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The *Natural Inquirer* Monograph Series

THE BEE FREQUENCY

How Does Lawn Mowing Affect Bee Populations?

USDA

FOREST SERVICE
DEPARTMENT OF AGRICULTURE

FIND OUTDOORS

Natural Inquirer

Monograph Series

THE BEE FREQUENCY

How Does Lawn Mowing Affect Bee Populations?

Produced by

Forest Service, an agency of the U.S. Department of Agriculture (USDA)

FIND Outdoors

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Join us in being green!

The following educator resources are now available exclusively on the *Natural Inquirer* website at **http://www.naturalinquirer.org**.

These resources can be found with the "*Natural Inquirer* Monograph Series" journal and on the "For Educators" pages.

- **Note to Educators**
- **Lesson Plan**
- **Reflection Section Answer Guide**
- **National Education Standards**

Natural Inquirer

Editorial Review Boards

Mrs. Lauer's 8th grade Living Environment Class
Fredonia Middle School • New York

Ms. Borger's 6A2 Global Scholars Virtual Class
Altman MS 172 • New York

"I liked how there were reflection sections to recap what happened in the article."

"The most important thing I learned was that there are much more pollinators other than bees."

"I think it would be very helpful if you included a few footnotes under words instead of having a glossary (The footnote would include the meaning of the word). I think this is more efficient than having to look at a glossary, and rereading the whole section."

"A suggestion I would give is next time you should add more details about how you can sample bees. Other than that this was a great article and I loved how I was able to learn about different kinds of bees, how to sample them, and how lawn mowing is both good and bad."

"The most useful graphic is probably figure 3 on page 9 which shows the Stigma and Anthers. It is useful because I didn't have any idea what the Stigma and Anthers looked like. It gave me a visual idea and it helped me connect to memories I had of other flowers that had the Stigma and Anthers."

"I learned that mowing less (about every two weeks) can help the bee population."

"You should add a part about how this effects your readers. Good luck!"

"A comment/ suggestion I have for Natural Inquirer is to have a white background instead of the lightly tinted green background because it would be easier to read."

"I found this article very interesting, and educational. It taught me a lot about pollination, before I had read these articles, I didn't understand thoroughly how animals pollinate flowers."

"The most important thing I learned was how something as little as lawn mowing could have a huge impact on our environment. Who ever thought there was a specific time that you should mow your lawn in order for it to have a good impact on your environment!"

About *Natural Inquirer* Monographs!

Scientists report their research in a variety of special books, called journals. Although journals have been produced in hard copy, they are increasingly also produced online. Journals usually contain between four and seven scientific papers. Journals enable scientists to share their research with one another. A monograph is a type of journal about research that focuses on a single scientific paper.

This monograph of a *Natural Inquirer* article was created to give scientists the opportunity to share their research with you and other students. The monograph presents scientific research conducted by U.S. Department of Agriculture (USDA) Forest Service scientists and other scientists. If you want to learn more about the Forest Service, you can read about it on the inside back cover of this monograph, go to the Forest Service website at http://www.fs.usda.gov, or visit the *Natural Inquirer* website at http://www.naturalinquirer.org.

All of the research in this *Natural Inquirer* monograph concerns the natural environment, such as trees, forests, soils, animals, insects, outdoor activities, and water. First, you will "meet the scientists" who conducted the research. Then you will read about one of the many interesting aspects of science and about the natural environment. You will also read about a specific research project. The research article follows the format that scientists use when they publish research in scientific journals. Then YOU become the scientist as you go through the FACTivity associated with the article. Don't forget to look at the glossary and the special sections highlighted in the article. These sections give you extra information that is educational and interesting.

At the end of each section of the article, you will find a few questions to help you think about what you have read. These questions will help you think like a scientist. They will help you think about how scientists conduct research. Your teacher may use these questions in a class discussion, or you may discuss these questions in a small group.

Each *Natural Inquirer* monograph will help you explore the exciting world of science and prepare you to become a young scientist. You will learn about the scientific process, how to conduct scientific research, and how to share your own research with others.

