



# Land Use Journey – Plan for Bats!

## Background

All plants and animals, whether they are wild or domesticated, have the same basic needs. A habitat is the place where an animal or plant lives and gets everything it needs to survive, including food, water, shelter (protection from predators and the environment including sun, rain, snow, etc.) and adequate space to live. If one or more of these necessary components are removed from a plant or animal's habitat, it will not survive.

Habitat includes the entire area that contains the components needed by a plant or animal. While thinking of habitat as a plant or animal's home is a good way to explain habitat, it is really much bigger than just a house. Habitat is the entire neighborhood where an animal gets the food, water, shelter, and space it needs to survive. The amount and quality of these needs varies a great deal from species to species. A deer's habitat might be a combination of forests and fields. A sea turtle's habitat might be the ocean and the beach. An eastern red bat's habitat may stretch from the forests of Wisconsin where it breeds in the summer to the forests of Kentucky where it spends the winter.

## Habitats for Bats

Bats have very complex habitat needs. They use a variety of habitat types depending on the species of bat, the time of year, and what they are doing – hunting for food, raising their babies, or hibernating through the winter. In order to survive, insectivorous bats need insects to eat, water to drink, places to sleep and raise their young (called roosts), and places to hibernate in the winter.

Some bats use caves or other natural cavities such as rock outcrops, cliff faces, or even exfoliating bark on trees to roost and to hibernate. Other bats, such as the big brown bat, even use buildings. The eastern red bat can migrate hundreds of miles south to find warmer temperatures during the winter.

Because bats have such specific habitat requirements, development of land and habitat fragmentation by humans can have damaging effects on bats. In fact, habitat loss is the most widespread risk to bats worldwide.

## Land Use

Land Use is a term that describes how humans manage and modify the natural environment to meet their own needs. Human land use affects bat habitats and also has impacts on bat populations that are often species specific.

As human populations grow and more land is developed for human use, it is important to consider how land use affects wildlife species, especially misunderstood species such as bats.

## EXPLORATION QUESTIONS

"How do different types of land use affect different species of bats? Is it possible to design towns or housing developments so they are more bat-friendly?"

## MATERIALS

- Projector or a way to show a YouTube video to the class
- Copies of Journey 2050: Land Use Student Worksheet
- Copies of Student Lab Instructions
- Copies of Land use Planning – Student Reading Page
- Copies of Close Up View of Three Bats - Student Reading Page
- Copies of three land use scenarios and simulation land use Activity Sheets
- Copies of Post-Lab Questions
- A set of 100 counters (dry lentils, M&Ms, etc.) that can easily be spread out and collected for each small group or individual student
- Stochastic event cards (optional)

## OVERVIEW

Students will review information about different bat species and types of land use. They will then participate in a simplified simulation of how land use affects the survival of three different bat species. Students will identify how each bat species responds to land use decisions and then model bat populations. At the end of the simulation students will have the opportunity to create their own land use map.

## VOCABULARY

Land use, habitat, species, exponential growth, wind energy, prescribed fire, ecosystem, urban sprawl, carrying capacity, stochastic events

## GROUP SIZE

Any

## AGE

13 and above

In this activity, students will examine how three different bat species are affected by different types of land use, including turbines for wind energy, high-density development, and prescribed burning.

### **Bats and Turbines for Wind Energy**

While wind energy offers many advantages, it is not completely benign. Wind energy is considered a clean fuel source – it doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. This means that wind turbines don't produce atmospheric emissions that cause acid rain or the greenhouse effect. Wind energy is sustainable and is one of the lowest-priced renewable energy technologies available today. Yet, wind turbines and their associated infrastructure — notably power lines and towers — are among the fastest-growing threats to birds and bats in the United States and Canada.

Studies show that in North America, turbines for wind energy kill hundreds of thousands of bats each year. Researchers think that bats may be attracted to the turbines because bats think they are large trees or places to search for insects. Concerns around mass mortality of bats by wind turbines are heightened because many bat populations are on the decline due to White-Nose Syndrome, a disease that kills bats as they hibernate in mines and caves to survive the winter.

Many bat populations have declined greatly because of White-Nose Syndrome and are especially vulnerable to the additional threats caused by wind turbines. In addition to the threats posed directly by bats flying into the turbines, these structures also result in modification of habitat as they include construction sites and roads, which may further reduce bat habitat or foraging areas.

Wind energy is a valuable form of renewable energy that is beneficial in shifting away from fossil fuels, but its effect on wildlife cannot be ignored. In recent years scientists have found that interventions like feathering wind turbines – idling turbines at low wind speeds during peak bat migration seasons or when bats are most likely to be flying – can reduce the risk of bat mortality while not significantly reducing the amount of energy created. Researchers have also developed

a new ultrasonic acoustic system that could be used to interfere with bat echolocation and deter them from flying near the turbines. Efforts to get the industry to adopt measures to reduce turbine impacts on bats are ongoing.

### **Bats and Low/High-Density Development**

Wooded landscapes are often targeted for housing and commercial development. This type of development can result in the loss of habitat for bats and other wildlife and fragmentation of the remaining forest. Low-density housing typically has fewer houses built per acre and they are usually single-family homes versus condos or apartments. This usually means there is more space between houses and fewer roads than what is found in high-density developments.

High-density housing is more densely populated with single-family houses on small lots, along with townhouses and apartments. There are often more businesses and buildings become multiple stories.

Both low and high-density developments impact bat populations by altering available foraging and roosting habitat. Forest habitats are shown to have the highest amount of bat activity. While studies show that bats can sometimes adapt to human dominated landscapes, the overall effects vary depending on the land use. For example, conversion of a forest to farmland or urban uses, may result in modified habitat that may have little or no habitat value for forest-dependent bat species. Conversely, when timber harvest occurs in a forested landscape, it is likely to only result in a temporary reduction in habitat for species that rely on mature forests.

When forests are removed and replaced with open farmland or high-density development, there is little vegetation or tree cover to support bat populations. While the big brown bat is able to survive in both urban and forested areas, most of our North American bat species need forested habitats. For this reason, land use managers should maintain landscapes with a diversity of tree stands and vegetation alongside development to provide habitat for bats and other wildlife. Natural ecosystems throughout the world are under pressure by human activities. The resulting habitat loss and modification represents critical threats to biodiversity.

### **Bats and Prescribed Burning**

Prescribed burning refers to the controlled application of fire by a team of fire experts under specified weather conditions to restore health to ecosystems that depend upon fire. Prescribed burning has long been recognized as an important tool for conserving and creating habitat for many wildlife species, including bats. Studies show that prescribed burning can have a range of effects from neutral to positive on bat populations.

Fires can create more crevices in trees where bats can roost. They occasionally kill trees as well creating snags (standing dead trees) that some bat species prefer for roost sites. Grasses, legumes, and other herbaceous plants flower following a prescribed fire and harbor the delicious insects that bats love to eat – another beneficial effect. However, prescribed burning can injure bats if they are in torpor and are unable to arouse quickly enough to escape the fire. Managers can reduce the risk to bats by using ignition tactics that reduce the intensity of the fire and choosing the appropriate time of year to burn.

Specialists write burn plans for prescribed fires. Burn plans identify – or prescribe – the best conditions under which trees and other plants will burn to get the best results safely. Burn plans consider temperature, humidity, wind, moisture of the vegetation, and conditions for the dispersal of smoke. They also include any mitigation measures that will be taken to provide wildlife. Prescribed fire specialists compare conditions on the ground to those outlined in burn plans before deciding whether to burn on a given day.

Natural Resource Managers use prescribed burning not only to maintain healthy forests, but also to protect human life. Prescribed fires help to reduce leaf litter and forest debris that build up on the forest floor. If this debris builds up and is ignited, it can cause a wildfire. A wildfire is an unplanned fire caused by lightning or by accidental (or arson-caused) human ignitions. Wildfires can cause catastrophic damage to forests, homes, communities, and to human life. Prescribed fire is one of the most effective tools we have preventing wildfires and managing the intensity and spread of wildfires.

### **Note to Educators about Timing**

We recommend breaking this activity up into two class periods. The Get Ready – Background Activities and the Get Set – Explore Three Different Land Use Scenarios could be one class period of about one hour. The Get Set – Learn about Three Bat Species and the Go! – Simulation Activity along with the post-lab questions could be another class period of about one hour. Before you start the second class period, do a short discussion reviewing the background materials and the answers to the pre-lab questions.

### **Get Ready-Background Activities**

1. To assess your students' knowledge of land use discuss the questions below:
  - Why is land a precious resource?
  - What factors do we need to think about when deciding how to use land?
  - What are the different ways land is used in our city/town/county?
2. Tell the class that they will be doing an activity that will explore different types of land uses and how these land uses can impact three different bat species. Explain that they will begin by watching a video that focuses on agricultural land use. And, that after watching the video, your students will explore other types of land use and how they can impact wildlife.
3. Hand out the Journey 2050: Land Use Student Worksheet. Tell the students that they will fill out the answers to section one while watching the video
4. Watch the [Journey 2050: Land Use](#) video. Discuss the student's answers to the questions on their worksheet. You can have them exchange papers to check answers or review them as a class. Make sure the students have their original papers back before continuing the activity.
5. Ask your students if they think it is important to consider the environment and wildlife when deciding on how to use our limited amount of land. Discuss the questions below:
  - How do we improve our land use choices so that we can feed a growing world and still have a high-quality life and environment?

- How do you think land use choices like building wind turbines, housing developments, or cities might impact wildlife?
- Do you think Best Management Practices might exist that can minimize negative effects of land use choices?

6. Provide students with the “Land Use Planning – Student Reading Page.”

7. Have the students read through the fact sheet individually. Have them answer the questions under section two of their “Journey 2050: Land Use Student Worksheet” after completing the reading. Discuss the students’ answers to the questions on their worksheets.

