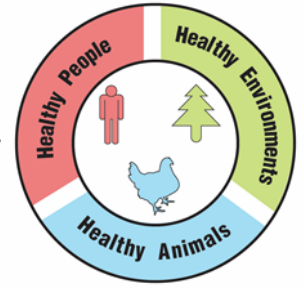


LSLC Virtual Field Trip – Teacher Guide

Ticks, Biodiversity, and Climate



Virtual Field Trip Summary:

Students virtually follow a high school student named Jada as she volunteers at a local veterinary hospital. During the course of Jada's 6-week internship she helps diagnose a patient with a tick-borne disease. Students will examine the data to figure out why the incidence of tick-borne diseases are on the rise. Additionally, students will determine the factors contributing to increases in ticks and the diseases they carry.

Core Concepts:

- The increased-risk of tick-borne pathogens may be related to biodiversity and climate change.
- Tick-borne pathogens pose a growing risk to human health.
- A One Health approach identifies and seeks solutions to problems that affect the health of humans, animals, and the environment.

Suggested Grade Levels: Grades 9-12

Class time required (approximately 180 – 220 minutes):

- Part 1: What kinds of ticks are present in the ecosystem? **30 minutes**
- Part 2: What pathogens can ticks carry? **30 minutes**
- Part 3: Analyzing patterns in tick-borne diseases **30 - 40 minutes**
- Part 4: Do living things influence the pattern of tick-borne diseases? **30 - 40 minutes**
- Part 5: What should concerned pet owners know about tick-borne diseases? **30 - 40 minutes**
- Part 6: One Health and tick-borne diseases **30 - 40 minutes**

Teacher Preparation:

Materials/Supplies Overview:

1. Electronic devices for accessing the internet individually or in groups. Provide access to:
 - Google (Docs, Google Slides, Jamboard, etc.). If needed, convert these programs into another platform such as Microsoft products (Word, PowerPoint, etc.)
 - PowerPoint or similar digital program for making slides, or poster paper and markers.
2. Confirm that you have access to the **Ticks, Biodiversity and Climate Virtual Field Trip** website.
 - Click the link below to preview the virtual field trip to become familiar with the website: <https://sites.google.com/view/ticksbiodiversityclimate/home>

3. The **Digital Lab Notebook** serves as an answer sheet, data collection tool, and record of their virtual lab activities. The Digital Lab Notebook can also be used for extra credit assignments. **Each student will need to make their own copy of the Digital Lab Notebook:**

https://docs.google.com/presentation/d/1INoR_zitShQvE6Edr2UM5M27iSKb0FQbM7tSPnBDZf0/copy

Note: Provide the PowerPoint version of the **Digital Lab Notebook** for students who do not have access to Google Slides.

General Information:

1. Read Suggested Procedures section of this guide for each part.
2. Answer Keys have been included in this Teacher Guide for your use. Review the information and answer keys below:
 - **Tick Identification Key** including:
 - **Tick Photographs**
 - **Human Diseases Transmitted by Ticks Reference Sheet**
 - **Ticks, Biodiversity and Climate Answer Key**
 - **Tick Pathogen Detection Video Protocol**
3. Share the link for the **Ticks, Biodiversity and Climate** Virtual Field Trip with each student.
4. Share the link OR provide printed copies of the **Digital Lab Notebook**.
5. Students can be told to work individually or in pairs to complete this virtual field trip.
6. The virtual field trip can be completed within the time schedule preferred by the teacher. It should be completed in sequential order - Part 1, before Part 2, and so on.

(Optional) Parking Lot Suggestion:

The topic of this virtual field trip is rich enough to trigger conversations and questions that go beyond the immediate content in this lesson. Teachers may set up a “Parking Lot” for collecting student questions or ideas for additional connections/research. If participation in the virtual field trip is done with video conferencing formats, breakout rooms or a Google Jamboard can also be used for this Parking Lot Strategy in place of using sticky notes and poster paper.

Parking Lot Strategy

- Make a large poster paper or bulletin board area in the classroom as your Parking Lot.
- When students have a question or additional connection, have them write it on a sticky note and hand it to you or put it in the Parking Lot.
- Only answer questions immediately if they are essential for completing the lesson.
- Put sticky notes with other questions or connections in the Parking Lot.
- At the end of the lesson, review the Parking Lot questions.
- Remove questions that were answered by the lesson.
- Ask students which remaining questions and connections they would like to discuss.

(Optional) Team Science Suggestion:

Teachers can introduce the concept of **Team Science** if students will be working in groups. **Team Science** is a popular approach in research where large projects are divided among individuals as they work in one or more groups to solve problems. For more on team science: <https://www.apa.org/science/about/psa/2013/04/team-science>.

To promote additional student engagement during each part of the virtual field trip, a different set of students can volunteer or be assigned to the roles below. Alternatively, a set of students working in a small group can be assigned or given a role for their group. *If you identify additional roles for promoting student engagement, describe them in your Teacher Evaluation feedback.*

1. **Timekeeper:** Student who will keep track of time allowed and spend on each part. The teacher will provide the Timekeeper with the time limit for the virtual field trip part. The Timekeeper is given a physical timer to monitor time or is provided access to a clock. The Timekeeper should be given a printed copy of the [Antibiotic-Resistant Bacteria Virtual Field Trip Log](#) (see page xvii) and pencil or pen to record the actual time spent on the part. If more time is needed than allotted, the teacher can choose to provide more class time to finish, or direct students to complete the rest during out of school time. Timekeeper then announces to the class the total time that will be provided for the “Part” of the virtual field trip. For example, this can be done by saying,

- *I am the Timekeeper for Part 1. Our 20 minutes for Part 1 begins now!*
- *We have 5 minutes left in Part 1,*
- *We have 1 minute left in Part 1,*
- *Part 1 is finished, click the “Next Page” button on the bottom of your screen.*

2. **Recordkeeper:** Student who will remind the class to record their responses in their Digital Lab Notebooks following each question/activity. When the Timekeeper announces 5 minutes left, the Recordkeeper can follow the announcement by saying,

- *Remember to record your data and observations in your Digital Lab notebook.*

When the Timekeeper announces the end of Part 1, the Recordkeeper can say,

- *Make you sure all Part 1 responses are in your Digital Lab Notebook.*

Note: *For those using a Google Slide version, the Digital Lab Notebook is “autosaved” to the student account. If using a PowerPoint version of the Digital Lab Notebook, the Recordkeeper can also remind students to save the file. This will prevent loss of data. The following announcement can be made,*

- *Click “save” in your Digital Lab Notebook before moving to the next part.*

Suggested Procedures (Parts 1-6):

Part 1: What kinds of ticks are present in the ecosystem? (30 minutes)