Visit for more information, articles, and resources.

Be sure to try the Bee Frequency Make a Phrase and eyeChallenge on pages 36 and 37!

WHO ARE SCIENTISTS?

Scientists collect and evaluate information about a wide range of topics. Some scientists study the natural environment.

To be a successful scientist, you must:

Be curious:
Are you interested in learning?

Photo courtesy of Michelle Kondo, USDA Forest Service.

Photo courtesy of Jose Mercado, USDA Forest Service.

Be enthusiastic:
Are you excited about a particular topic?

Photo courtesy of Kathy Smith, USDA Forest Service.

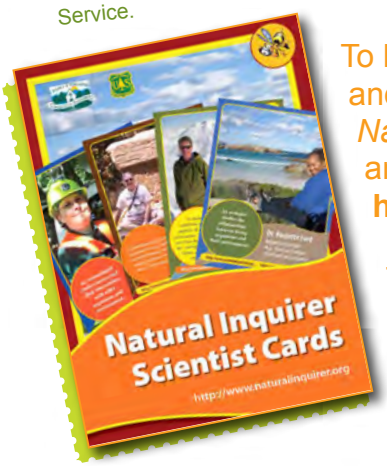
Be careful:
Are you accurate in everything you do?

Photo courtesy of Ted Weller, USDA Forest Service

Be open-minded:
Are you willing to listen to new ideas?

Photo courtesy of Amanda Uowolo, USDA Forest Service.

Question everything:
Do you think about what you read and observe?



To learn more about scientists and their work, you can find *Natural Inquirer* scientist cards and posters online at **http://www.naturalinquirer.org**.

This website also contains a series of scientist videos you can view to help you plan, design, and conduct your science fair project.

Welcome to the *Natural Inquirer* Pollinator Edition!

Photo courtesy of Lance Cheung, USDA.

Glossary words are in **bold** and are defined on page 30.

Each night during the spring months in the desert of the Southwest United States, large white flowers open atop tall saguaro cacti (figure 1). These flowers have a distinct fragrance that attracts lesser long-nosed bats. The bats are there for dinner, consuming the plant's **nectar**, a sugar-rich liquid.

Figure 1. The flowers of the saguaro cactus open at night and stay open during the first part of the day. At night, lesser long-nosed bats visit the flowers for their nectar. During the day, bees and numerous bird species also visit the flowers.

Photo courtesy of Tomascastelazo / CC BY-SA (https://creativecommons.org/licenses/by-sa/3.0).

To learn more about monographs, read "About *Natural Inquirer* Monographs!" on page 5.

These visits are an important step in producing the next generation of cacti. For example, as a bee moves from one flower, sticky **pollen** from the male part of the flower, called **anthers**, attaches to the bee (figures 2a and 2b). Moving to another flower to feed, the bee unknowingly transfers the pollen to the female parts of the flower, called **stigma** (figure 3). The result is **fertilization**. This same process occurs with bats and the saguaro cacti.

Figure 2a. A bee visits a flower. Photo courtesy of Lance Cheung, USDA.

Figure 2b. As animals visit flowers, pollen collects on their bodies. As the animals move from plant to plant, pollen from one flower ends up on the flowers of another plant. Photo courtesy of Lance Cheung, USDA.

Figure 3. The anther and stigma are the most important parts of a flower for pollination. Anthers produce pollen and stigma collect pollen. Pollinators come in contact with both as they feed on nectar, transferring pollen from plant to plant.
Photo courtesy of Babs McDonald.

While wind, water, or rain pollinate some plants, the majority of flowering plants, like the saguaro cactus, require animal pollination. This includes plants that produce many of our favorite foods. Everything from strawberries to almonds to watermelons to tomatoes require animal-assisted pollination. In fact, scientists estimate that one out of every three bites of food you consume are connected to animal pollinators!

Pollinators include more than just bees. Butterflies, birds, beetles, flies, ants, moths, wasps, and even lizards are all pollinators (figure 4). Some pollinator species pollinate only one plant species, and some pollinate many different plant species. For instance, hummingbirds may visit anywhere from 1,000 to 3,000 different flower blossoms each day.