8. Ask your students if they think an exponentially growing human population is sustainable? Why or why not?

### **Get Set – Explore Three Different Land Use Scenarios**

1. You can do the remainder of this activity in small groups or have the students work alone. If they are working in small groups, divide them into groups of 2-6. They will work together with this group during the second session of this activity as well. To maintain social distancing, individuals working as groups can be assigned specific tasks to complete. For example, one student runs the simulation, one records the data, etc.

2. Provide each group of students with a copy of the three different land use scenarios. This will be the foundation for the simulation they will complete during the next class period.

3. After reading each of the three land use scenarios, ask the students to consider the following pre-lab questions in their small groups: How would land converted from a forest to each of the land use scenarios impact wildlife that live in that forest? Would the impact be positive, negative, or neutral?

4. Optional. Ask your students to research three bat species before returning for the second portion of this activity – eastern red bat (*Lasiurus borealis*), northern long-eared bat (*Myotis septentrionalis*), and big brown bat (*Eptesicus fuscus*). A summary sheet is provided that will be

used in the simulation so you can decide if you want the students to do research on their own or you can just use the “Close Up View of Three Bats - Student Reading Page.”

This is the end of the first section of the activity.

### **Second Session - Get Set – Learn about Three Bat Species**

1. The students should get into their small groups from the previous day. You will assign each group one of the three simulations. One third of the students (or small groups) will conduct the wind energy simulation, one third will conduct the high-density development scenario, and one third will conduct the prescribed burning scenario.

2. Distribute a copy of the “Close Up View of Three Bats - Student Reading Page” to each of the students or small groups. Have volunteers read aloud the information about each bat species.

3. Tell the students that they will be refining their answers to the pre-lab questions they completed during the last classroom session based on the new information about three bat species. How would land converted from a forest to each of the land use scenarios impact the three different bat species? Would the impact be positive, negative, or neutral?

4. Hand out copies of the activity sheets for all three land use scenarios to each group. While they will only complete the simulation for one land use scenario, they will gather data from the other groups.

5. Ask the students to write down their answers to the pre-lab questions for each land use scenario on their activity sheets. They will need this information to determine whether a bat survives or dies when it encounters a particular land use during the simulations.

6. Provide each group with a copy of the “Student Lab Instructions.”

7. For each group, or individual student, give them a set of 100 counters small enough to fit at least two counters in each grid cell (dry lentils, M&Ms, etc.). We recommend you print the land use maps out on 11” by 16” paper. Ask students to read the “Student Lab Instructions” as you pass out the counters.

### **Go! - Simulation Activity**

1. Review the definition of carrying capacity. Carrying capacity is the number of people, other living organisms, or crops that an area can support without environmental degradation. Since there are only 100 counters for this activity, that is our carrying capacity. Make sure you explain to your students that even if births should make the bat populations exceed 100, those additional bats would leave the area or die because the area can only support 100 bats.

2. Instruct students to determine how many pups (baby bats) each bat species has per year. They will add that many pups for every 2 surviving bats to the "births" column of the simulation table.

3. Have the students conduct the simulation by randomly scattering the counters across the land use map. You will repeat the simulation 10 times (to represent 10 years) for each of the 3 bat species.

- The 100 counters will represent one species of bat at a time.
- Students will need to fill out a table for each species for each land use. Bats that land on the grey squares encounter the land use while bats on the white squares encounter undisturbed forest. If a counter is at all touching the grey square (even if only a little bit) then count it as though it was inside the gray box.

4. **OPTIONAL:** Explain that stochastic (random and unpredictable) events can also affect bat survival. As students are conducting the lab, announce that a stochastic event has happened that may impact a bat population. You can choose to randomly select a subset of students or a particular small group that will be impacted by each event. Because a stochastic event is random, it may not affect all the groups. Try to call out at least one stochastic event during each simulation. Students will need to record how many bats die as a result of a stochastic event in their table. Each stochastic event will result in the death of 50% of the bat population. For years when there is no stochastic event, students will simply record a zero in their table. (Optional: print pages 13 and 14 double-sided to create stochastic event cards. draw a card and read it aloud periodically

throughout the simulation. This makes the activity more like a game, but you can also just read the stochastic events below.)

**Stochastic Events** (for which half of the students' bats will die):

- Disease strikes – White-nose Syndrome is a fungal disease that disrupts bats that hibernate in caves and mines. It wakes them up when they should be sleeping, but there is no food available in the winter. This will impact northern long-eared and big brown bats while they hibernate in the winter.
- Flooding occurs within a cave and drowns bats while they are hibernating – this will impact northern long-eared and big brown bats.
- A landowner decides to cut down trees and accidentally removes a maternity colony.
- A landowner decides to spray pesticides which kills the insects your bats depend on for food.
- A group of people go into a cave. They litter and set off fireworks. All the commotion disturbs your bats while they are hibernating.
- A mudslide knocks over the grove of the trees your bats were sleeping in.
- A homeowner decides he does not want bats in his house, so he puts up an exclusion device so that they cannot get back in. Since there is nowhere to live, the bats leave. This will only impact big brown bats.
- Winter is early this year and the bats have not made it to their hibernating sites.
- An owl sees your bats leaving their roost and decides they would make a tasty snack.
- Climate change causes some of your bats to shift their range, half of them leave.
- A tornado knocks down trees that your bats were sleeping in.
- A wildfire is started by a lightning strike which destroys thousands of acres of important bat habitat.

5. Have the students record their data from each round of their simulation in the appropriate tables on the Activity Sheets. After the simulation is completed for the three bat species, the students



will plot the “remaining number of bats” for all three species on a single graph.

6. Project or create data tables on the board and have one group from each land use scenario share their data, so the whole class can complete the post lab questions about all of the land use scenarios. Instruct the students to record their classmates’ data for the other two scenarios in the respective activity sheets.

7. Have the students answer the post lab questions alone or in their groups. Discuss the answers as a class.

### **Go Even Further – Additional Activities**

1. Have the students consider their own community and think about any new construction projects that are occurring. Discuss as a class how these projects may impact local bat populations based on what they learned from the simulations.

- In groups, have the students choose a construction project and research how they think this project will impact bat populations using the suggested resources below. They could focus on how it would impact one bat species or many.
- Have the students write a letter to the company or organization building the project informing them of the risks the project poses to bat populations in the area and how they could mitigate these potential risks.

2. If you have access to a computer lab and Google Earth use [this lesson](#) for students to practice mapping and think more deeply about the land use in their town. The lesson walks students through using Google Earth to create a map that shows the different types of land use in their own town. Based on the maps the students create discuss how they would change their own town to balance land use especially in reference to bat populations.



## **Further Reading and Resources – Discover More**

### **About Land Use:**

Journey 2050: Land Use Video – <https://www.youtube.com/watch?v=RMu7NtScdhU&feature=youtu.be>

Information about Human Population Growth - <http://www.prb.org/Publications/Lesson-Plans/HumanPopulation/PopulationGrowth.aspx>

More Information on Land Use - <https://enviroliteracy.org/land-use/>

### **About Wind Energy:**

FAQs and Basic Information about Wind Energy - <http://www.ewea.org/wind-energy-basics/faq/>

Bats & Wind Energy - <https://www.batcon.org/our-work/research-and-scalable-solutions/wind-energy/>

Bats and Wind Turbines - <https://www.scientificamerican.com/article/bat-killings-by-wind-energy-turbines-continue/>  
<https://psmag.com/environment/jamming-echolocation-could-help-save-the-bats>

### **About Prescribed Fire:**

Prescribed Fire - <https://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/prescribed-fire.cfm>

Burning for Bats - <https://blog.burnsmcd.com/burning-for-bats-using-fire-to-benefit-endangered-species>

### **About Bats:**

Bats in Your State - Species Profiles - <http://www.batcon.org/index.php/resources/media-education/species-profiles>.

Bat Conservation Guide - <https://www.torontozoo.com/!/pdfs/Bats-ConservationGuide.pdf>

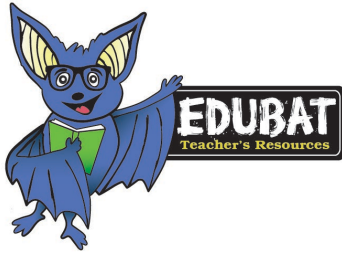
### **About White-Nose Syndrome:**

National White-Nose Syndrome (WNS) Website <http://whitenosesyndrome.org/>

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<p>Disease strikes – White-nose Syndrome is a fungal disease that disrupts bats that hibernate in caves and mines. It wakes them up when they should be sleeping, but there is no food available in the winter. This will impact northern long-eared and big brown bats while they hibernate in the winter.</p>	<p>Flooding occurs within a cave and drowns bats while they are hibernating – this will impact northern long-eared and big brown bats.</p>	<p>A landowner decides to cut down trees and accidentally removes a maternity colony.</p>	<p>Climate change causes some of your bats to shift their range, half of them A landowner decides to spray pesticides which kills the insects your bats depend on for food leave.</p>
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<p>A homeowner decides he does not want bats in his house, so he puts up an exclusion device so that they cannot get back in. Since there is nowhere to live, the bats leave. This only impacts big brown bats</p>	<p>Winter is early this year and the bats have not made it to their hibernating sites.</p>	<p>An owl sees your bats leaving their roost and decides they would make a tasty snack.</p>	<p>A wildfire is started by a lightning strike which destroys thousands of acres of important bat habitat.</p>





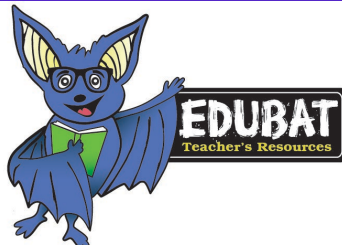
# Journey 2050: Land Use Student Worksheet

## Section 1. Complete this Section as you watch the Journey 2050: Land Use video.

1. What percentage of the earth's surface is land and what percentage is water?
2. What are three different ways that people use land other than agriculture?
3. If you were considering trying to grow more crops on a piece of land, what are a few things that you might have to give up in order to do that?
4. What are Best Management Practices?
5. Although Best Management Practices can be more costly, what are two benefits of using them?