1. Share **Ticks, Biodiversity and Climate** Virtual Field Trip website link with each student. <https://sites.google.com/view/ticksbiodiversityclimate/home>
 - Teachers can screen share to show students the website before the students work independently or in groups.
 - Teachers should direct students to watch the video on the **Home** page. Dr. Alcéna-Stiner, from the Life Sciences Learning Center, provides an overview for the field trip in the video.
2. Teachers should explain that the virtual field trip has six parts. Students are about to participate in **Part 1: What kinds of ticks are present in the ecosystem?**
3. The website will guide students through the identification of ticks that are present in the ecosystem.
 - If students are using a mobile device and not a computer, they will need to scroll downward when the directions direct them to use the **Tick Identification Key** on the right.
 - Students using computers will see the **Tick Identification Key** on their right.
 - All students will answer three multiple choice questions in the **Tick Identification Key** then scroll downward to progress forward with new instructions.
4. Provide the link for students to download their own **Digital Lab Notebook**.
https://docs.google.com/presentation/d/1INoR_zitShQvE6Edr2UM5M27iSKb0FQbM7tSPnBDZf0/copy
 - Teachers can have students share their individual **Digital Lab Notebook** links for grading or extra credit for participating in the activities.
5. After students have identified all three ticks they are directed to click Next on the bottom right of the screen.
6. The new page directs students to learn more about One Health concepts, connecting the human, animal and environmental health using the link provided.
 - Students are informed that they will start **Part 2** when given access from their teacher.

Part 2: What pathogens can ticks carry? (30 minutes)

1. Share **Ticks, Biodiversity and Climate** Virtual Field Trip website link with each student.
 - Teachers can screen share to show students the website before the students work independently.
 - Students can be encouraged to work with one or more partners to complete Part 2.
 - Teachers should explain that the virtual field trip has six parts. Students are about to participate in **Part 2: What pathogens can ticks carry?**
2. Read the information in the top text box aloud to the class or have students read individually.
3. The website will guide students through a simulated Gel **Electrophoresis** Tick DNA from the three dogs (Max, Daisy and Lainey).
 - All students will record their observations along with answers to the posted questions in their digital lab notebooks.
 - Remind students that the data from today will be recorded in their digital lab notebook for Part 2. The lab notebook has the questions and prompts that each student will need to have a complete set of notes for part 2.
4. Students should open their **Digital Lab Notebook (Part 2)**.
 - Teachers can have students share their individual **Digital Lab Notebook** links for grading or extra credit for participating in the activities.
 - Answer keys are provided below for teachers to check answers.
5. After students have recorded all data in their lab notebooks, they are directed to click Next Page on the bottom right of the screen.
6. The new page directs students to learn more about ticks using the link provided.
 - Students are informed that they will start **Part 3** when given access from their teacher.

Part 3: Analyzing patterns in tick-borne diseases (30 - 40 minutes)

1. Share **Ticks, Biodiversity and Climate** Virtual Field Trip website link with each student.
 - Teachers can screen share to show students the website before the students work independently.
 - Students can be encouraged to work with one or more partners to complete Part 3.
 - Teachers should explain that the virtual field trip has six parts. Students are about to participate in **Part 3: Analyzing patterns in tick-borne diseases**
2. Read the information in the top text box aloud to the class or have students read individually.
3. The website will guide students through data analysis.
 - All students will record their observations along with answers to the posted questions in their digital lab notebooks.
 - Remind students that the data from today will be recorded in their digital lab notebook for Part 3. The lab notebook has the questions and prompts that each student will need to have a complete set of notes for part 3
4. Students should open their **Digital Lab Notebook (Part 3)**.
 - Teachers can have students share their individual **Digital Lab Notebook** links for grading or extra credit for participating in the activities.
 - Answer keys are provided below for teachers to check answers.
5. After students have recorded all data in their lab notebooks, they are directed to click Next on the bottom right of the screen.
6. The last page directs students to learn more about climate and tick behaviors using the link provided.
 - Students are informed that they will obtain access to **Part 4** when given access from their teacher.

Note: For the *Relatively Humidity* graph students may need help understanding that $0.2 = 20\%$.

Part 4: Do living things influence the pattern of tick-borne diseases? (30 - 40 minutes)

1. Share **Ticks, Biodiversity and Climate** Virtual Field Trip website link with students.
 - Teachers can screen share to show students the website before the students work independently.
 - Students can be encouraged to work with one or more partners to complete Part 4.
 - Teachers should explain that the virtual field trip has six parts. Students are about to participate in **Part 4: Do living things influence the pattern of tick-borne diseases?**
2. Read the information in the top text box aloud to the class or have students read individually.
3. The website will guide students through data analysis.
 - All students will record their observations along with answers to the posted questions in their digital lab notebooks.
 - Remind students that the data from today will be recorded in their digital lab notebook for Part 4. The lab notebook has the questions and prompts that each student will need to have a complete set of notes for part 4
4. Students should open their own **Digital Lab Notebook (Part 4)**.
 - Teachers can have students share their individual **Digital Lab Notebook** links for grading or extra credit for participating in the activities.
 - Answer keys are provided below for teachers to check answers.
5. After students have recorded all data in their lab notebooks, they are directed to click Next on the bottom right of the screen.
6. The last page directs students to learn more about climate and tick behaviors using the link provided.
 - Students are informed that they will start **Part 5** when given access from their teacher.
7. Debrief answers as a class. The teacher may consider asking questions like, “What patterns do you notice?”, “What differences do you see across the three maps?” Encourage use of reliable sources of information using the resource links provided.

Part 5: What should pet owners know about tick-borne diseases? (30 - 40 minutes)

1. Share **Ticks, Biodiversity and Climate** Virtual Field Trip website link with students.
 - Teachers can screen share to show students the website before the students work independently.
 - Teachers should explain that the virtual field trip has six-parts. Students are about to participate in **Part 5: What should pet owners know about tick-borne diseases?**
2. Ask 1-2 students to read the information in the Part 5 text box aloud to the class.
3. The website will guide students asking them to click a question (note it has a hyperlink) that takes them to a new website.
 - Students work individually to answer each of the questions. Alternatively, students could work in groups of four and each student could research one question. As a team of four, students would develop the FAQ page which can be paper or electronic.
 - All students will record their responses to the questions in their digital lab notebooks.
 - Remind students that the data from today will be recorded in their digital lab notebook for Part 5. The lab notebook has the questions and prompts that each student will need to have a complete set of notes for part 5.
 - Make sure students know to return back to the field trip website after finding information to answer their question.
 - Each question will take students to a new website.
 - Here are the 6 steps to be shared with students:
 - 1) Read the question below.
 - 2) Click the question to visit a website to help you find a response for your answer.
 - 3) Find an answer and record it in your Digital Lab Notebook.
 - 4) Return to this page to read the next question
 - 5) Repeat the process starting at step 1 until you have all four answers.

or

Make sure you recorded all four answers in your Digital Lab Notebook

 - 6) Click Next Page on the bottom right when you are finished.
4. Students should open their **Digital Lab Notebook (Part 5)**.
 - Teachers can have students share their individual **Digital Lab Notebook** links for grading or extra credit for participating in the activities.
 - There are no correct responses for Part 5. Answers can vary.
5. After students have recorded all responses in their lab notebooks, they are directed to click Next Page on the bottom right of the screen (step 6 in their instructions).

