitz workshop on 4 May 2018.

Question No.	Text of Question	Type of Question	% Correct (N = 48)
Pre-test 1	“Approximately how many tick species are known to occur in NJ?”	Multiple choice	50
Pre-test 2	“Ticks are active only during the warmer months of the year just like mosquitoes”	True or False	86.4
Pre-test 3	“Like mosquitoes only adult ticks bite”	True or False	97.7
Pre-test 4	“How many different human pathogens are known to be transmitted by ticks in NJ?”	Multiple Choice	86.4
Post-test 1	“Which tick genus can be differentiated from all the others based on the location of the anal groove?”	Multiple Choice	89.4
Post-test 2	“Which tick stage is the most likely to transmit a pathogen to humans?”	Multiple Choice	42.6
Post-test 3	“Where can people be exposed to ticks?”	Checkboxes	77.1
Post-test 4	“Do ticks in NJ transmit any deadly diseases?”	Yes or No	97.9

One additional question was included on each test but was not scored. On the pre-test, this question asked if participants were familiar with methods to survey ticks, and if so, to give an example. Seventy-five percent of respondents said they were familiar with tick collection methods, and 69.2% of those named tick drags (only 3.8% mentioned CO₂ traps). On the post-test this question asked

“Do you expect surveying for ticks will be much different from surveying mosquitoes?” and 76.6% of respondents selected “Yes.”

Overall, the post-test mean score (mean ± SD = 3.45 ± 0.68) was higher than the pre-test mean score (2.94 ± 1.12) (Paired *t*-test, *p* = 0.0212).

3.3. Participant Surveys: Final Survey

The final survey was sent to participants that both attended the training workshop and participated in Tick Blitz collection (*N* = 45). Responses were received from 25 participants, (55.6% response rate). Results of the survey indicate mosquito control professionals in NJ have ample exposure to ticks during their job and everyday lives (72% encounter daily or frequently) and most were either slightly (36.0%) or moderately (48.0%) knowledgeable about ticks prior to the Tick Blitz (Table 2).

Table 2. Results of Final Survey of Tick Blitz participants, *N* = 25 responses.

Survey Section	Question	Answers	% Respondents
Participant background	Years in mosquito control	0–5	32.0
		6–10	12.0
		11–20	36.0
		21–30	8.0
		More than 30 years	12.0
	Experience outside mosquito control?	Yes	64.0
		No	36.0
	If yes to above, Other fields with experience	Biology	43.8
		Environmental science	25.0
		Parks & Recreation	12.5
Public Health		31.3	
Public works		0.0	
	Other (write-in answers included retail, construction, food service, landscaping, private sector pest management, etc.)	93.8	
Pre-Tick Blitz questions	How often participants encountered ticks	On a daily basis	28.0
		Frequently (every couple weeks)	44.0
		Occasionally (a few times a year)	24.0
		Rarely (once or twice in life)	4.0
		Never	0.0
	Level of knowledge about ticks prior to Tick Blitz	Not at all knowledgeable	0.0
		Slightly	36.0
		Moderately	48.0
		Very	4.0
		Extremely knowledgeable	12.0
Tick Blitz experience	How did tick collections compare to expectations?	Fewer than expected	41.7
		About the same as expected	37.5
		More than expected	20.8
	Rating of each aspect: (First number = extremely + very effective, Second number = moderately + slightly effective)	Advertising about the Tick Blitz	87.5, 12.5
		Collection kit provided	95.8, 4.2
		Communication from organizers	91.7, 8.3
		Guidance for site selection	87.5, 12.5
		Hands on portion of workshop	75.0, 25.0
		Incentives to participate	79.2, 20.8
		Lecture portion of workshop	95.8, 4.2
Standard operating procedures (SOPs) provided		95.8, 4.2	
Website for entering data	87.5, 12.5		
Aspects of Tick Blitz that could be improved	Advertising about the Tick Blitz	4.2	
	Collection kit provided	8.3	
	Communication from organizers	4.2	
	Guidance for site selection	8.3	
	Hands on portion of workshop	20.8	
	Incentives to participate	12.5	
	Lecture portion of workshop	12.5	
	SOPs provided	0.0	
Website for entering data	0.0		

Table 2. Cont.

Survey Section	Question	Answers	% Respondents
Post- Tick Blitz questions	Level of knowledge after Tick Blitz	Not at all knowledgeable	0.0
		Slightly	0.0
		Moderately	37.5
		Very	45.8
		Extremely knowledgeable	16.7
	Comfort level: (First number = extremely + somewhat comfortable, second number = neither uncomfortable nor comfortable + somewhat uncomfortable)	Answering residents' questions about ticks	100.0, 0.0
		Collecting ticks	95.8, 4.2
		Identifying ticks to genus	75.0, 25.0
		Naming tick-borne pathogens in NJ	91.6, 8.4
		Protecting myself from tick bites	100.0, 0.0
	Collected ticks outside of (after) the Tick Blitz?	Recognizing tick habitat	91.6, 8.4
		Yes	41.7
	If yes, on how many days?	No	58.3
		One	30.0
		2–5	20.0
6–10		20.0	
Plans to collect ticks next year (2019)?	On a regular basis (weekly, monthly, etc.)	30.0	
	Definitely yes	41.7	
	Probably yes	41.7	
	Might or might not	16.7	
	Probably no	0.0	
Tick Surveillance needs in NJ	Which of the following items would your county need to establish a tick surveillance program? (% Has, % Need)	Definitely no	0.0
		Actionable outcomes (what to do w/info)	40.9, 59.1
		Detailed SOPs for tick collection.	0.0, 100.0
		Employee motivation	72.7, 27.3
		Expertise in Tick ID	9.1, 90.9
		Funding for supplies/equipment	10.0, 90.0
		Funding for personnel	41.2, 58.8
		Guidance from NJ State Office of Mosquito Control Coordination (OMCC)	63.6, 36.4
		Guidance from Rutgers	50.0, 50.0
		Legal authority	47.4, 52.6
		Permission from administration	42.1, 57.9
		Support of residents	85.0, 15.0

After the Tick Blitz, knowledge increased slightly, with participants who were slightly knowledgeable before becoming moderately knowledgeable, and participants who were moderately knowledgeable becoming very knowledgeable ($\chi^2 = 25.9$, $df = 6$, $p = 0.0002$). After the Tick Blitz, participants felt most comfortable answering residents' questions (100% either extremely or somewhat comfortable) but least comfortable identifying ticks to genus (75% extremely or somewhat comfortable).

In total, 41.7% of participants were inspired to collect ticks outside of or after the Tick Blitz (Table 2) and 83.4% said they definitely or probably would collect ticks in 2019. Most of those collecting outside the Tick Blitz had a background in Biology (26.7%). Interestingly, participants that collected fewer ticks than they expected during the Tick Blitz were less likely to have collected afterwards ($\chi^2 = 7.13$, $df = 2$, $p = 0.028$).

3.4. Surveillance Website

Tick identification results were made available to participants using a surveillance website platform hosted at Rutgers University (<http://acari.rutgers.edu/tickblitz/>). Each county received a unique login and password that participants could use to enter site information and review data. They could also view statewide data embedded in a Google Map for each tick species (Google Inc., Mountain View, CA, USA). A subset of the data (aggregated by county to obscure sensitive site locations) is available to the public via a link on the site.