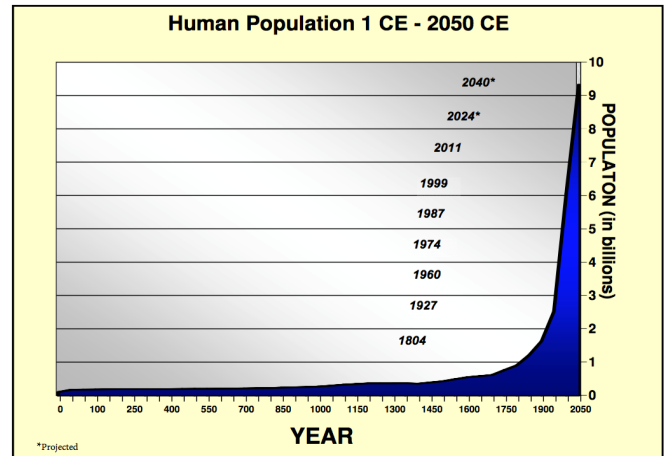
## Section II – Complete this section after reading through the Land Use Planning Fact Sheet.

1. Why is the human population growing so quickly?
2. How many people were on earth in 1800? \_\_\_\_\_ 1950? \_\_\_\_\_  
Today? \_\_\_\_\_
3. What do you call the type of growth described in question number two?
4. What is a land use map and why is it important?



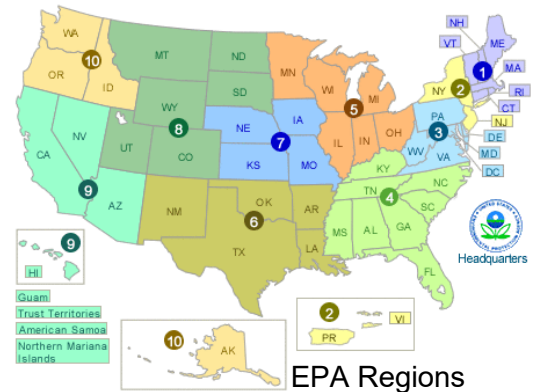
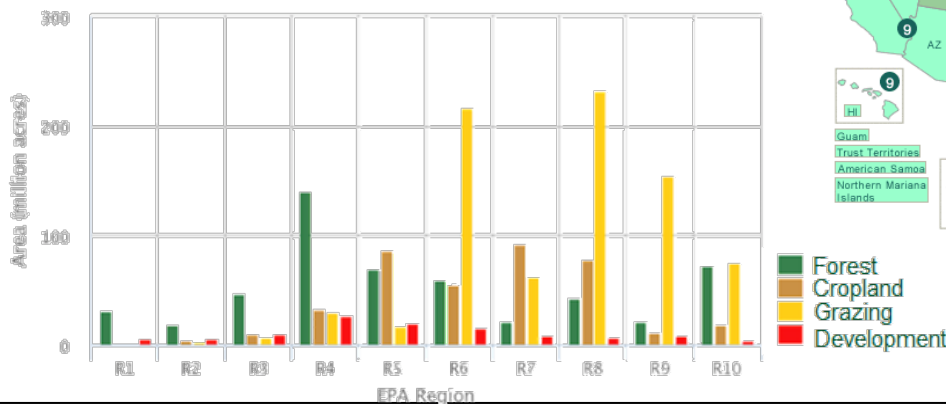
# Land Use Planning – Student Reading Page

The human population is growing exponentially which means that as we add more people to the population (births) the population growth becomes more rapid. Look at Figure 1 and notice how the blue curve continues to get steeper through 2040. Scientists believe that humans have existed for nearly 3 million years. Historically, human population levels were low because we relied on hunting and gathering to survive. However, intensive agriculture and other developments such as improvements in medicine and technology have enabled the population to grow much more quickly. Around 1800, the human population had reached 1 billion, by 1950 it had grown to 2.5 billion, and now there are over 7.5 billion people worldwide. Scientists expect the human population growth rate to decrease at some point in the future. However, with so many people in the world it is important to plan where people will live, where they will grow food and raise livestock, and where they will produce goods and services.

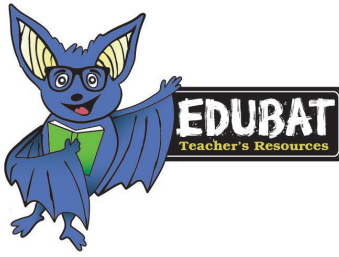


**Figure 1:** Human population growth by year. Source: University of Maryland, Geology Department.

Land Use is a term that describes how humans manage and modify the natural environment to meet their needs. According to the U.S. Environmental Protection Agency, the major land uses in the United States are cropland, livestock grazing, timber production, and development (Figure 2). A land use map is a map that shows the potential uses of a specific area of land. Land use maps can encompass large or small areas of land and display single or multiple land uses. They are often used to plan city and neighborhood development. They can also be used to manage environmental resources like forests and parks. During this lab you will see three different land use maps and determine how land use affects three bat species that live in the United States and Canada.



**Figure 2:** Land Use in the United States in 2012 (U.S. EPA Environmental Report <https://www.epa.gov/roe/>).



# Land Use Scenario 1: Wind Energy

Humans depend on electricity for many things including air conditioning, lighting, and just about anything that you have to plug in to use! About six percent of the electricity that we use in the United States is supplied by wind energy and that number is rising. Wind turbines (Figure 1) work by converting moving air or wind into mechanical energy. Wind energy is typically considered a clean and renewable energy source that does not result in waste production or



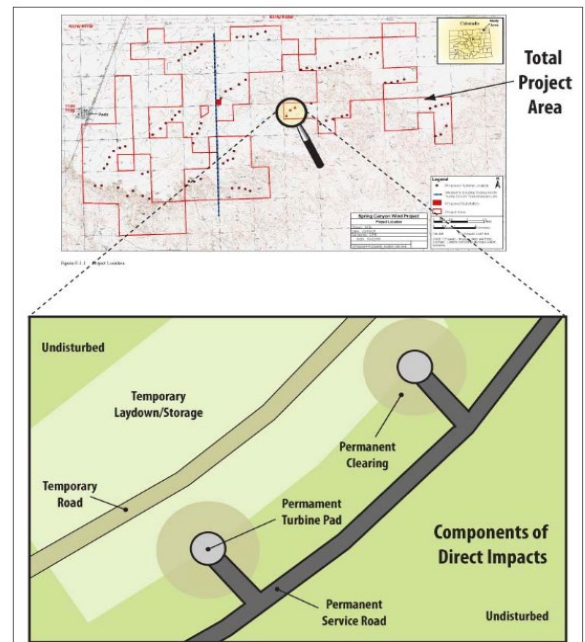
**Figure 1:** Wind turbines along a mountain ridge.

pollution such as carbon gases that contribute to global climate change. Construction of wind turbines is usually more expensive than traditional energy sources like fossil fuels; however, turbines are relatively inexpensive to maintain once constructed. It is important to carefully choose areas that are often windy when building wind turbines. If there is no wind, then the turbine will not spin and cannot generate electricity.

There is concern about the negative impacts that wind turbines can have on wildlife. For example, wind turbines have the potential to kill birds and bats as they migrate between

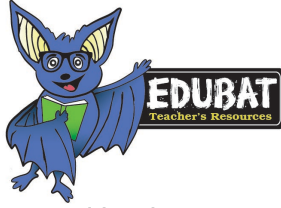
summer and winter sites.

Figure 2 is a land use planning map for the construction of a wind farm. The top picture shows an aerial view of the whole wind farm. The bottom picture zooms in to display both permanent and temporary impacts on the land. Think about how each of these impacts (roads, turbines, permanent clearings, and temporary clearings) might affect wildlife and specifically bats. Will all bat species be affected in the same way? For this scenario, imagine that we are constructing a wind farm in the mountains of West Virginia, where the U.S. Department of Energy said there is adequate wind to produce electricity. Each turbine will need at least three acres of land cleared before construction. The contiguous forest will now have increased edge habitat and less interior forest. We will also have to construct permanent roads to access each turbine for maintenance.



**Figure 2:** Example wind farm land use map with permanent and temporary land impacts. Source: Land Use Requirements of Modern Wind Power Plants in the United States by P. Denholm, M. Hand, M. Jackson, and S. Ong.

