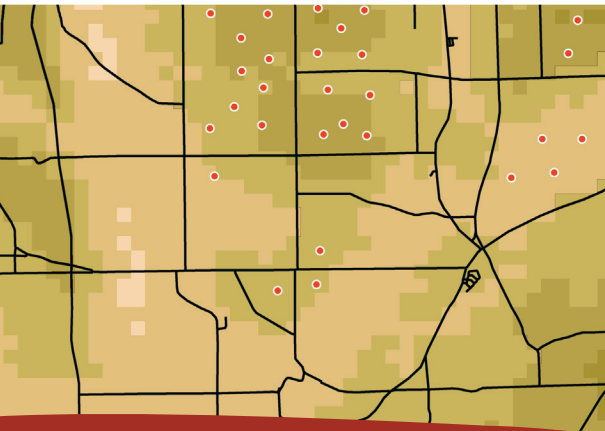
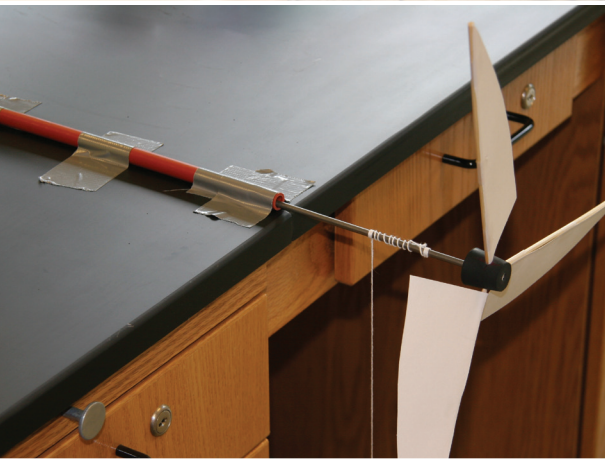


# WindWise Education

*Transforming the Energy of Wind into Powerful Minds*



## A Curriculum for Grades 6–12

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2<sup>nd</sup>  
edition



[www.WindWiseEducation.org](http://www.WindWiseEducation.org)



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# CAN WE REDUCE RISK TO BATS?



LESSON  
**14**

## KEY CONCEPT

Students analyze bat behaviors and propose a wind farm operational plan that could reduce the risk of bat mortality.

## TIME REQUIRED

1 class period

## GRADES

6–8  
9–12

## SUBJECTS

Living Environments  
Technology

## BACKGROUND

A wind developer must determine when it will operate the turbines in order to generate enough electricity to maximize profitability while doing what is necessary to protect the environment. Whether the turbines are turned on or off can influence the level of bat mortality at a wind farm. In this lesson, students will learn about the behaviors of different bat species and create a schedule of when the turbines can be turned on and off to reduce the potential for bat mortality.

## OBJECTIVES

At the end of the lesson, students will:

- understand the behavior of different bat species
- explore the relationship between technology and nature

## METHOD

Students will work in small groups to learn about the behaviors of different bat species near a wind farm. Based on these data, students will design a **dispatch schedule** for a wind farm that lowers the risk of bat mortality. Each group will present its dispatch schedule to the class for discussion of the pros and cons.

## MATERIALS

You will need one set of the following materials for each group:

- Worksheet for each student\*
- Information packets for each team (bat fact sheets, bat mortality data)\*

\*included with activity

### GETTING READY

Prepare copies of the worksheets, reading passage, and information packets for all of the students.

### ACTIVITY

#### Step 1: Beginning questions for students

If students have not studied wind energy before, begin the class by asking students what they know about wind energy and how wind turbines affect wildlife. Ask some specific questions about bat behaviors to get students thinking about how bats may be impacted by wind farms.

- When do bats fly?
- Where do bats live?
- What do bats eat?
- Where do bats go in the winter?
- What can happen when bats fly in the area of a wind turbine?

Provide students with the reading passage and career profile either before the lesson or for homework afterward.