Figure 4. Pollinators such as butterflies are valuable to ecosystems and agriculture. Here, a monarch butterfly visits a flower at the Cranberry Mountain Nature Center on the Monongahela National Forest.

Photo courtesy of the Forest Service Eastern Region, Flickr.

Of the many pollinators, however, the estimated 20,000 bee species worldwide may be the most important to our everyday lives. They are responsible for pollinating native plants in ecosystems across the world. Additionally, the U.S. Department of Agriculture (USDA) estimates that up to 100 major crops rely on bee pollination. Pollination by bees in the United States results in larger crop growth, valued at nearly $15 billion dollars per year.

However, honey bee populations are shrinking. According to the USDA, honey bee **colonies** in the United States have shrunk from 6 million to 2.5 million since the 1940s. As with other pollinators facing population decline, many issues are to blame, such as habitat destruction, viruses, pollution, and invasive species. For instance, as large industrial farms and other development have replaced native grasslands, we have lost many native plants that honey bees rely on for food to survive (figures 5a and 5b).

Other pollinators face challenges similar to those the bees face. Scientists believe that we can help these bees and other pollinators. One simple way to improve the health of pollinators is to create more habitat with food resources. We can do this by planting native flowering plants in yards, parks, and farms, and by limiting mowing to allow these flowers to grow. Scientists suggest limiting chemical use on farms and in gardens and using no-till gardening methods to avoid damaging the nests of ground-nesting bees. Scientists also suggest reducing greenhouse gas emissions to limit the impacts of a changing climate on native plants and animals.

As you read this, think about pollinators you see in your daily life. Which pollinators do you see frequently? What can you do to improve your local environment for pollinators?

Number Crunch

Write out the number 15 billion.

Figures 5a and 5b. As native habitat is lost to development, pollinators lose many of the native plants they require as food.

Photo 5a courtesy of Babs McDonald and photo 5b courtesy of Jessica Nickelsen.

Photo courtesy of Lance Cheung, USDA.

What is a Pollinator Garden?

Many of us enjoy the beauty of a garden full of flowers. For pollinators, though, a garden of native flowering plants is important habitat that provides the resources they need for survival. Even a small garden of native plants is enough to support a host of pollinator species.

The National Pollinator Garden Network is a partnership of conservation organizations, gardening groups, volunteer civic associations, and Federal agencies that work together to inspire people and organizations to create more pollinator habitat. This cooperative team encourages participation in the Million Pollinator Garden Challenge. The challenge is a call to everyone across the United States to preserve and create pollinator habitat where they live, work, and play. The network collects information about pollinator habitat locations across the Nation.

If you have a pollinator garden at your home, school, or local park, you can add that pollinator habitat to the map. If you want to chip in and create new pollinator habitat, the Forest Service has a number of helpful suggestions.

Suggestions for Creating New Pollinator Habitat

- **Bee native.** Pollinators are best adapted to local, native plants, which often need less water than ornamental plants.
- **Bee showy.** Flowers should bloom in your garden throughout the growing season.
- **Bee bountiful.** Plant big patches of each plant species so pollinators can access food resources quickly and without much effort.
- **Bee patient.** It takes time for native plants to grow and for pollinators to find your garden, especially if you live far from wild lands.
- **Bee gentle.** Most bees avoid stinging, and usually only sting in self-defense. Male bees do not sting.
- **Bee chemical free.** Pesticides and herbicides kill pollinators.
- **Bee sunny.** Provide areas with sunny, bare soil that's dry and well-drained, preferably with south-facing slopes.
- **Bee homey.** Make small piles of branches to attach chrysalis or cocoons. Provide hollow twigs, rotten logs with wood-boring beetle holes, and bunchgrasses. Leave stumps, old rodent burrows, and fallen plant material for nesting bees. Leave dead or dying trees for woodpeckers.
- **Bee friendly.** Create pollinator-friendly gardens at home, at schools, and in public parks. Teach people about pollinators and native plants.
- **Bee aware**. Observe pollinators when you walk in nature. Notice which flowers attract bumble bees or solitary bees, and which attract butterflies.
- **Bee a little messy.** Most of our native bee species (70 percent) nest underground, so avoid using weed cloth or heavy mulch.
- **Bee diverse.** Plant a variety of flowering species with abundant pollen and nectar and provide specific plants for feeding butterfly and moth caterpillars.

