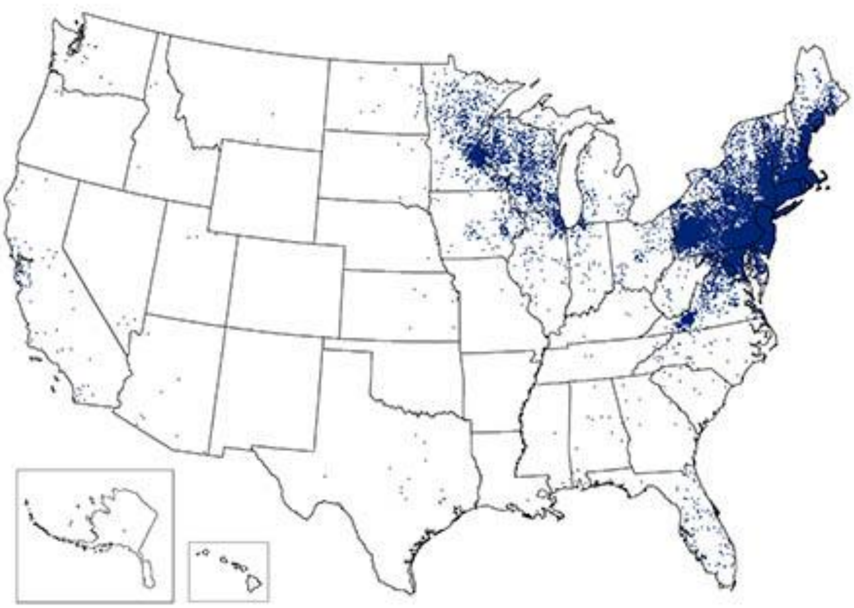
Level 1: Lyme Disease Connections

❖ **Background Information:**

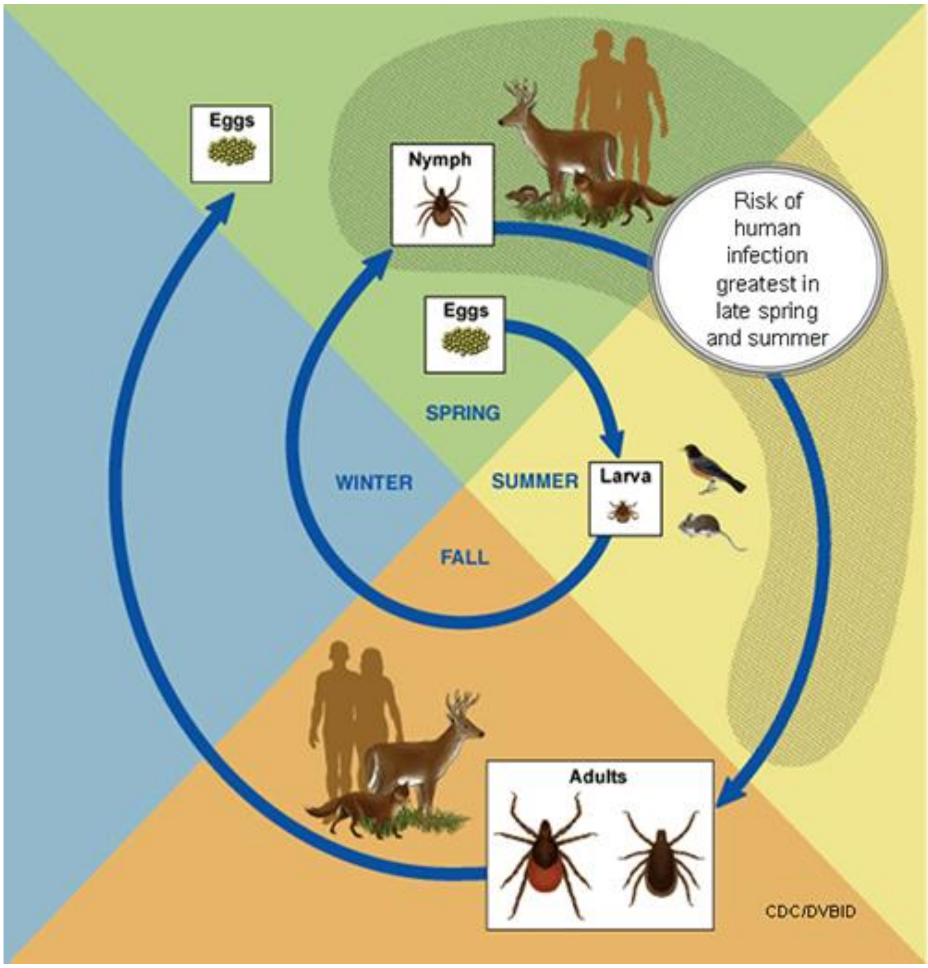


Source: Center for Disease Control: http://www.cdc.gov/lyme/stats/maps.html

Since the early 1980s, Lyme disease has been a growing scourge for residents of the Northeastern United States. The Center for Disease Control now estimates that as many as 300,000 Americans are diagnosed annually with Lyme disease, which causes fever, exhaustion, joint pain/stiffness, headaches, forgetfulness, facial paralysis and more (CDC 2015). The black-legged tick (*Ixodes scapularis*) is the primary vector of the bacterium that causes Lyme disease, which is called *Borrelia burgdorferi*. In recent years, the black-legged tick has also begun to more frequently transmit anaplasmosis, babesiosis, and Powassan disease to humans.

Dutchess County (home of the Cary Institute) is considered a Lyme disease hotspot: from 2002-2006 Dutchess County had the highest number of reported Lyme disease cases in the United States (Pfeiffer 2012). Cary Institute grounds are home to the world's longest running study on the ecology of Lyme disease. Long-term research by Cary Ecologist Dr. Rick Ostfeld and his collaborators has revealed the complex interactions among infected ticks, environmental conditions, and disease risk.

Understanding the spread of Lyme disease requires some basic knowledge of tick biology. The tick life cycle has four stages: egg—larva—nymph—adult. At each life-stage (except for the egg stage), a tick requires just one blood meal to provide enough food and energy to move to the next stage. Note: only *female* adult black-legged ticks require a blood meal.



Black-legged tick life cycle. Only nymph and adult ticks can spread Lyme disease.
Source: Centers for Disease Control and Prevention

Larval ticks that have just hatched from eggs do not have the Lyme disease bacteria. They can only acquire it by feeding on the blood of an infected host animal. Black-legged nymphs are about the size of a poppy seed and are typically considered the most dangerous stage to humans, as only nymphs and adults can transmit the disease, but nymphs are much harder to detect and remove from the skin.