#### Step 2: Creating a dispatch schedule

Organize students into teams of four. Present this scenario to each team:

*Last year, the Eco3Wind Company installed a 360 MW (megawatt) wind farm with 120 turbines. Each turbine has a maximum capacity of 3 MW. Recently, the Bat Protection Coalition, a local citizens group, has expressed concern about the impact of the wind farm on local bat populations. In response to these concerns, the company is looking for ways to reduce the likelihood of bat mortality on its wind farm. The company has hired a bat biologist to identify which bat species are present on or near the wind farm.*

*Your team has been asked to examine the data collected by the bat ecologist and recommend a schedule for when to turn the turbines on and off. This schedule, called a dispatch schedule, will be designed to reduce the risk of bat mortality while also generating enough power to make the company profitable. Your proposal should include an explanation of which bat species your team has prioritized (if any) and how your schedule will help protect them.*

Provide students with the worksheet. Each student in the group will select one bat species to read about and will complete the corresponding column of the table. When the table is complete, ask each team to discuss the behaviors of all 4 bat species and determine which bat species they will prioritize (if any). Tell students to design a schedule of when they would recommend turning the turbines on and off, based on the species information.

**Step 3: Wrap up**

After every team has completed its dispatch schedule, hold a class discussion to compare results. To make comparisons easier, summarize results in a table.

Use some of the following questions to generate a discussion about the exercise:

- Were there any significant similarities or differences among the dispatch schedules?
- Did any of the groups prioritize 1 or 2 bat species over the others and, if so, why?
- Which dispatch schedule appears to provide the best protection for bats and why?

**VOCABULARY**

barotrauma – Trauma caused by rapid or extreme changes in air pressure; in the case of bats, barotrauma results in death.

cut-in speed – The minimum wind speed at which the wind turbine will generate usable power. For most turbines, this is typically between 7 and 10 mph.

dispatch schedule – The “brains” of the wind turbine, the mechanism that collects data (such as wind speed) and tells the turbine when to turn on and off.

echolocation – A system of making high-frequency sounds to determine the direction and distance of objects.

endangered species – A species in danger of extinction throughout all or a significant portion of its range.

hibernate – To spend the winter in a dormant or torpid state.

migrate – The movement of an animal from one location to another, often across very long distances, in search of food, water, and breeding opportunities and locations.

start-up speed – The speed at which the rotor and blade assembly begins to rotate.

**ECHOLOCATION**

### RELATED ACTIVITIES

- Lesson 12: How Does Energy Affect Wildlife?
- Lesson 13: What Is Wind's Risk to Birds?

### ADDITIONAL RESOURCES

BATS AND WIND ENERGY COOPERATIVE—<http://kwind.me/d3f>—This website provides links to studies related to bats and wind energy.

CAN BATS AND WIND POWER GET ALONG?—<http://kwind.me/y2b>—“Science Friday,” National Public Radio. Broadcast on October 2, 2009.

EFFECTIVENESS OF CHANGING WIND TURBINE CUT-IN SPEED TO REDUCE BAT FATALITIES AT WIND FACILITIES—<http://kwind.me/x7c>—PDF 2008 Annual Report.





## EASTERN RED BAT

*Lasiurus borealis* (lay-zee-your-us bor-ee-al-is)

The eastern red bat has reddish-orange fur with a brownish-black tail and wing membranes. This bat lives or roosts in trees during the day. When hanging by one foot in trees, the bat will swing slightly, which make it look like dead leaves or pine cones. This provides excellent camouflage from potential predators such as opossums.

Eastern red bats often fly in a diving pattern to catch insects. They begin foraging about 1 to 2 hours after sunset and will focus their feeding within ½ mile of their day roosts. While foraging can occur throughout the night, activity appears to peak within the first 4 hours after sunset. They are often found feeding near lights, which attract insects, and along the edges of forests and clearings.

Eastern red bats can fly up to 40 mph when on a straight, level course. These bats have been seen flying well above the tree canopy (30 m and higher), but when foraging, they are found at lower altitudes (15 to 30 m). As with most bats, they are less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.

These bats are typically solitary, but will come together in groups to mate and migrate. They mate in August and September and often give birth to twins. In the fall (September/October), these bats migrate in large groups over 900 miles to southern parts of their range until the following spring (May/June).

The life span of the eastern red bat is thought to be as long as 12 years. Eastern red bats are not considered threatened.