Refer to "Attracting Pollinators to Your Garden Using Native Plants" (https://www.fs.fed.us/wildflowers/pollinators/documents/AttractingPollinatorsEasternUS_V1.pdf) to learn more about planting a pollinator garden. Visit the Forest Service "Gardening for Pollinators" website <https://www.fs.fed.us/wildflowers/pollinators/gardening.shtml> for more information about planting for pollinators.

THE BEE FREQUENCY:
How Does Lawn Mowing Affect Bee Populations?

Photo by Jessica Nickelsen.

MEET THE SCIENTISTS!

Photo courtesy of Susannah Lerman, used with permission.

◀ SUSANNAH LERMAN,
Research Ecologist

My favorite experience is discovering exciting birds and insects in our backyards and neighborhood parks. I spend a lot of time exploring local habitats and talking with neighbors about the wildlife that visit their communities. I love listening to the public talk about their experiences with local nature—everyone has a story to share. I also enjoy talking with the public about ways they can enhance the habitat in their yards and parks and make these spaces better for wildlife.

Photo courtesy of Alexandra Contosta, used with permission.

◀ ALEXANDRA CONTOSTA, Soil Biogeochemist

One of my favorite science experiences happened during my first field ecology job. I was working for the USDA Forest Service in the White Mountains of New Hampshire and Maine. The job involved looking at visual signs of tree health to be able to compare them to the amount of nutrients in the soil. Trees are like people in this way. If they don't get the right nutrition, they can get sick. We were working in remote parts of the national forest, traveling every day to plots that were way off the main trails. I learned a lot about how to find my way in the woods using a Global Positioning System (GPS) and a compass. I also saw parts of the forest that most people don't get to visit.

One day we were in a section that had a lot of beech trees. They have smooth, gray bark that has always reminded me of an elephant's skin, which made it easy to spot scratch marks up and down the trunk. I looked up, saw clumps of sticks in the branches, and realized I was looking at black bear nests! I had heard that bears like to build these nests in the fall while they feast on beechnuts but had never seen them, either before or since. This experience has always stuck with me as a reminder to keep my eyes open for the unexpected. Scientific discovery often happens when I see something I did not mean to look for, like finding bear nests when I was supposed to look at tree health.

did you know?

Black bear nests are not like bird's nests. The black bear "nests" are created when the bears are feeding and there are leftover materials. Unlike birds, the bears don't use the nest as a home.

Photo courtesy of Joan Milam, used with permission.

◀ JOAN MILAM,
Research Melittologist

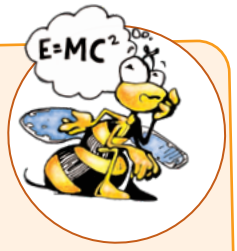
My favorite experiences are catching uncommon bees throughout North America with fellow bee scientists (**melittologists**) and identifying them in my lab. I especially enjoy catching bees that collect pollen from just one plant species, meaning the bee is an **oligolege,** and collecting cuckoo bees. Cuckoo bees are **parasitic** bees that lay their eggs in the nests of bees that worked hard to collect pollen to feed their young! Learning about bees means that you also must know about plants (botany) and where plants grow. I also like catching bees on flowers that grow in a tree canopy of maple and cherry trees; that means putting traps up in trees as high as 70 feet! I enjoy giving public talks and workshops about pollinators to get people excited about the many amazing pollinators that live around us, including in city parks and backyards.

WHAT KIND OF SCIENTISTS DID THIS RESEARCH?

Research Ecologist: This scientist studies the relationship between living things and their living and nonliving environment.

