Test Bank for Ecology 5th Edition by Bowman

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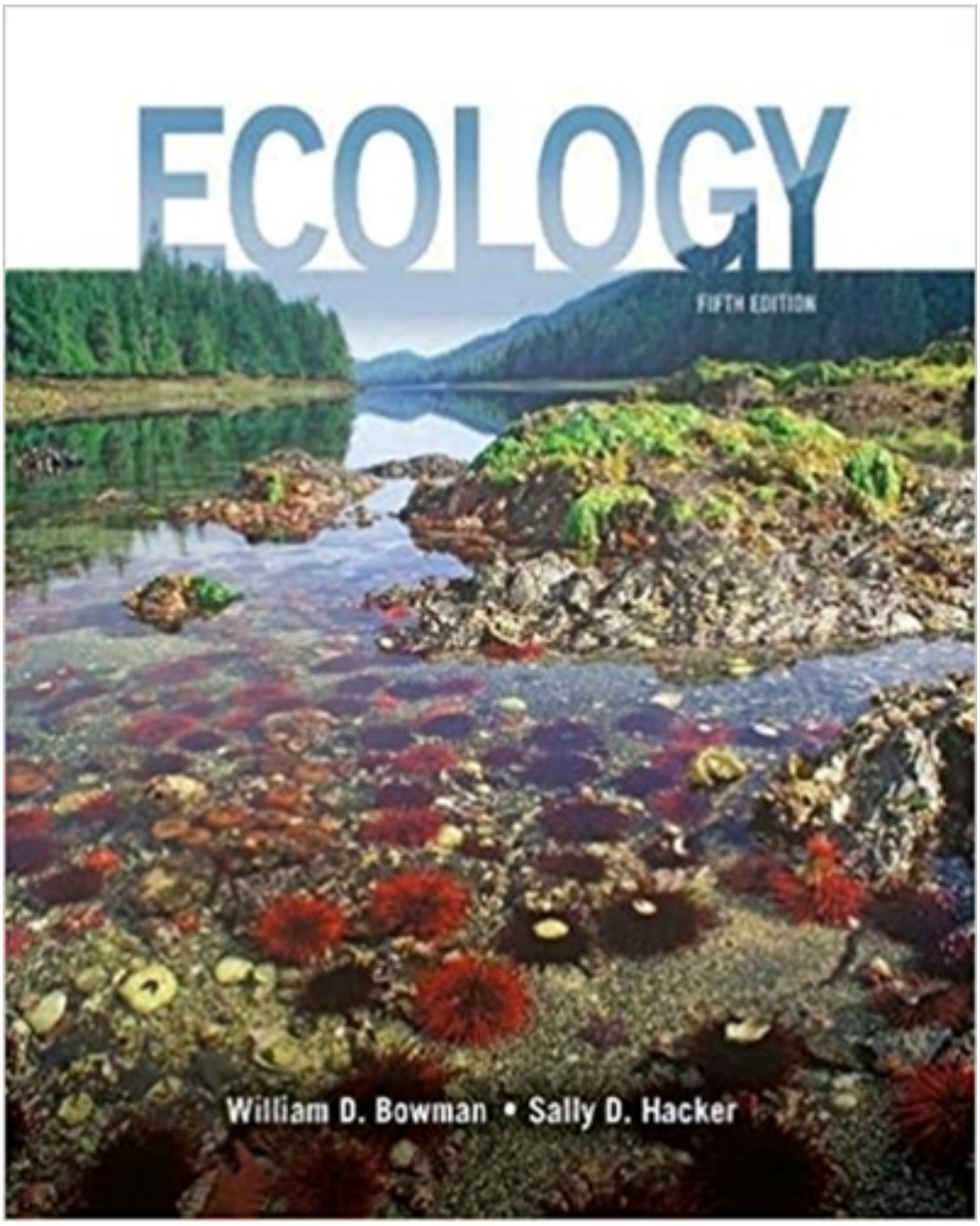


Test Bank

Test Bank

to accompany

Ecology, Fifth Edition

Bowman • Hacker

Chapter 1: The Web of Life

TEST BANK QUESTIONS

Multiple Choice

1. What is one reason that amphibians are especially good biological indicators of environmental conditions?
a. They live in both terrestrial and aquatic environments.
b. It is difficult for pollutants to pass through their skin.
c. They are declining in number.
d. They can tolerate high levels of pollution.
Answer: a
Textbook Reference: Deformity and Decline in Amphibian Populations: A Case Study
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

2. The ecological study of the effect of *Ribeiroia* and pesticides on frog populations suggests that all of these statements about the study of ecology are true *except* that
a. it describes how organisms affect the environment.
b. it describes how the environment affects organisms.
c. it studies how biotic and abiotic factors affect each other.
d. humans are not part of its subject matter.
Answer: d
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 3. Applying

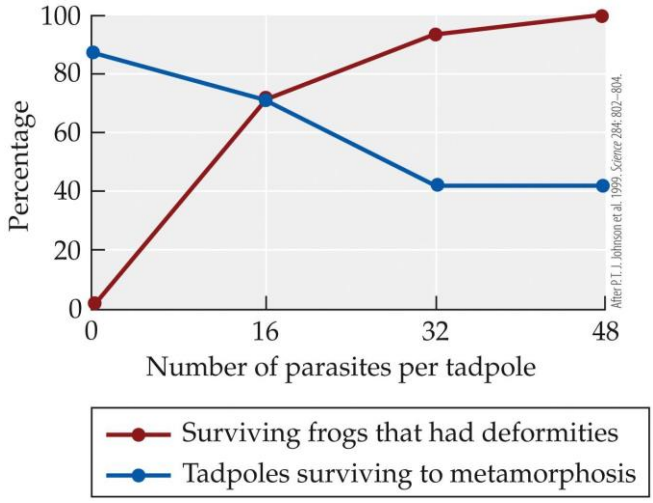
3. West Nile virus can be considered an example of an unintended consequence of ecological interactions because it
a. originated in Africa.
b. is transmitted by mosquitoes.
c. emerged due to human impacts on the environment.
d. is increasing rapidly due to a rise in trematode populations.
Answer: c
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 3. Applying

4. In 1878, seal hunters introduced rabbits to Macquarie Island, between Australia and Antarctica. The rabbit population soared and the Myxoma virus was then introduced to kill off rabbits. It worked, but the islands' cats, which had depended on the rabbits for food, began eating seabirds instead. To save the seabirds, scientists started a program to kill off the cats. Twenty-four years later, in 2009, the rabbit population had exploded again, and rabbits were ravaging native plant species and devastating the island's ecosystem. This story appears to be an example of
a. sound, responsible ecological management.
b. unintended ecological consequences.
c. predictable but unavoidable consequences.
d. a series of catastrophes resulting from random chance.
Answer: d
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 4. Analyzing

5. What evidence led Ruth and Sessions to conclude that parasites could be the cause of some of the deformities in the frogs found in the ponds of Northern California?
a. None of the deformed frogs found in the ponds were infected with the parasites.
b. They directly observed the parasites causing the deformities.
c. Glass beads placed near the location of limb development in tadpoles mimicked the effect of parasites and caused deformities.
d. Deformities in the frogs occurred in nature but not in the laboratory.
Answer: c
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

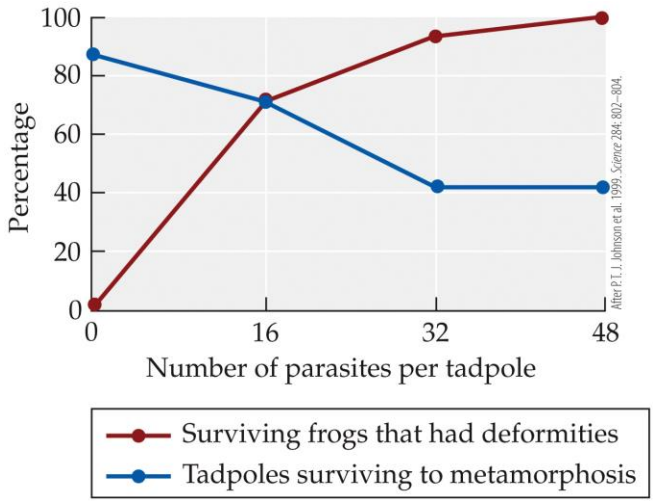
6. In addition to the frogs themselves, which organisms act as hosts for the flatworm that has been linked to deformities in frogs?
a. Birds and snails
b. Snails and turtles
c. Turtles and birds
d. Snails and clams
Answer: a
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 1. Remembering

7. Refer to the figure.



The figure is based on Johnson's experiment on the effects of trematode parasites on tadpoles. Which statement best describes the control group in the experiment?
a. Tadpoles were grown in the absence of trematode parasites.
b. Tadpoles were allowed to grow in nets in their natural environment.
c. Tadpoles were grown in the presence of only one trematode parasite.
d. Tadpoles were grown in a tank in which the concentration of trematode parasites was similar to the parasite concentration of ponds in which deformed frogs were found.
Answer: a
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

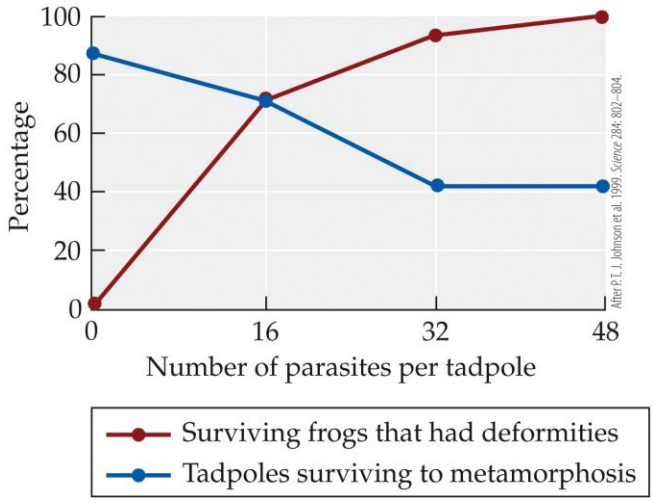
8. Refer to the figure.



The figure is based on Johnson's experiment on the effects of trematode parasites on tadpoles. Which claim is supported by the figure?