4. Discussion

The New Jersey Tick Blitz successfully collected specimens of the target species *Dermacentor variabilis* throughout the state of NJ and demonstrated that professionals in local agencies dedicated to pest management and/or public health can be trained and, importantly, are interested, motivated and competent to participate in statewide tick surveillance activities.

We note that one-day sampling does not give a proper estimate of tick density or abundance at sites, as there may be day-to-day fluctuations in questing tick populations within a site due to weather, host availability and other factors [56–60]. Also, sites chosen to sample within a county may not be representative of tick populations in the county as a whole. Additionally, because there are no standardized leave-on-site traps or other investigator-independent strategies for tick surveillance, having different tick collectors (many relatively inexperienced) is likely to introduce variability in collections across locations, for example each group may walk faster/slower or be more or less likely to spot tiny larvae on the flag, which could affect numbers and/or species of ticks collected.

Despite the limitations discussed above, the New Jersey Tick Blitz was able to improve on our general understanding of tick distributions in New Jersey. Resulting data clearly supported the *a priori* hypothesis [55] that *D. variabilis* is widespread throughout the state. We also learned that the distribution of *A. americanum* extended farther northward than previously thought [37] with specimens collected from Middlesex and Somerset counties. Importantly, first time detections of the exotic tick *H. longicornis* in Mercer and Middlesex counties prompted the US Department of Agriculture and the NJ Department of Agriculture to work with livestock facilities in these counties to protect their animals and spurred additional surveillance efforts for this tick species in NJ.

The collection of two specimens of *H. leporispalustris* was intriguing as this species is not typically sampled in collections of questing ticks due to their host specificity [61,62]. In fact, earlier collections of questing *Haemaphysalis* in Union County NJ from 2013, originally presumed to be *H. leporispalustris*, were later identified as *H. longicornis* [63]. The presence of both these species in questing tick collections in NJ emphasizes the need for careful identification to distinguish these two species [52]. Of note, despite the ongoing northward expansion of *A. maculatum* into Delaware and Maryland [13], and its utilization of similar types of habitat and seasonal timing as *D. variabilis* [64], we did not detect *A. maculatum* during our sampling in NJ. It is possible *A. maculatum* has not yet made it across the Delaware Bay, or alternatively, populations are still low enough that they could not be detected using our sampling approach. Indeed, there is evidence that capturing and sampling hosts directly may be a more sensitive means to detect nascent tick populations than flagging/dragging [65,66].

Both the workshop pre- and post-tests and final survey demonstrated that New Jersey mosquito professionals were already somewhat experienced and knowledgeable about ticks prior to the Tick Blitz, and that the workshop and overall Tick Blitz experience achieved significant improvement in their knowledge and comfort levels. It also captured a noteworthy level of interest and enthusiasm for working on ticks: 41.7% of participants reported collecting ticks outside of the Tick Blitz, despite that task falling outside their job duties. This was especially so for those with a prior background in biology, indicating a strong natural curiosity and intrinsic motivation among this group of professionals.

However, there were aspects of the Tick Blitz primarily associated with the workshop that can be improved. Open-ended comments from participants included suggestions to break attendees up into smaller groups, giving each person time to handle the tick sweep and try collecting, as well as getting real-time feedback from trainers. There were also suggestions to improve the lecture portion, including providing physical specimens to examine under the microscope for the identification (ID) portion and more advanced (e.g., beyond genus level) ID training. As a result, we recommend that other groups wishing to implement a Tick Blitz in their territory give their participants more hands on experience in both viewing and identifying ticks as well as handling and collecting ticks in the field. Participants were especially eager to have direct feedback from the trainers (“Am I doing this right?”). The receipt of feedback can be an important component of learning [67] and effective feedback has been shown to improve retention of volunteers in activities like citizen science projects [68] and contributions to

online data pools [69]. In particular, lack of encouraging feedback may have contributed to participants' concerns about their competency in collecting ticks (i.e., feelings that they collected fewer ticks than they should have), thus affecting their confidence and motivation to participate in additional sampling.

As a result, we recommend better managing participants' expectations so that they understand there are myriad reasons why they may collect few ticks in a given site or on a given day, and that this may not necessarily reflect the tick abundance at that site or their collecting ability. Specific examples from the literature or the instructor's experience will help improve the trainee's confidence and prevent them from becoming discouraged with tick collection. Lack of confidence in the results obtained may also help explain why individuals who collected fewer ticks than expected were less likely to collect after the Tick Blitz, although an alternative explanation is that they simply felt there were not many ticks in their county and did not see a need for additional surveillance. In either case, a better understanding of variability in tick collection and the drawbacks of current surveillance is needed [70,71].

In the last part of the survey, we asked the respondents what they thought were the constraints to developing standardized tick surveillance in New Jersey. We found that the majority of participants were already highly motivated from personal experience or that of their employees (72.7%) and resident inquiries (85.0%), however most noted the need for specific funding for tick surveillance (90.0%), training in tick identification (90.9%), and standard operating procedures (SOPs) for tick collection (100.0%) (Table 2). This is an encouraging sign that if funding and better educational support was provided, mosquito control professionals would be willing to enact more formal tick surveillance and their constituents would be supportive. In our experience, building an exploratory tick surveillance program by funding mosquito control professionals is an excellent way to leverage existing resources.

We are confident that the existing significant experience with standardized surveillance practices among the extensive NJ network of mosquito control professionals facilitated training in tick surveillance and the quality of the resulting data. This is an asset that is often missing in other US states [72]. However, the same workshop combined with a hands-on Tick Blitz could be implemented for other types of professionals such as private pest control operators. In fact, in our experience even interested citizens can become effective pest managers if educated and guided [73]. These approaches are not meant to replace a properly funded and well-designed tick surveillance program, where experienced collectors visit a range of sites multiple times over a season. However, in areas lacking such capability or wishing to build capacity, a "Tick Blitz"-like approach could provide critical baseline data on local tick populations that could be used to justify the establishment of a larger program.

5. Conclusions

While we acknowledge that the New Jersey Tick Blitz was conceived as a pilot study with inherent limitations and biases, it nonetheless added significant new knowledge on tick distributions in New Jersey. The mosquito control professionals that participated indicated in their survey responses that the experience provided important training, materials, and risk information, helping them to address the evident and pressing TBD concerns of their residents. On a broader scale, the success of this initiative may provide a template for researchers and government officials in other states with tick-borne disease concerns to obtain baseline tick surveillance data by training and partnering with existing personnel. This data can then be leveraged to secure additional funding for surveillance projects to protect human health by monitoring the changing tick-borne disease landscape.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2075-4450/10/8/219/s1>, Table S1: Tick species and life stages collected during the 2018 New Jersey Tick Blitz, by county.