Soil Biogeochemist: This scientist studies the interactions between the biotic (living) and abiotic (nonliving) components of soils.

Melittologist: This scientist studies bees.



Thinking About Science

Scientists use many different tools and technologies to complete research. They are increasingly using high-tech, computer-based instruments that require special knowledge or skills. However, not all scientific endeavors require high-tech equipment. Many sciences still use the same technologies that scientists used many years ago. For instance, scientists studying chemistry may still use beakers. Scientists have used beakers in chemistry since the 1800s, and modern beakers are similar to the ones used then.

Scientists may also use their creativity to find simple items at the grocery store that they can use for experiments. In this study, the scientists evaluated how mowing lawns affects bees. The easiest way to capture and learn about bees is to use inexpensive, disposable plastic bowls painted with bright, fluorescent colors that make the bowls resemble flowers. Soapy water inside the bowls prevented the bees from flying away before the scientists could identify and count them.

The scientific process requires a great deal of creativity. As you read this study, think about a question you want to investigate using the scientific process. What tools or technologies could you use to test your question?

Thinking About the Environment

Green, grassy lawns cover a large portion of the United States (figure 6). The scientists in this study found that grass lawns cover more than 400 million acres in the United States. That's an area approximately equivalent to the State of Alaska, the largest State in the United States. You may see lawns at homes, at schools, near businesses, in parks, and at golf courses.

Figure 6. Lawns are areas covered mostly in grass. Many lawns are small but, together, they cover a large part of the United States.

Photo courtesy of Michelle Andrews.

Lawns can be easy to maintain, attractive, and provide a good place to play or picnic. Chemical-free lawns can also be good for the environment. For instance, lawns can slow stormwater runoff, store carbon, and lower temperatures caused by the **urban heat island effect**. These benefits are especially important in urban and suburban areas with limited green space.

While lawns do have benefits, the scientists knew that most lawns are not an ideal habitat for many plants and animals. Keeping lawns looking good often requires chemical treatments that can pollute waterways and can also kill some pollinators. Lawns also require frequent mowing to maintain a tidy look. In fact, there are even some places in the United States where the law requires mowing! While mowing makes a lawn look neat, scientists know that frequent mowing can make it difficult for native plants and animals to survive (figures 7a, 7b, and 7c).

Figure 7a. Frequent mowing can lead to a lawn with fewer plant species. While it provides a tidy look that many people enjoy, a mowed lawn is not the ideal habitat for wildlife.

Photo courtesy of Jessica Nickelsen.

Figure 7b. What differences do you notice between the freshly mowed lawn (left) and the unmown portions (right) of the lawn?

Photo courtesy of Jessica Nickelsen.

Figure 7c. In this figure, again look closely to see the freshly mowed lawn (left) and the unmown lawn (right). What differences do you notice in this photo between the mowed lawn and the unmown portion? How does this photo compare to the photo in figure 7b?

Photo courtesy of Babs McDonald.

Introduction

Lawns are a common sight in the United States. As discussed in "Thinking About the Environment," lawns can have both good and bad effects on the environment and on pollinators. Because humans find lawns so desirable, removing lawns altogether is not likely to happen.

The scientists found previous research showing that lawns mowed frequently or treated with chemicals had limited flowering plants for pollinators. Without frequent mowing and treatment with chemicals, however, lawns are home to numerous native, flowering plants (figures 8a and 8b). Pollinators are in decline across much of the United States. Therefore, the scientists determined that lawns with flowering plants could play an important role in providing habitat and food to pollinators. This determination is especially important in suburban and urban areas where there isn't a lot of natural pollinator habitat.

The scientists **hypothesized** that mowing less and providing fewer chemical treatments to lawns could increase the diversity of flowering plants. In turn, more flowering plants would improve the **abundance** of bees on lawns.

Figure 8a. Lawns do not always provide a good habitat for pollinators, but lawns that are allowed to grow do have many flowering plants that wildlife can use.

Photo courtesy of Susannah Lerman, USDA Forest Service.

Figure 8b. Notice the pollinator enjoying the flowering plants in this lawn.
Photo courtesy of Babs McDonald.