6. The last page directs students to learn more about One Health: connecting humans, animals, and environmental health using the link provided.
 - Students are informed that they will start **Part 6** when given access from their teacher.
7. Optional: Teacher can consider having students develop an FAQ webpage.
8. Debrief student answers to the FAQs.

Part 6: One Health and tick-borne diseases (30 - 40 minutes)

1. Share **Ticks, Biodiversity and Climate** Virtual Field Trip website link with students.
 - Teachers can screen share to show students the website before the students work independently.
 - Teachers should explain that the virtual field trip has six parts. Students are about to participate in **Part 6: One Health and tick-borne diseases**
2. Read the information in the top text box, One Health Problem aloud to the class or have students read individually.
3. Students work with their partner to complete question 1.
4. Consider modeling how to complete the Problem part of the chart by asking students to suggest one idea for each section (animal, human, environment).
 - Depending on the class level, you should explain how many items you expect students to have in each section. For example: At least 2 for each section, or a total of 8.
5. Students can work individually or work in groups based on teacher preference for question 1 and 2.
6. Have several students share their answer to question 1. It is important for students to have this correct before moving on to question 2.
 - If small group activity is preferred using video conferencing (i.e. Zoom) consider using Breakout room for students to work in small groups to discuss ideas.
 - Partners can take turns reading questions aloud for others.
 - The entire class can discuss this collectively if desired.
7. Read the information in the second text box aloud to the class or have students read individually.
8. Students can work with a partner or groups to complete question 2 – their digital slide. *Note: Students without access to digital slide programs like Google or PowerPoint can produce a paper version.*
9. The website will guide students to record their responses to the questions in their digital lab notebooks. Students open their own **Digital Lab Notebook (Part 6)**.
 - Remind students that the data from today will be recorded in their digital lab notebook for Part 6. The lab notebook has the questions and charts that each student will need to have a complete set of notes for part 6, unless you prefer group submissions.
 - Make sure students know to return back to the field trip website after completing each chart and the answers to questions 3-5.
 - Teachers can have students share their individual **Digital Lab Notebook** links for grading or extra credit for participating in the activities.
 - There are no correct responses provided in the answer key for Part 6. Answers can vary.
 - Students receive full credit if their slide links tick-borne diseases to the health of humans, animals and the environment.

- Suggestion – Collect the digital slides into one slide deck. Share this slide deck with the class. If you have ample class time, you may consider having students present and explain their slides.
 - Optional extension: Have students identify another example of a One Health problem. Have students use their idea to create a similar digital slide that explains why their example is a One Health problem.
10. After students have recorded all responses in their lab notebooks, they are directed to click Next Page on the bottom right of the screen.
 11. The last page provides students with an opportunity to provide feedback on the virtual field trip, using the **Ticks, Biodiversity, and Climate LSLC Virtual Field Trip Student Evaluation** form. Guide students to complete and submit the evaluation form.

Student Evaluation Form: https://redcap.link/2022-LSLC-VFT1-Student_Feedback

Note: Students will be asked to “Enter your teacher’s school email address.” Provide students with the teacher’s email address. Make sure students use and enter the correct email address.

12. Teachers are encouraged to provide feedback on the virtual field trip using the **LSLC Virtual Field Trip Teacher Evaluation** form.

Teacher Evaluation Form: https://redcap.link/2022-LSLC-VFT-Teacher_Feedback

13. The bottom of the last page directs students to learn more about One Health using the links provided.

Suggested Online Resources:

*Links to additional resources are added after some parts of the virtual field trip. If you would like to, you could use them for additional asynchronous time for information discovery and reflection on concepts. Below is a full list of the **Suggested Resources**:*

- **Centers for Disease Control and Prevention (CDC) - One Health**
<https://www.cdc.gov/onehealth/index.html>
- **Centers for Disease Control and Prevention (CDC) – Ticks**
<https://www.cdc.gov/ticks/index.html>
- **Climate and Tick Behavior**
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5226345/>
- **Lyme Disease Geographic Distribution and Tick Behavior**
<https://www.usgs.gov/news/it-s-heat-and-humidity-new-study-finds-why-lyme-disease-common-north-rare-south>
- **Tick Life Cycle and Ecology**
<https://www.pnas.org/content/109/27/10942>
- **Ticks and pets**
https://www.cdc.gov/ticks/removing_a_tick.html
- **Precautions to prevent tick bites on pets**
https://www.cdc.gov/ticks/avoid/on_pets.html
- **Precautions to prevent human tick bites**
https://www.cdc.gov/ticks/avoid/on_people.html
- **Help for pet owners when a pet is diagnoses with tick-borne disease**
<https://www.avma.org/resources/pet-owners/petcare/lyme-disease-pet-owners-guide>

NGSS Correlation:

<p>Working Towards Performance Expectations</p> <p>MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]</p> <p>MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]</p> <p>HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]</p>		
<p>Science and Engineering Practices</p> <ul style="list-style-type: none"> • Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. 	<p>Disciplinary Core Ideas</p> <ul style="list-style-type: none"> • Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. 	<p>Cross Cutting Concepts</p> <ul style="list-style-type: none"> • Patterns can be used to identify cause and effect relationships. • Much of science deals with constructing explanations of how things change and how they remain stable. (Stability and Change) • Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Small changes in one part of a system might cause large changes in another part.

Tick Identification Key

1. *Does the rear edge of the tick have a band that appears segmented with many square plates known as festoons? (See illustration below.)*

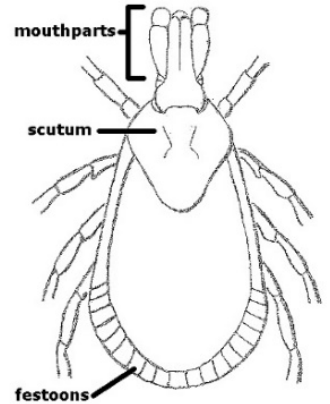
YES: Go to 3.

NO: Go to 2.

2. *Are the mouthparts long enough that they extend out from the body and are visible when looking at the tick from above?*

YES: This may be a **blacklegged tick**, also known as the “deer tick” (*Ixodes scapularis*). They range from dark brown to bright red and have black legs.

NO: This is a “**soft tick**” (Argasidae). These ticks are soft, while all other ticks mentioned here are “hard ticks.” Soft ticks rarely, if ever, transmit disease. They are often associated with domestic birds upon which they feed.



3. *Are there several irregular silvery-white marks in the center of the tick’s back?*

YES: This is an **American dog tick** (*Dermacentor variabilis*). It usually feeds on dogs and other small mammals but will bite people. The silvery-white marks streak across the backs of males. On females, the silvery-white marks are found only on the scutum. These ticks are oval shaped, and their mouthparts are relatively short and broad.

NO: Go to 4.

4. *Are there white markings on the rear edge of the tick’s back OR a single white spot in the center of the back?*

YES: This is the **lone star tick** (*Amblyomma americanum*). They have long, narrow mouthparts and their bodies are somewhat round in shape rather than oval-shaped like other ticks.

NO: This may be a **brown dog tick** (*Rhipicephalus sanguineus*). The brown dog tick is oval in shape and has shorter and thicker mouthparts than some other ticks. It feeds primarily on dogs. This tick seldom bites or transmits disease to people.