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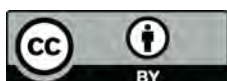
References

- Adams, D.A.; Thomas, K.R.; Jajosky, R.A.; Foster, L.; Baroi, G.; Sharp, P.; Onweh, D.H.; Schley, A.W.; Anderson, W.J. Summary of Notifiable Infectious Diseases and Conditions—United States, 2015. *MMWR* **2017**, *64*, 1–143. [[CrossRef](#)] [[PubMed](#)]
- Herwaldt, B.L.; McGovern, P.C.; Gerwel, M.P.; Easton, R.M.; MacGregor, R.R. Endemic babesiosis in another eastern state: New Jersey. *Emerg. Infect. Dis.* **2003**, *9*, 184–188. [[CrossRef](#)] [[PubMed](#)]
- Nicholson, W.L.; Gordon, R.; Demma, L.J. Spotted fever group rickettsial infection in dogs from eastern Arizona: How long has it been there? *Ann. N. Y. Acad. Sci.* **2006**, *1078*, 519–522. [[CrossRef](#)] [[PubMed](#)]
- Adrian, E.R.; Aucott, J.; Lemke, K.W.; Weiner, J.P. Health care costs, utilization and patterns of care following Lyme disease. *PLoS ONE* **2015**, *10*, e0116767. [[CrossRef](#)] [[PubMed](#)]
- Goldstein, M.D.; Schwartz, B.S.; Friedman, C.; Maccarillo, B.; Borbi, M.; Tuccillo, R. Lyme disease in New Jersey outdoor workers: A statewide survey of seroprevalence and tick exposure. *Am. J. Public Health* **1990**, *80*, 1225–1229. [[CrossRef](#)] [[PubMed](#)]
- Zhang, X.; Meltzer, M.I.; Pena, C.A.; Hopkins, A.B.; Wroth, L.; Fix, A.D. Economic impact of Lyme disease. *Emerg. Infect. Dis.* **2006**, *12*, 653–660. [[CrossRef](#)] [[PubMed](#)]
- Paddock, C.D.; Lane, R.S.; Staples, J.E.; Labruna, M.B. Changing paradigms for tick-borne diseases in the Americas. In *Global Health Impacts of Vector-Borne Diseases: Workshop Summary*; National Academies Press: Washington, DC, USA, 2016.
- Eisen, R.J.; Kugeler, K.J.; Eisen, L.; Beard, C.B.; Paddock, C.D. Tick-borne zoonoses in the United States: Persistent and emerging threats to human health. *ILAR J.* **2017**, 1–17. [[CrossRef](#)]
- Egizi, A.; Fefferman, N.H.; Jordan, R.A. Relative risk for Ehrlichiosis and Lyme disease in an area where vectors for both are sympatric, New Jersey, USA. *Emerg. Infect. Dis.* **2017**, *23*, 939–945. [[CrossRef](#)]
- Ei Houry, M.Y.; Camargo, J.F.; White, J.L.; Backenson, B.P.; Dupuis, A.P.; Escuyer, K.L.; Kramer, L.; St. George, K.; Chatterjee, D.; Prusinski, M.; et al. Potential role of Deer tick virus in Powassan encephalitis cases in Lyme disease-endemic areas of New York, USA. *Emerg. Infect. Dis.* **2013**, *19*, 1926–1933. [[CrossRef](#)]
- Raoult, D.; Parola, P. Rocky Mountain spotted fever in the USA: A benign disease or a common diagnostic error? *Lancet Infect. Dis.* **2008**, *8*, 587–589. [[CrossRef](#)]
- Stromdahl, E.Y.; Jiang, J.; Vince, M.; Richards, A.L. Infrequency of *Rickettsia rickettsii* in *Dermacentor variabilis* removed from humans, with comments on the role of other human-biting ticks associated with spotted fever group Rickettsiae in the United States. *Vector Borne Zoonotic Dis.* **2011**, *11*, 969–977. [[CrossRef](#)] [[PubMed](#)]
- Florin, D.A.; Brinkerhoff, R.J.; Gaff, H.; Jiang, J.; Robbins, R.G.; Eickmeyer, W.; Butler, J.; Nielsen, D.; Wright, C.; White, A.; et al. Additional, U.S. collections of the Gulf Coast tick, *Amblyomma maculatum* (Acari: Ixodidae), from the State of Delaware, the first reported field collections of adult specimens from the State of Maryland, and data regarding this tick from surveillance of migratory songbirds in Maryland. *Syst. Appl. Acarol.* **2014**, *19*, 257–262. [[CrossRef](#)]
- Beard, C.B.; Eisen, R.J.; Barker, C.M.; Garofalo, J.F.; Hahn, M.B.; Hayden, M.; Monaghan, A.J.; Ogden, N.H.; Schramm, P.J. Chapter 5: Vectorborne diseases. In *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*; U. S. Global Change Research Program: Washington, DC, USA, 2016; pp. 129–156.