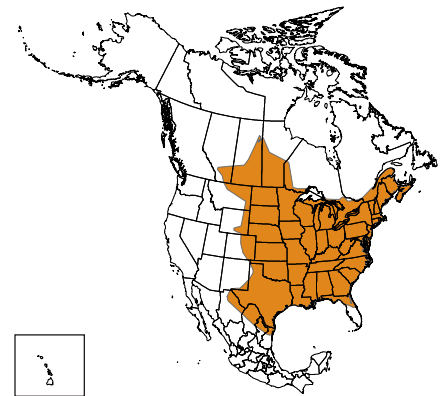
### Sources:

- Bat Conservation International
- [www.esf.edu/aec/adks/mammals/red\\_bat.htm](http://www.esf.edu/aec/adks/mammals/red_bat.htm)
- Saunders, D. A. 1988. *Adirondack Mammals*. State University of New York, College of Environmental Science and Forestry. 216pp.
- Shump, K.A. Jr., and A.V. Shump. 1982. "*Lasiurus borealis*." *Mammalian Species*, 183:1-6.
- William Caire, et al. Capture Heights and Times of *Lasiurus borealis* (Chiroptera: Vespertilionidae) in Southeastern Oklahoma
- Photo: Merlin D. Tuttle, Bat Conservation International, [www.batcon.org](http://www.batcon.org)
- Map data: National Atlas of the United States and Bat Conservation International



Photo © Merlin D. Tuttle

### Range of Eastern Red Bat



## HOARY BAT

*Lasiurus cinereus* (lay-zee-your-us sa-near-ee-us)

The hoary bat is often found roosting 10 to 15 feet above the ground in deciduous and coniferous woodlands.

Hoary bats typically begin feeding after dark and will feed all through the night until about an hour before sunrise. They are most active about five hours after sunset and forage as far as 24 miles from where they roost.

Hoary bats can reach speeds of 13 mph. They often forage near tree tops. These bats have been seen flying well above the tree canopy (30 meters and higher), but when foraging, they are found at lower altitudes (15 to 30 meters). Hoary bats feed on insects, especially moths. As with most bats, they are less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.

These bats are solitary, but migrate in large groups and may even fly with groups of birds. During migrations, they can be found flying as early as sunset. Traveling over 900 miles, they reach Florida around October/November in the fall. They begin their return migration between February and May.

Due to its abundance, the hoary bat species is not considered threatened.

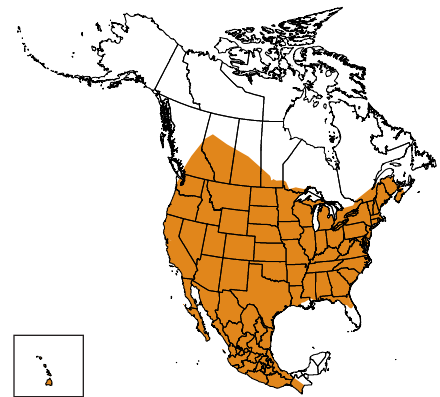
### Sources

- Bat Conservation International
- Photo: Merlin D. Tuttle, Bat Conservation International, [www.batcon.org](http://www.batcon.org)
- Map data: National Atlas of the United States and Bat Conservation International



Photo © Merlin D. Tuttle

### Range of Hoary Bat





## BIG BROWN BAT

*Eptesicus fuscus* (ep-tess-a-cus fuss-cuss)

Big brown bat is a very abundant species and lives in a wide range of habitats, from forests to suburbs to agricultural areas. These bats live in large maternity colonies in buildings, barns, bridges, bat houses, and beneath loose bark or in small openings of trees.

These bats eat insects, especially small beetles. They typically forage between 0.6 and 1.2 miles from where they roost. Big brown bats typically starts foraging about 18 minutes after sundown, fly continuously while eating, and spend about 90 minutes a night foraging. They have been observed to catch between 5 and 20 insects in a minute. Big brown bats prefer to forage along the edge of forests, over land or water, in clearings, and lake edges. They can eat the equivalent of their body weight in a single night.

Big brown bats migrate distances of less than 300 miles. They will typically hibernate in the winter, and the length of hibernation depends on the length of the winter.