Tick removed from **Lainey**



Tick removed from **Daisy**

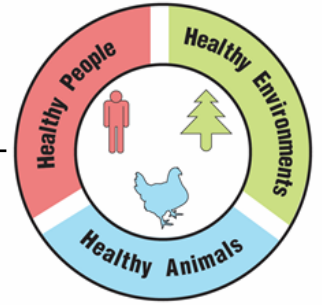


Tick removed from **Max**

Human Diseases Transmitted by Ticks

Disease	Transmitted by	Symptoms
Anaplasmosis	Blacklegged tick	Fever, chills, severe headache, nausea, vomiting, diarrhea, rash
Babesiosis	Blacklegged tick Brown Dog Tick	Common: Fever, chills, sweats, fatigue, joint pain, headache, nausea Less common: cough, sore throat, depression
Ehrlichiosis	Brown Dog Tick <i>Lone Star Tick</i>	Fever, chills, headache, muscle pain, nausea, vomiting, diarrhea, altered mental status, rash
Lyme disease	Blacklegged tick	Red ring-like expanding rash; classic rash is not present in all cases, flu-like symptoms, headache, fever, joint pain, muscle pain, heart abnormalities, facial paralysis
Rocky Mountain Spotted Fever	Brown Dog Tick <i>Lone Star Tick</i> American Dog Tick	High fever, severe headache, muscle pain, swelling around eyes and on the back of hands, nausea, vomiting, altered mental status, coma, respiratory distress, multi-organ system damage
'Stari' borreliosis	<i>Lone Star Tick</i>	Red, expanding “bull’s-eye” lesion, fatigue, headache, fever, and muscle pains.
Tularemia	American Dog Tick	Fever, chills, headache, fatigue, muscle pain, chest discomfort, cough, sore throat, vomiting, diarrhea, abdominal pain

Ticks, Biodiversity, and Climate ANSWER KEYS



Part 1: What kinds of ticks are present in the ecosystem?

Jada’s high school required twenty hours of community service in order to graduate. Jada was interested in a career as a veterinary technician (“vet tech”). As a vet tech, Jada would assist the veterinarian in diagnosing and treating animals. To learn what is involved in the job of a vet tech, Jada decided that she would volunteer at her local veterinarian’s office. Dr. Louis, the veterinarian, encouraged Jada to join her during most pet examinations.

The first patient of the morning was Max, a large sheepdog mix. As Dr. Louis examined Max’s ears, she noticed a small white “bump”. Dr. Louis showed Jada and explained that this bump was actually a tick. Ticks are tiny animals that embed their pointy mouth parts in their host’s skin to feed on blood. Dr. Louis immediately removed the tick from Max’s ear and placed it in a petri dish. Dr. Louis said that the tick could be carrying diseases that could harm Max. In order to find out if the tick was dangerous, they would first need to identify what kind of tick was on Max.



1. Use the photograph of the tick found on Max and the **Tick Identification Key** to identify the tick found on Max. What type of tick was found on Max?

Brown dog tick

2. Support your identification by checking the characteristics the tick had that helped in identification.

- Festoons
- Long mouth parts
- Several silvery markings
- One single white spot

3. Use the **Human Diseases Transmitted by Ticks** reference page to determine what diseases, if any, this kind of tick is likely to be carrying.

They are capable of transmitting Rocky Mountain spotted fever, Ehrlichiosis and Babesiosis.

Throughout the course of the day, Dr. Louis examined two more dogs, Lainey and Daisy. Both dogs loved the outdoors and took long walks through the woods with their human companion. Dr. Louis removed ticks from each of these dogs as well!

4. Use the **Tick Identification Key** to identify the tick found on Lainey. What type of tick was found on Lainey?

Blacklegged Tick

5. Support your identification by checking the characteristics the tick had that helped in identification.

- Festoons
 Long mouth parts
 Several silvery markings
 One single white spot

6. Use the **Human Diseases Transmitted by Ticks** reference page to determine what diseases, if any, this kind of tick are likely to be transmitted to humans.

The blacklegged tick is capable of transmitting several diseases to humans. These diseases include Borrelia burgdorferi (Lyme Disease), Babesiosis, and Anaplasmosis

7. Use **Tick Identification Key** to identify the tick found on Daisy. What type of tick was found on Daisy?

Lone Star Tick

8. Support your identification by circling the characteristics the tick had that helped in identification.

- Festoons
 Long mouth parts
 Several silvery markings
 One single white spot

9. Use the **Human Diseases Transmitted by Ticks** reference page to determine what diseases, if any, this kind of tick is likely to transmit to humans.

Lone star ticks can infect humans with Rocky Mountain Spotted Fever, 'Stari' borreliosis and Erlichiosis.

Tick Pathogen Detection Video Protocol

1. DNA stain is made by adding 20 ml of tap water to a plastic bag labeled DNA Stain.
2. The plastic bag is sealed and gently swirled so the DNA stain dissolves.
3. The Simulated Electrophoresis Gel is then added to the plastic bag.
4. The plastic bag is sealed, then placed on a flat surface.
5. After a few minutes a color change can be observed showing the banding patterns (pink bands) for each of the dogs (Max, Daisy, Lainey).

(Note: The video above does not have audio)

Tick Pathogen Standard Key				
	Borrelia Burgdorferi	Ehrlichia chaffeensis	Francisella tularensis	Anaplasma phagocytophilum
13				
12				
11				
10				
9				
8				
7				
6				
5				
4				
3				
2				
1				

Part 2: What pathogens can ticks carry?

Dr. Louis was concerned that the ticks might be carrying pathogens (viruses and other disease-causing microorganisms) that could harm the dogs. These pathogens would be living inside of the tick's body and are transmitted to the dog during the bite. Dr. Louis packaged the ticks into sealed plastic bags and sent them to the local veterinary laboratory for analysis.

To test for pathogens, a lab technician places DNA samples from the ticks into different wells on an electrophoresis gel. Gel electrophoresis separates DNA fragments (pieces) on the basis of size. Large DNA fragments move slowly through the gel. Small DNA fragments move quickly through the gel.

The video shows a simulated electrophoresis gel that the lab technician made for each of the ticks removed from Max and the two other dogs, Lainey and Daisy. The DNA pieces are not visible on the gel because DNA is colorless. In order to see the DNA, the lab technician will add a DNA stain to the gel. This stain will attach to the DNA fragments on the gel and turn them pink. Watch the video.

Use the **Tick Pathogen Detection video** to determine if any of the ticks removed from Dr. Louis' patients were carrying pathogens. To record the banding pattern on the diagram below, place an "X" on the line where you observed a pink color change in the video for the simulated electrophoresis gel.

	Max	Daisy	Lainey
13			
12		X	
11			
10		X	
9			
8			X
7	X		
6			
5		X	
4			
3	X		
2			
1			

The **Tick Pathogen Standard Key** displays banding patterns for common tick-borne pathogens. Compare the banding patterns in the tick samples to the Tick Pathogen Standard Key.