15. Piesman, J.; Eisen, L. Prevention of Tick-Borne Diseases. *Ann. Rev. Entomol.* **2008**, *53*, 323–343. [[CrossRef](#)] [[PubMed](#)]
16. Kogan, M. Integrated Pest Management: Historical Perspectives and Contemporary Developments. *Ann. Rev. Entomol.* **1998**, *43*, 243–270. [[CrossRef](#)] [[PubMed](#)]
17. Rose, R.I. Pesticides and public health: Integrated methods of mosquito management. *Emerg. Infect. Dis.* **2001**, *7*, 17–23. [[CrossRef](#)] [[PubMed](#)]
18. Scola, B.L. Current laboratory diagnosis of Q fever. *Semin. Pediatr. Infect. Dis.* **2002**, *13*, 257–262. [[CrossRef](#)]
19. Raoult, D.; Paddock, C.D. *Rickettsia parkeri* Infection and Other Spotted Fevers in the United States. *N. Engl. J. Med.* **2005**, *353*, 626–627. [[CrossRef](#)]
20. Nadolny, R.M.; Wright, C.L.; Sonenshine, D.E.; Hynes, W.L.; Gaff, H.D. Ticks and spotted fever group rickettsiae of southeastern Virginia. *Ticks Tick Borne Dis.* **2014**, *5*, 53–57. [[CrossRef](#)]
21. Guglielmono, A.A.; Robbins, R.G. *Hard Ticks (Acari: Ixodida: Ixodidae) Parasitizing Humans: A Global Overview*; Springer International Publishing: New York, NY, USA, 2018.
22. Steere, A.C.; Broderick, T.F.; Malawista, S.E. Erythema chronicum migrans and lyme arthritis: Epidemiologic evidence for a tick vector. *Am. J. Epidemiol.* **1978**, *108*, 312–321. [[CrossRef](#)]
23. Burgdorfer, W.; Barbour, A.G.; Hayes, S.F.; Benach, J.L.; Grunwaldt, E.; Davis, J.P. Lyme disease—a tick-borne spirochetosis? *Science* **1982**, *216*, 1317. [[CrossRef](#)]
24. Schmid, G.P.; Horsley, R.; Steere, A.C.; Hanrahan, J.P.; Davis, J.P.; Bowen, G.S.; Osterholm, M.T.; Weisfeld, J.S.; Hightower, A.W.; Broome, C.V. Surveillance of Lyme Disease in the United States, 1982. *J. Infect. Dis.* **1985**, *151*, 1144–1149. [[CrossRef](#)] [[PubMed](#)]
25. Dennis, D.T.; Nekomoto, T.S.; Victor, J.C.; Paul, W.S.; Piesman, J. Forum: Reported Distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the United States. *J. Med. Entomol.* **1998**, *35*, 629–638. [[CrossRef](#)] [[PubMed](#)]
26. Eisen, R.J.; Eisen, L.; Beard, C.B. County-Scale Distribution of *Ixodes scapularis* and *Ixodes pacificus* (Acari: Ixodidae) in the Continental United States. *J. Med. Entomol.* **2016**, *53*, 349–386. [[CrossRef](#)] [[PubMed](#)]
27. White, D.J.; Chang, H.G.; Benach, J.L.; Bosler, E.M.; Meldrum, S.C.; Means, R.G.; Debbie, J.G.; Birkhead, G.S.; Morse, D.L. The geographic spread and temporal increase of the Lyme disease epidemic. *JAMA* **1991**, *266*, 1230–1236. [[CrossRef](#)] [[PubMed](#)]
28. Falco, R.C.; Daniels, T.J.; Fish, D. Increase in abundance of immature *Ixodes scapularis* (Acari: Ixodidae) in an emergent Lyme disease endemic area. *J. Med. Entomol.* **1995**, *32*, 522–526. [[CrossRef](#)]
29. Schulze, T.L.; Jordan, R.A.; Hung, R.W. Comparison of *Ixodes scapularis* (Acari: Ixodidae) populations and their habitats in established and emerging Lyme disease areas in New Jersey. *J. Med. Entomol.* **1998**, *35*, 64–70. [[CrossRef](#)] [[PubMed](#)]
30. Dammin, G.J.; Spielman, A.; Benach, J.L.; Piesman, J. The rising incidence of clinical *Babesia microti* infection. *Hum. Pathol.* **1981**, *12*, 398–400. [[CrossRef](#)]
31. Schwartz, I.; Fish, D.; Daniels, T.J. Prevalence of the rickettsial agent of human granulocytic ehrlichiosis in ticks from a hyperendemic focus of Lyme disease. *N. Engl. J. Med.* **1997**, *337*, 49–50. [[CrossRef](#)]
32. Schaubert, E.M.; Gertz, S.J.; Maple, W.T.; Ostfeld, R.S. Coinfection of blacklegged ticks (Acari: Ixodidae) in Dutchess County, New York, with the agents of Lyme disease and human granulocytic ehrlichiosis. *J. Med. Entomol.* **1998**, *35*, 901–903. [[CrossRef](#)]
33. Varde, S.; Beckley, J.; Schwartz, I. Prevalence of tick-borne pathogens in *Ixodes scapularis* in a rural New Jersey County. *Emerg. Infect. Dis.* **1998**, *4*, 97–99. [[CrossRef](#)]
34. Holman, M.S.; Caporale, D.A.; Goldberg, J.; Lacombe, E.; Lubelczyk, C.; Rand, P.W.; Smith, R.P. *Anaplasma phagocytophilum*, *Babesia microti*, and *Borrelia burgdorferi* in *Ixodes scapularis*, Southern Coastal Maine. *Emerg. Infect. Dis.* **2004**, *10*, 744–746. [[CrossRef](#)] [[PubMed](#)]
35. Ijdo, J.W.; Magnarelli, L.A.; Anderson, J.F.; Fikrig, E.; Stafford, K.C.I. Detection of *Ehrlichia chaffeensis* DNA in *Amblyomma americanum* ticks in Connecticut and Rhode Island. *J. Clin. Microbiol.* **2000**, *38*, 4655–4656. [[PubMed](#)]
36. Mixson, T.R.; Campbell, S.R.; Gill, J.S.; Ginsberg, H.S.; Reichard, M.V.; Schulze, T.L.; Dasch, G.A. Prevalence of Ehrlichia, Borrelia, and Rickettsial agents in *Amblyomma americanum* (Acari: Ixodidae) collected from nine states. *J. Med. Entomol.* **2006**, *43*, 1261–1268. [[CrossRef](#)]