Big brown bats typically fly at an altitude of 6 to 50 meters over forests and roadways. As with most bats, they are less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.

Due to their abundance and ability to live in more populated areas, this bat is not a threatened species.

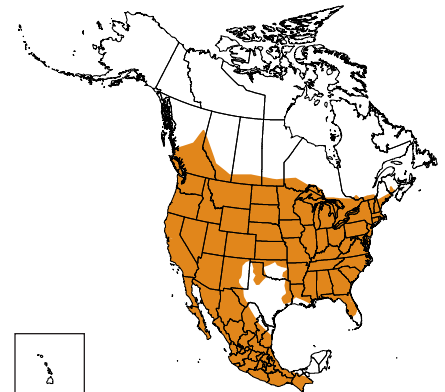
### Sources

- Bat Conservation International
- Whitaker et al. 1977
- Photo: Merlin D. Tuttle, Bat Conservation International, [www.batcon.org](http://www.batcon.org)
- Map data: National Atlas of the United States and Bat Conservation International



Photo © Merlin D. Tuttle

### Range of Big Brown Bat



## INDIANA MYOTIS

*Myotis sodalis* (my-oh-tis so-dal-is)

The Indiana myotis is a small gray bat that roosts in crevices or under the loose bark of trees during the summer. Indiana myotis bats tend to move regularly between roosts.

Indiana myotis bats primarily eats insects and typically forages within a mile of the roost tree. These bats tend to be most active just after sunset, with their peak activity occurring within the first 2 hours following sunset. Indiana bats usually forage and fly within an air space from 2 to 30 m above ground level.

Indiana myotis bats migrate up to 500 miles between winter hibernacula and their summer roosts. They hibernate in caves during the winter, with the majority of them found in Indiana, Kentucky, and Missouri.

While no Indiana bat fatalities have been confirmed at active wind energy facilities, other *Myotis* species (*Myotis sp*) that exhibit similar life history characteristics and behaviors have been killed; therefore, there may be some risk associated with this species.

The Indiana myotis is federally identified as an endangered bat. One of the contributing factors to the bat's decline could be a loss of adequate habitat. While caves where the Indiana myotis hibernates have been largely protected, the loss of forested areas where the bat roosts in the summer are not protected.

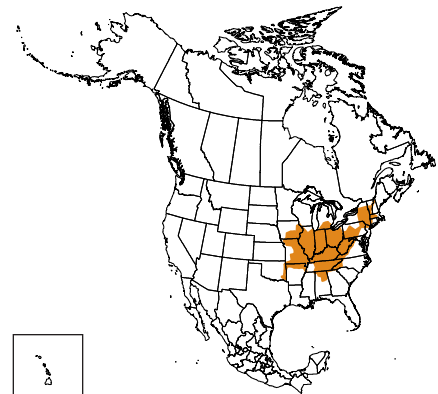
### Sources

- Bat Conservation International—<http://kwind.me/s5b>—Species profiles
- Animal Diversity Web— <http://kwind.me/u0i>—Hoary Bat profile
- Normandeau. Zephyr Duke Michigan Fatal Flaw Report
- Humphrey et al. 1977
- Photo: Merlin D. Tuttle, Bat Conservation International, [www.batcon.org](http://www.batcon.org)
- Map data: National Atlas of the United States and Bat Conservation International



Photo © Merlin D. Tuttle

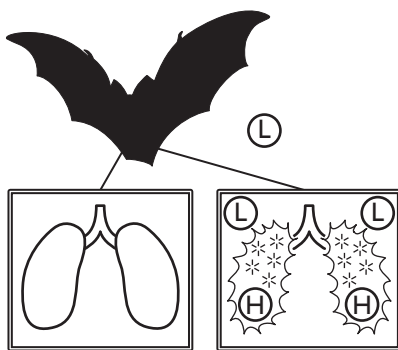
### Range of Indiana Myotis



**READING PASSAGE: BATS AND WIND TURBINES**

Bats sometimes have a bad reputation based on movie and Halloween images. Despite this, it is important to realize that bats are very helpful to people. The US is home to 45 different species of bats, nearly all of which eat insects. Some bats can eat their weight in insects every night. Millions of bats eating insects every night is what you call great bug control! Just consider what life would be like without bats.