Animals that are able to transfer the Lyme disease bacteria to ticks are called reservoir species. These animals have the *Borrelia burgdorferi* bacteria in their blood, and they can transfer the bacteria to a host when they are bitten. Some animals, such as mice and chipmunks are very good at transferring Lyme disease to ticks. Other animals, like raccoons and opossums, infrequently transfer Lyme disease to ticks. The ability to transfer Lyme disease to a tick is known as "reservoir competence". White-footed mice (*Peromyscus leucopus*) have the greatest reservoir competence. Laboratory studies at the Cary Institute showed that 90% of larval ticks that fed on white-footed mice picked up the Lyme disease bacteria (LoGiudice et al, 2003; LoGiudice et al. 2003; Keesing et al., 2009). White-footed mice also tend to have many ticks on their bodies; Cary researchers have found as many as 100 larval ticks on one mouse! Thus, Lyme disease prevalence within Dutchess County seems to be closely linked to the white-footed mouse population.

A Cary researcher shows off a white-footed mouse with a large number of black-legged ticks embedded on its ear.

White-footed mouse populations depend on many factors, such as predation, competition with other small mammals, climate, and food availability. Each year, researchers at the Cary Institute monitor tick and small mammal populations, and study the "seed rain" that falls from trees. This dataset shows the populations of mice, tick nymphs, and acorns that they collected in the Cary forest from1993-2007. The dataset will allow you to explore connections between the three types of organisms.

- **Dataset Variables:**
  - Year (1993-2007)
  - Average nymph tick population during peak density (ticks/m^2): This shows how many nymph ticks the researchers would expect to find in an average square meter of the forest during *peak density*, or the time when the greatest number of tick nymphs are active in the forest.
  - Average acorn population density (acorns/m^2): Acorns are collected by catching them as they fall from oak trees. This number shows how many acorns you would expect to catch in a typical 1 m^2 -basket placed under a tree.
  - Average mouse population density (mice/ha): The researchers trapped mice throughout the summer, then used their findings to estimate how many mice we would expect to catch if we placed traps in a hectare of forest during the nymphal tick peak density.

- **Dataset Timeframe:**
  - The scientists sampled the forest from 1993-2007, although you will notice they started sampling the mice in 1994 and the ticks in 1995.
  - Researchers sampled the forest during the growing seasons from April through November.