37. Schulze, T.L.; Jordan, R.A.; White, J.C.; Roegner, V.E.; Healy, S.P. Geographical distribution and prevalence of selected *Borrelia*, *Ehrlichia*, and *Rickettsia* infections in *Amblyomma americanum* (Acari: Ixodidae) in New Jersey. *J. Am. Mosq. Control Assoc.* **2011**, *27*, 236–244. [[CrossRef](#)] [[PubMed](#)]
38. Ammerman, N.C.; Swanson, K.I.; Anderson, J.M.; Schwartz, T.R.; Seaberg, E.C.; Glass, G.E.; Norris, D.E. Spotted-Fever Group Rickettsia in *Dermacentor variabilis*, Maryland. *Emerg. Infect. Dis.* **2004**, *10*, 1478–1481. [[CrossRef](#)] [[PubMed](#)]
39. Goethert, H.K.; Shani, I.; Telford, S.R. Genotypic Diversity of *Francisella tularensis* Infecting *Dermacentor variabilis* Ticks on Martha's Vineyard, Massachusetts. *J. Clin. Microbiol.* **2004**, *42*, 4968–4973. [[CrossRef](#)] [[PubMed](#)]
40. Burgdorfer, W. Review Article: A Review of Rocky Mountain Spotted Fever (Tick-Borne Typhus), its Agent, and its Tick Vectors in the United States. *J. Med. Entomol.* **1975**, *12*, 269–278. [[CrossRef](#)]
41. Jordan, R.A.; Egizi, A. The growing importance of lone star ticks in a Lyme disease endemic county: Passive tick surveillance in Monmouth County, NJ, 2006–2016. *PLoS ONE* **2019**, *14*, e0211778. [[CrossRef](#)]
42. Hallman, W.; Weinstein, N.; Kadakia, S.; Chess, C. Precautions taken against Lyme disease at three recreational parks in endemic areas of New Jersey. *Environ. Behav.* **1995**, *27*, 437–453. [[CrossRef](#)]
43. Herrington, J.E. Risk perceptions regarding ticks and Lyme disease: A national survey. *Am. J. Prev. Med.* **2004**, *26*, 135–140. [[CrossRef](#)]
44. Hook, S.A.; Nelson, C.A.; Mead, P.S. U.S. public's experience with ticks and tick-borne diseases: Results from national HealthStyles surveys. *Ticks Tick Borne Dis.* **2015**, *6*, 483–488. [[CrossRef](#)] [[PubMed](#)]
45. Valente, S.L.; Wemple, D.; Ramos, S.; Cashman, S.B.; Savageau, J.A. Preventive behaviors and knowledge of tick-borne illnesses: Results of a survey from an endemic area. *J. Public Health Manag. Pract.* **2015**, *21*, E16–E23. [[CrossRef](#)] [[PubMed](#)]
46. Patterson, G.M. *The Mosquito Crusades: A History of the American Anti-Mosquito Movement from the Reed Commission to the First Earth Day*; Rutgers University Press: New Brunswick, NJ, USA, 2009.
47. Sonenshine, D.E.; Stout, I.J. Use of Old-Field Habitats by the American Dog Tick, *Dermacentor variabilis*. *Ann. Entomol. Soc. Am.* **1968**, *61*, 679–686. [[CrossRef](#)] [[PubMed](#)]
48. Carroll, J.F.; Nichols, J.D. Parasitization of meadow voles, *Microtus pennsylvanicus* (Ord), by American dog ticks, *Dermacentor variabilis* (Say), and adult tick movement during high host density. *J. Entomol. Sci.* **1986**, *21*, 102–113. [[CrossRef](#)]
49. Carroll, J.F.; Schmidtman, E.T. Tick Sweep: Modification of the tick drag-flag method for sampling nymphs of the deer tick (Acari: Ixodidae). *J. Med. Entomol.* **1992**, *29*, 352–355. [[CrossRef](#)]
50. Keirans, J.E.; Litwak, T.R. Pictorial keys to the adults of hard ticks, Family Ixodidae (Ixodida: Ixodoidea), east of the Mississippi River. *J. Med. Entomol.* **1989**, *26*, 435–448. [[CrossRef](#)]
51. Rainey, T.; Occi, J.L.; Robbins, R.G.; Egizi, A. Discovery of *Haemaphysalis longicornis* (Ixodida: Ixodidae) parasitizing a sheep in New Jersey, United States. *J. Med. Entomol.* **2018**, *55*, 757–759. [[CrossRef](#)]
52. Egizi, A.M.; Robbins, R.G.; Beati, L.; Nava, S.; Evans, C.R.; Occi, J.L.; Fonseca, D.M. A pictorial key to differentiate the recently detected exotic *Haemaphysalis longicornis* Neumann, 1901 (Acari, Ixodidae) from native congeners in North America. *ZooKeys* **2019**, *818*, 117–128. [[CrossRef](#)]
53. Folmer, O.; Black, M.; Hoeh, W.; Lutz, R.; Vrijenhoek, R. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Mol. Mar. Biol. Biotechnol.* **1994**, *3*, 294–299.
54. Occi, J.L.; Egizi, A.M.; Goncalves, A.; Fonseca, D.M. Spotted fever Rickettsia in American dog ticks (*Dermacentor variabilis* Say) and lone star ticks (*Amblyomma americanum* Linnaeus) in New Jersey. *J. Med. Entomol.*.. manuscript in preparation.
55. Occi, J.L.; Egizi, A.M.; Robbins, R.G.; Fonseca, D.M. Annotated list of the hard ticks (Acari: Ixodida: Ixodidae) of New Jersey. *J. Med. Entomol.* **2019**, *56*, 589–598. [[CrossRef](#)] [[PubMed](#)]
56. Vail, S.G.; Smith, G. Air temperature and relative humidity effects on behavioral activity of blacklegged tick (Acari: Ixodidae) nymphs in New Jersey. *J. Med. Entomol.* **1998**, *35*, 1025–1028. [[CrossRef](#)] [[PubMed](#)]
57. Schulze, T.L.; Jordan, R.A. Influence of meso-and microscale habitat structure on focal distribution of sympatric *Ixodes scapularis* and *Amblyomma americanum* (Acari: Ixodidae). *J. Med. Entomol.* **2005**, *42*, 285–294. [[CrossRef](#)]
58. Perret, J.L.; Rais, O.; Gern, L. Influence of climate on the proportion of *Ixodes ricinus* nymphs and adults questing in a tick population. *J. Med. Entomol.* **2004**, *41*, 361–365. [[CrossRef](#)] [[PubMed](#)]

59. Ginsberg, H.S.; Zhioua, E. Influence of deer abundance on the abundance of questing adult *Ixodes scapularis* (Acari: Ixodidae). *J. Med. Entomol.* **1999**, *36*, 376–381. [[CrossRef](#)] [[PubMed](#)]
60. Perkins, S.E.; Cattadori, I.M.; Tagliapietra, V.; Rizzoli, A.P.; Hudson, P.J. Localized deer absence leads to tick amplification. *Ecology* **2006**, *87*, 1981–1986. [[CrossRef](#)]
61. Camin, J.H.; Drenner, R.W. Climbing behavior and host-finding larval rabbit ticks (*Haemaphysalis leporispalustris*). *J. Parasitol.* **1978**, *64*, 905–909. [[CrossRef](#)]
62. Burgdorfer, W. Ecology of tick vectors of American spotted fever. *Bull. World Health Organ.* **1969**, *40*, 375–381.
63. Beard, C.B.; Occi, J.; Bonilla, D.L.; Egizi, A.M.; Fonseca, D.M.; Mertins, J.W.; Backenson, B.P.; Bajwa, W.I.; Barbarin, A.M.; Bertone, M.A.; et al. Multistate infestation with the exotic disease-vector tick *Haemaphysalis longicornis*—United States, August 2017–September 2018. *MMWR* **2018**, *67*, 1310–1313. [[CrossRef](#)]
64. Nadolny, R.M.; Gaff, H.D. Natural history of *Amblyomma maculatum* in Virginia. *Ticks Tick Borne Dis.* **2018**, *9*, 188–195. [[CrossRef](#)]
65. Ogden, N.H.; Koffi, J.K.; Lindsay, L.R. Assessment of a screening test to identify Lyme disease risk. *Can. Commun. Dis. Rep.* **2014**, *40*, 83–87. [[CrossRef](#)] [[PubMed](#)]
66. Hamer, S.A.; Tsao, J.I.; Walker, E.D.; Hickling, G.J. Invasion of the Lyme Disease Vector *Ixodes scapularis*: Implications for *Borrelia burgdorferi* Endemicity. *EcoHealth* **2010**, *7*, 47–63. [[CrossRef](#)] [[PubMed](#)]
67. Hattie, J.; Timperley, H. The Power of Feedback. *Rev. Educ. Res.* **2007**, *77*, 81–112. [[CrossRef](#)]
68. Van Der Wal, R.; Sharma, N.; Mellish, C.; Robinson, A.; Siddharthan, A. The role of automated feedback in training and retaining biological recorders for citizen science. *Conserv. Biol.* **2016**, *30*, 550–561. [[CrossRef](#)] [[PubMed](#)]
69. Cheshire, C.; Antin, J. The social psychological effects of feedback on the production of internet information pools. *J. Comput. Mediat. Commun.* **2008**, *13*, 705–727. [[CrossRef](#)]
70. Dobson, A.D. Ticks in the wrong boxes: Assessing error in blanket-drag studies due to occasional sampling. *Parasites Vectors* **2013**, *6*, 344. [[CrossRef](#)]
71. Clow, K.M.; Finer, R.; Lumsden, G.; Jardine, C.M. Assessing the repeatability of tick dragging as a method for *Ixodes scapularis* surveillance. *Vector Borne Zoonotic Dis.* **2018**, *18*, 628–631. [[CrossRef](#)]
72. NACCHO. *Mosquito Control Capabilities in the U.S.*; National Association of County and City Health Officials: Washington, DC, USA, 2017.
73. Johnson, B.J.; Brosch, D.; Christiansen, A.; Wells, E.; Wells, M.; Bhandoola, A.F.; Milne, A.; Garrison, S.; Fonseca, D.M. Neighbors help neighbors control urban mosquitoes. *Sci. Rep.* **2018**, *8*, 15797. [[CrossRef](#)]