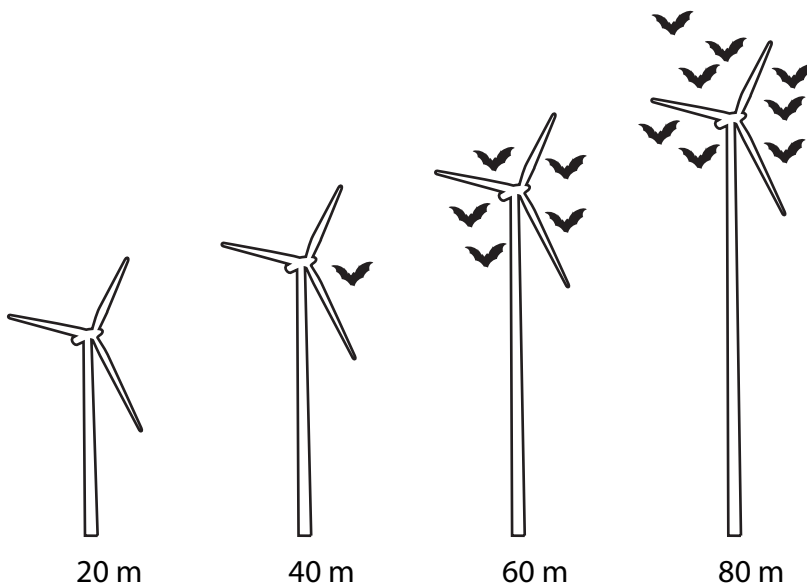
Bats are unique and interesting animals found to have been living as long as 50 million years ago. Bats are the only mammals that fly. While many people think of bats as living or roosting in caves, many bats roost in trees, buildings, or even underneath the bark of trees. Bats use echolocation to navigate and find food, but they also have excellent vision. When colder weather arrives, some bats migrate to warmer areas while others hibernate. Bats can live a long life—in some cases more than 30 years—but they have a slow reproductive cycle in which they typically have only one baby or “pup” at a time. Four species of bats in the US have been categorized as endangered, meaning that there is a threat of extinction if their populations do not increase.



**Barotrauma occurs when sudden changes in pressure cause a bat’s lungs to burst. Moving turbine blades can cause such a drop in pressure close to the rotor.**

While researchers are learning more about bats every day, there are still many things we do not know about them. One of the great mysteries of bats is how they are impacted by wind turbines. Dead bats have been found near wind farms around the world. While in some cases the bat hit the turbine, many bats die from barotrauma, which is caused by extreme change in air pressure close to the moving wind turbine blades. Researchers have found that the majority of bat deaths occur in the summer and fall (June–September) during the migration season. Three bat species that roost in trees and make long-distance migrations tend to be killed more than any other species. These deaths often occur in the autumn. As the height of wind turbine towers has increased, the mortality of bats has increased as well.

Researchers face many challenges when trying to learn about and protect bats. It is difficult to count bats;



thus, the actual population of each species is unknown. While some technologies are available for detecting bats, we are still unable to determine the exact number of bats in a particular area. Researchers also have many questions about bats and their relationship to wind turbines. While researchers believe that the bats may be attracted to areas with wind turbines, they are not sure why. Are the bats attracted to the clearings around wind turbines or are they considering the turbines as potential roosting sites because bats often select the tallest trees? Or are they drawn to the insects?

While there are many unanswered questions, as researchers find more answers, wind farms will be better equipped to lower their impact on bat populations. Recently, researchers have found that bat mortality is higher on nights with low wind speeds. It is believed that bats are more likely to fly when wind speeds are lower. Some experiments have been conducted where wind turbines were turned off until the wind speeds reached a higher threshold—called the cut-in speed. This has been found to be an effective mechanism for lowering fatality rates.