1. Complete the laboratory form to return the results to Dr. Louis by placing an “X” in the box where pathogens were detected.

Patient’s Name	Type of Pathogen Detected			
	Borrelia burgdorferi <i>(Lyme Disease)</i>	Ehrlichia chaffeensis <i>(Ehrlichiosis)</i>	Francisella tularensis <i>(Tularemia)</i>	Anaplasma phagocytophilum <i>(Anaplasmosis)</i>
Max		X		
Daisy	X			
Lainey				

2. Which pet’s owners should be notified of possible pathogen transmission to their dog?

Both Daisy’s and Max’s owners should be contacted.

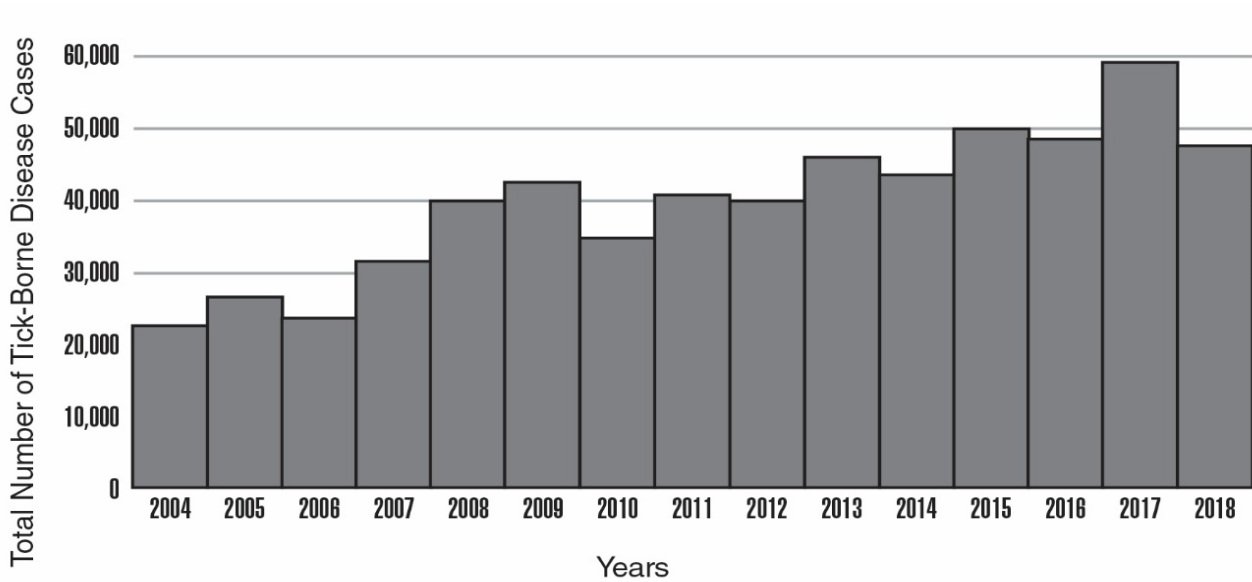
3. During a follow up visit with Daisy, Dr. Louis was informed that Daisy’s owner was walking through the woods with Daisy when she was bitten by the tick. Dr. Louis was concerned that Daisy’s owner may also have been exposed to the pathogen through a tick bite. List some of the symptoms that Daisy’s owner might exhibit if he was exposed to this pathogen.

Some symptoms could include a red ring-like expanding rash; flu-like symptoms, headache, fever, and joint pain.

Part 3: Analyzing patterns in tick-borne diseases

The veterinary lab that Dr. Louis uses participates in a research project that collects data on tick-borne diseases in dogs. The US Centers for Disease Control and Prevention (CDC) collects similar data on tick-borne diseases in humans. Researchers can use this data to recognize patterns in the dog and human tick-borne infections.

Total number of reported tick-borne diseases in humans from 2004-2018



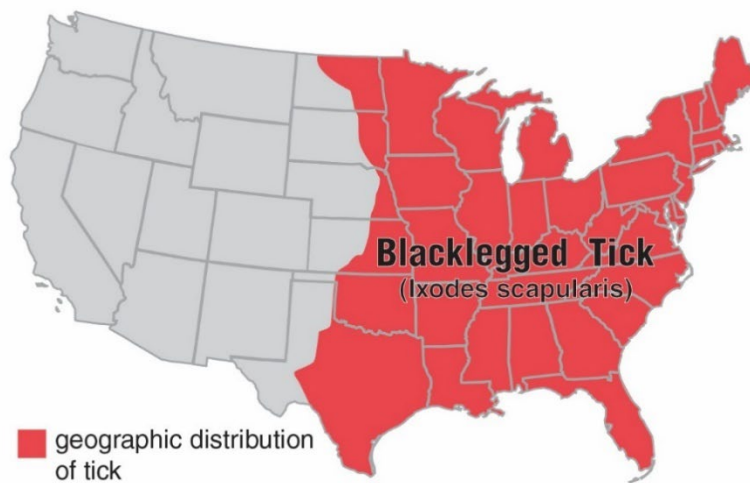
Modified from CDC <https://www.cdc.gov/ticks/data-summary/index.html>

1. Use the graph above to describe the overall *trend* in the incidence of tick-borne diseases in the United States.

Tick-borne diseases have increased in the United States

Researchers decided to focus on the blacklegged tick because this tick can carry several diseases that are transmissible to humans, including the pathogen that causes Lyme disease. In 2018, the CDC developed a map to illustrate the geographic distribution of the blacklegged tick in the United States. This map is shown below.

Map of Blacklegged Tick Distribution

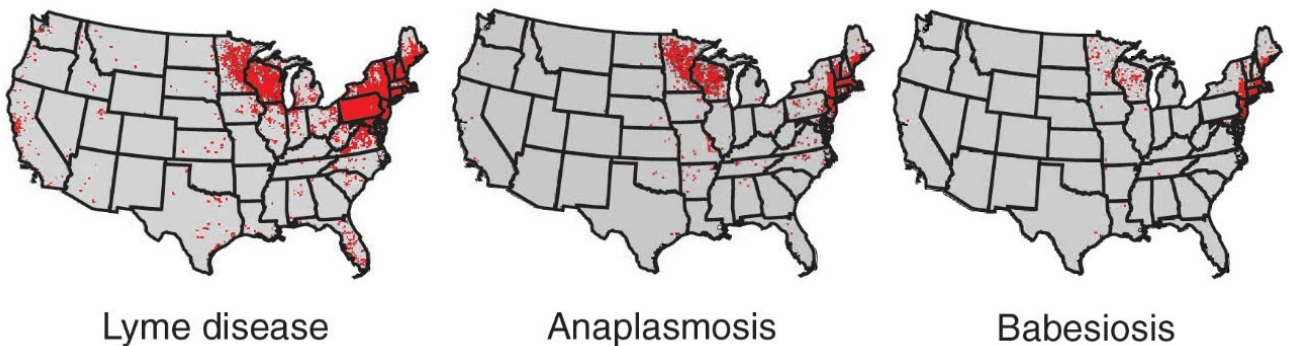


Modified from CDC https://www.cdc.gov/ticks/geographic_distribution.html

2. What part of the United States would you most likely find blacklegged ticks?

The Eastern part of the US.