**Prelab Question Part 1: How would land converted from a forest to wind turbines impact wildlife that live in that forest? Would the impact be positive, negative, or neutral?**



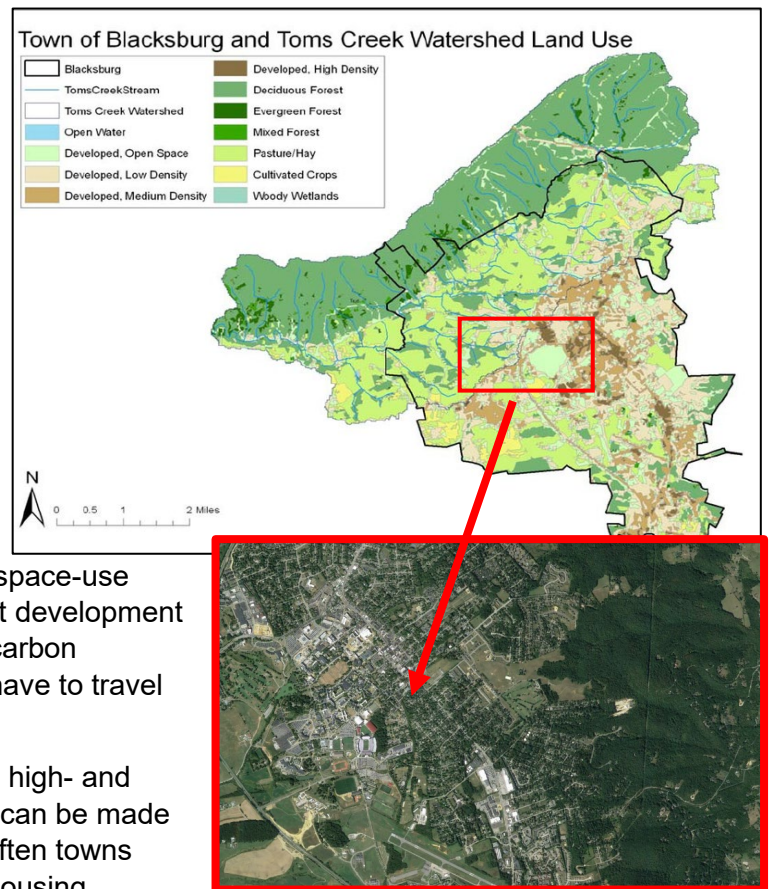
## Land Use Scenario 2: High-Density Development

Forested landscapes are often targeted for housing and commercial development. This type of development can result in the loss of habitat for bats or fragmentation of forested lands. Low-density housing has fewer houses built per acre and they are usually single-family homes versus condos or apartments. Typically, this means there is more space between houses and fewer roads than what is found in high-density developments. High-density housing is more densely populated with single-family houses on small lots, townhouses, and apartments. There are often more businesses and buildings become multiple levels. This simulation will involve considering the impacts of high-density urban development on three bat species. Figure 1 displays a land use map and aerial imagery of Blacksburg, Virginia.

As the human population grows and the demand for more homes and businesses increases, some towns may have to rely more on higher density development. While areas of high-density development do not typically provide good habitat for wildlife, they do decrease urban sprawl and the total amount of space needed for development. However, there is concern that this might result in higher housing costs. There would be additional costs for professionals to design and implement a useable urban development plan for the town. Construction costs may also be higher since homes will need extra noise insulation, underground parking, and careful space-use planning. However, if done correctly, compact development can increase business and even reduce the carbon emissions from cars because people do not have to travel as far.

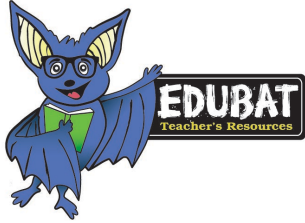
Examine the map to see differences between high- and low-density developments. Notice that towns can be made up of many different types of development. Often towns have zoning laws that specify what types of housing and businesses can be built in certain locations. For this scenario, imagine that we are building a town with an apartment complex, a subdivision of houses, and roads for access.

**Prelab Question Part 1: How would land converted from a forest to high-density development impact wildlife that live in that forest? Would the impact be positive, negative, or neutral?**



**Figure 1:** Blacksburg, Virginia land use map. Source: Implementing watershed based green infrastructure for stormwater management: Case study in Blacksburg, Virginia by M.P. Warren, T. Younos, and J. Randolph.





## Land Use Scenario 3: Undeveloped Forest Managed by Prescribed Burning

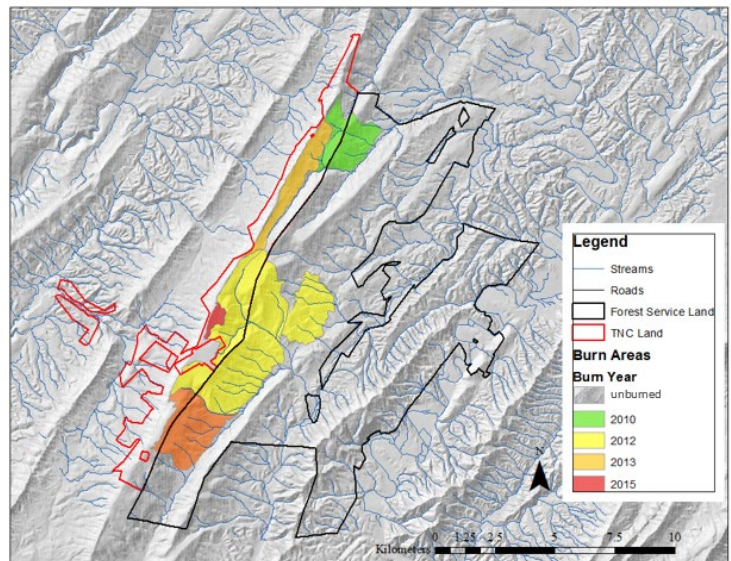
Prescribed fire is a controlled application of fire that is intentionally ignited by professionals to achieve a specific objective. One of the most common prescribed fire objectives is to promote human safety by reducing leaf litter or fuel. Over time, and without treatment, leaf litter and other forest debris can accumulate such that if there were a wildfire, it would be harder to extinguish and could put human lives in danger. Another prescribed fire objective is to promote fire-dependent communities of plants and animals. For example, some trees species, like oaks, are adapted to fire and without fire they are outcompeted by other trees species, such as maples. There are animals that in turn depend on fire-adapted tree species for food or shelter –



**Figure 1:** Picture of TNC land in Bath County, VA after a higher intensity prescribed fire.

remember that oaks produce acorns that animals such as deer, bear, squirrels and turkey depend upon to get through cold winters. Thus, fire can be an important part of a healthy ecosystem. Other prescribed fire objectives can include invasive species control, improving livestock forage, and promoting native grasses and flowering plants.

Below is a land use planning map (Figure 2) that shows land owned by the USDA Forest Service and The Nature Conservancy (TNC) in Bath County, Virginia. The prescribed fire objectives are to preserve biodiversity, control invasive plant species, and to promote the growth of fire-dependent pine and oak forests. Each color on the map represents the year a prescribed burn occurred. The units will be burned again in the future. Prescribed fire creates a diversity of habitats across an area. While most prescribed fire is low intensity (only grass and fallen leaves are burned), in some areas they can be a much higher intensity (whole trees burn) like in Figure 1. For this scenario imagine that the prescribed fire was high intensity and all of the foliage is now gone and some trees were killed. This fire also created loose bark and burned crevices into the trunks of other trees.



**Figure 2:** Land use planning map of prescribed fire occurrences in Bath County, Virginia.

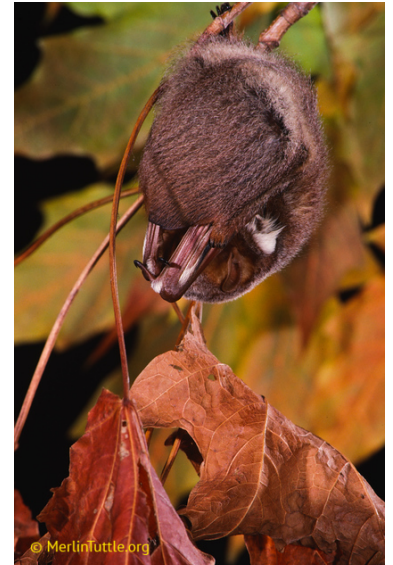
**Prelab Question Part 1: How would land converted from a forest to a prescribed burn area impact wildlife that live in that forest? Would the impact be positive, negative, or neutral?**



## Close Up View of Three Bats - Student Reading Page

### Eastern Red Bat (*Lasiurus borealis*)

The eastern red bat is a foliage roosting bat, which means that during the day it sleeps hidden among leaves. This beautiful bat curls its furred tail membrane around its body and hangs from a branch to keep warm. Each winter this species migrates south over long distances (hundreds of miles) to areas with warmer temperatures. It is common for eastern red bats to roost under leaf litter on the forest floor in the winter. If it gets too cold to find insects, eastern red bats can enter torpor, which is a deep slumber. In the spring, eastern red bats migrate to their summer habitat and females give birth usually to two pups, who are twins. Females raise their young alone. Eastern red bats only form groups to mate and to migrate.



### The Big Brown Bat (*Eptesicus fuscus*)



The big brown bat is a generalist, which means it can use a variety of habitats including both urban and forested areas. During the summer big brown bats can roost in houses, barns, or under tree bark. In the winter, big brown bats hibernate in caves. While big brown bats do travel between

caves and summer habitat, they are not considered long distance migrators like the eastern red bat. In the spring, females typically give birth to one pup per year. Big brown bat females form maternity colonies where females with pups roost in the same area so that they can help each other raise their young. Until the pups can fly (3 to 5 weeks), the females carry the pups between different roosts.

### The Northern Long-eared Bat (*Myotis septentrionalis*)

Northern long-eared bats roost in interior forests in tree crevices or under bark of live and dead trees, they typically do not roost in houses. In the fall, they travel to nearby caves to hibernate through the winter. In the spring, females give birth to one pup. Similar to the big brown bat, female northern long-eared bats also form maternity colonies, but they are generally smaller with only 30-60 females. Maternity colonies typically choose specific roost trees based on the tree's ability to provide cracks and cavities suitable for roosting. This bat was recently listed under the Endangered Species act as threatened primarily due to declines caused by White-Nose Syndrome a disease that kills bats as they hibernate in caves and mines. Northern long-eared bats have declined up to 99 percent in the Northeast based on counts from their hibernation sites.



## Student Investigation Worksheet – Land Use Impacts

Name \_\_\_\_\_

### **Prelab Questions Part 2: Wind Energy**

How would land converted from a forest to a wind development impact the three different bat species? Would the impact be positive, negative, or neutral for each bat species? Support your answer with good rationale.

**Eastern Red Bat:**

**Big Brown Bat:**

**Northern Long-eared Bat:**

### **Prelab Questions Part 2: High-Density Development**

How would land converted from a forest to high-density housing impact the three different bat species? Would the impact be positive, negative, or neutral for each bat species? Support your answer with good rationale.