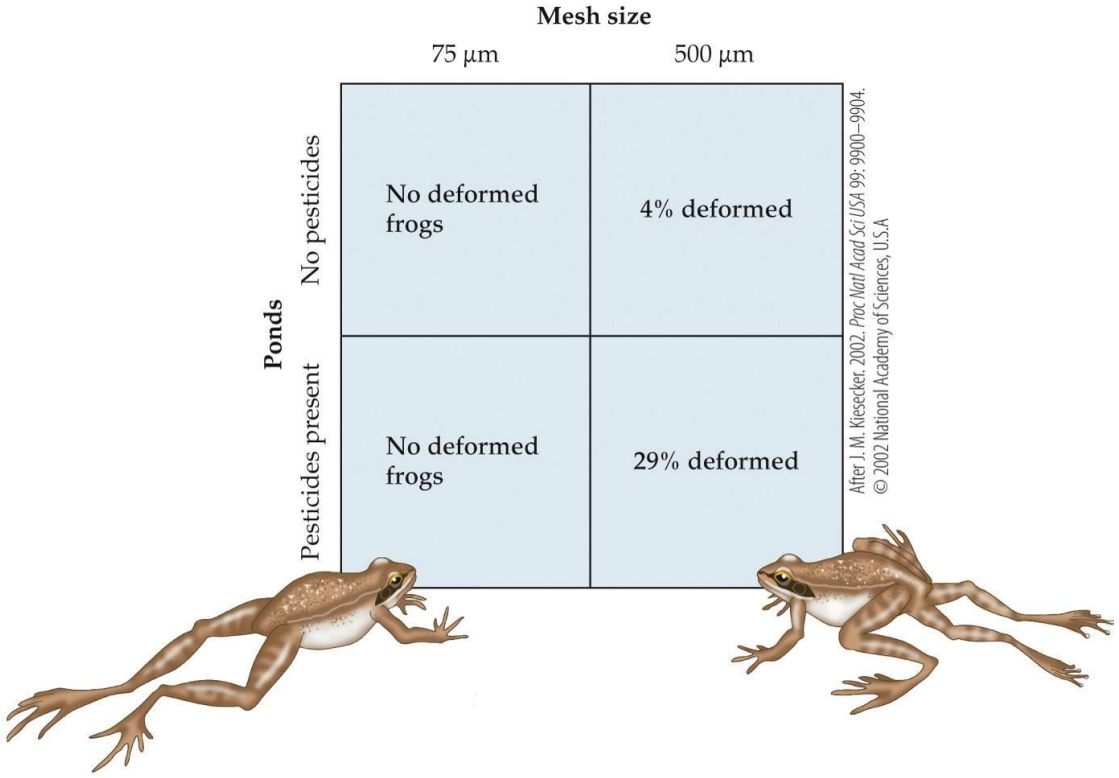
a. As the number of parasites that the tadpoles were exposed to decreased, the percentage of surviving frogs with deformities increased.
b. As the number of parasites that the tadpoles were exposed to increased, the percentage of surviving tadpoles decreased.
c. If there were no parasites present, 100% of the tadpoles survived to metamorphosis.
d. Tadpoles with moderate levels of parasites had the lowest percent of deformities in adults.
Answer: b
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 4. Analyzing

9. Refer to the figure.



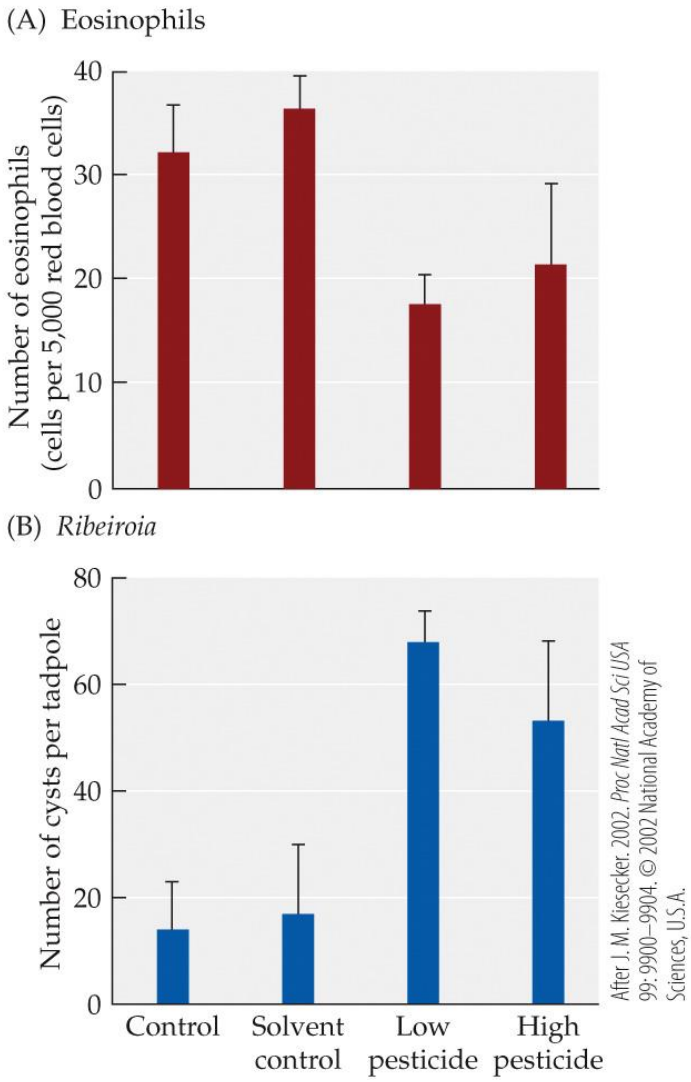
The figure is based on Johnson's experiment on the effects of trematode parasites on tadpoles. Suppose that 60 tadpoles are exposed to 32 parasites per tadpole. Based on the results of the figure, about how many tadpoles would you expect to survive to metamorphosis?
a. 12
b. 25
c. 40
d. 58
Answer: b
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 3. Applying

10. Refer to the figure.



The figure is based on Kiesecker's field experiments testing the effects of parasites and pesticides on frogs. Which statement is the most valid interpretation of the results?
a. Exposure to parasites was necessary for the frogs to become deformed.
b. All frogs exposed to parasites were deformed.
c. Exposure to pesticides was necessary for frogs to become deformed.
d. Exposure to pesticides had no effect on the percentage of frogs that became deformed.
Answer: a
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 4. Analyzing

11. Refer to the figure.



The figure is based on studies of the effects of pesticides on the tadpole immune system. In a laboratory experiment, wood frog (*Rana sylvatica*) tadpoles were exposed to low or high concentrations of a pesticide, and then *Ribeiroia* parasites. The tadpoles were then examined for (A) numbers of eosinophils and (B) numbers of *Ribeiroia* cysts. Error bars show one SE of the mean. Which statement is supported by the evidence shown in the figure?

a. Tadpoles exposed to high levels of pesticides had more cysts per tadpole than those exposed to low levels of pesticides.

b. Tadpoles exposed to pesticides had fewer eosinophils than those not exposed to pesticides.

c. The number of cysts per tadpole was similar in the solvent control and low pesticide groups.

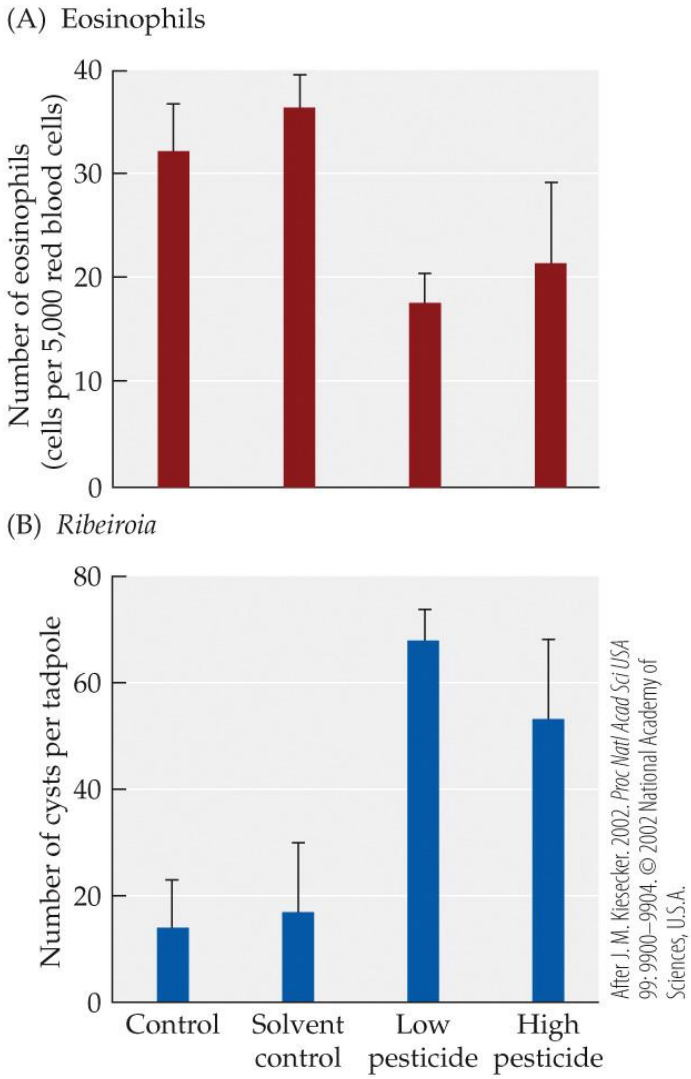
d. Pesticides decreased eosinophils more when tadpoles were exposed to high concentrations of pesticides than when they were exposed to low concentrations.

Answer: b

Textbook Reference: 1.1 Events in the natural world are interconnected.

Learning Objective: Not aligned
Bloom's Level: 4. Analyzing

12. Refer to the figure.



The figure is based on studies of the effects of pesticides on the tadpole immune system. In a laboratory experiment, wood frog (*Rana sylvatica*) tadpoles were exposed to low or high concentrations of a pesticide, and then *Ribeiroia* parasites. The tadpoles were then examined for (A) numbers of eosinophils and (B) numbers of *Ribeiroia* cysts. Error bars show one SE of the mean. Compared with the control group, the frogs exposed to low concentrations of pesticides showed an increase _____ percent in the number of eosinophils.
a. 18
b. 32
c. 55
d. 78

Answer: c
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: Not aligned
Bloom's Level: 4. Analyzing

13. Which statement is *least* accurate in describing the field of ecology?
a. Ecology involves the scientific study of interactions between organisms and their environment.
b. Ecology is an interdisciplinary field that incorporates concepts from the natural sciences, politics, and ethics.
c. Ecology involves the scientific study of interactions that determine the distribution and abundance of organisms.
d. Ecological research can focus on many scales, from individuals up to biospheres.
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.1 Summarize how the inquiries of ecologists and environmental scientists differ.
Bloom's Level: 1. Remembering

14. An ecologist studying ecosystems would be most interested in which question?
a. Is a predator species maintaining species diversity by selectively preying on the most abundant prey species?
b. How much nitrogen is being taken up by organisms in a given place?
c. How does temperature affect survivorship of marmots?
d. How do features of the landscape affect the movement of bears?
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.1 Summarize how the inquiries of ecologists and environmental scientists differ.
Bloom's Level: 3. Applying

15. Scientists are concerned about the growing problem of dead zones in the Gulf of Mexico, which are caused primarily by fertilizer runoff entering the Mississippi River. Which question related to this topic would most likely be studied by an environmental scientist, as opposed to an ecologist?
a. How does the presence of fertilizers in river water affect fish populations along the river?
b. What is the total amount of fertilizer runoff reaching the Gulf of Mexico per year?
c. What economic incentives might be offered to farmers to encourage them to decrease fertilizer runoff?
d. Which types of algae and bacteria undergo population explosions in the Gulf due to increased nutrient content, and during what times of year do they occur?
Answer: c

Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.1 Summarize how the inquiries of ecologists and environmental scientists differ.
Bloom's Level: 3. Applying