#### Sources

- USGS powerpoint presentation: [www.mesc.usgs.gov/Products/Publications/22170/22170.pdf](http://www.mesc.usgs.gov/Products/Publications/22170/22170.pdf)
- Bat Conservation International
- Barclay et al. 2007; *Can. J. Zool.* 85:381–387
- Arnett et al. 2008; *J. Wild. Man.* 72: 61–78
- Johnson 2005, *Bat Research News* 46: 45–49
- Cryan and Brown 2007, *Biological Conservation* 139: 1–11

### CAREER PROFILE: ALLISON POE, BAT BIOLOGIST

I didn't grow up wanting to be a bat biologist; I didn't even know there was such a thing! After I completed a B.A. in psychology with a minor in sociology, I worked as a white water rafting guide in Colorado. It was there that I developed a deep appreciation for wildlife and decided to pursue a career in wildlife biology. I began by volunteering for a local environmental consulting firm where I joined a bat research trip, which was a creepy, scary, and very exciting experience. After we caught a few bats, I was hooked. Later I participated in a number of life-changing internships. I spent five months studying sea birds on a remote island in Alaska and helped with a Hawksbill sea turtle project and a bat project in Hawaii. I got my master's degree at the University of Western Ontario, where I focused on bats.

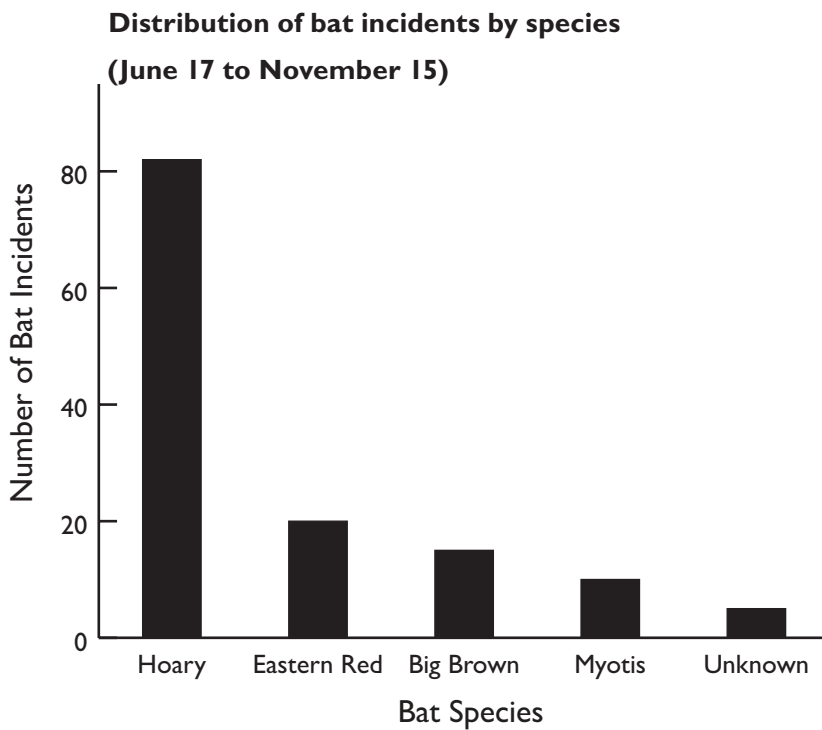
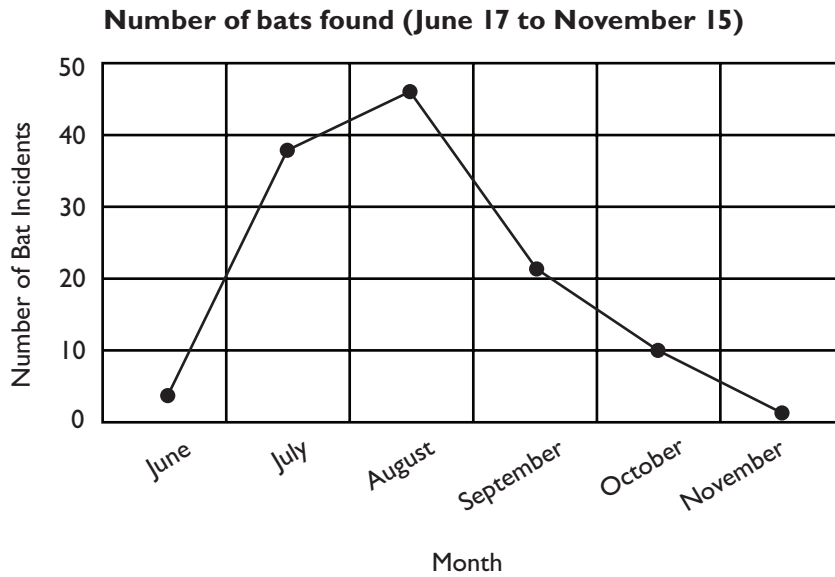