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Review

Advancing the Science of Tick and Tick-Borne Disease Surveillance in the United States

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Abstract: Globally, vector-borne diseases are an increasing public health burden; in the United States, tick-borne diseases have tripled in the last three years. The United States Centers for Disease Control and Prevention (CDC) recognizes the need for resilience to the increasing vector-borne disease burden and has called for increased partnerships and sustained networks to identify and respond to the most pressing challenges that face vector-borne disease management, including increased surveillance. To increase applied research, develop communities of practice, and enhance workforce development, the CDC has created five regional Centers of Excellence in Vector-borne Disease. These Centers are a partnership of public health agencies, vector control groups, academic institutions, and industries. This special issue on tick and tick-borne disease surveillance is a collection of research articles on multiple aspects of surveillance from authors that are affiliated with or funded by the CDC Centers of Excellence. This body of work illustrates a community-based system of research by which participants share common problems and use integrated methodologies to produce outputs and effect outcomes that benefit human, animal and environmental health.

Keywords: citizen science; National Ecological Observatory Network; One Health; species distribution modeling; state-space modeling; surveillance

1. Introduction

Globally, vector-borne diseases are an increasing public health burden. In the United States, >75% of all vector-borne diseases are tick-borne, and the number of reported cases of tick-borne infections doubled between 2004 and 2016. More than 40,000 cases of tick-borne disease have been reported since 2011, yet there is likely an eight-to-ten fold higher number of cases than are reported [1]. Despite underreporting, increases in tick-borne diseases have been documented for Lyme disease [2], human babesiosis [3], rickettsiosis [4], and ehrlichiosis [5].

In addition to the spread and increase of the most common tick-borne diseases, new disease-causing pathogens such as *Borrelia miyamotoi*, a relapsing fever group of *Borrelia* [6] and *Ehrlichia muris eauclairensis* (Xu et al., 2018) have been discovered. Viral agents such as Powassan virus have shown a rapid increase in human cases [1], and previously undescribed viruses such as Bourbon virus and Heartland virus have been found in rapidly expanding populations of *Amblyomma americanum* [7]. It is evident that the pathogen landscape in the U.S. and elsewhere is rapidly changing, and the need to address this change is acute.

The causes of this global increase in tick-borne diseases are multi-factorial but have been attributed to the characteristics defined by the current Anthropocene geologic epoch. Climate change, land cover change, land use change, population growth, global transportation, global trade, and socio-economic

forces have converged to alter the biogeophysical composition of our planet, and these alterations have catalyzed the increase in vector-borne diseases [8,9]. Despite these broad patterns of converging factors implicating global change in the rise of vector-borne diseases, the mechanisms underlying transmission and ultimately prevention remain, in many cases, elusive due to the complex nature of vector-borne disease epidemiology. It is within these murky details that the value and necessity of vector and vector-borne disease surveillance become evident.

The United States Centers for Disease Control and Prevention (CDC) has recognized this national need for resilience to the vector-borne disease burden and has called for increased partnerships and sustained networks to identify and respond to the most pressing challenges that face vector-borne disease management. As part of that response, the CDC created a network of five nationwide Centers of Excellence that provides a focus on workforce development, communities of practice that increase local and state capacities to manage the disease burden and its causes, and applied research into prevention and control [10]. To achieve these goals, Centers are a partnership of public health agencies, vector control groups, academic institutions, and industries. This special issue on tick and tick-borne disease surveillance is a collection of research articles on multiple aspects of surveillance from authors that are affiliated with or funded by the CDC Centers of Excellence. While not representing all aspects of vector-borne disease research funded by this CDC partnership, surveillance is recognized as a key aspect of a functioning public health response.

2. The Science of Surveillance and Its Application

Surveillance is one of the pillars of infectious disease management. In its most basic form, surveillance, whether passive or active, can provide early warnings of newly emerging pathogens [11] such as the discovery of *Borrelia miyamotoi* found in a surveyed population of *Ixodes scapularis* in 2001. Twelve years later, the first human case attributed to this pathogen occurred [12] and was likely detected by health professionals because of the earlier surveillance efforts. Likewise, the incursion of exotic vectors such as the Asian longhorned tick, *Haemophysalis longicornis*, was first identified in New Jersey in 2017, which created awareness of this potentially devastating human and animal disease vector [13]. Increased vigilance and enhanced surveillance as a result of this finding has suggested that the tick is established in multiple eastern states [14].

Surveillance as a field of science receives relatively little consideration. Two papers in this special issue report on the practical evaluation of surveillance methodology. Glass et al. [15] used a literature review of tick surveys in Florida to assess the myriad of different surveying techniques, and compared surveillance outcomes to illustrate the importance of choosing the best surveillance technique a priori in order to meet the objectives of surveillance. They then provided a methodology and rationale for the type of sampling required to generate species distribution models. The resulting discussion makes recommendations for the establishment of surveillance that can lead to a better understanding of the biogeography of medically important ticks in ecologically diverse regions like Florida.

The second paper that evaluates the science of surveillance [16] demonstrates how data acquired from passive surveillance influence subsequent aspects of targeted intervention, treatment, and public health. Oftentimes, surveillance analyses, such as species distribution models (SDMs), input data from biased surveys because they are the best available data. Though SDM researchers warn against the impacts of these flaws, few studies have compared how much of an impact these biases have. Kessler and colleagues [16] compared data from a 'typical' citizen science survey with a standardized data collection for the same tick species in Florida. The results illustrated a discrepancy in the predicted distribution associated with biased data. Nonetheless, biased data sets still provide important information on where vectors do occur, but they are limited in their utility for extrapolating results to other places.

An example of keen a priori surveillance planning to achieve an objective can be found in the study by Egizi et al. [17]. While acknowledging that active surveillance requires funding and infrastructure that most agencies lack, these authors harnessed the infrastructure that New Jersey has

in place for vector control, the New Jersey mosquito control community, and demonstrated that with minimal resource investment, they could perform a standardized tick survey for an understudied and underappreciated disease vector, *Dermacentor variabilis*. The result was an increased knowledge of the distribution of this tick and other species that inhabit grasslands and meadows, as well as a working protocol for engaging vector control communities in active surveillance of ticks.

While the majority of the public health burden due to tick-borne diseases is in the northeastern US and increasingly in the upper Midwest US, other regions struggle with less well understood tick-borne diseases. Diseases such as southern tick-associated rash illness (STARI) have unknown pathological agents, and many diseases such as ehrlichiosis and rickettsiosis have multiple aetiological agents that are only beginning to be understood [18]. Two papers in this special issue provide survey results for tick-borne pathogens in previously under-surveyed areas of the United States: Mendell et al. [19] conducted a targeted survey in a public space in Texas, while De Jesus et al. [20] conducted a statewide survey of bacterial tick-borne pathogens throughout Florida. These studies took a broad approach to molecular screening in questing ticks, using assays that detected multiple related bacterial species. Surveillance of this type can help piece together the epidemiological and aetiological puzzle for poorly understood tick-borne diseases. As with other forms of surveillance, these studies also help to inform the public as to risks associated with outdoor activities and provide baseline data for infectious disease clinicians who struggle to maintain vigilance of emerging tick-borne disease threats like Powassan virus [21] and Lyme disease [22].