Red dots on the following maps of the U.S. illustrate the geographic distribution for several blacklegged tick-borne diseases in humans. The data was collected in 2016.



Modified from CDC <https://www.cdc.gov/ticks/tickbornediseases/overview.html>

3. On the map below, circle the region of the country researchers focus on because blacklegged tick-borne diseases are prevalent there.

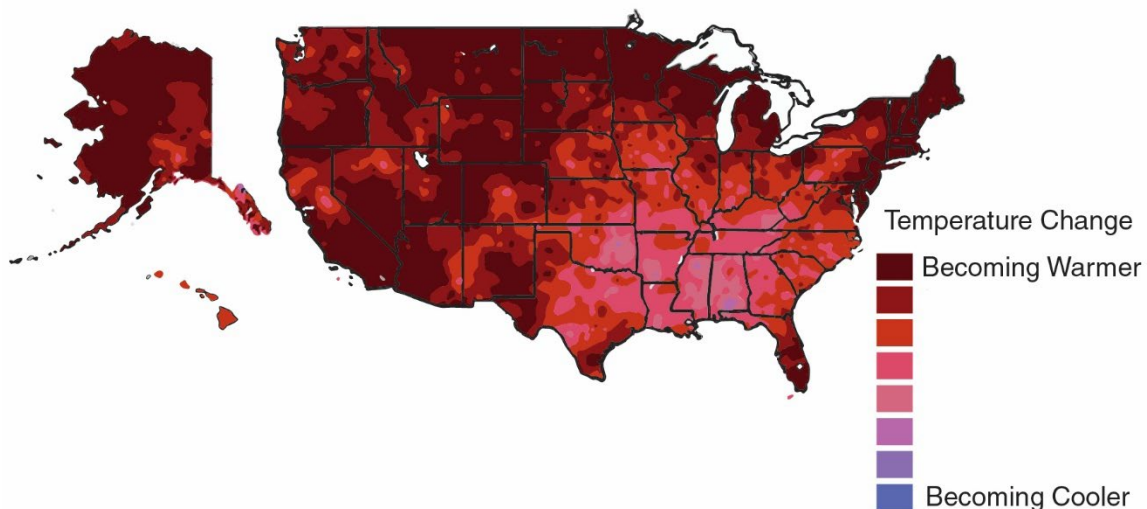


4. Does the incidence of these diseases correlate with the entire geographic range of the blacklegged tick? Support your answer.

The incidence of disease does not correlate with the range of the blacklegged tick. Disease seems to only occur in the northern part of the tick's range.

The first step in determining a cause for the trend in tick-borne diseases is to find non-living, environmental factors (abiotic factors) related to the tick's life cycle that correlate with the trend. The first data studied by the scientists was temperature data. The scientists wondered if changes in annual average temperature for the region could explain the trend in tick-borne diseases.

Change in Average Annual Temperature



Modified from Climate Science Special Report <https://science2017.globalchange.gov/chapter/6/>

5. What is the trend in annual temperature in the region you identified as important to tick-borne diseases?

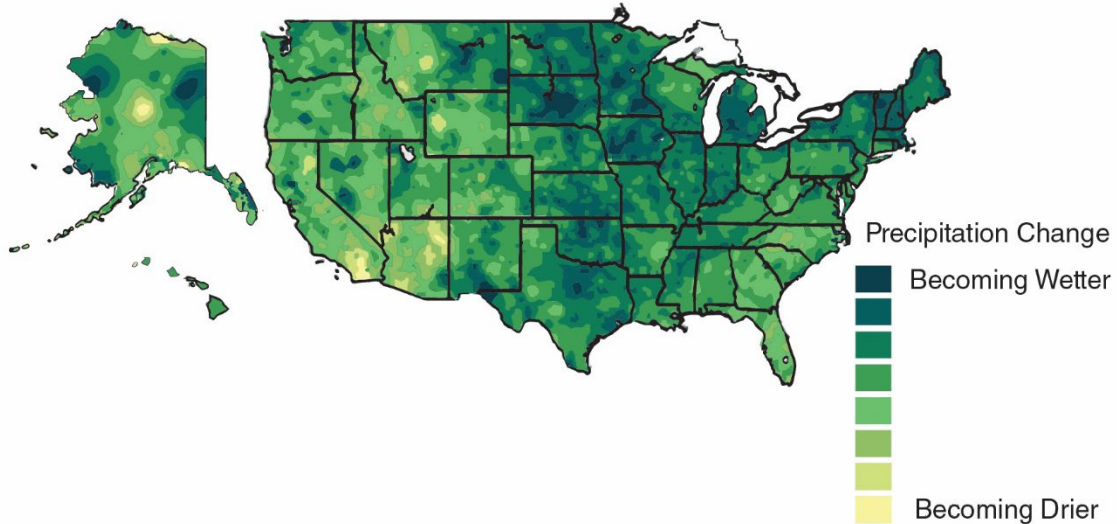
Temperatures are getting warmer on average in this region.

6. Can this pattern in temperature change provide an explanation for the increase in tick-borne diseases in this entire region? Support your answer with information from the Change in Average Annual Temperature map and the previous maps.

Increased temperature cannot be the only factor because there are other regions in the tick's range that have an increase in temperature.

Researchers continued to look at environmental data from this region. This time they focused on changes in annual average precipitation over time.

Change in Average Annual Precipitation



Modified from Climate Science Special report <https://science2017.globalchange.gov/chapter/7/>

7. What is the trend in annual precipitation in the region you identified as important to tick-borne disease?

Rainfall has increased in this region.

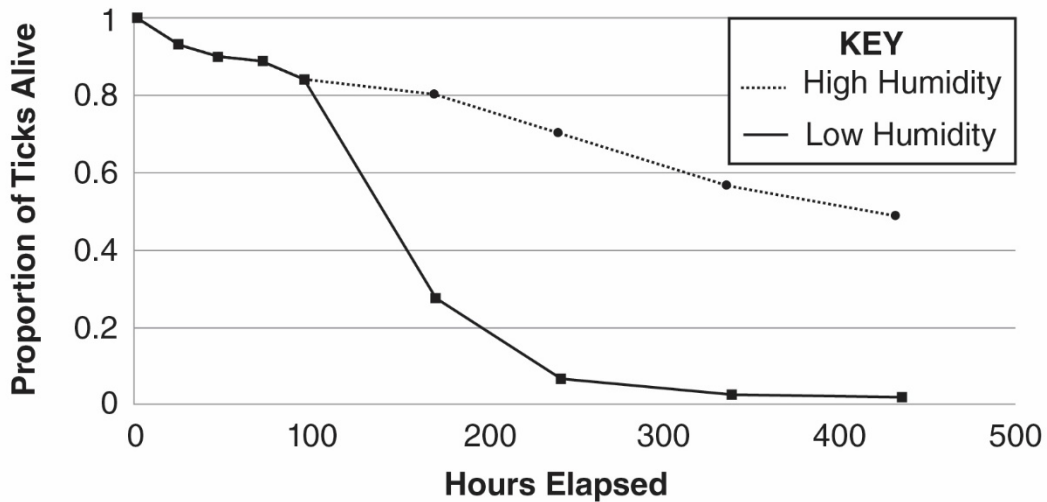
8. Can this pattern in precipitation change provide an explanation for the increase in tick-borne diseases in this entire region? Support your answer with information from the Change in Average Annual Precipitation map and the previous maps.