16. Scientist A works in a laboratory, studying the effects of CO_2 levels on algae and zooplankton. Scientist B works at a field station studying how changing CO_2 levels in the atmosphere affect algae and zooplankton in the ocean. Scientist C works in Washington, D.C., lobbying members of Congress to pass legislation to lower CO_2 emissions from cars and power plants. How would these three scientists most likely be classified?
a. Scientists A and B are ecologists; Scientist C is an environmental scientist.
b. Scientist A is an ecologist; Scientists B and C are environmental scientists.
c. Scientists A and B are environmental scientists; Scientist C is an ecologist.
d. All three are environmental scientists.
Answer: a
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.1 Summarize how the inquiries of ecologists and environmental scientists differ.
Bloom's Level: 3. Applying

17. The most appropriate spatial scale for a study of world climatic processes would likely be
a. cubic millimeters.
b. cubic centimeters.
c. cubic meters.
d. cubic kilometers.
Answer: d
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when testing their hypotheses.
Bloom's Level: 4. Analyzing

18. It is difficult to study the process of evolution in most species of organisms because
a. evolution occurs over many generations, so time scales required for studies are very long.
b. the effects of evolution are usually difficult or impossible to observe.
c. evolutionary studies require collecting data on many species at the same time.
d. there is no way to know what a species' ancestors were like.
Answer: a
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when

testing their hypotheses.
Bloom's Level: 4. Analyzing

19. Suppose that individuals of a particular strain of the fruit fly, *Drosophila melanogaster*, reproduces rapidly and uses up its food supply quickly, resulting in a population explosion and rapid die-off within its laboratory container. This phenomenon can be considered evidence that
a. nature requires a balance that must be maintained.
b. all species are interconnected and interact with each other.
c. all species are dependent on the non-living environment.
d. a change in one aspect of a life cycle can alter other parts.
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 3. Applying

20. Which statement is *not* likely to be true within an ecological community?
a. Organisms have unlimited resources.
b. Environmental conditions change over time.
c. Environmental conditions change from one place to another.
d. Species evolve over time.
Answer: a
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

21. An ecosystem undergoes a disturbance, and as it recovers, its species composition changes: the new ecosystem is different from the original. This suggests that
a. the necessary balance of nature has been maintained.
b. ecosystems remain unchanged through time.
c. ecosystems may change with changing circumstances.
d. the new ecosystem was incorrectly described; it is the same as the original.
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 3. Applying

22. A group of individuals of a single species of swamp sparrows lives in the Quabbin Reservoir in Massachusetts, and these individuals interact with one another. This is an example of a(n)
a. biosphere.
b. community.
c. ecosystem.

d. population.
Answer: d
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

23. Which term refers to a community of organisms plus the physical environment in which they live?
a. Individual
b. Community
c. Population
d. Ecosystem
Answer: d
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 1. Remembering

24. Which sequence represents the correct order of levels of biological organization, from largest to smallest?
a. Biosphere > ecosystem > population > community
b. Biosphere > population > ecosystem > community
c. Biosphere > ecosystem > community > population
d. Ecosystem > biosphere > community > population
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

25. Which quality is a biotic feature of the environment?
a. The density of consumers
b. The average minimum temperature at night
c. The number of days during which at least 1 mm of rain falls
d. The pH of the soils
Answer: a
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

26. Which statement about the concept of natural selection is *false*?
a. During natural selection, different individuals survive and reproduce at different rates based on their specific characteristics.

b. During natural selection, organisms who survive and reproduce at a greater rate pass on more of their genes to the next generation.
c. The frequency of a trait favored by natural selection will increase over generations whether the trait is heritable or not.
d. Only natural selection can produce adaptations consistently.
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

27. An example of a trait that *cannot* evolve by natural selection is a trait that
a. increases the time during which females are capable of reproduction.
b. increases the ability of an organism to survive high temperatures but not low temperatures.
c. increases the ability of an organism to survive low temperatures but not high temperatures
d. results from an individual's life experiences and does not have a genetic basis.
Answer: d
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 3. Applying

28. A plant species has two different varieties, the characteristics of which are heritable. One grows very quickly to a large size, while the other grows slowly and remains small. The large plants produce 500 seeds when they reproduce; 20 of those seeds sprout and survive to become large adult plants. The small plants produce 100 seeds; 40 of those seeds sprout and survive to become small adult plants. Which variety is more likely to be better adapted to its environment?
a. The small plant variety is better adapted.
b. The large plant variety is better adapted.
c. The two varieties are equally well adapted.
d. There is not enough information to decide.
Answer: a
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 5. Evaluating

29. Which statement about the relationship between consumers and producers is true?
a. Consumers obtain energy by eating other organisms; producers obtain energy by decomposing dead matter.
b. Consumers obtain energy from an external source to produce their own food; producers obtain energy by decomposing dead matter.

c. Consumers obtain energy by eating other organisms; producers use energy from an external source to produce their own food.
d. Consumers and producers both obtain energy by eating other organisms; the difference lies in what types of organisms they eat.
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

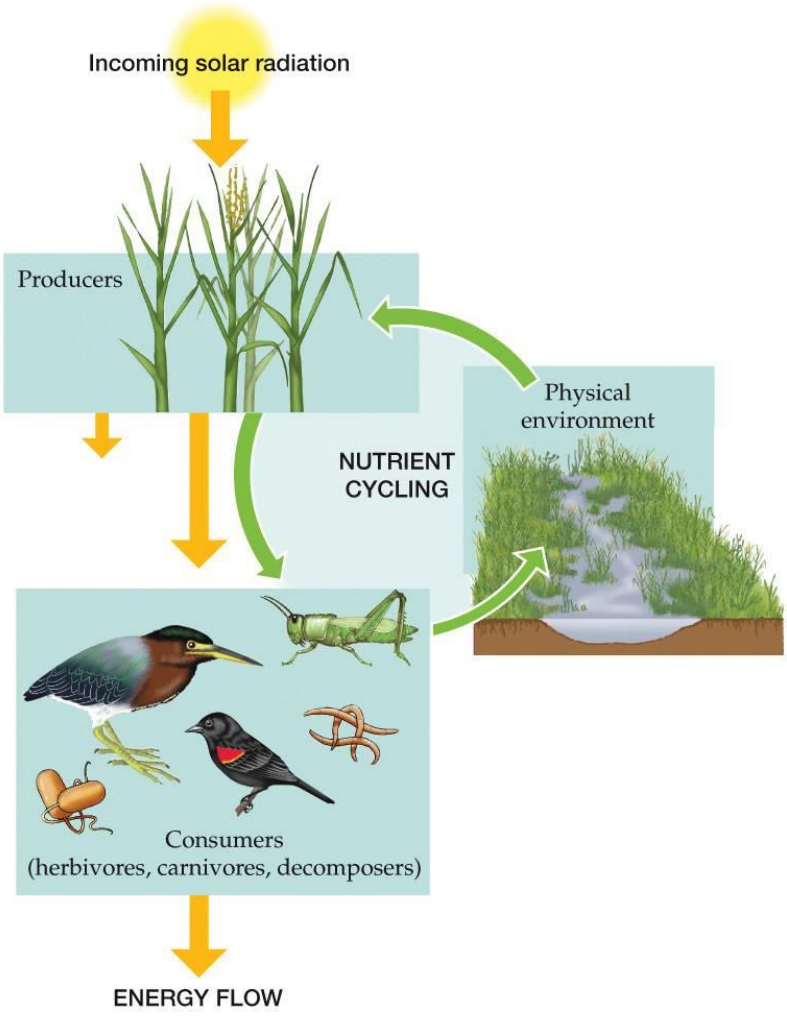
30. Net primary production (NPP) is the amount of
a. heat lost through respiration, minus the energy gained by photosynthesis or other means.
b. energy that producers fix by photosynthesis or other means, minus the amount lost as heat in cellular respiration.
c. energy gained through consumption, minus the amount lost as heat in cellular respiration.
d. energy that producers fix by photosynthesis or other means, minus the amount lost through death of tissue.
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 1. Remembering

31. In a grassland ecosystem, plants capture 180 units per day of solar energy, and use 70 units per day in respiration. Animals consume about 20 units per day of the plants. The NPP of this system, in units per day, is
a. 70.
b. 90.
c. 110.
d. 180.
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 3. Applying

32. Which statement about the movement of energy through ecosystems is true?
a. Energy can be recycled through consumers and producers.
b. Energy can move in one direction only and cannot be recycled.
c. Energy can reverse direction if organisms are allowed to decompose.
d. Recent technology allows us to recycle the energy in our ecosystem.
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.

Learning Objective: Not aligned
Bloom's Level: 2. Understanding

33. Refer to the figure.



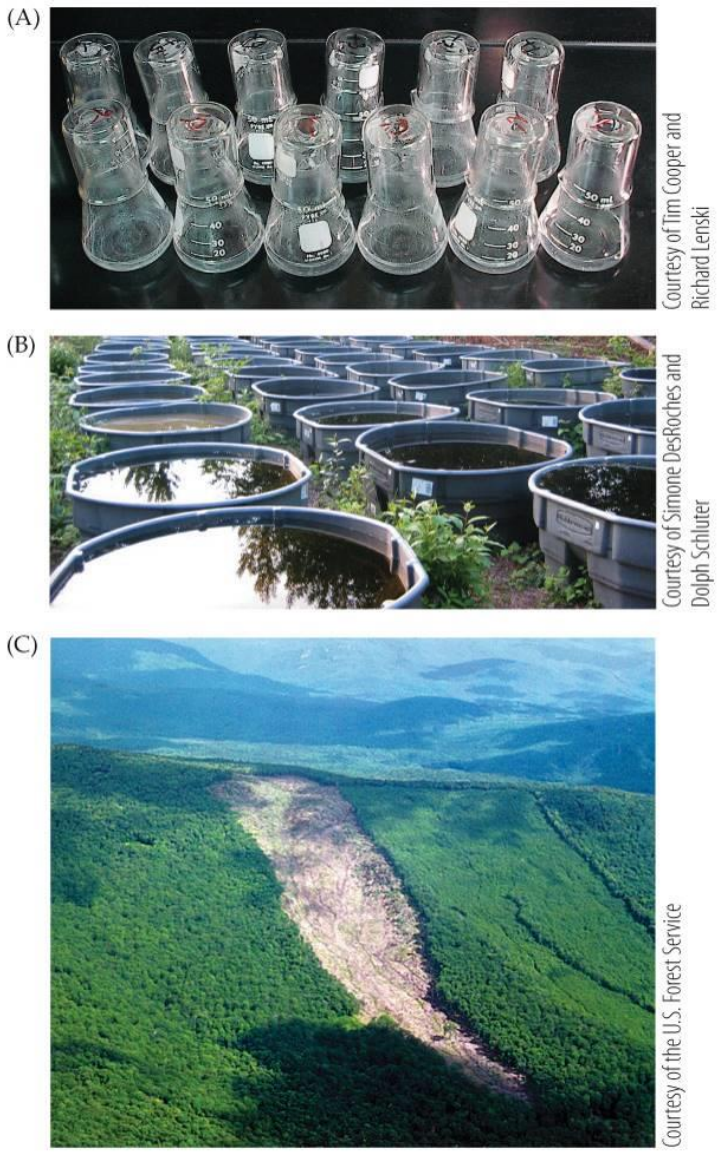
The figure represents energy flow and nutrient cycling through the major components of natural ecosystems. Based on the figure, which statement best describes a major difference between nutrient cycling and energy flow?
a. Nutrients flow through producers and consumers but not through the physical environment.
b. Energy flows through producers and consumers but not through the physical environment.
c. Both nutrients and energy are lost as they travel through the ecosystem.
d. Incoming solar radiation plays a limited role in both nutrient cycling and energy flow.
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned

Bloom's Level: 4. Analyzing

34. An ecologist wants to study a large forest ecosystem which was last studied more than 50 years ago. She hopes to document the changes that have occurred in plant species composition, in light of recent global warming. She will probably begin her study using which method?
a. Field observations
b. Field experiments
c. Controlled laboratory experiments
d. Quantitative mathematical models
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 3. Applying

35. An ecologist is studying the impacts of the aquaculture of a fish species on an estuary. His study involves three experimental setups: 1) A controlled laboratory experiment in which fish are kept in small aquaria, 2) A controlled field experiment in which the fish are kept in large tanks, and 3) A field experiment in the estuary itself, in which the fish are kept in mesh cages so their secretions enter the estuary water. In all cases, the ecologist measures specific chemical factors to determine the fishes' effect on water quality. Later, he will combine results of all experiments into an aquaculture model. Why might the ecologist choose to use this complex set of experimental setups rather than just choosing one?
a. Each spatial scale provides different types of information, resulting in a more thorough and precise picture of the aquaculture ecosystem's impacts.
b. Each spatial scale gives one part of the total picture; putting them all together provides complete information on all characteristics of the aquaculture ecosystem.
c. Using several types of experimental designs allows the scientist to compare the different sets of data and decide which one is most accurate.
d. The different experimental setups represent replications of the aquaculture ecosystem; averaging them gives an accurate picture of the total system.
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 3. Applying

36. Refer to the figure.



The figure shows three types of experimental setups: laboratory, small-scale field study, and large-scale field study. In which of the following cases would the large-scale field study be the most appropriate?
a. When very detailed, precise measurements are required
b. When the organisms being studied are small and rare
c. When events being studied are long-term or cover large geographic areas
d. When the study is being conducted by environmental scientists rather than ecologists
Answer: c
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 5. Evaluating

37. Biologists find that worms treated with a hormone live 1.3 days longer than untreated worms. To assess whether these differences are significant, the biologists would most likely use which aspect of the scientific process?
a. A control group
b. Replication
c. Mathematical modeling
d. Statistical analysis
Answer: d
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 2. Understanding

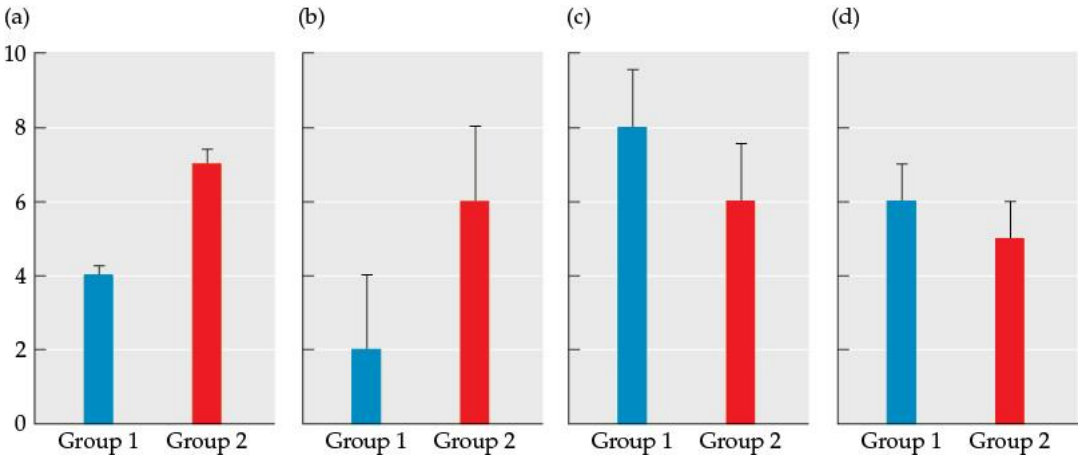
38. Ecologists try to reduce the likelihood that variables that are not under the control of the experimenter will unduly influence the results of an experiment by
a. replicating each treatment, including the control.
b. assigning treatments to subjects or plots methodically.
c. never performing the same experiment twice, but trying instead to improve each experiment.
d. carefully setting up experiments so that the results are identical and do not need to be statistically analyzed to prove the result.
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 2. Understanding

39. In studies of seed production, why is it important to assign plots of land to either the control group or treatment group at random?
a. It increases the likelihood that the treatment group will show a difference from the control group.
b. It decreases the likelihood that plots receiving a particular treatment share other characteristics that might influence seed production.
c. It increases the likelihood that the study can be scaled up to a higher level.
d. It decreases the likelihood that the results of the study will be challenged.
Answer: b
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 2. Understanding

40. Which of the following is *not* part of the scientific method used in studying frog deformities?

a. Observations of nature leading to questions about those observations
b. Understanding the social and political consequences of the study
c. Use of previous knowledge to develop possible answers to the hypotheses
d. Evaluation of competing hypotheses by means of experiments and careful observation
Answer: b
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 3. Applying

41. Refer to the figure.



Which figure provides the clearest evidence of a biologically important difference between two treatment groups?
a. Figure a
b. Figure b
c. Figure c
d. Figure d
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 5. Evaluating

42. Suppose you were examining whether a synthetic chemical reduced the growth rate of mice. Which action would you take to ensure a controlled experiment?
a. Allow some mice to roam between cages, while having others remained confined to a single cage.
b. Exclude one group of mice from exposure to the chemical, but otherwise treat all of the mice in the same manner.

c. Compare a natural population of mice exposed to the chemical to a natural population not exposed to the chemical.
d. Use computer programs to analyze the results from all treatment groups.
Answer: b
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 3. Applying

43. Refer to the figure.

The figure shows a field set up to do controlled ecological experiments, divided into 112 plots each 5 × 5 meters. Suppose 40 plots are chosen for a study, 20 as controls and 20 as experimental plots. The control plots are left untreated. The 20 experimental plots all receive the same treatment: a specific level of insecticide. These experimental plots represent
a. 20 separate experimental treatments.
b. 20 replications of the same treatment.
c. the minimum number of plots needed for statistical analysis.
d. the number of plots needed to match the control plots.
Answer: b
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.

Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 3. Applying

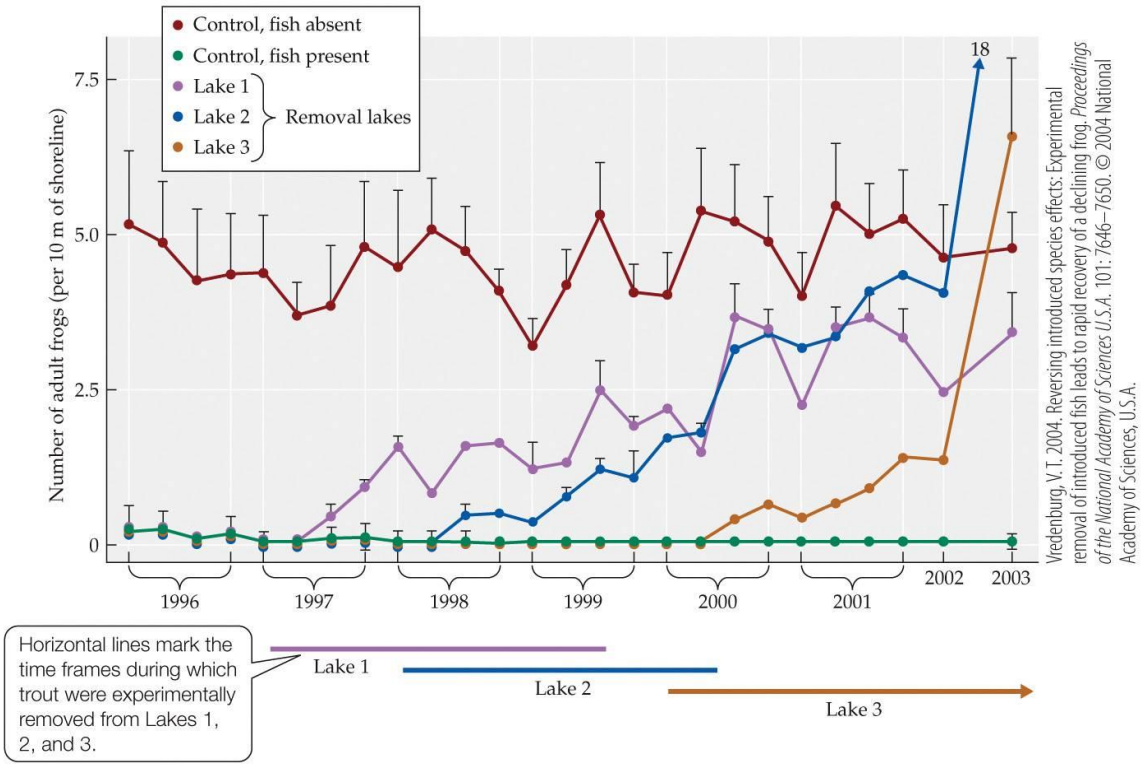
44. Refer to the table.

Lake status	Average frog density (per 10 m of shoreline)
Trout absent	184.8
Trout present	15.3

Vredenburg, V. T. 2004. Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. Proceedings of the National Academy of Sciences U.S.A. 101: 7646–7650. © 2004 National Academy of Sciences, U.S.A.

The table represents the result of a survey of 39 lakes, some with and some without introduced rainbow or brook trout. The values are averages of the number of frogs present along a 10-meter piece of shoreline in lakes with and without trout. Given these results, one can conclude that
a. introducing trout into a lake seriously depletes the number of frogs present.
b. introducing trout into a lake has little or no effect on the number of frogs present.
c. introduced rainbow trout decrease frog populations but introduced brook trout do not.
d. introduced brook trout decrease frog populations but introduced rainbow trout do not.
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 4. Analyzing

45. Refer to the figure.



The figure represents the results of an experiment by Vredenburg, who compared the numbers of frogs in several categories of lakes: lakes never having trout (control), lakes having trout (control), and lakes from which he removed trout at different times. He observed changes in frog populations over eight years in all lakes. Based on evidence from the figure, which conclusion can be made about the effect of trout removal on frog populations?
a. Frog populations in some lakes overpopulate after the removal of trout.
b. Frog populations increase in some removal lakes but not in others.
c. Frog populations never recover once trout have been introduced.
d. Frog populations begin to recover once trout are removed.
Answer: d
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 4. Analyzing

46. What is the current consensus view regarding the primary cause of amphibian deformities and declines?
a. The primary cause is habitat loss.
b. The primary cause is parasites and diseases.
c. The primary cause is global warming.
d. There is no current consensus as more research is needed.
Answer: d

Textbook Reference: A Case Study Revisited: Deformity and Decline in Amphibian Populations
Learning Objective: Not aligned
Bloom's Level: 1. Remembering

Short Answer/Essay

1. Humans often build dams on rivers for hydroelectric power or other purposes. Dam-building obstructs fish movement and alters fish populations above and below the dam, sometimes leading to declines in threatened species. One effect is delayed movement of fish to new locations. This increases fish densities in certain locations, resulting in greater competition for space and likelihood of spread of diseases. Fish may be slower in reaching spawning or feeding grounds, and have less energy available for reproduction and for later attempts to reach the new location. What unexpected or unintended ecological consequences would occur in this scenario?
Answer: Unexpected consequences are those that occur one or several steps removed from the initial cause. In this scenario, the initial cause is the dammed river. Before the dam was built, fish (for example, salmon) had unrestricted movement up the river to reach spawning grounds. After the dam was built, this movement was restricted or completely obstructed. Fish numbers would build up farther down the river, and as they are unable to reach their spawning grounds, they would often die without reproducing. Other fish may fail to reach food sources farther up the river and either die of starvation or be smaller and less healthy. In any case, the disruption of fish movement by dams would have a negative effect on both reproduction and energy availability.
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 3. Applying

2. A college student is trying to choose a major and is deciding between ecology and environmental science. She enjoys delving into ecological questions, especially ones related to climate change that require detailed and concentrated research in the field and the computer lab. She is also extremely concerned about the impact of humans on world climate, loss of habitat and species, and other ecological problems, but she is often uncomfortable in social or political situations. Given this information, what would you advise this student to major in? Justify your answer.
Answer: Because of the student's interest in doing research on detailed questions relating to complex subjects such as climate change, and her lack of comfort in social and political situations, she would probably be most suited to a career in ecology, rather than environmental science. This does not mean she cannot be an environmental activist; she could find other ways to contribute to the environmental movement—for example, by using her ecological expertise to write about environmental problems.
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.