As a bat biologist, I do a variety of things, all pertaining to understanding bats and their biology and ecology. My focus is on the effects that wind farms have on bat populations. I use special acoustic bat detectors to survey areas in which wind farms are proposed to assess the levels of bat activity and what species of bats are present in the area. I use computer software that allows me to see the recorded bat echolocation calls. This is called a spectrogram. Because different bat species sound different when they echolocate, I use the spectrogram to identify the species of bat that emitted the echolocation call. This is important because bats are difficult to capture. Using this software eliminates the need to see the bat up close to know what kind it is. With this information, we can show wind developers where the high risk areas are and help them make decisions that will minimize impacts to bats.

I really enjoy my work because of the variety. I get to go out in the field to potential wind farm sites and install bat monitoring equipment on meteorological towers, drive around at night looking for bats with acoustic bat detectors, and analyze echolocation call data in an effort to understand where the bats are and when they appear in an area. I work closely with other biologists and computer specialists to come up with new and improved methods to monitor bat activity. The work that I do is very rewarding and always keeps me on my toes.

### BAT MORTALITY DATA AT THE ECO3WIND FARM

The following are bat mortality data that the Eco3Wind Company has collected at its wind farm during the months when bats are present in the area.





Name \_\_\_\_\_

Date \_\_\_\_\_

Class \_\_\_\_\_

**WHAT DO WE KNOW ABOUT LOCAL BAT POPULATIONS?**

Each team member will select one bat species, read the information packets (fact sheets on each species, range maps, tables, etc.), and complete the portion of the table that corresponds with his or her bat species. When the team’s table is complete, discuss the questions below and begin creating your team’s dispatch schedule.

<b>BAT SPECIES</b>				
	<i>Lasiurus borealis</i> (Eastern Red Bat)	<i>Lasiurus cinereus</i> (Hoary Bat)	<i>Eptesicus fuscus</i> (Big Brown Bat)	<i>Myotis sodalis</i> (Indiana Bat)
<b>RANGE</b> Does this species live in New York?				
<b>MIGRATION</b> Does this species migrate?				
If so, what months are these bats probably present?				
<b>FLIGHT TIMES</b> What time of day do these bats fly?				
<b>HABITAT</b> Where do the bats live and forage?				
<b>THREATENED OR ENDANGERED SPECIES</b> Is the species threatened or endangered?				
<b>WIND SPEEDS</b> At what wind speed does this species fly?				
<b>PRESENCE</b> Has this bat species been found at this wind facility?				
<b>MORTALITY</b> Is this species known to die near wind turbines? If so, has it been found at this wind farm?				





**Questions to discuss with group members**

1. Compare and contrast the four species. Identify the factors you think are most important.
2. Does the team want to prioritize any bat species? If yes, why?

**Design the dispatch schedule**

The dispatch schedule is the computer system or “brains” of the wind turbine, the mechanism that collects data (such as wind speed) and tells the turbine when to turn on and off.

Determine the dispatch schedule specifications that your team would recommend for reducing potential bat mortality.

Consider the following questions when completing the table below:

- At what times of day is the risk of bat mortality highest?
- At what wind speeds do the bats fly?
- Are there times of the year when the bats are more likely to be at risk?