Increased rainfall cannot be the only factor because there are other regions in the tick's range that have an increase in rainfall.

Even though rainfall has increased in the Northeast, the overall relative humidity of the Northeast remains lower than the relative humidity of the Southeast. The researchers hypothesized that this lower relative humidity in the northeast promotes tick survival and reproduction. To test this idea, scientists placed ticks in environments with different humidity levels and monitored their survival rate over time.

Relative Humidity
a measure of the amount of moisture in the air

This graph represents the data that the scientists collected:



Modified from PLoS ONE <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5226345/>

9. What effect does relative humidity have on the proportion of ticks alive after 200 hours?

More ticks are alive after 200 hours in higher humidity.

10. Does the data support the scientists' hypothesis? Why or why not?

The data does not support the hypothesis because more ticks survive in high humidity.

In addition to abiotic (non-living) factors like temperature, rainfall and humidity, researchers also investigated factors related to living things (biotic factors). The scientists discovered that ticks from the Northeast U.S behave differently compared to ticks in the Southeast U.S. Ticks in the Southeast tend to hide under leaf litter located on the ground. Ticks in the Northeast climb on plant stems.

11. Explain how this difference in behavior could lead to more tick-borne pathogens spreading to humans in the Northeast.

In the south, people walk on top of the leaves and are less likely to come in contact with the ticks. In the north, the ticks are on plants and as people walk by they may come in contact with the tick on exposed skin of their legs or arms.

Part 4: Do living things influence the pattern of tick-borne diseases?

The researchers involved in the voluntary reporting project studying the patterns in tick-borne diseases realized that this was a very complex problem that may involve even more factors. They decided to enlist the help of an environmental scientist. Environmental scientists use their knowledge of science to protect the environment. They gather data and monitor environmental conditions related to ecosystems, which are an intertwined web of interacting abiotic and biotic factors. The environmental scientist explained that ticks are part of a complex system of interactions. **Models** are a way to visualize interactions within an ecosystem. Scientists use models to help answer the question, “Are biotic factors in the ecosystem involved in the pattern of tick-borne diseases?”

1. According to the **Complex Interactions Model** model, what organism is eaten by immature ticks?

Small mammals, like chipmunks.

2. What effect would an increase in acorns have on the number of ticks in the environment? Explain.

An increase in acorns would increase the number of ticks because acorns are food for the small mammals. An increase in food would increase the population of small mammals. An increase in small mammals would increase the number of ticks by providing a food source for the ticks.

3. What effect would an increase in the number of small mammal predators have on the number of ticks?

An increase in predators would decrease the number of small mammals which would decrease the number of ticks.

The squiggly arrows shown on the **Steps to Infection** in the **Complex Interactions Model** represent the movement of ticks through the ecosystem. If you did not do so yet, [Click Here](#) to see if you found where the bacteria that causes Lyme disease is transferred to the tick, then answer questions 4-5.

Students should circle the area around the chipmunk and the immature tick.

This is the link provided to students online when they use the “Click Here”

<https://docs.google.com/presentation/d/10sbYTPcefVqtRhQzhguvMIeNIHlyHaOXI7D5xA4d1nk/edit?usp=sharing>

4. Use the information from the **two diagrams** to explain how Daisy and her owner were most likely exposed to *Borrelia burgdorferi*, the bacteria that causes Lyme disease. Write numbers (2-8) on the lines to place the events in the correct order.

 4 Immature tick feeds on chipmunk.

 8 Ticks bite Daisey and her owner.

 1 Adult ticks mate on deer.

 3 Immature ticks leave deer to find a small mammal host.

 6 Tick leaves small mammal host, waits for new host on plants.

 5 Bacteria is transferred from chipmunk to tick.

 2 Immature ticks hatch from eggs on deer.

 7 Ticks leave the plant for a dog or human host.

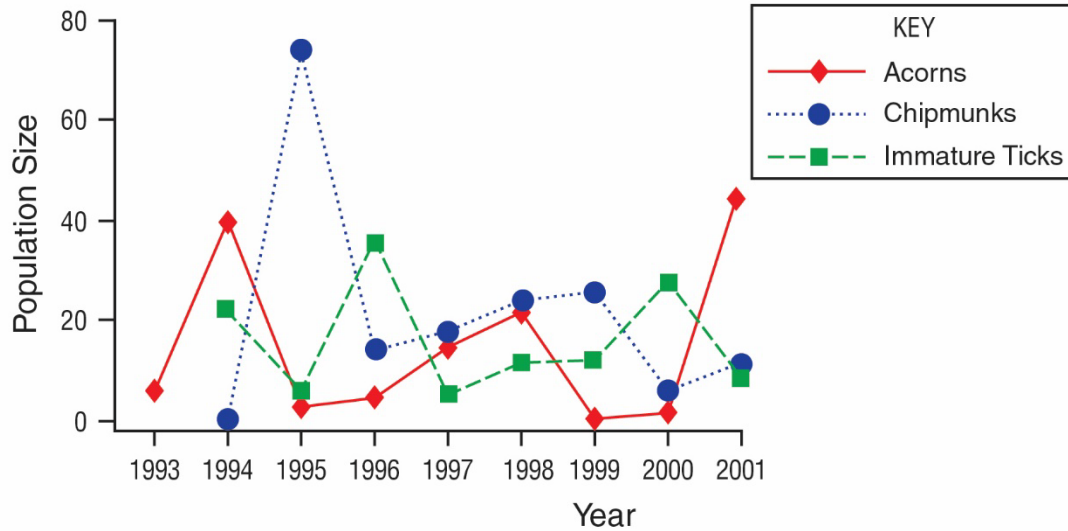
 9 Tick bites transfer bacteria to Daisy and her owner.

5. People often read in the newspaper that when deer populations are high, there is an increased risk for tick-borne diseases. Explain why a large deer population *may* increase the transmission of tick-borne diseases.

Deer are nurseries for immature ticks. When there are many deer, ticks may reproduce more, with more immature ticks surviving. More ticks in the environment means more risk for transmission of disease.

The environmental scientist had been monitoring the number of small mammal hosts, acorns and ticks for eight years. Her data are below:

Figure 1.



Modified from PLoS Biology <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1457019/>

6. Below is a timeline that will help make sense of events in this ecosystem. Use the graph above to:

- Place a letter **A** in the box on the timeline corresponding to each year there was a peak in the number of **acorns**.
- Place a letter **C** in the box on the timeline corresponding to each year there was a peak in the number of **chipmunks**.
- Place a letter **T** in the box on the timeline corresponding to each year there was a peak in the number of immature **ticks**.