While the aforementioned surveys all used active surveillance to drag, flag, or attract ticks with CO₂, passive surveillance can provide additional insight not available using the above-mentioned surveillance methods. Lee et al. [23] formed a network of collaborators that included veterinary offices, animal shelters and wildlife rehabilitation centers throughout Wisconsin to passively survey for ticks attached to companion animals and wildlife. The resulting survey increased the known distribution of certain tick species in Wisconsin and established a baseline for future surveillance. In addition, the network of colleagues established in this study has the potential to build social capital that can be leveraged to sustain surveillance efforts and increase public health awareness.

3. Leveraging Surveillance Data to Further Understand Tick Biology, Distribution, and Management

In addition to identifying pathogen occurrence or defining vector communities, surveillance provides insight into the environmental factors that drive vector population processes. Climate change has been predicted to alter vector-borne disease dynamics [24], and for some pathogens like *Borrelia burgdorferi*, climate warming is anticipated to facilitate sylvatic transmission [25] due to increased overwinter survival [26,27]. Using these insights, Linkse et al. [28] took a mechanistic approach to understanding the both broadscale and fine-scale environmental processes that drive overwinter survival in the vector of *B. burgdorferi* and *Ixodes scapularis*. Using replicate mesocosm experiments, they showed that leaf litter, more than snow accumulation, facilitates the overwinter survival of larvae, which has practical land management applications for both public and private landholders.

Ultimately, it is surveillance data that are necessary for modeling the dynamics and distributions of ticks and tick-borne diseases [29], but standardized surveillance data collected over multiple years are difficult to sustain due to a lack of consistent funding or political will. Exceptions, however, exist. The National Science Foundation National Ecological Observatory Network (NEON) is a nationwide survey and monitoring effort that is standardized across 81 sites in the United States. The mission of NEON is to provide long-term biogeophysical data in the continental US to better understand how global changes to the environment affect ecological processes. As part of its organismal sampling efforts, NEON collects ticks in a standardized fashion. Klarenberg and Wisely [30] utilized these data from one site to demonstrate the utility and power of this type of surveillance to model tick population dynamics using a state-space modeling approach. They showed that even a five year dataset demonstrates changes in abundance over time and illustrates the potential power of this nationwide government monitoring effort.

In addition to population dynamic modeling, robust species distribution models can be created from surveillance datasets. Kessler et al. [31] utilized three years of systematically collected data to generate ensemble SDMs that included both presence and “true” absence data to predict the distribution of medically important tick species throughout Florida. Importantly, the a priori spatial sampling considerations described in Glass et al. [15] were utilized in this research to address the design shortcomings of many modeling efforts. The results of the modeling exercise illustrate where human risks of encountering ticks is high, and the results can therefore be used to target human interventions.

Species distribution models can also be used to indicate where targeted surveillance should occur for potentially invasive tick species. Pascoe et al. [32] used geographic records of four *Amblyomma* tick species found in the Americas to model their potential distribution and invasion potential into California. They demonstrated that while some species may have the ability to persist in California, the climate is not conducive for other species. The resulting maps indicated areas where invasion potential is high and therefore should be targeted for enhanced surveillance.

4. Conclusions

As human cases of tick-borne disease continue to rise in the United States, the CDC urges local monitoring and surveillance in order to manage vector species and educate health care workers and the public about local disease risks. As evidenced by the collection of publications in this special issue on “Tick and Tick-borne Disease Surveillance,” effective surveillance and useful products resulting from surveillance efforts require collaboration among stakeholders with expertise in diverse disciplines. By incorporating humans, animals, and the environment, surveillance inherently becomes a One Health enterprise [33] that places the science and management of vector-borne diseases in a broader socio-ecological context. This holistic approach provides for a community-based system of research by which participants share common problems and use integrated methodologies to produce outputs and effect outcomes that benefit human, animal, and environmental health.

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References

1. Rosenberg, R.; Lindsey, N.P.; Fischer, M.; Gregory, C.J.; Hinckley, A.F.; Mead, P.S.; Paz-Bailey, G.; Waterman, S.H.; Drexler, N.A.; Kersh, G.J.; et al. Vital signs: Trends in reported vectorborne disease cases—United States and territories, 2004–2016. *Morb. Mortal. Wkly. Rep.* **2018**, *67*, 496–501. [[CrossRef](#)] [[PubMed](#)]
2. Hoen, A.G.; Margos, G.; Bent, S.J.; Diuk-Wasser, M.A.; Barbour, A.; Kurtenbach, K.; Fish, D. Phylogeography of *Borrelia burgdorferi* in the eastern United States reflects multiple independent Lyme disease emergence events. *Proc. Natl. Acad. Sci. USA* **2009**, *106*, 15013–15018. [[CrossRef](#)] [[PubMed](#)]
3. Diuk-Wasser, M.A.; Liu, Y.; Steeves, T.K.; Folsom-O’Keefe, C.; Dardick, K.R.; Lepore, T.; Bent, S.J.; Usmani-Brown, S.; Telford, S.R., III; Fish, D.; et al. Monitoring human babesiosis emergence through vector surveillance New England, USA. *Emerg. Infect. Dis.* **2014**, *20*, 225–231. [[CrossRef](#)] [[PubMed](#)]
4. Drexler, N.A.; Dahlgren, F.S.; Heitman, K.N.; Massung, R.F.; Paddock, C.D.; Behravesh, C.B. National surveillance of spotted fever group rickettsioses in the United States, 2008–2012. *Am. J. Trop. Med. Hyg.* **2016**, *94*, 26–34. [[CrossRef](#)]
5. Heitman, K.N.; Dahlgren, F.S.; Drexler, N.A.; Massung, R.F.; Behravesh, C.B. Increasing incidence of ehrlichiosis in the United States: A summary of national surveillance of *Ehrlichia chaffeensis* and *Ehrlichia ewingii* infections in the United States, 2008–2012. *Am. J. Trop. Med. Hyg.* **2016**, *94*, 52–60. [[CrossRef](#)]