	<b>LOW RISK OF BAT MORTALITY</b> <i>(when to turn the turbine ON)</i>	<b>HIGH RISK OF BAT MORTALITY</b> <i>(when to turn the turbine OFF)</i>
<b>TIME OF DAY</b>		
<b>MONTHS</b>		
<b>WIND SPEED</b>		

**WHAT DO WE KNOW ABOUT THE LOCAL BAT POPULATIONS?**

<b>BAT SPECIES</b>				
	<i>Lasiurus borealis</i> (Red Bat)	<i>Lasiurus cinereus</i> (Hoary Bat)	<i>Eptesicus fuscus</i> (Big Brown Bat)	<i>Myotis sodalis</i> (Indiana Bat)
<b>RANGE</b> Does this species live in New York?	Yes	Yes	Yes	Yes, part of New York
<b>MIGRATION</b> Does this species migrate?	<i>In the fall (September/October), these bats migrate in large groups over 900 miles to southern parts of their range until the following spring (May/June).</i>	<i>Traveling over 900 miles, they reach Florida around October/November in the fall. They begin their return migration between February and May.</i>	<i>This species migrates distances of less than 300 miles. These bats typically hibernate in the winter, and the length of hibernation depends on the length of the winter.</i>	<i>This species migrates up to 500 miles between winter hibernacula and summer roosts. They hibernate in caves during the winter, with most of them in caves in Indiana, Kentucky, and Missouri.</i>
<b>FLIGHT TIMES</b> What time of day do they fly?	<i>This species begins foraging 1–2 hours after sunset and they focus their feeding within ½ mile of their day roosts. While foraging can occur throughout the night, activity appears to peak within the first 4 hours after sunset.</i>	<i>This species begins feeding after dark and feeds all through the night until about an hour before sunrise. These bats are most active about 5 hours after sunset and forage as far as 24 miles from where they roost.</i>	<i>This species starts foraging about 18 minutes after sundown, flies continuously while eating, and spends about 90 minutes a night foraging.</i>	<i>These bats tend to be most active just after sunset, with peak activity occurring within the first 2 hours following sunset.</i>
<b>HABITAT</b> Where do the bats live and forage?	<i>This species lives or roosts in trees during the day; are often found feeding near lights, which attract insects, and along the edges of forests and clearings. When foraging, they are found at lower altitudes (15–30 m).</i>	<i>This species roosts 10–15 ft above the ground in deciduous and coniferous woodlands. This species has been seen flying well above the tree canopy (30 m and higher), but when foraging, these bats are found at lower altitudes (15–30 m).</i>	<i>These bats live in large maternity colonies in buildings, barns, bridges, bat houses, and beneath loose bark or in small openings of trees. This species prefers to forage along the edge of forests, over land or water, in clearings, and lake edges.</i>	<i>This species roosts in crevices or under the loose bark of trees during the summer. These bats tend to move regularly between roosts.</i>

<b>THREATENED OR ENDANGERED SPECIES</b> Is the species threatened or endangered?	No	No	No	Endangered
<b>WIND SPEEDS</b> At what wind speed does this species fly?	<i>This species is less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.</i>	<i>This species is less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.</i>	<i>This species is less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.</i>	Unknown
<b>PRESENCE</b> Has this bat species been found at this wind facility?	Yes	Yes	Yes	No
<b>MORTALITY</b> Is this species known to die near wind turbines? If so, has it been found at this wind farm?	Yes, Yes	Yes, Yes	Yes, Yes	None confirmed, No

**Questions to discuss with group members**

- Compare and contrast the four species. Identify the factors you think are most important.  
*Students may decide to focus on different factors depending upon how they view the information.*
- Does the team want to prioritize any bat species? If yes, why?  
*Students may decide to focus on different species depending upon how they view the information.*

**Design the dispatch schedule**

Consider the following questions when completing the table below:

Determine the dispatch schedule specifications that your team would recommend for reducing potential bat mortality.

*The dispatch schedule suggested will vary from student to student. Students should factor in which bats they are prioritizing, the time of day those species fly, the months the species lives in the area, and the wind in which they are most likely to be flying.*

- At what times of day is the risk of bat mortality highest?  
*Bats are most at risk when they are foraging (after sunset and before dawn).*
- At what wind speeds do the bats fly?  
*They are less likely to fly at higher altitudes when wind speeds are above 6 to 8 m/sec.*
- Are there times of the year when the bats are more likely to be at risk?  
*The bats will be more at risk when they are living in the area of the wind farm. When the bats migrate away from the turbine, the risk will fall.*