Learning Objective: 1.2.1 Summarize how the inquiries of ecologists and environmental scientists differ.
Bloom's Level: 4. Analyzing

3. A team of researchers is investigating the effects of fertilizer on the growth of forest trees. They use an old Christmas tree plantation with pine trees of the same species and age, and divide a section of the plantation into 4,000 plots, with each plot measuring 10 cm × 10 cm. They separate the plots into two groups of 2,000 and apply different amounts of fertilizer to the two groups. They collect data on tree growth in each plot for 12 hours and quantify the growth rates with high and low fertilizer applications. Discuss the validity of this design, concentrating on possible spatial and temporal flaws. Based on this experimental design, would the researchers be able to draw valid conclusions about the effect of fertilizer on tree growth rates? Why or why not? Consider the spatial and temporal scales of the design.
Answer: The spatial and temporal scales are both wildly off in this experiment. The plots are tiny compared to the size of a single tree where they should be large enough to encompass one or several trees. The time scale is also off. A data collection time of only 12 hours is far too short to measure tree growth; if changes did occur, they probably wouldn't be because of the fertilizer. To be accurate, tree growth should be measured over a period of years, not hours. Because of these spatial and temporal defects in the design, the researchers would not be able to draw valid conclusions about tree growth.
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when testing their hypotheses.
Bloom's Level: 4. Analyzing

4. A rare, highly endangered bird species lives in a very remote area of the Amazonian rainforest. Almost nothing is currently known about this species' diet, behavior, life-span, breeding system, or its interactions with other species. Which ecological level or levels, from organism to biome, would you focus on in a research study? Consider scale when justifying why you would choose this level or levels, and explain why you would *not* choose the others.
Answer: Focusing on the individual, population, or community levels would make the most sense. As there is very little known about this species, it would be smartest to focus on the smaller scales first—to begin to gather data on this species and understand how it interacts with other organisms in its immediate environment. The ecosystem and biosphere levels are probably too large in scale to be of use in learning more about one particular species of interest, especially a very rare one.
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when testing their hypotheses.
Bloom's Level: 5. Evaluating

5. A rare, highly endangered bird species lives in a very remote area of the Amazonian rainforest. Almost nothing is currently known about this species' diet, behavior, life-span, breeding system, or its interactions with other species. Ecological research can be conducted at five major levels or scales (note that one has already been entered into the table). Complete the table, listing the four other potential levels of ecological study in order from the lowest to the highest level. For each level, list one potential research question that could be asked in a study of the endangered bird species.

	Level name	**Potential research question**
Lowest level ↑		
	Population	
↓ Highest level		

Answer: (Note: The potential research questions given are examples; other similar questions could be equally correct.)

	Level name	**Potential research question**
Lowest level ↑	Individual	How does the quality of diet affect reproductive output?
	Population	What type of breeding system does this species have?
	Community	What types of predators does this species have?
	Ecosystem	How does this species affect the biotic and abiotic factors within its biome?
↓ Highest level	Biosphere	How do global weather patterns affect the actions of this species?

Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 4. Analyzing

6. Create a table showing a cost and a benefit of conducting research in a lab versus in the field.
Answer:

	Cost	Benefit
Lab experiments	Might create artificial conditions that are not relevant in nature	Allows more control over conditions and variables
Field experiments	Many factors may be outside of the control of the researcher, so the results might be difficult to interpret	Since conditions are natural, field experiments may provide better insight into how the experimental system functions naturally

Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 4. Analyzing

7. Would you use an observational, experimental, or modeling approach to study a rare, endangered bird species? Why would the approach you chose be a better choice than the others for your study?
Answer: An observational approach would likely be the best choice given the rarity of the species. It would allow for the collection of basic data about the species to begin to gain an understanding of its natural history, without many of the risks of an experimental approach. If the species is indeed highly endangered, it is unlikely that most experimental approaches could be justified because any manipulation may have adverse effects on the very small number of individuals. A modeling approach would also not be preferred due to the almost complete lack of information about the species—it is very difficult to create a model if there is no background information about the species.
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 5. Evaluating

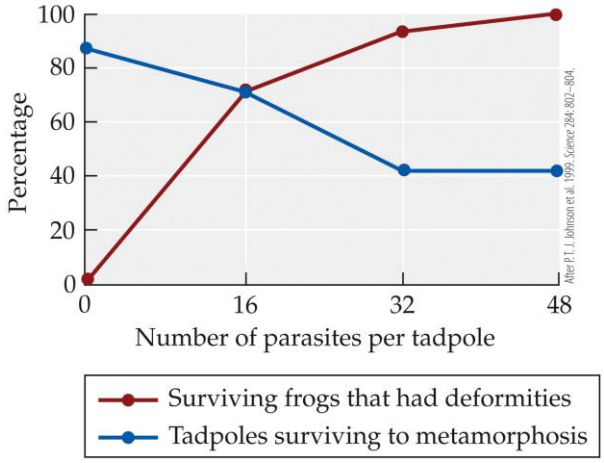
8. A team of researchers is investigating the effects of fertilizer on the growth of forest trees. They use an old Christmas tree plantation with pine trees of the same species and age, and divide a section of the plantation into 60 plots. They separate the plots into two

groups of 30. They apply high fertilizer levels to the group to the east of the plantation and low fertilizer levels to the western group. They set up the experiment to run for ten years and measure growth of all trees at the end of each year. Discuss the validity of the experimental design, concentrating on the formation of treatment groups and the use of controls. Based on this design, would the researchers be able to draw valid conclusions about the effect of fertilizer on tree growth rates? Why or why not?
Answer: The formation of treatment groups in this experiment suffers from two flaws. First, there is no control group. A better design would be three groups of 20 plots, with low fertilizer, high fertilizer, and a third control group receiving no fertilizer. This would help ensure that any changes seen are really due to the effects of fertilizer. Second, the plots in the treatment groups were not randomly selected. Random selection ensures that differences are not due to a difference (in this case) between the eastern and western sides of the plantation. Because of these two design defects, researchers would not be able to draw valid conclusions about the effects of fertilizer on tree growth rates.
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 4. Analyzing

9. A team of researchers investigated the effects of fertilizer on the growth of forest trees. They used an old Christmas tree plantation with pine trees of the same species and age, dividing it into plots and testing growth rates at different levels of fertilization. They calculate averages from their treatment groups, and see that the low-fertilizer group had a higher growth rate than the high-fertilizer group. They conclude that applying a small amount of fertilizer always causes all trees to grow faster than applying a large amount. Is this conclusion valid? Explain.
Answer: No, the conclusion is not valid. First, the researchers conducted no statistical analysis to determine how great the difference between groups was, and if it was significant. If the difference was very small, and/or if the variation within groups was very high, the difference could have been due to chance, with no real biological difference between groups. Second, their conclusions were far too broad. They applied the conclusion to "all trees," but they tested only one species, and all of the trees tested were the same age. The conclusions should be based only on the type of trees tested. Finally, their conclusions were based on only one experiment. A good experimental design would include many replications of the same experiment.
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 4. Analyzing

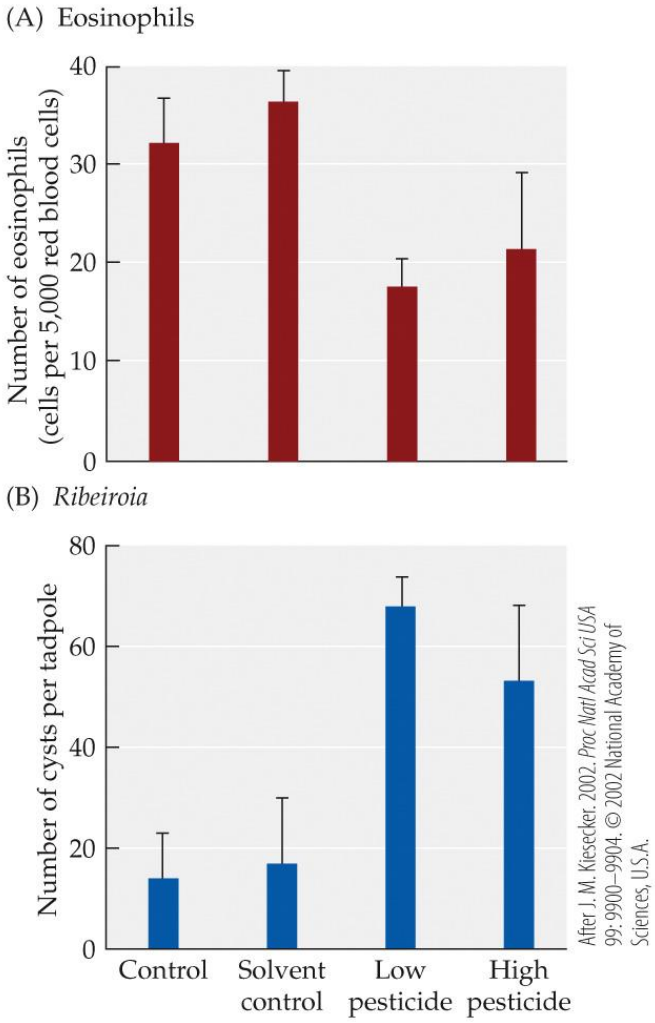
COMPANION WEBSITE QUIZ QUESTIONS

1. Refer to the figure.



The figure is based on Johnson's experiment on the effects of trematode parasites on tadpoles. According to the figure, how did adding 16 parasites per tadpole to a group of tadpoles affect their survival?
a. It caused a 20% increase.
b. It resulted in no change.
c. It caused a 10% decrease.
d. It caused a 20% decrease.
Answer: d
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 3. Applying

2. Refer to the figures.



The figures are based on studies of the effects of pesticides on the tadpole immune system. In a laboratory experiment, wood frog (*Rana sylvatica*) tadpoles were exposed to low or high concentrations of a pesticide, and then to *Ribeiroia* parasites. The tadpoles were then examined for (A) numbers of eosinophils and (B) numbers of *Ribeiroia* cysts. Error bars show one SD of the mean. Compared with the control group, the frogs exposed to low concentrations of pesticides had about how many times as many parasite cysts?
a. 1.5
b. 3
c. 4.5
d. 10
Answer: c
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 3. Applying

3. How do connections in nature lead to unanticipated side effects in the case of amphibian deformities?
a. Increased pollution levels decrease predation, which allows even deformed frogs to survive and reproduce.
b. Increased nutrients in ponds stimulate algal growth and provide the snails with a more abundant food source, which also increases the number of *Ribeiroia*.
c. The increased pollution kills off the frogs' prey and makes it more difficult for them to survive.
d. Higher levels of pesticides increase the number of eosinophils in frogs.
Answer: b
Textbook Reference: 1.1 Events in the natural world are interconnected.
Learning Objective: 1.1.1 Explain how interactions between organisms and their environment can affect other organisms and potentially lead to unexpected consequences.
Bloom's Level: 2. Understanding

4. A scientist monitors both the pollution entering a city's water supply and the changing populations of fish and other organisms thought to be affected by this pollution. He also speaks regularly at city council meetings, giving the results of his studies, and suggests changes in local laws that could help control the pollution. Based on his activities, this person could best be described as
a. an ecologist.
b. an environmental scientist.
c. a politician.
d. an activist.
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.1 Summarize how the inquiries of ecologists and environmental scientists differ.
Bloom's Level: 1. Remembering

5. Many species live in the Quabbin Reservoir in Massachusetts, and these different species interact to varying degrees. This is an example of a(n)
a. biosphere.
b. community.
c. ecosystem.
d. population.
Answer: b
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when testing their hypotheses.
Bloom's Level: 2. Understanding

6. An association of individuals of the same species living in the same area is called a(n)
a. biosphere.

b. community.
c. ecosystem.
d. population.
Answer: d
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when testing their hypotheses.
Bloom's Level: 1. Remembering

7. One ecologist is studying the genetic changes in a fish species in Africa over several decades, monitoring several populations of the species in different lakes. A second ecologist is studying changes in the same fish species throughout history, relying not only on present-day data, but on information from fossils, preserved specimens, and DNA changes over time. Both scientists are interested in how this species fits into its environment and how it's changed as its environment has changed. What is the difference in the approach of these two scientists?
a. Both are studying fish evolution, but they are using different temporal scales.
b. Both are studying fish evolution, but they are using different spatial scales.
c. The first scientist is studying ecology; the second is studying evolution.
d. The first scientist is studying evolution; the second is studying ecology.
Answer: a
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: 1.2.2 Outline how ecologists use spatial and temporal scales when testing their hypotheses.
Bloom's Level: 2. Understanding

8. Which statement is *not* correct in regards to the basic tenets of ecology?
a. At some point, every population will experience checks on its growth and resource use.
b. Whatever affects one organism can affect others as well.
c. Evolution took place in the past, but it is no longer occurring.
d. Ecosystems change over space and time.
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 2. Understanding

9. Which of the following is an abiotic feature of the environment?
a. The average minimum temperature at night
b. The number of days during which a predator is actively hunting
c. The prevalence of parasites in an area
d. The density of plants in an area
Answer: a

Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Textbook Reference: Not aligned
Bloom's Level: 2. Understanding

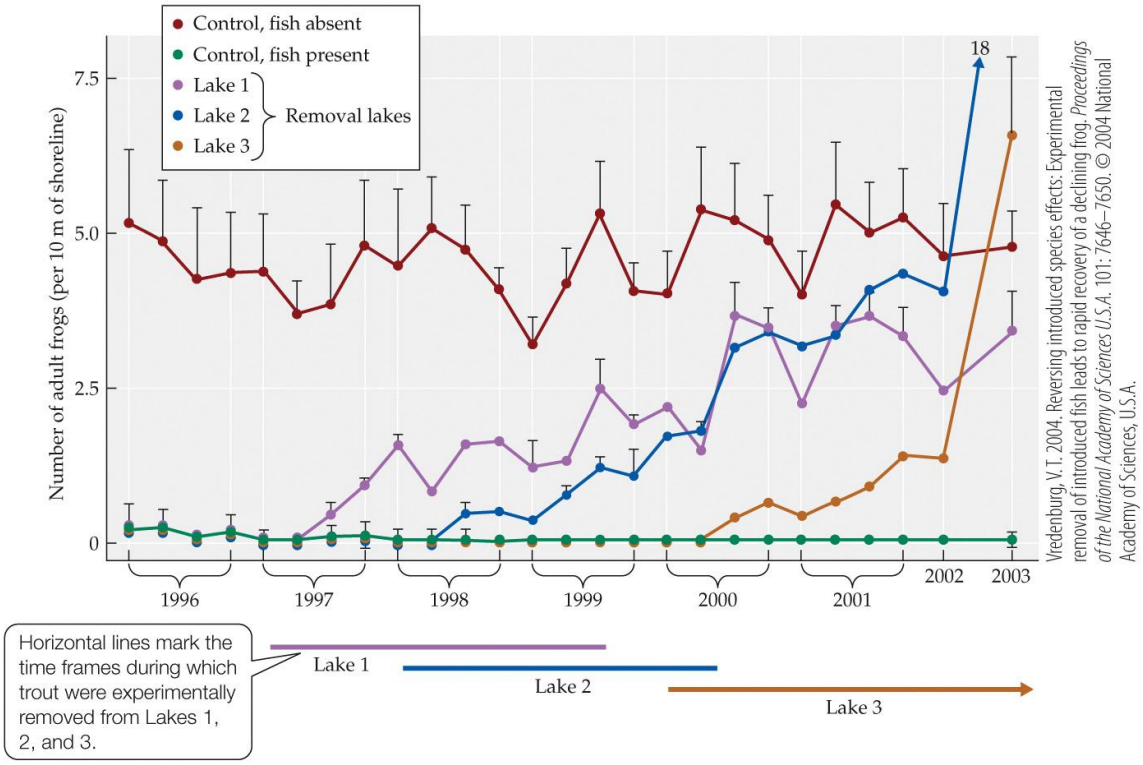
10. In a desert ecosystem, plants capture 120 units per day of solar energy and they use up to 70 units per day in respiration. Animals consume about 30 units per day of the plants. The NPP of this system is how many units per day?
a. 20
b. 30
c. 50
d. 120
Answer: c
Textbook Reference: 1.2 Ecology is the scientific study of interactions between organisms and their environment.
Learning Objective: Not aligned
Bloom's Level: 3. Applying

11. Refer to the figure.

The figure represents an ecological study done by Carson and Root to study how herbivorous insects affected a plant community. Based on the figure, what type of study were Carson and Root most likely performing?
a. A controlled field experiment
b. An uncontrolled field experiment

c. A laboratory experiment
d. An observational study
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 1. Remembering

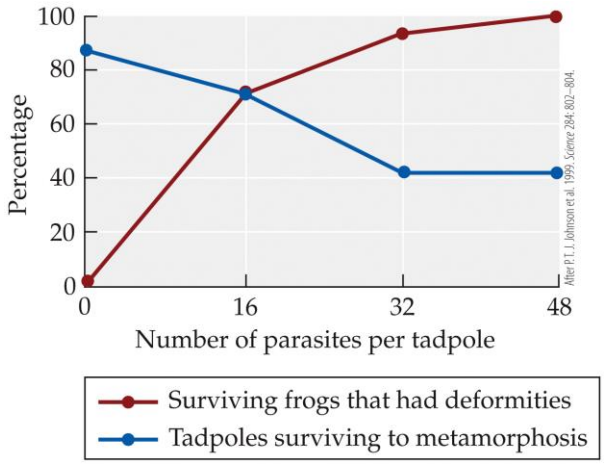
12. Refer to the figure.



Vredenburg studied the impact of the introduction of rainbow and brook trout on a species of amphibian, the mountain yellow-legged frog (*Rana muscosa*). After showing greatly decreased frog populations in lakes with trout, he set up an experiment using three categories of lakes: lakes from which he removed trout, lakes that had never had trout, and lakes that still contained trout. He compared the number of adult frogs per 10 m of shoreline in all groups, as shown in the figure. What is the most likely reason that Vredenburg chose to use a large-scale experimental design such as this, rather than a single lake or laboratory experiments?
a. The larger design allowed Vredenburg the ability to do replications.
b. A smaller study would not adequately answer the experimental question.
c. In a larger study, it is easier to manipulate the various experimental treatments.
d. In a real-world situation such as this, all variables can be more easily controlled.
Answer: b

Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.1 Compare the advantages and disadvantages of using field observations, field experiments, and lab experiments to test ecological hypotheses.
Bloom's Level: 5. Evaluating

13. Refer to the figure.

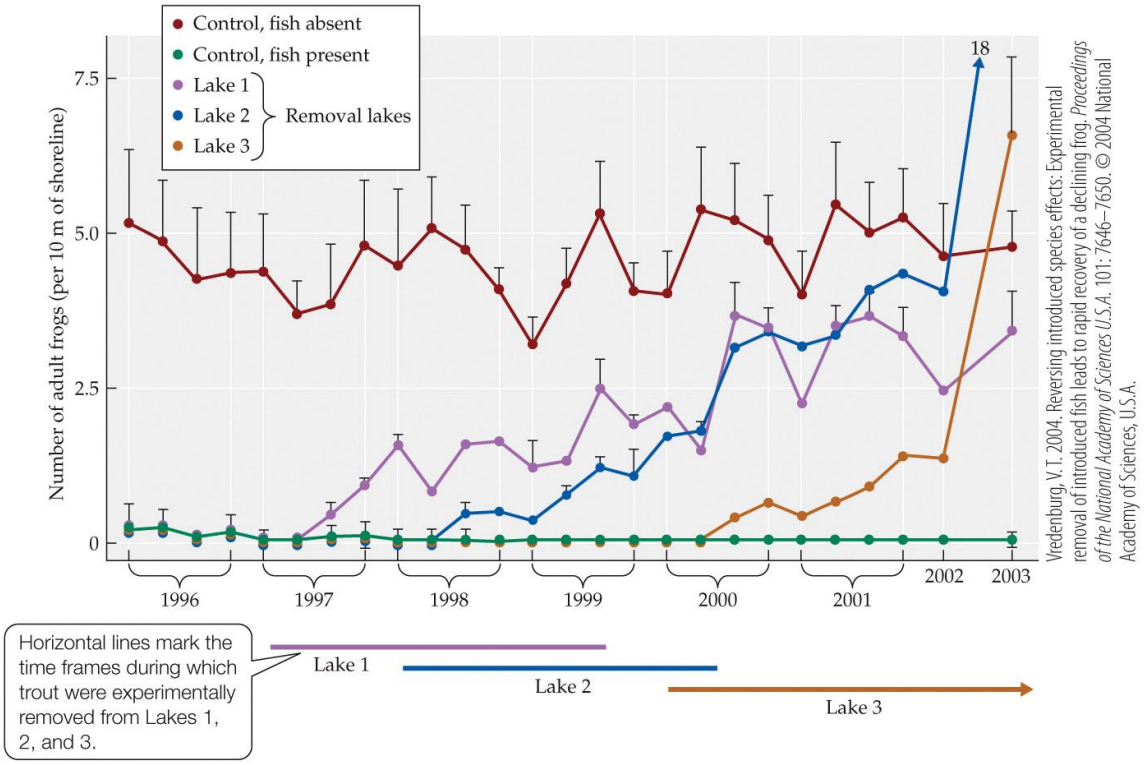


The figure is based on Johnson's controlled experiment on the effects of trematode parasites on tadpoles. The groups in the experiment were the groups containing a specific and different number of parasites per tadpole (0, 16, 32, 48). Which of these groups is the control group?
a. 0.
b. 16
c. 32
d. 48
Answer: a
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 2. Understanding

14. Biologists find that tomato plants treated with an insecticide produce 2.2% more tomatoes compared to untreated plants. To assess whether these differences are significant, the biologists would most likely use
a. a control group.
b. statistical analysis.
c. replication.
d. mathematical modeling.
Answer: b
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.

Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 2. Understanding

15. Refer to the figure.



Vredenburg studied the impact of introduction of rainbow and brook trout on a species of amphibian, the mountain yellow-legged frog (*Rana muscosa*). After showing greatly decreased frog populations in lakes with trout, he set up an experiment using three categories of lakes: lakes from which he removed trout, lakes that had never had trout, and lakes that still contained trout. He compared the number of adult frogs per 10 m of shoreline in all groups, as shown in the figure. In Vredenburg's experimental design, why did he use two control groups?
a. To be doubly sure his results were correct
b. To ensure that he had enough data for statistical analysis
c. To control for unknown factors that might be present in the lakes
d. To control for the effects of two known natural conditions
Answer: d
Textbook Reference: 1.3 Ecologists evaluate competing hypotheses about natural systems with observations, experiments, and models.
Learning Objective: 1.3.2 Describe the importance of hypotheses, controls, replication, and data analysis to the scientific process.
Bloom's Level: 4. Analyzing

Online Analyzing Data

to accompany

Ecology, Fifth Edition

Bowman • Hacker

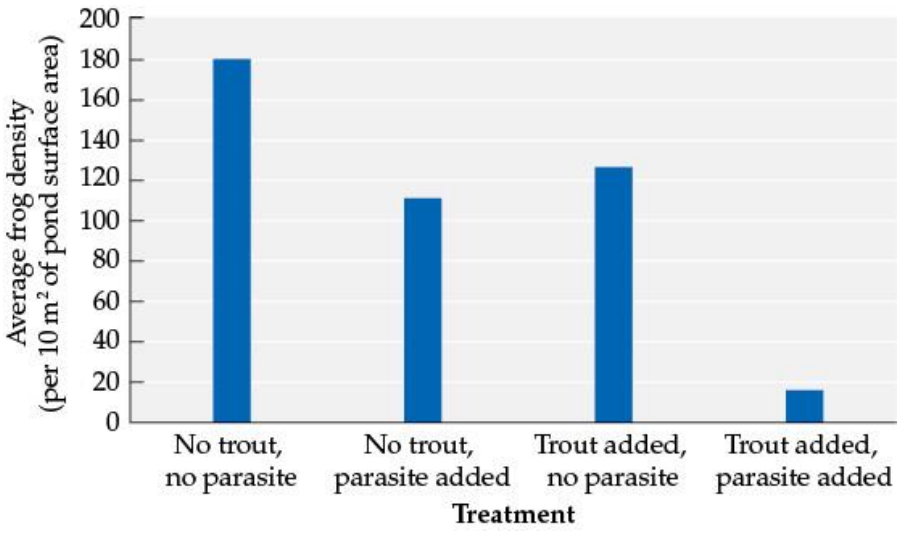
1.1 What Are the Combined Effects of Introduced Predators and Parasites on Amphibian Populations?

Suppose that researchers wanted to examine the combined effects of an introduced predator (a trout) and the trematode parasite *Ribeiroia* on amphibian populations. To do this, they established frog populations in each of 40 artificial ponds. Each pond was assigned at random to one of four treatments (10 ponds per treatment): 1) neither trout or parasites were added to the pond (the "No trout, no parasite" treatment); 2) no trout were added but parasites were added ("No trout, parasite added"); 3) trout were added but parasites were not added ("Trout added, no parasite"); and 4) both trout and parasites were added ("Trout added, parasite added"). Each pond contained refugia where tadpoles could avoid attack by trout, to avoid fish predators driving frog populations to extinction in an artificial pond, unlike what typically occurs in a natural pond. After two breeding seasons, the researchers estimated the density of frogs in each pond. The results are shown in the table.

Treatment	Average frog density (per 10 m^2 of pond surface area)
No trout, no parasite	180.2
No trout, parasite added	111.4
Trout added, no parasite	125.8
Trout added, parasite added	14.3

Question 1. Construct a bar graph showing the average density of frogs for each of the four treatments (see Web Stats Review 1.1.2 for a description of bar graphs).

Answer:



Question 2. Independent of any possible effects of trout, estimate the reduction in frog density caused by the addition of parasites. Justify the calculations used to answer this question.

Answer: To remove any possible effects of trout and estimate how parasites alone affected frog density, the average frog density in the "No Trout, no parasite" treatment is compared to the average frog density in the "No Trout, parasite added" treatment. Based on the results in the table, parasites alone reduced frog density by 180.2 – 111.4 = 68.8 frogs per 10 m^2 of pond surface area.

Question 3. Independent of any possible effects of parasites, estimate the reduction in frog density caused by the addition of trout. Justify the calculations used to answer this question and compare the relative effects of trout and parasites on amphibian populations.

Answer: To remove any possible effects of parasites and estimate how trout alone affected frog density, the average frog density in the "No Trout, no parasite" treatment is compared to the average frog density in the "Trout added, no parasite" treatment. Based on the results in the table, trout alone reduced frog density by 180.2 – 125.8 = 54.4 frogs per 10 m^2. In this experiment, parasites reduced frog densities by a slightly greater amount (68.8 frogs per 10 m^2) than did trout (54.4 frogs per 10 m^2).

Question 4. Describe the combined effects of parasites and trout on frog densities. Interpret this result and suggest a hypothesis for why this may have occurred.

Answer: When both parasites and trout were added, frog densities dropped by an average of 180.2 – 14.3 = 165.9 frogs per 10 m^2. To interpret this result, recall that the reduction in frog density caused by parasites alone was 68.8 frogs per 10 m^2, while the reduction in frog density caused by trout alone was 54.4 frogs per 10 m^2. Thus, when both parasites and trout were added, we might expect that frog densities would have dropped by a total of 68.8 + 54.4 = 123.2

frogs per 10 m^2. However, the addition of both parasites and trout caused frog densities to drop by 165.9 frogs per 10 m^2—a value that is about 35% higher than our expected value of 123.2 frogs per 10 m^2. One hypothesis that could explain this result is that infection by parasites made frogs more vulnerable to trout, thereby reducing frog densities more greatly than would occur from the combined (additive) effects due to parasites alone plus those due to trout alone.

Hands-On Problem
to accompany
Ecology, Fifth Edition
Bowman • Hacker

1.1 When a Mosquito Flaps Its Wings…: Connections in the Natural World

(This exercise is based on the hypothesis proposed in Chase, J. M. and T. M. Knight. 2003. Drought-induced mosquito outbreaks in wetlands. *Ecology Letters* 6: 1017–1024.)

INTRODUCTION

One of the main themes of Chapter 1 is that ecology is the study of the connections in nature. In this exercise, you will read the abstract of a paper that proposes a hypothesis about how weather patterns are connected to mosquito population dynamics. You will then look for further connections between weather patterns and mosquito-borne diseases in human populations.

In the paper, J. M. Chase and T. M. Knight (2003) argue that episodes of drought result in dramatically increased mosquito populations (**Figure 1**) the following year in wetlands that dry every few years (called semi-permanent wetlands).

Figure 1 Mosquitoes are aquatic in the larval stage. (CDC/James Gathany)

The authors suggest that it is species interactions—specifically, predation and competition—that limit larval mosquito populations in permanent wetlands. They divide wetlands into three types by how frequently they dry out: permanent wetlands that never dry, temporary wetlands that dry every year, and semi-permanent wetlands that dry only

during drought years. Examples of each of these types of wetlands are shown in **Figure 2**.

(A)

(B)

(C)

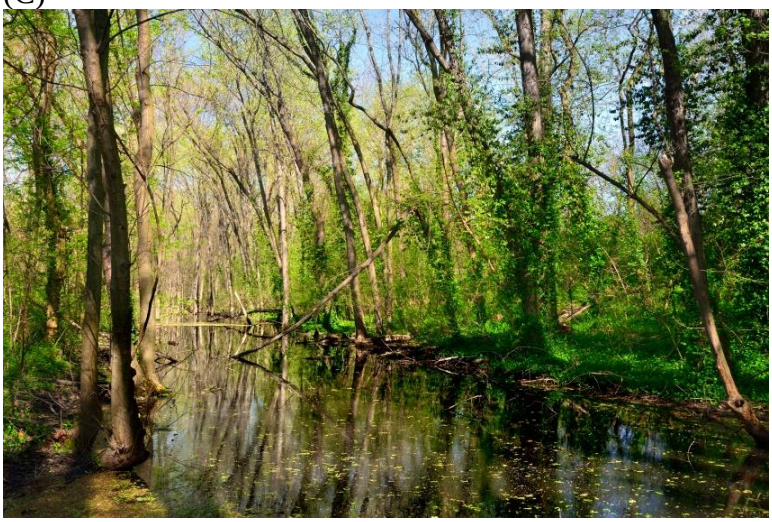


Figure 2 Wetlands (A) Permanent wetlands like this deep pond or lake; (B) Temporary wetlands like this shallow, seasonal pool that only has water during the spring and early summer; (C) Semi-permanent wetlands like this small pond which dries completely only during severe drought periods. (A © mw_listing/iStock, B © grebcha/iStock, C © Joesboy/iStock)

In permanent wetlands, there are always many predators and competitors that limit larval mosquito survival such as mosquitofish eating mosquito larvae. Similarly, in temporary wetlands, there is a suite of competitors that are adapted to annual drying that compete with and limit survival of larval mosquitoes. Zooplankton are competitors in temporary wetlands.

However, in semi-permanent wetlands, few competitors and predators are adapted to rapid recolonization after periodic drought and drying episodes. After a drought, when the semi-permanent wetlands refill, mosquitoes quickly recolonize and exploit the food resources there, producing a spike in populations before competitors or predators are able to recolonize. Thus, the lack of competitors in the year following a drought produces large mosquito populations in such wetlands.

One of the connections highlighted in Chapter 1 is that between human activities and West Nile virus (WNV). West Nile virus can cause severe sickness in humans. It was first identified in the Congo in the 1930s, and subsequently spread nearly worldwide in temperate and tropical areas. It was first documented in the U.S. in New York in 1999. West Nile virus is transmitted by infected mosquitoes (mainly genus *Culex*) when they bite humans (**Figure 3**).

Figure 3 Female common house mosquito (*Culex* sp.) obtaining a human blood meal. (CDC/James Gathany)

QUESTIONS

We are interested in exploring the connection between climate variation, specifically drought periods and the incidence of this mosquito-borne disease. Because of the relationship between mosquito outbreaks and drought identified in the paper we reviewed, and the suggestion that higher populations of mosquitoes should result in higher incidence of West Nile virus in humans, we can predict that WNV outbreaks might follow severe droughts. We will explore these connections by comparing patterns of drought to patterns of WNV incidence.

Question 1

The most reliable measure of drought is the Palmer Drought Severity Index (PDSI). The Palmer Drought Severity Index incorporates both temperature and precipitation into a single index. Positive values of PDSI indicate wet periods and negative values indicate drought. We can find historic drought data from the following website.

Palmer Drought Severity Index

We want to determine whether there might be a relationship between severe drought and the incidence of mosquito-borne diseases. The reasoning is that in the year after a drought, the larger mosquito populations from semi-permanent wetlands would be more likely to result in transmission of mosquito-borne diseases.

Test for a relationship between drought and incidence of West Nile disease by plotting mean PDSI (lagged by one year) on the x-axis and number of reported cases of WNV on the y-axis for each of the four states in the tables below. The term “lagged by one year” in the previous sentence means we match the PDSI from one year to the next year number of WNV cases. For example, the PDSI for 2001 should be plotted against WNV cases for 2002, the PDSI for 2002 should be plotted against WNV cases for 2003, and so

forth. Remember, the prediction is that drought in the previous year will result in higher numbers of mosquitoes in the current year (as the semi-permanent wetlands refill), and higher numbers of mosquitoes will result in more WNV cases. You can use the website below if you choose to explore cases of WNV in other locations.

West Nile virus disease frequency

Do you see evidence of a link between severe drought and WNV? If drought (negative values on the PDSI scale) is associated with higher WNV cases, it will appear as a negative relationship in the plot. Were drought periods always followed by increases in WNV? What might be the limitations of using the pattern observed by Chase and Knight to infer incidence of disease by mosquito vectors?

Pennsylvania

Year	Drought Severity Index	WNV cases
2001	-1.863	
2002	-1.525	62
2003	2.221	237
2004	4.504	15
2005	0.1	25
2006	1.177	9
2007	0.325	10
2008	0.243	14
2009	0.364	0
2010	-0.419	28
2011	3.404	6
2012	-0.136	60
2013	0.428	11
2014	0.736	13
2015	-0.298	30
2016	-1.273	16
2017	1.163	20
2018	4.135	130

Florida

Year	Drought Severity Index	WNV Cases
2001	-3.183	
2002	-0.204	28
2003	1.474	94
2004	-0.471	41
2005	0.417	21
2006	-2.908	3
2007	-5.312	3

Year	Drought Severity Index	WNV Cases
2008	-3.218	3
2009	-0.873	3
2010	-1.024	12
2011	-4.128	24
2012	-1.508	73
2013	0.682	7
2014	0.756	17
2015	-1.153	13
2016	-0.632	8
2017	-0.498	5
2018	0.386	35

Illinois

Year	Drought Severity Index	WNV Cases
2002	0.348	
2003	-0.116	54
2004	0.793	60
2005	-1.891	252
2006	-0.324	215
2007	-0.542	101
2008	2.985	20
2009	4.706	5
2010	3.775	61
2011	1.275	34
2012	-2.353	290
2013	0.425	117
2014	1.094	44
2015	2.732	77
2016	2.753	154
2017	0.455	90
2018	1.599	176

New York

Year	Drought Severity Index	WNV Cases
1999	-1.03	
2000	1.324	14
2001	-1.658	15
2002	-0.294	82
2003	1.614	71
2004	2.767	10
2005	2.204	38

Year	Drought Severity Index	WNV Cases
2006	2.788	24
2007	2.312	22
2008	2.604	46
2009	1.89	7
2010	0.405	128
2011	3.262	44
2012	-0.971	107
2013	1.015	32
2014	1.332	26
2015	-0.447	57
2016	-0.933	22
2017	1.894	51
2018	2.116	98

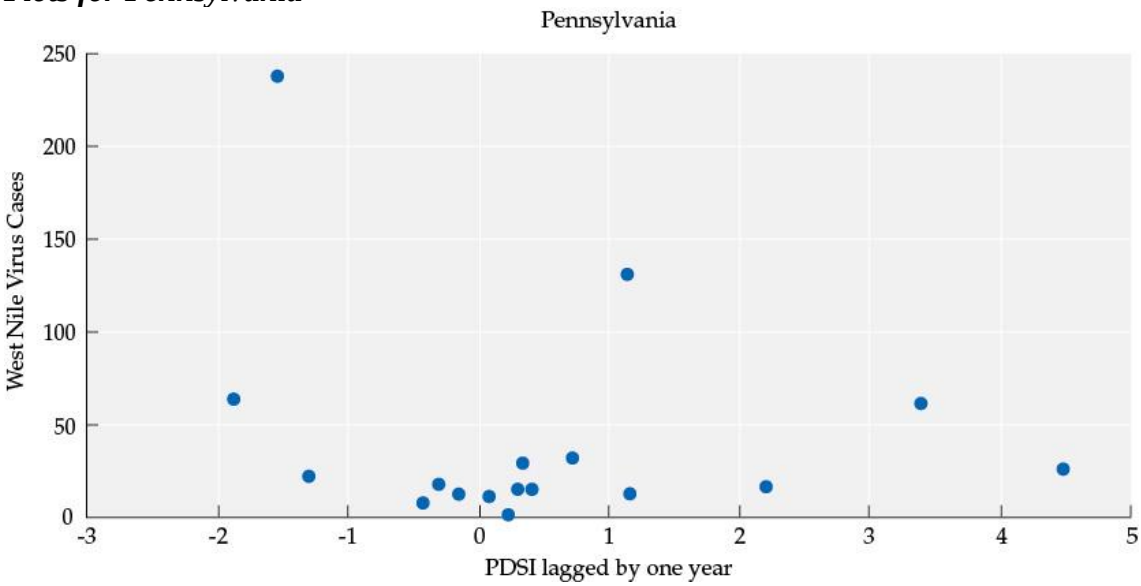
Answer

See the plots below. WNV incidence seems to be in response to drought in some cases (see Pennsylvania data for 2002 PDSI and 2003 WNV), but in most states there seems to be little relationship. Severe droughts are relatively rare in Pennsylvania, New York, and Illinois, but more common in Florida. This is a good opportunity to talk about correlative versus experimental data. Of course, many other factors may be influencing the incidence of WNV. The virus has been spreading rapidly through the country over the last 20 years, so part of the variation is undoubtedly due to availability and spread of avian hosts.

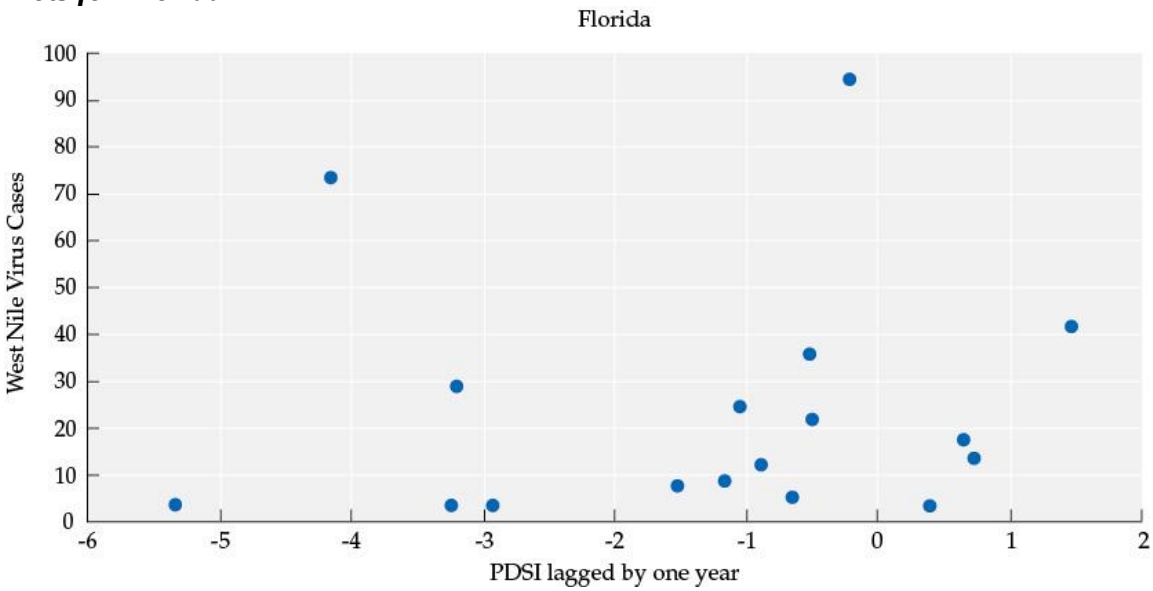
In addition, the model proposed in the paper may be geographically limited. The relative availability of semi-permanent wetlands may be somewhat specific to Pennsylvania, so the importance of drought in creating mosquito population fluctuations may vary among geographic regions.

Finally, there is a behavioral response by humans to disease that may confound incidence data. Increased spraying for mosquitoes and increased vigilance by informed humans may alter rates of disease contraction independently of drought-driven mosquito population dynamics.

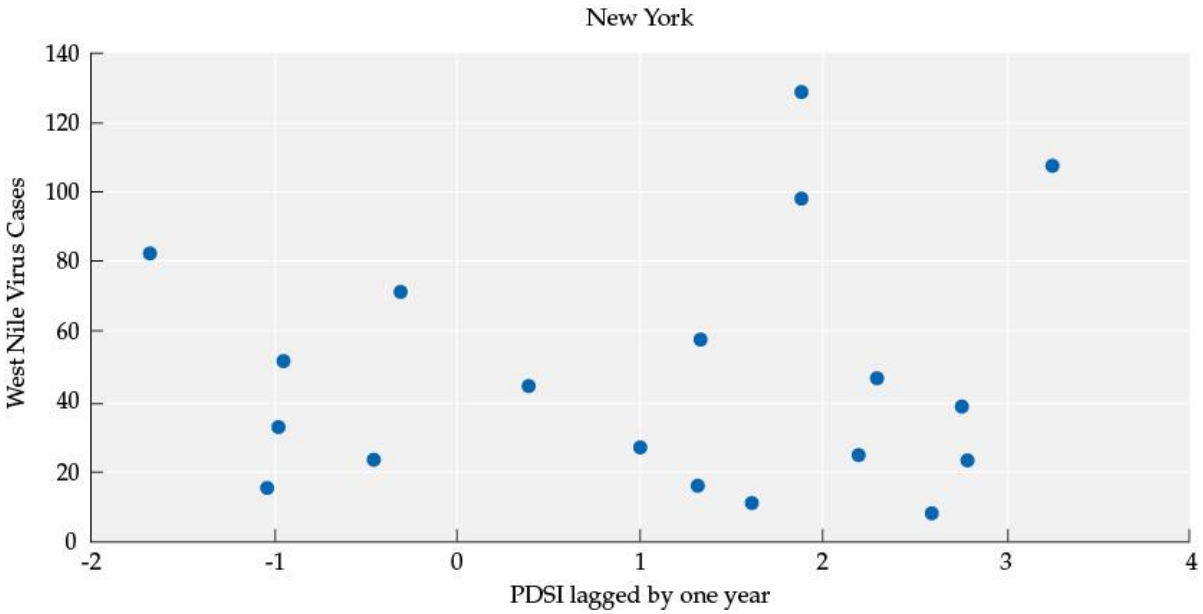
Plots for Pennsylvania



Plots for Florida



Plots for New York



Plots for Illinois