**Eastern Red Bat:**

**Big Brown Bat:**

**Northern Long-eared Bat:**

### **Prelab Questions Part 2: Undeveloped Forest Managed with Prescribed Fire**

How would undeveloped land that was managed with prescribed fire impact the three different bat species? Would the impact be positive, negative, or neutral for each bat species? Support your answer with good rationale.

**Eastern Red Bat:**

**Big Brown Bat:**

**Northern Long-eared Bat:**

Write down the number of pups for that each bat species has annually.

**Eastern Red Bat:** \_\_\_\_      **Big Brown Bat:** \_\_\_\_      **Northern Long-eared Bat:** \_\_\_\_



## Student Lab Instructions

### Simulation: Modeling Land Use Impacts on Bats

Get ready to participate in a simplified simulation of how different types of land use impact three different bat species. You will only be conducting a simulation for one land use type; however, your classmates will share their data, so that you can complete the post lab questions.

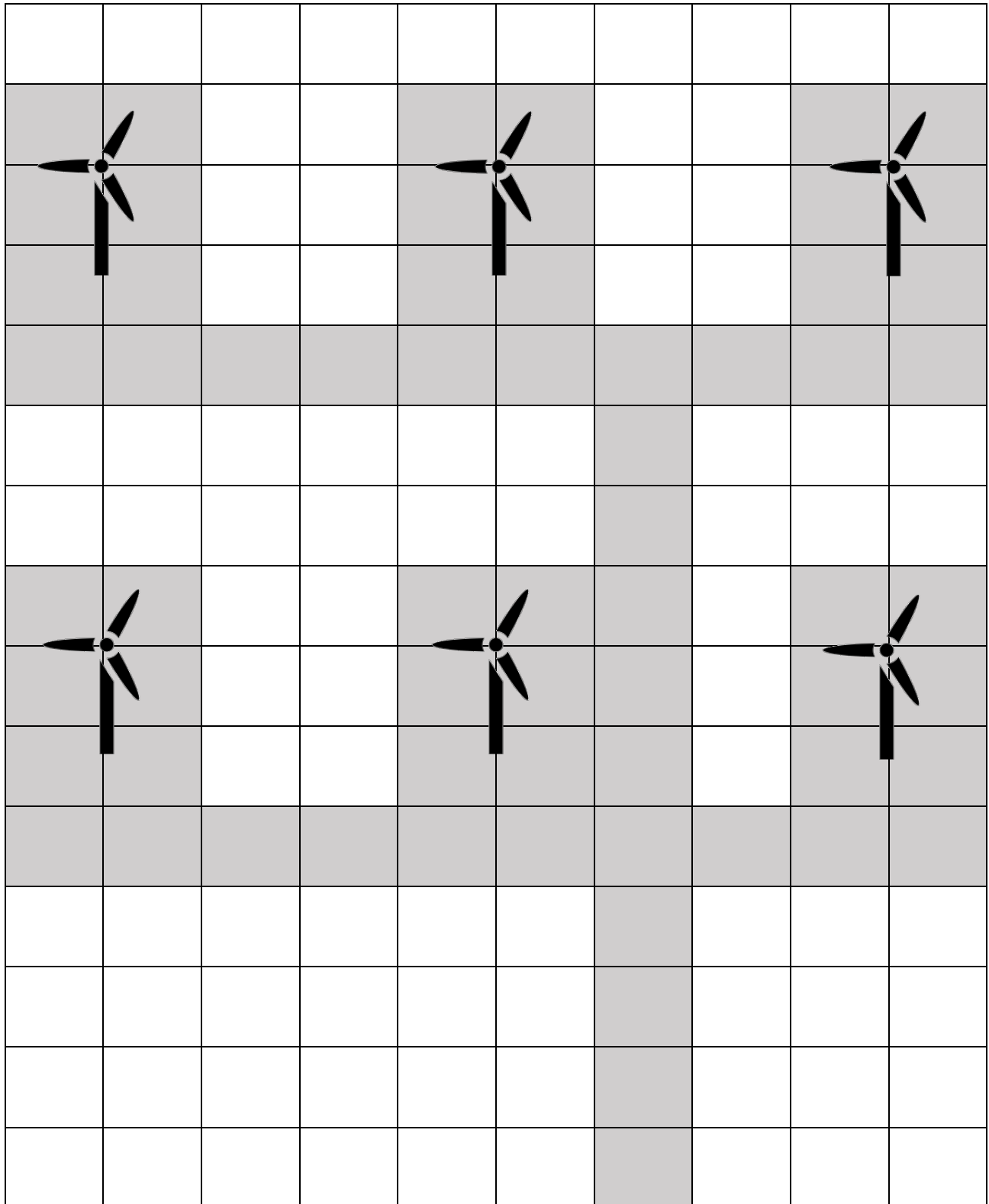
1. Prelab Question Part 2: Before starting the simulations, write down whether you think each land use scenario will have a positive, negative, or neutral effect on each of the different bat species on the “Student Investigation Worksheet – Land Use Impacts.” You will need this information to determine which bats will survive in the simulation.
2. After reading the “Close Up View of Three Bats - Student Reading Page,” identify the number of pups (bat babies) each species of bat has per year. Write these numbers down on your worksheet. You will also need this information for your simulations.
3. Let’s start the simulation!
  - a. Conduct your group’s assigned simulation by starting with the eastern red bat.
  - b. Randomly scatter the 100 counters across your group’s assigned land-use map. These 100 counters represent a population of 100 bats.
  - c. Bats that land on the grey squares encounter the land-use while bats on the white squares encounter undisturbed forest. If a counter is at all touching the grey square (even if only a little bit) then count it as though it was inside the grey box. Use your answers from Prelab Question Part 2 to determine which bat species die or survive when they land on the grey squares.
  - d. Record your data for year one in the table. For any bats that “die,” remove those counters from the board before starting the next round.
  - e. Determine how many pups (bat babies) each bat species has per year. Add that many pups for every two surviving bats to the “birth” column of the simulation table. Add the number of pups to your counters before starting the next round.
  - f. Repeat steps a to e nine more times to represent a total of 10 years of the eastern red bat encountering your assigned stimulation disturbance.
  - g. You will then repeat this process for the big brown bat and northern long-eared bat, but make sure you refer back to your answers to Prelab Question Part 2 to know how each species will be impacted by the land use.

#### **Things to think about while we do the simulation – stochastic events!**

Stochastic (random and unpredictable) events sometimes occur, and they can have impacts on bat survival. While you are conducting your simulations, beware. Your teacher may occasionally call out a stochastic event. You will need to record how many bats die because of a stochastic event in your table. For years when there is no stochastic event, simply record a zero.

4. Students that completed the other two simulations will share their data after the simulation is complete. Record the data from your classmates for the other two simulations in the respective tables.
5. Plot your “**Remaining number of bats**” column on the graph space. You will need to plot the three different species on the same graph for each land-use.
6. Answer all of the post lab questions.

# Wind Energy Activity Sheets – Land Use Map



## Wind Energy Activity Sheets – Record Your Data

Name: \_\_\_\_\_

### Eastern Red Bat

Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

### Big Brown Bat

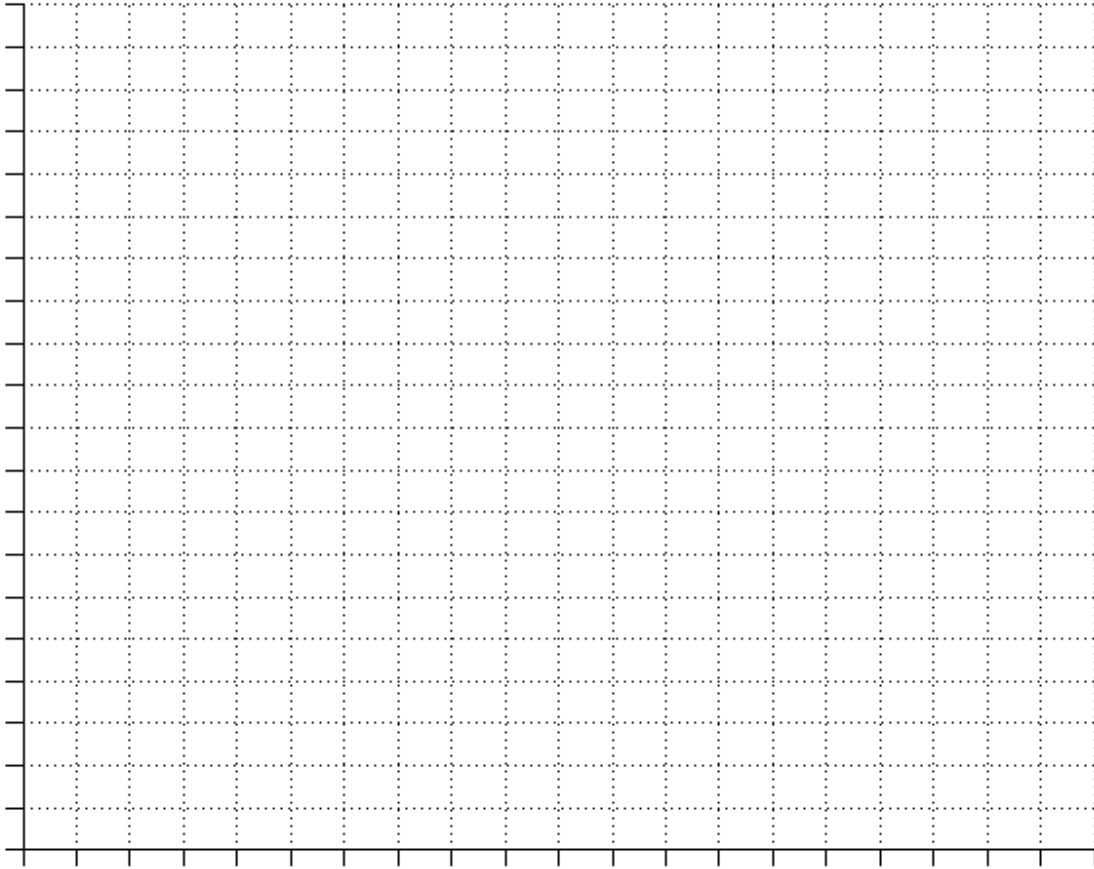
Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