Review the scientists' hypothesis. In your own words and in the form of a question, what are the scientists studying in this research?

How did the scientists use the research of other scientists to inform their study?

Methods

The scientists conducted their research in the city of Springfield, Massachusetts (figure 9). They chose 16 homes in the city that had similar lawns of approximately the same size. The lawns had no or limited flower gardens and were separated by at least 500 meters.

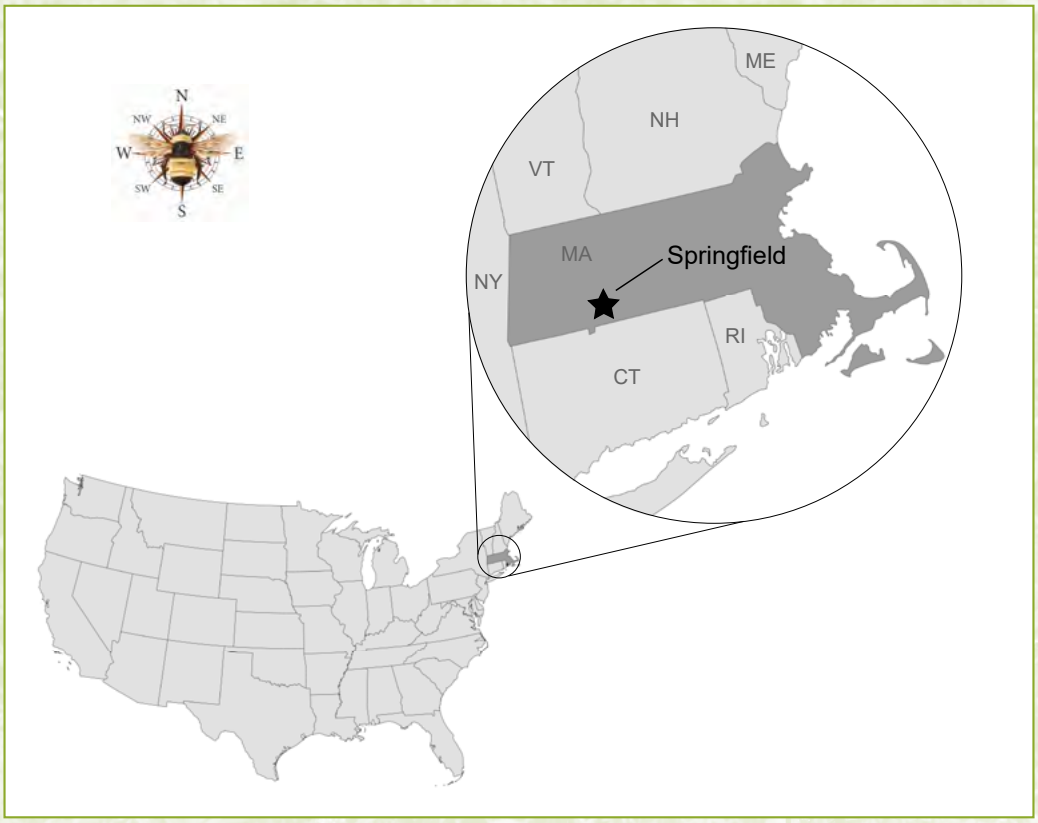
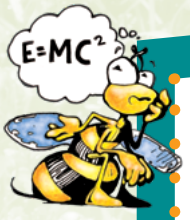


Figure 9. Springfield is a small city in the northeastern United States. It is the third largest city in the State of Massachusetts.
Map by Carey Burda.



Number Crunch

Lawns in the study were at least 500 meters apart. There are approximately 3.2 feet in each meter. How many feet are in 500 meters?

The scientific team used a Toro 19-inch push mower (figure 10) to mow lawns from May through September during 2013 and 2014. They used the same mowing techniques and equipment for each lawn and left all grass clippings on the lawn after mowing.

To determine the impact mowing had on the 16 lawns, the scientists chose 1 of 3 mowing **regimes**:

- