Calculate the Value of Bats

EXPLORATION QUESTION

"Why are bats important to our economy and to our natural world?"

MATERIALS

- Pencils
- Activity Sheets A and B
- Calculator (optional)

OVERVIEW

There are many reasons for students to care about bats. They are fascinating and beautiful animals. In this activity, students will use math skills to learn about the ecological and economic impacts of bats. Students will also use communication skills to convey the importance of bats to our economy and natural world and the potential effects of White-Nose Syndrome.

VOCABULARY

Adaptation, gravity, mammal, membrane, wingspan

GROUP SIZE

Any

AGE

10-14

This activity is adapted from *Discover Bats*, a publication of Bat Conservation International. Used with permission. www.batcon.com

Background

One of the best ways to persuade people to protect bats is to explain how many insects bats can eat. Scientists have discovered that some small bats can catch up to 1,000 or more small insects in a single hour. A nursing mother bat eats the most – sometimes catching more than 4,000 insects in a night.

Little brown bats (*myotis lucifugus*) eat a wide variety of insects, including pests such as mosquitoes, moths, and beetles. If each little brown bat in your neighborhood had 500 mosquitoes in its evening meal, how many would a colony of 100 bats eat? By multiplying the average number eaten (500) times the number of bats in the colony (100), we calculate that this colony would eat 50,000 mosquitoes in an evening (500 x 100 = 50,000)!

Using a calculator and multiplying 50,000 mosquitoes times 30 days (the average number of days in a month), you can calculate that these same bats could eat 1.5 million mosquitoes in a month (50,000 x 30 = 1,500,000), not to mention the many other insects they would catch!

Do bats really eat billions of bugs?

Bracken Cave, just north of San Antonio, Texas, is home to about 20 million Mexican free-tailed bats. How many insects do you think 20 million bats can eat in a night or a month? We know that one mother Mexican free-tailed bat can eat approximately 10 grams of insects (equal to the weight of two nickels) in a night. That doesn't sound like much, but for the whole colony it actually adds up to 220 tons of insects – the approximate weight of 55 elephants!

Why do we need bats and other animals to eat insects?

Most insects are highly beneficial. Fewer than one in 100 species is a pest that attacks crops or bites people. Nevertheless, the few species that become pests are normally those that reproduce the most rapidly. Without predators, they would soon cause great damage to whole ecosystems and threaten our own survival. Bats, birds, and other predators help keep insect populations in balance. When these animals are able to do their jobs, we get to benefit from the helpful insects without being harmed too much by those that become pests.

Insect pests that attack farmers' crops can lay hundreds of eggs in just a few hours or days. This means that if a bat eats a female insect before she lays eggs, the bat is actually protecting local farmers from hundreds of this insect's offspring – the grubs and caterpillars that eat crops and gardens.

If a mosquito can lay 200 eggs that take a week to hatch and become new adults, and half (100) of those new adults are females, within just one month that one mosquito's eggs, along with those of her daughters and their daughters, could result in100,000,000 (100 x 100 x 100 x 100) new female mosquitoes (adults die soon after

laying eggs). Imagine, if none of those mosquitoes were eaten by predators like bats, how many mosquitoes would there be in two months or a year!

Now you see why we need to be kind to the animals that keep pest insects in check. These animals include bats, birds, frogs, toads, lizards, shrews, spiders, fish, and predatory insects such as ladybird beetles, wasps, and praying mantises. All these animals and insects tend to feed on different kinds of insects at different times, keeping the pest insect numbers in check. While birds and other animals eat countless millions of insects by day, bats do the same at night.

Are bats really economically important?

To assess the economic value of bats, you can research their impact on agriculture throughout the world. Bats are our most important natural predators of night-flying insects consuming mosquitoes, moths, beetles, crickets, leafhoppers, chinch bugs, and much more! Many of these insects are serious agricultural or forests pests, and others spread disease to humans or livestock. Every year bats save us billions of dollars in pest control by simply eating insects.

An article in Science, "The Economic Importance of Bats in Agriculture" estimates that bats provide between 3.7 and 22.9 billion dollars each year in pest control services in North America. The article also mentions that a single colony of 150 big brown bats in Indiana has can eat nearly 1.3 million insects that are agricultural pests each year. For these reasons, it is important to have healthy bat populations.

Recently, a unique field experiment was implemented to assess the ecological and economic effects of bats in corn agriculture (see resources list). This study found that bats not only decreased pest numbers and crop damage, but they also indirectly suppressed the presence of fungus growing on the corn. In plots of land where bats were prevented from entering, roughly 60% more corn earworm larvae were gnawing on the ears of corn. Corn is an essential crop for many farmers and is grown on more than 370 million acres worldwide. Annually, bats prevent nearly a billion dollars in pest damage to corn around the world! Even walnut growers in California are beginning to install bat houses along their orchards to attract bats that can eat coddling moths and prevent spraying of pesticides.

How has white-nose syndrome affected bats?

White-nose syndrome (WNS) is a disease that is killing bats as they hibernate in caves and mines. The disease was named for the white fuzzy fungus that appears on the muzzle, ears, and wings of affected bats. Scientist identified a previously unknown species of cold-loving fungus *Pseudogymnoascus destructans* as the cause of WNS. *P. destructans* thrives in low temperatures (40-55 F) and high humidity – conditions commonly found in caves and mines where bats hibernate.

The white powdery fungus is not always visible on affected bats. Sometimes bats with WNS simply display unusual behavior such as flying outside during the day in near-freezing weather or clustering near the entrances of hibernacula. This quickly uses up their fat reserves at a time when insects are not available for food. As a result, you may see dead or dying bats on the ground or in buildings or other structures.

First documented in New York in the winter of 2006-2007, WNS has spread rapidly across the United States and Canada. White-nose syndrome killed over 6 million bats in just six years. Bats have been found sick and dying in unprecedented numbers in and around caves and mines. In some hibernacula, 90 to 100 percent of bats have died.

Scientists around the world are urgently studying WNS. Many field and laboratory projects are underway as scientist try to discover how WNS is killing our bats, what we can do to fight it, and how to protect our surviving bats.

Get Ready -Background Activities

1. Have the students and/or the teacher read: Calculating the Value of Bats: Background Information.

2. Show your classroom the short video, "Battle for Bats: Surviving White-Nose Syndrome" (available at http://vimeo.com/76705033).

3. Lead a discussion or have student groups use a jigsaw strategy to briefly summarize each section of the background information for the entire class.

Get Set – Hand Out Materials

1. Provide each student a copy of Activity Sheets A and B.

2. If desired, provide calculators for students. Calculators will be helpful, but are not necessary.

Go! – Calculate the Value of Bats

1. Give students time to calculate their answers on the two activity pages.

2. Have students can exchange papers to check answers. Teachers and/or student volunteers can pick problems to present and explain.

3. Lead a further discussion of the implications of insect consumption by bats, which might include the following topics:
Noting the numbers of insects that bats eat and the number of eggs those insects would lay could lay is a good introduction to a discussion on the importance of predators in maintaining the balance of nature. You can also relate these numbers to the total number of people living in your town or city. Further, the answers to the problems provide a good opportunity to discuss unusually large numbers. For example, students might enjoy discussing what it would mean to be a millionaire or a billionaire.

Without a wide variety of predators such as minnows, larger insects, spiders, and bats, insects such as mosquitoes could multiply at astonishing rates and cause far more serious problems. Would it be easier to control the insects using just bats or just minnows, or might we be more successful by helping as many natural predators as possible? When we spray pesticides for mosquitoes, do we only kill mosquitoes? The answer is no. The chemicals we use to kill mosquitoes can also impact and sometimes kill their predators, such as bats.

Comparatively, the natural enemies or predators of insects often reproduce far more slowly. For example, bats typically have only one or two young per year. In the long run, the loss of bats will benefit pests such as mosquitoes and we have to use stronger insecticides which could cause greater risk to people and our environment.

Reflect – Student Assessment

1. Solve math questions correctly?

2. Persuasively describe how important bats are in balancing the number of insects in the ecosystem.

3. Accurately describe what happens if a large number of bats die.

4. Discuss the effects of White-Nose Syndrome.

Extensions – Continue the Lesson

How can you creatively and persuasively convey the importance of the quantities of insects a bat can eat in a single night, month, or whole summer season? For example, you could create interesting bat facts similar to the “55 elephants” statistics stated in the background information. You could also create a physical model or demonstration.

Research bat species that live in your region and state. Write a report or lead a discussion on specific topics. For example, “How are bats beneficial?” or “What environmental issues affect bats?”

Write a persuasive argument about how white-nose syndrome might change the magnitude of the economic and ecosystem value of bats in the eastern United States. What challenges do bat biologists face in trying to provide information to support your argument? What can students and teachers do to help bats and bat biologists?

Further Reading and Resources – Discover More

About the Value of Bats

Bats are important
http://batcon.org/index.php/why-bats/bats-are/bats-are-important

Bats are worth $1 billion to corn industry
http://www.popsci.com/bats-are-worth-1-billion-to-corn-industry

Bats can save farmers $27 billion a year!
http://www.batcon.org/index.php/resources/media-education/bci-handouts

Bats in walnut orchards: What’s the benefit?
http://westernfarmpress.com/tree-nuts/bats-walnut-orchards-what-s-benefit

BATS Magazine archive
http://www.batcon.org/resources/media-education/bats-magazine

Bats Aloft – BATS 14(3): 7-10.
Bats & Mosquitoes – BATS 28(1): 6-7
The Lives of Mexican free-tailed bats – BATS 12(3): 6-14.

Bats worth billions to agriculture: pest-control services at risk.
http://www.usgs.gov/newsroom/article.Asp?ID=2743#.U6xGwpRdUSU

Ecological and economic importance of bats (Order Chiroptera)
http://www.hindawi.com/journals/ism.biodiversity/2013.187415

Losing all these bats... what does it mean?
https://www.whitenosesyndrome.org/blog/losing-all-these-bats-what-does-it-mean

About White-Nose Syndrome

National White-Nose Syndrome (WNS) Website – http://whitenosesyndrome.org/
Learn all about WNS including the latest from the field and WNS investigations, information about partners that are involved in fighting WNS, and the most up-to-date scientific information.

Teacher Answer Page

Answers to "Calculate This" Activity Sheets

A – Calculate This! - Mexican free-tailed bats *(Tadarida brasiliensis)*

1. 4 x 10 = 40 moths
2. 20 x 500 = 10,000 eggs
3. 13 ÷ 20 = $0.65
4. 20 x $0.65 = $13
5. 4 x 454 = 1,816 moths
6. 1,816 x 400,000 = 726,400,000 moths (7.264×10^8 moths)

Bonus questions

1. 5 x 400,000 = 2,000,000 pounds (2×10^6 pounds)
2. 4,540 x 2,000,000 = 9,090,000,000 insects (9.08×10^9 insects)

Just for Fun

Your weight /2 = _____lbs

Your weight*0.5 lbs (weight of a Big Mac) = _____Big Macs Each Night!

B – Calculate This! - Little brown bats *(Myotis lucifugus lucifugus)*

1. 15 x 60 = 900 insects
2. 20 x 1,000 = 20,000 mosquitoes (2×10^4 mosquitoes)
3. 10 x 10 x 20 = 2,000 moths (2×10^3 moths)

Bonus questions

1. 200 x 4,500 = 900,000
   900,000 x 7 = 6,300,000 insects per week (6.3×10^6 insects per week)
2. 900,000 ÷ 4 = 225,000 mosquitoes (2.2×10^5 mosquitoes)
   225,000 mosquitoes in a night ÷ 2 = 112,500 female mosquitoes
   112,500 x 200 = 22,500,000 eggs! (2.25×10^7 eggs!)
3. 90% = 0.90
   0.90 x 900,000 = 810,000 insects/night that would not be caught
   0.90 x 6,300,000 = 5,670,000 (or $5.67 \times 10^{6)}$ insects/week that would not be caught
   0.90 x 225,000 = 202,500 (or $2.025 \times 10^{5)}$ mosquitoes not caught
   0.90 x 22,500,000 = 20,250,000 (or $2.025 \times 10^{7)}$ eggs laid

C – Calculate This! - Bats and Corn

1. 325 bushels X 200 acres = 65,000 bushels
2. 65,000 bushels X $3.75 = $243,750
3. 200 acres ÷ 2.47 acres X $7.88 = $638.06 per year
4. 100,000 acres ÷ 2.47 acres X $7.88 = $319,028.34 per year

Bonus Question: 370,000,000 ÷ 2.47 acres X $7.88 = $1,180,404,858.30 per year

Activity Sheet A

Calculate This!
Mexican free-tailed bats (*Tadarida brasiliensis*)

The Mexican free-tailed bats that roost in Bracken Cave in Texas eat huge number of insects during the seven months they live there. These insects include crop pests, such as corn earworm moth and the cucumber beetle, that cost American farmers billions of dollars each year. A mother Mexican free-tailed bat eats up to 10 grams of insects in a night, and one of her favorite foods is a moth that weighs one-quarter of a gram each, meaning that it takes four moths to make one gram.

1. How many of these moths does one mother Mexican free-tailed bat have to catch to equal 10 grams?

2. If half of the moths eaten are females and each female could have laid 500 eggs, how many eggs would 20 females have laid if they had not been caught?

3. If 20 female moths in one acre of crops can cause a farmer to spray pesticides to kill them, and the spraying costs $13 an acre, how much does each female moth cost the farmer?

4. At the above rate, what would a mother Mexican free-tailed bat feeding on moth pests over a farmer's crops be worth each night? Assume that half of the moths caught were females and the bats catch 20 female moths in one acre.

5. Large colonies of Mexican free-tailed bats eat many thousands of pounds of insects nightly. How many moths would it take to make one pound if four moths weigh one gram and 454 grams equal one pound?

6. The Mexican free-tailed bats at Bracken Cave in Texas eat approximately 400,000 pounds of insects nightly. How many moths that weigh one-quarter of a gram each would these bats have to catch to equal the weight of 400,000 pounds of insects?

Calculate This!
Mexican free-tailed bats (*Tadarida brasiliensis*)

Bonus questions

1. There are approximately 100 million Mexican free-tailed bats in central Texas. If the 20 million bats from Bracken Cave eat 400,000 pounds of insects in one night, how many pounds would the 100 million free-tailed bats from all of central Texas eat in one night?

2. Large numbers of moths are not always available, forcing the bats to switch to other varieties of smaller insects. On a night when they feed mostly on insects that weigh just one tenth of a gram each, it takes 4,540 of the smaller insects to make one pound. How many of these insects would the 100 million Mexican free-tailed bats of central Texas eat in one night?

Just For Fun:
Some bats eat about 1/2 their body weight in insects each night! How many Big Macs would you have to eat each night to eat the same amount of food as a bat? A Big Mac weighs about ½ of a pound.

Activity Sheet B – Calculate This!
Little brown bats (*Myotis lucifugus*)

Before White-nose Syndrome, little brown bats were among the most common bats in America and they often live near people. They eat many kinds of insects, including pest such as mosquitoes, moths, and beetles. Just one little brown bat can easily catch 1,000 mosquito-sized insects in an hour, and a nursing mother eats approximately 4,500 insects every night.

1. If a young little brown bat catches 15 insects in a minute, how many does it catch in one hour if it continues to catch insects at that rate? (60 minutes = one hour)

2. If a bat house in your neighborhood attracts 20 little brown bats and they each catch 1,000 mosquitoes in one hour, how many could all 20 bats catch in one hour?

3. If one evening, instead of eating mosquitoes, your 20 bats ate a kind of moth that weighs one-tenth of a gram (it takes 10 moths to make one gram), and each bat ate 10 grams of food, how many moths would the bats eat?

Bonus Questions

1. If you build a bat house that attracts 200 little brown bat mothers, and each bat eats approximately 4,500 insects each night, how many insects would these bats eat in one night? In one week?

2. Assume that one-quarter of the insects caught by this colony in a single night are mosquitoes. How many mosquitoes would have been caught by little brown bats? If half of the mosquitoes caught are females, and each female could have laid 200 eggs, how many eggs would the mosquitoes have laid if they had not been caught?

3. Assume that in the last six years, white-nose syndrome has killed 90% of the little brown bats in this colony. Use your answers from questions 2 and 3 to determine: How many insects would not be caught in a night and a week? How many mosquitoes would not be caught? How many eggs would those mosquitoes lay?

Activity Sheet C

Calculate This!
Bats and Corn

Worldwide, corn is grown on more than 370 million acres and is an essential crop for many farmers. Corn earworms are moths that cause major damage to corn crops by feeding on leaves and ears during their larval stage. Indirectly, corn earworm larvae also decrease the value of crops by creating avenues for infection by harmful fungi. Several species of bats commonly feed on adult corn earworms providing an important service to farmers and to those who like to eat corn. **Be sure to round to the hundredths place at the end of your calculations!**

1. An average corn crop in the United States can produce about 325 bushels of corn per acre. If you had a 200 acre farm, how many bushels of corn would you produce in a year?

2. If the average cost for a bushel of corn is currently $3.75, how money does your farm receive from your 200 acres of corn?

3. If the value of bats to corn farmers has been demonstrated at $7.88 per 2.47 acres, how much would bats provide to your farm?

4. If you had an even larger farm that produced 100,000 acres of corn, what would be the value of bats be to your farm using the rate listed above?

Bonus Question – Advanced Calculation:
4. At the above rate, how much value would bats add to farmers if there are 370 million acres of corn grow worldwide?

Common Core State Standards

Math (for main activity)
CCSS.MATH.CONTENT.6.RP.A.3
Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
- CCSS.MATH.CONTENT.6.RP.A.3.B
Solve unit rate problems including those involving unit pricing and constant speed. For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?
- CCSS.MATH.CONTENT.6.RP.A.3.C
Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.
- CCSS.MATH.CONTENT.6.RP.A.3.D
Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Writing (for extension activity)
CCSS.ELA-Literacy.W.6.1
Write arguments to support claims with clear reasons and relevant evidence.
- CCSS.ELA-Literacy.W.6.1.a
Introduce claim(s) and organize the reasons and evidence clearly.-
- CCSS.ELA-Literacy.W.6.1.b
Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.
- CCSS.ELA-Literacy.W.6.1.c
Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.
- CCSS.ELA-Literacy.W.6.1.d
Establish and maintain a formal style.
- CCSS.ELA-Literacy.W.6.1.e
Provide a concluding statement or section that follows from the argument presented.

Next Generation Science Standards

Middle School Life Science (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.

Common Core State Standards Connections:

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)