6. Wormser, G.P.; Shapiro, E.D.; Fish, D. *Borrelia miyamotoi*: An emerging tick-borne pathogen. *Am. J. Med.* **2019**, *132*, 136–137. [[CrossRef](#)]
7. Raghavan, R.K.; Peterson, A.T.; Cobos, M.E.; Ganta, R.; Foley, D. Current and future distribution of the lone star tick, *Amblyomma americanum* (L.) (Acari: Ixodidae) in North America. *PLoS ONE* **2019**, *14*, e0209082. [[CrossRef](#)]
8. Parham, P.E.; Waldock, J.; Christophides, G.K.; Hemming, D.; Agosto, F.; Evans, K.J.; Fefferman, N.; Gaff, H.; Gumel, A.; LaDeau, S.; et al. Climate, environmental and socio-economic change: Weighing up the balance in vector-borne disease transmission. *Phil. Trans. R. Soc. B* **2015**, *370*, 20130551. [[CrossRef](#)]
9. Hotez, P.J. Neglected tropical diseases in the Anthropocene: The cases of Zika, Ebola, and other infections. *PLoS Negl. Trop. Dis.* **2016**, *10*, e0004648. [[CrossRef](#)]
10. Petersen, L.R.; Beard, C.B.; Visser, S.N. Combatting the increasing threat of vector-borne disease in the United States with a national vector-borne disease prevention and control system. *Am. J. Trop. Med. Hyg.* **2019**, *100*, 242–245. [[CrossRef](#)]
11. Sutherst, R.W. Global change and human vulnerability to vector-borne diseases. *Clin. Microbiol. Rev.* **2004**, *17*, 136–173. [[CrossRef](#)] [[PubMed](#)]
12. Gugliotta, J.L.; Goethert, H.K.; Berardi, V.P.; Telford, S., III. Meningoencephalitis from *Borrelia miyamotoi* in an immunocompromised patient. *New Engl. J. Med.* **2013**, *368*, 240–245. [[CrossRef](#)] [[PubMed](#)]
13. Rainey, T.; Occi, J.L.; Robbins, R.G.; Egizi, A. Discovery of *Haemaphysalis longicornis* (Ixodida: Ixodidae) parasitizing a sheep in New Jersey, United States. *J. Med. Entomol.* **2018**, *55*, 757–759. [[CrossRef](#)] [[PubMed](#)]
14. United States Department of Agriculture. National *Haemaphysalis longicornis* (Asian Longhorned Tick) Situation Report. 2019. Available online: https://www.aphis.usda.gov/animal_health/animal_diseases/tick/downloads/longhorned-tick-sitrep.pdf (accessed on 6 August 2019).
15. Glass, G.E.; Ganser, C.; Wisely, S.M.; Kessler, W.H. Standardized Ixodid tick survey in mainland Florida. *Insects* **2019**, *10*, 235. [[CrossRef](#)] [[PubMed](#)]
16. Kessler, W.H.; Ganser, C.; Glass, G.E. Estimating species distributions: Convenience samples versus targeted survey data. *Insects* **2019**, *10*, submission.
17. Egizi, A.M.; Occi, J.L.; Price, D.C.; Fonseca, D.M. Leveraging the expertise of the New Jersey Mosquito Control community to jump start standardized tick surveillance. *Insects* **2019**, *10*, 219. [[CrossRef](#)]
18. Stromdahl, E.Y.; Hickling, G.J. Beyond Lyme: Aetiology of tick-borne human diseases with emphasis on the South-Eastern United States. *Zoonoses Public Health* **2012**, *59*, 48–64. [[CrossRef](#)]
19. Mendell, N.L.; Reynolds, E.S.; Blanton, L.S.; Hermance, M.E.; Londoño, A.F.; Hart, C.E.; Quade, B.R.; Esterly, A.T.; Hendrix, C.F.; Teel, P.D.; et al. Detection of Rickettsiae, Borreliae, and Ehrlichiae in ticks collected from Walker County, Texas, 2017–2018. *Insects* **2019**, *10*, 315. [[CrossRef](#)]
20. De Jesus, C.E.; Ganser, C.; Kessler, W.H.; White, Z.S.; Bhosale, C.R.; Glass, G.E.; Wisely, S.M. A survey of tick-borne bacterial pathogens in Florida. *Insects* **2019**, *10*, 297. [[CrossRef](#)]
21. Hermance, M.E.; Thangamani, S. Powassan virus: An emerging arbovirus of public health concern in North America. *Vector-Borne Zoonotic Dis.* **2017**, *17*, 453–462. [[CrossRef](#)]
22. Frazier, N.M.; Douce, R.W. First reported case of Lyme carditis in Southwest Michigan. *Spartan Med Res. J.* **2017**, *1*, 5933.
23. Lee, X.; Murphy, D.S.; Hoang Johnson, D.; Paskewitz, S.M. Passive animal surveillance to identify ticks in Wisconsin, 2011–2017. *Insects* **2019**, *10*, 289. [[CrossRef](#)] [[PubMed](#)]
24. Altizer, S.; Ostfeld, R.S.; Johnson, P.T.J.; Kutz, S.; Harvell, C.D. Climate change and infectious diseases: From evidence to a predictive framework. *Science* **2013**, *341*, 514–519. [[CrossRef](#)] [[PubMed](#)]
25. Levi, T.; Keesing, F.; Oggenfuss, K.; Ostfeld, R.S. Accelerated phenology of blacklegged ticks under climate warming. *Philos. Trans. R. Soc. B Biol. Sci.* **2015**, *370*, 20130556. [[CrossRef](#)] [[PubMed](#)]
26. Brownstein, J.S.; Holford, T.R.; Fish, D. Effect of climate change on Lyme disease risk in North America. *Ecohealth* **2005**, *2*, 38–46. [[CrossRef](#)] [[PubMed](#)]
27. Ogden, N.H.; Maarouf, A.; Barker, I.K.; Bigras-Poulin, M.; Lindsay, L.R.; Morshed, M.G.; O’Callaghan, C.J.; Ramay, F.; Waltner-Toews, D.; Charron, D.F. Projections for range expansion of the Lyme disease vector *Ixodes scapularis*, in response to climate change. *Int. J. Parasitol.* **2006**, *36*.
28. Linske, M.A.; Stafford, K.C.; Williams, S.C.; Lubelczyk, C.B.; Welch, M.; Henderson, E.F. Impacts of deciduous leaf litter and snow presence on nymphal *Ixodes scapularis* (Acari: Ixodidae) overwintering survival in coastal New England, USA. *Insects* **2019**, *10*, 227. [[CrossRef](#)]

29. Hollingsworth, T.D.; Pulliam, J.R.; Funk, S.; Truscott, J.E.; Isham, V.; Lloyd, A.L. Seven challenges for modelling indirect transmission: Vector-borne diseases, macroparasites and neglected tropical diseases. *Epidemics* **2015**, *10*, 16–20. [[CrossRef](#)]
30. Klarenberg, K.; Wisely, S.M. Evaluation of NEON Data to Model Spatio-Temporal Tick Dynamics in Florida. *Insects* **2019**, *10*, 321. [[CrossRef](#)]
31. Kessler, W.H.; Ganser, C.; Glass, G.E. Modeling the distribution of medically important tick species in Florida. *Insects* **2019**, *10*, 190. [[CrossRef](#)]
32. Pascoe, E.L.; Marcantonio, M.; Caminade, C.; Foley, J.E. Modeling potential habitat for *Amblyomma* tick species in California. *Insects* **2019**, *10*, 201. [[CrossRef](#)] [[PubMed](#)]
33. Jourdain, F.; Samy, A.M.; Hamidi, A.; Bouattour, A.; Alten, B.; Faraj, C.; Roiz, D.; Petrić, D.; Pérez-Ramírez, E.; Velo, E.; et al. Towards harmonisation of entomological surveillance in the Mediterranean area. *PLoS Negl. Trop. Dis.* **2019**, *13*, e0007314. [[CrossRef](#)] [[PubMed](#)]



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