- **Information About Sites**
  - Field studies were conducted on the 2,000-acre property of the Cary Institute of Ecosystem Studies in central Dutchess County, southeast New York (41° 50'N, 73° 45' W). Cary property is a mix of forest, old agricultural fields, and buildings.
  - This sampling was all performed on six forest grids that are 2.25 hectares in size and are dominated by oak trees.

- **Data Collection Methods:**
  - **Mice:**
    - White-footed mice (*Peromyscus leucopus*) were live-trapped in a small metal box called a Sherman trap. Each grid had 242 evenly spaced traps, which were set out in pairs underneath a wooden coverboard. Traps were baited with whole oats and opened between 4:00 and 6:00pm. During weeks where the temperature was expected to drop below 50°F, black-oil sunflower seed and raw cotton were added to the traps in addition to the oats to provide a fattier food source and warm bedding material. Traps were checked between 7:30 and 11:30am the following day. Each grid was trapped for two consecutive days, then given a 2-3 week rest before it was trapped again.

A tagged mouse in front of a Sherman trap. When a rodent walks into a Sherman trap, the door closes behind them. Mice are not harmed by the trap, and actually spend the night in relative safety from predators. In fact, sometimes a released mouse will walk back into the trap as soon as a researcher sets the trap and walks away. The researchers call these mice "trap happy".

    - Each captured mouse was given a uniquely numbered metal eartag during its first capture, which helped the researchers track the mice through the summer. Animals were then released in the same place where they were caught.
    - The researchers couldn't expect to catch every single mouse in the grid when they trapped, so the number you see in the data sheet was produced by a bit of mathematical calculation called a "Minimum Known Alive" model, which uses the number of mice they caught to estimate the number that was in the grid at the time of the peak tick nymphal density.

- **Acorns**:
  - Acorns were collected in baskets as they fell off trees in a "seed rain".
  - Each spring the researchers set out 20-25 seed-collecting baskets per grid and then took them down in November. The baskets were emptied every four weeks, except during the fall when the seed rain was heavy and they were emptied twice as often.
  - The researchers identified and counted all seeds that fell into the basket, but the only results you will see in this dataset are from the acorns, which were from five species of oaks: White oak, Scarlet oak, Chestnut oak, Northern red oak, and Black oak.

Left: A tick crew member checking a seed basket.
Right: Checking a drag cloth for ticks.

- **Ticks**: Ticks were sampled by dragging a white 1 m^2 cloth along the ground in a long line called a "transect". Researchers dragged for a total of 450 m per grid every time they sampled. They then calculated the nymph density by dividing the total number of collected nymphs by the number of meters that they dragged. The number you see in the data sheet is the number of nymphs they found at *peak density*, when nymph populations were the highest. Researchers also found adult and larval ticks, but they only counted the larval ticks for this particular study.

- **Source of Dataset:**
  - Dr. Rick Ostfeld, Disease Ecologist at the Cary Institute: http://www.caryinstitute.org/science-program/our-scientists/dr-richard-s-ostfeld
  - If you have specific questions about this research that you would like to ask the scientists, please email caryeducation@caryinstitute.org and we will be happy to contact the scientists on your behalf.

- Researchers currently involved in this study include:

Dr. Richard Ostfeld Disease Ecologist (*center*)	**Kelly Oggenfuss** **Senior Research** **Specialist (*right*)**	**Many Project** **Assistants!**

Inquiry Idea Starters

Here are some sample questions you could ask using these data. These are just suggestions, and we hope you'll come up with many interesting questions of your own. Have fun!

- Do the populations change over time? You might consider creating a histogram (frequency diagram) to see if the populations seem stable over time or if they seem to grow and crash.
- Does there seem to be a relationship over time between the mouse and acorn populations? How about mice and nymphs? Or nymphs and acorns? You might consider using a line graph to show populations changing over time.
- Does there seem to be a difference in how strong any of these relationships are? A scatter plot would help you explore this question.

Additional Resources

- Search the large collection of lessons that are available through the Cary Institute "Teaching Materials" page, including several on biodiversity and Lyme disease ecology: http://www.caryinstitute.org/educators/teaching-materials/ecology-lyme-disease/ecology-lyme-disease
- More information on the "Acorn Connections" between ticks, mice, and Lyme disease: http://www.caryinstitute.org/science-program/research-projects/acorn-connections
- Background information from the Cary Institute on this research project and other components of our Lyme disease research program: http://www.caryinstitute.org/science-program/our-scientists/dr-richard-s-ostfeld

❖ References

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Members of the Tick Project have a high exposure to Lyme disease and other tick-borne illnesses. They stay safe by wearing white suits, which make it easier to see ticks, and by remembering to check their bodies for ticks every time they sample, especially if they've been in brushy areas.