### Northern Long-eared Bat

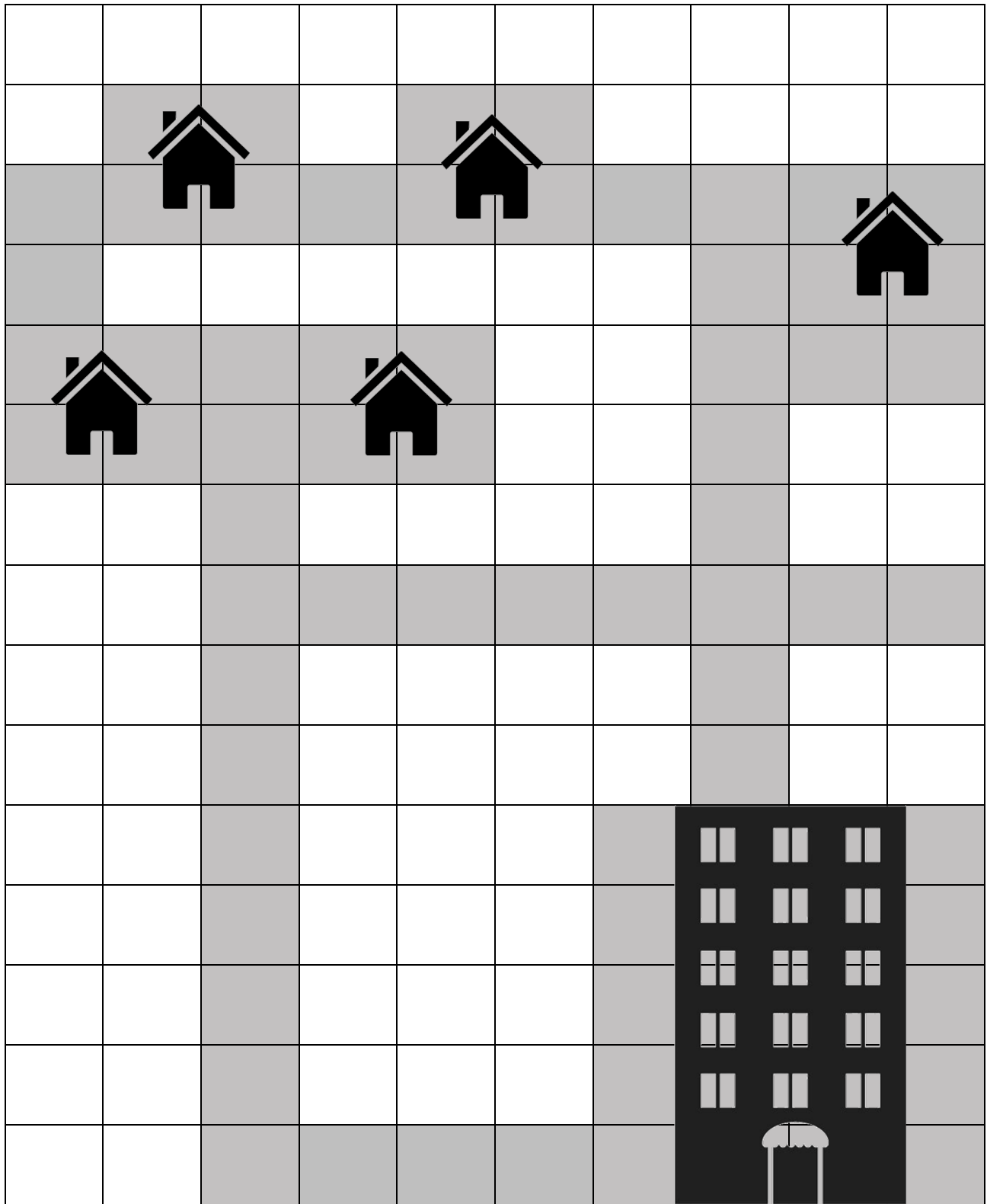
Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

## Wind Energy Activity Sheets – Graph It!

Plot each year's "remaining number of bats." Plot 100 bats at year 0. Plot all species on this graph with a different line for each species. Put a star on the graph for any year that bats died from a stochastic event.



# High-Density Development Activity Sheets – Land Use Map



# High-Density Development Activity Sheets – Record Your Data

Name: \_\_\_\_\_

## Eastern Red Bat

Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

## Big Brown Bat

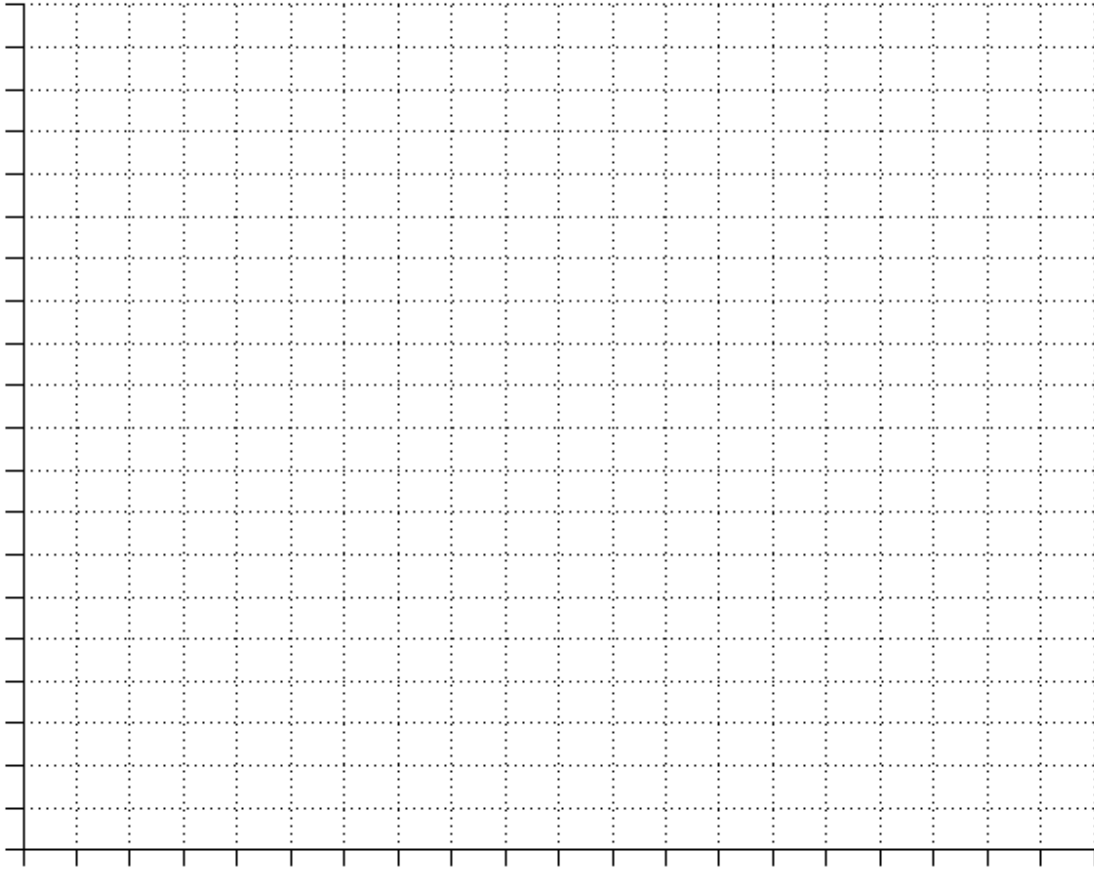
Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

## Northern Long-eared Bat

Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

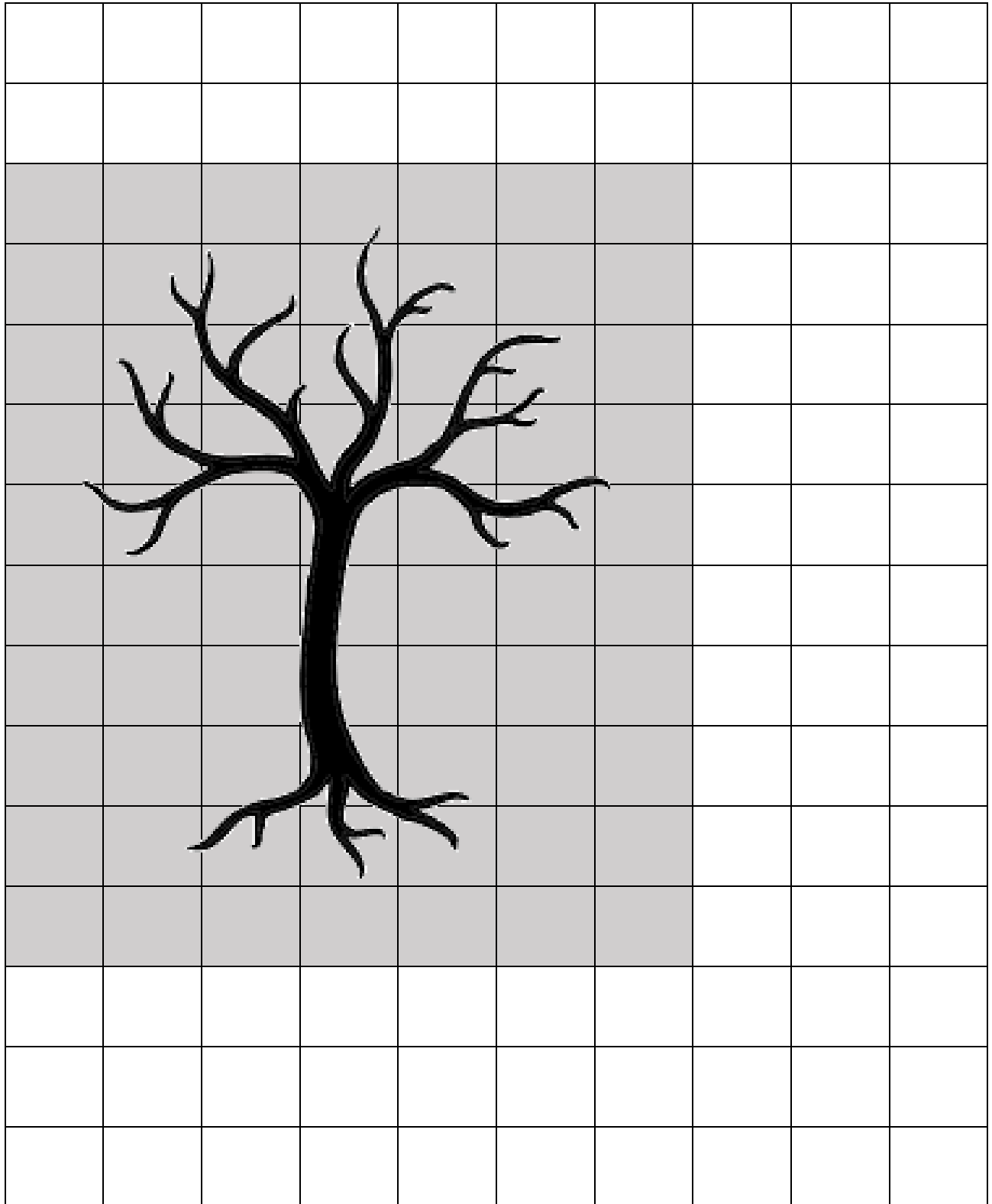
## High-Density Development Activity Sheets – Graph It!

Plot each year's "remaining number of bats." Plot 100 bats at year 0. Plot all species on this graph with a different line for each species. Put a star on the graph for any year that bats died from a stochastic event.





**Undeveloped Forest Managed with Prescribed Burning Activity Sheets - Land Use Map**



# Undeveloped Forest with Prescribed Fire Activity Sheets – Record Your Data

Name: \_\_\_\_\_

## Eastern Red Bat

Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

## Big Brown Bat

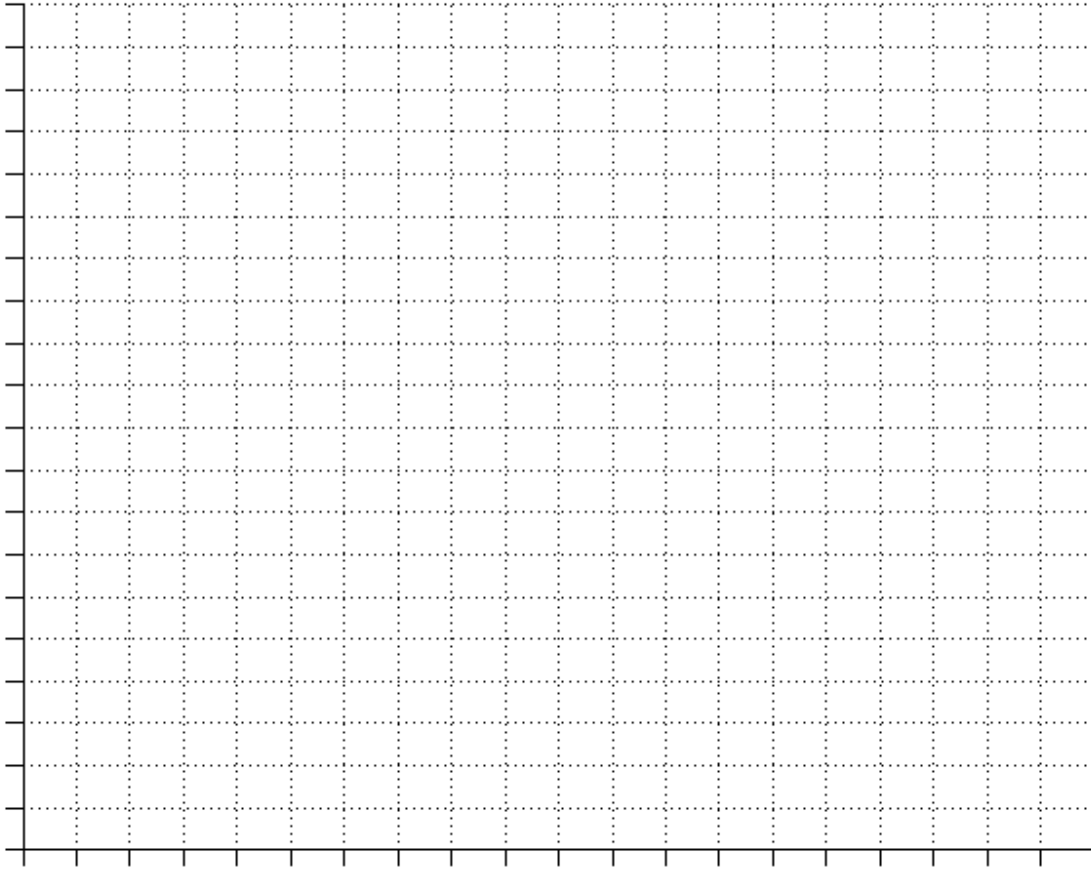
Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

## Northern Long-eared Bat

Year	Starting # Bats	Survivors	Deaths	Loss from Stochastic Event	Births	Remaining # Bats
1	100					
2						
3						
4						
5						
6						
7						
8						
9						
10						

## Undeveloped Forest with Prescribed Fire Activity Sheets – Graph it!

Plot each year's "remaining number of bats." Plot 100 bats at year 0. Plot all species on this graph with a different line for each species. Put a star on the graph for any year that bats died from a stochastic event.



## Student Investigation Worksheet – Post Lab Questions

1. Based on your graphs, which land use would be the best for bats in the long run and why?
2. Consider the three bat species we've discussed. Do you think they are equally susceptible to wind farms? Why?
3. On our wind farm map we said that bats would survive if they landed on a white square that did not represent a wind turbine or road. Do you think bats could actually survive there? Why or why not?
4. Identify three ways that prescribed fire might benefit bats and three ways it might negatively impact bats.
5. List two land uses not used in your simulations and explain why they will or will not affect each species.
6. What other factors might affect bat survival? Provide an argument for both why we should include these factors in our simulation and why we should not include them in our simulation.
7. Did one species seem less vulnerable to land use changes? Why?
8. Do you think that landing on a grey square during the simulation should have all had the same impact? For example, does landing on a grey square that represents a road have the same effect as a square that represents a turbine? Why or Why not?



# Teacher Answer Sheets

## Answers to Journey 2050: Land Use Student Worksheet:

### Section 1. Complete this Section as you watch the Journey 2050: Land use video.

1. What percentage of the earth's surface is land and what percentage is water?

**30% land and 70% water**

2. What are three different ways that people use land other than agriculture?

**Urban development, industrial development, oil and gas, mining, forestry, etc.**

3. If you were considering trying to grow more crops on a piece of land, what are a few things that you might have to give up in order to do that?

**Natural habitats, industry, homes, recreation, etc.**

4. What are Best Management Practices?

**BMPs are acceptable practices that when implemented protect water quality and promote soil conservation during forestry, construction, or farming activities.**

5. Although Best Management Practices can be more costly, what are two benefits of using them?

**Positive impact on the environment, increased crop yields, economic growth, benefits to society, etc.**

### Section II – Complete this section after reading through the Land Use Planning Fact Sheet.

1. Why is the human population growing so quickly?

**Intensive agriculture and other developments such as better medicine and technology have allowed us to grow more quickly than ever.**

2. How many people were on earth in 1800? **1 billion** 1950? **2.5 billion** Today? **7 billion**

3. What do you call the type of growth described in question number two?

**Exponential**

4. What is a land use map and why is it important?

**A land use map is a map that shows the potential uses of a specific area of land. These maps can help when planning a city, a forest, or a park.**

## Answers to Pre-lab Question Parts 1 and 2:

Pre-lab Question Part 1: How would land converted from a forest to the 3 scenarios impact wildlife that live in that forest? Would the impact be positive, negative, or neutral?

Pre-lab Questions Part 2: How would land converted from a forest to the 3 scenarios impact the three different bat species? Would the impact be positive, negative, or neutral for each bat species?

- **Land Use Scenario 1: Turbines for wind energy**

Part 1: generally negative

Part 2: This would most effect the eastern red bat because it is a long-distance migrator. Could possibly affect big brown bats and northern long eared bats since they migrate (shorter distances) between caves and summer roosting/foraging habitat although their flying habits and migratory routes make them less prone to wind turbine strike.

- **Land Use Scenario 2: High-density development**

Part 1: generally negative

Part 2: Because big brown bats can roost in houses, they would survive even if the counter lands on a grey square. Eastern red bats and northern long-eared bats do not roost in houses so they would die or emigrate out if they land on a grey square.

- **Land Use Scenario 3: Undeveloped forest with prescribed burn**

Part 1: generally positive

Part 2: Big brown bats and northern long-eared bats can roost in bark and in crevices so they can survive in a burned environment – burning may create more “snags” or dead trees with peeling bark, crevices, and cavities. The eastern red bat roosts in foliage so it will have less trees to use as roost immediately after the fire and thus will not survive grey squares in this simulation. In addition, if the burn occurred in the winter or early spring when eastern red bats roost under fallen leaves, twigs, and other dead plant material on the forest floor to avoid the cold, they could be at risk of being injured or killed by prescribed fires.

**Write down the number of pups for each bat species.**

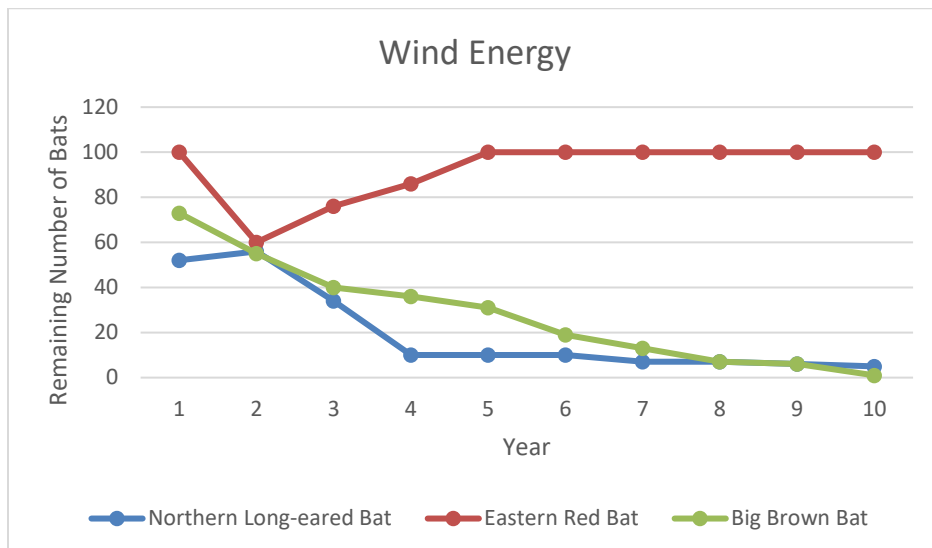
Northern Long-eared Bat: 1

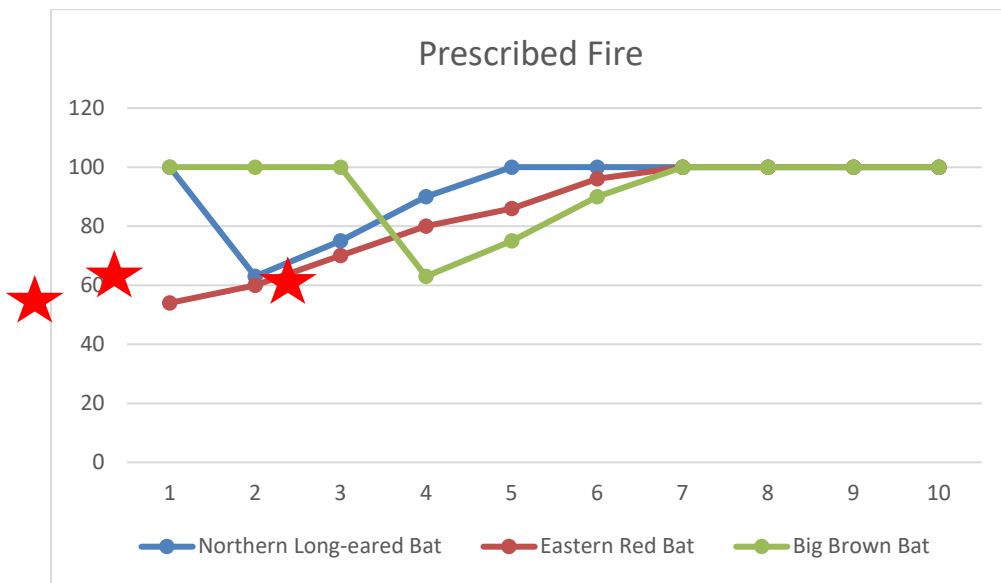
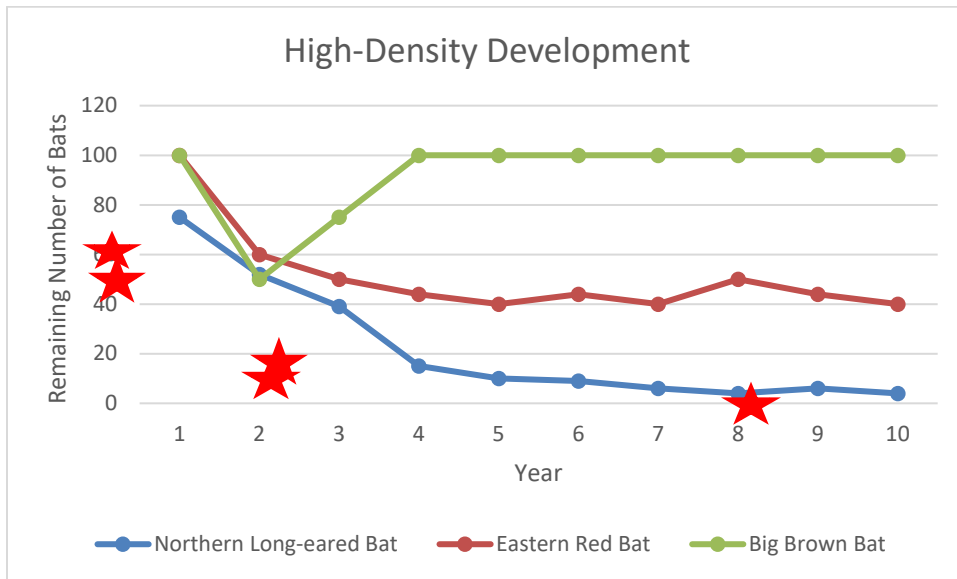
Eastern Red Bat: 2

Big Brown Bat: 1

**Graph Answers**

The students’ graphs will vary from the examples and from each other depending on how their counters fall and when their stochastic events occur. Some bats may not be affected by any of the stochastic events and some may succumb to multiple stochastic events. They are random events after all! However, the trends of the line should roughly follow these patterns. The stars on the graphs represent stochastic events.





Answers to Post-lab Questions:

1. Based on your graphs which land use would be the best for bats in the long run and why?

**Prescribed fire because the population of each species was able to remain stable or grow.**

2. Consider the three bat species we've discussed. Do you think they are equally susceptible to wind farms? Why?

**Red bats are probably the most susceptible to wind farms because they are long distance migrants, meaning they would be more likely to come into contact with a wind farm whereas bats that don't move as great of distances may not.**



3. On our wind farm map we said that bats would survive if they landed on a white square that did not represent a wind turbine. Do you think bats could actually survive there? Why or why not?

**Bats could probably not survive within the matrix of a windfarm; it would only be a matter of time before they came in contact with a turbine.**

4. Identify 3 ways that prescribed fire might benefit bats and 3 ways it might negatively impact bats.

**Fire could benefit bats by creating loose bark and crevices for some species to roost in. It could also open up the forest so that it's easier for bats to fly and provide better habitat for insects that serve as prey for bats. Fire may harm bats through direct contact with smoke or flames. It may also reduce the number of roosts available to foliage roosting bats if the fire is severe and reaches the canopy (unlikely, but possible). However, immediately after a fire there will be few insects, until their populations rebound or insects that prefer burned areas can colonize. Red bats could be impacted if prescribed fire occurred early in the spring while they were resting under leaf litter.**

5. List two land uses not used in this lab and explain why they will or will not affect each species.

**Answers will vary but should show thought and knowledge (from reading) on the part of the student. Here are some examples.**

**A. Agriculture –would negatively impact all three species because trees are drastically limited. There may also be high pesticide use.**

**B. Timberland-depending on tree species and type of timber harvest, may not affect bats.**

**C. Transportation-roads, railways, and other corridors would serve as efficient travel pathways for bats too, but they may be susceptible to getting hit by vehicles or by roost trees being removed.**

6. What other factors might affect bat survival? Provide an argument for both why we should include these factors directly in our simulation and why we should not include them directly in our simulation.

**Disease, climate change, roost disturbance, etc. Including these factors directly would make our simulation more accurate, but simple models are easier to implement, interpret, and update.**

7. Did one species seem less vulnerable to land use changes? Why?

**Answers may vary depending on graphs. Some students may choose the big brown bat because it can roost in developed and undeveloped areas. Some students may choose the eastern red bat because it has a higher birth rate and can bounce back from negative impacts faster.**

8. Do you think that landing on a grey square during the simulation should have all had the same impact? For example, does landing on a grey square that represents a road have the same effect as a square that represents a turbine? Why or Why not?

In reality, there would be differences. If a bat were to encounter a road, it may use it to travel, but could move into adjacent forest. However, if it directly encountered a wind turbine, it would likely die. Another difference would be with prescribed fire. After year one, bats would likely begin using the area that was burned. The simulation does not take this into account.

## **Curriculum/Standards Connections**

### **Next Generation Science Standards**

#### **Middle School Life Science (for worksheet question and for extension activity)**

MS-LS2-4. Ecosystems: Interactions, Energy, and Dynamics: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

### **High School Life Science**

Students who demonstrate understanding can:

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.

#### **HS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

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. (HS-LS2-2),(HS-LS2-6)

Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

### **Common Core State Standards Connections:**

#### **Middle School Writing**

ELA/Literacy -

RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)

RI.8.8. Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)

WHST.6-8.1. Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)

WHST.6-8.9. Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)

## High School Writing

CCSS.ELA-LITERACY.W.9-10.1

Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

CCSS.ELA-LITERACY.W.9-10.1.A

Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence.

CCSS.ELA-LITERACY.W.9-10.1.B

Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns.

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A Special Thanks! Project EduBat would like to thank Dr. W. Mark Ford, Unit Leader and Associate Professor, and Lauren Austin, Graduate Student, with USGS Virginia Cooperative Fish and Wildlife Research Unit, Virginia Polytechnic Institute and State University for their assistance with the creation of this activity. Dr. Ford has written many research papers about the impacts of land management on bats. We encourage you to search for his work.