	A	C	T		A	C	T	A
1993	1994	1995	1996	1997	1998	1999	2000	2001

7. Describe how the pattern of peaks in the chipmunk population compares to the pattern of peaks in the acorn population.

The chipmunk population peaks one year after the acorn population peaks.

8. Provide an explanation for this pattern.

More acorns mean more food is available for the chipmunks which allow their population to increase.

9. Describe how the pattern of peaks in the chipmunk population compares to the pattern of peaks in the tick population.

The chipmunk population peaks one year prior to the tick population peak.

10. Provide an explanation for this pattern.

Chipmunks are the hosts for ticks. As the chipmunk population increases, there are more hosts for ticks. This leads to an increase in the tick population.

11. In what 2 years would you expect to see an increase in tick-borne diseases? Why?

1996, 2000 would show an increase because there are more ticks.

12. Assume that 2001 is a peak in the acorn population. What year, following this peak would you warn people about a potential increase in tick-borne diseases? Why?

2003. Based on the pattern, ticks peak two years after the peak in acorns.

The environmental scientist explained that increasing the number and kinds of small mammal predators is important in controlling the transmission of tick-borne diseases. She said that some environmental scientists think that the key to controlling the number of ticks is the size of the population of apex predators such as coyotes and other animals at the top of the food chain.

13. Would environmental scientists worried about tick-borne diseases recommend an increase or a decrease in the population of apex predators?

Decrease

14. Explain why environmental scientists would make this recommendation.

Decreasing the number of apex predators increases the number of small predators; this decreases the number of small mammals. Less small mammals means less hosts carrying the diseases and transmitting them to the ticks.

15. Provide at least two actions an environmental scientist might suggest to decrease the number of tick-borne diseases that are transmitted to humans, based on the complex interactions in this ecosystem.

Answers will vary but may include decreasing apex predator populations, decreasing the number of acorns/acorn bearing trees in the area, increasing the number of small mammal predators, decreasing the number of deer.

Part 5: What should pet owners know about tick-borne diseases?

Dr. Louis, the veterinarian, was not surprised at the positive results. She has been seeing an increase in tick-borne diseases within the last few years. She keeps a visual reminder in her office to inform her clients about the increase in these diseases. Every time she receives a positive result back, she places a plastic coin in a jar on her office's welcome counter labeled, "Positive – Tick-borne Disease." Next to the jar, Dr. Louis posted a statement from the American Veterinary Medical Association:

Because people and their pets often spend time in the same environments where Lyme and other disease-transmitting ticks are found, the American Veterinary Medical Association (AVMA) and the American Academy of Pediatrics (AAP) are working together to offer advice to households with both children and pets. People who have been diagnosed with Lyme disease should consult their veterinarian to determine their pet's risk based on the animal's lifestyle and possible environmental exposures. Likewise, people whose animals have been diagnosed with Lyme disease may want to consult their physician about their own or their children's risk if they have concerns that the animals and family members might have been exposed to similar environmental risks.

Increasingly, Dr. Louis's clients have been inquiring about tick-borne diseases because of the doctor's visual reminder. Dr. Louis asked Jada to develop a FAQ sheet to display on the vet's website.

1. The following questions were identified by Dr. Louis as being **most** important to address for her veterinary clients. Use the internet resources provided in the chart on the next page to develop well-written responses to the questions that can be included in the FAQ for Dr. Louis.
 - What should I do if I see a tick on my pet?
 - What kind of precautions can I take to prevent tick bites on me?
 - What kind of precautions can I take to prevent tick bites on my pet?
 - If my pet is diagnosed with a tick-borne disease, why should I contact my own doctor?
2. Use the internet resources provided to develop well-written responses to the questions that can be included in the FAQ sheet for Dr. Louis.

Questions	Answers
<p>What should I do if I see a tick on my pet? https://www.cdc.gov/ticks/removing_a_tick.html</p>	<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>
<p>What kind of precautions can I take to prevent tick bites on me? https://www.cdc.gov/ticks/avoid/on_people.html</p>	<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>
<p>What kind of precautions can I take to prevent tick bites on my pet? https://www.cdc.gov/ticks/avoid/on_pets.html</p>	<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>
<p>If my pet is diagnosed with a tick-borne disease, why should I contact my own doctor? https://www.avma.org/resources/pet-owners/petcare/lyme-disease-pet-owners-guide</p>	<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>

Part 6: One Health and tick-borne diseases

One Health

A university is suggesting that the local government take a One Health approach to solving complex local problems, such as an increase in tick-borne diseases. A One Health approach uses the idea that complex problems often involve the health of people, animals, and the environment. Therefore, solutions to One Health problems must be designed to protect the health of people, animals, and the environment.



1. Use the information in the text box above to explain what must be involved in a complex problem for it to be considered a One Health problem.

It must involve humans, animals, and the environment.

To support adoption of a One Health approach, the university officials want to create a series of One Health digital slides to share with community members. Your team has been hired to create the first slide for this presentation. They want you to use the increase in tick-borne diseases as an example of a One Health problem. The slide you produce should answer the question, **“Why is the increase in tick-borne diseases a One Health problem?”**




Community members often get most of their information from this first slide – they tend to lose interest once in-depth discussion of the issue begins. Therefore, that first slide needs to give information in a way that people will remember. Using examples and pictures will help people understand and remember what the One Health approach involves.

2. Use the information in the text box above and what you learned about ticks and tick-borne diseases to develop your digital slide. The following template may help you organize your digital slide:

Why is an increase in tick-borne diseases a One Health problem?	
<i>Credit given for providing 1-2 sentences that respond /answer the question</i>	<i>Credit given for providing a picture with brief caption</i>
<i>Credit given for providing a picture with brief caption</i>	<i>Credit given for providing a picture with brief caption</i>

Optional Extension Activity and Questions:

1. Ask students to identify their own One Health Problem. They can use the table provided.

One Health Problem		
Environment	Animals	People
		
<p><i>Credit given for responses that include "environment." Answers will vary and be specific to each student.</i></p>	<p><i>Credit given for responses that include "animals." Answers will vary and be specific to each student.</i></p>	<p><i>Credit given for responses that include "people." Answers will vary and be specific to each student.</i></p>

2. Ask students to identify their own One Health Solutions. Have students complete and compare the **Possible One Health Solutions** in the chart below. Brainstorm ideas for actions that could be taken to "solve" parts of problem that you described in question 4. Be sure to include actions that would improve the health of humans, animals, and the environment.

One Health Solutions		
Environment	Animals	People
		
<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>	<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>	<p><i>Credit given for responding. Answers will vary and be specific to each student.</i></p>

3. Which One Health solution would be easiest for you to implement? Explain why you chose that solution.

Credit given for responding. Answers will vary and be specific to each student.

4. Which One Health solution would be easiest for local communities to implement? Explain why you chose that solution.

Credit given for responding. Answers will vary and be specific to each student.

5. Which One Health solution would have the greatest impact on solving the One Health problem caused by the invasion of ticks? Explain why you chose that solution.

Credit given for responding. Answers will vary and be specific to each student.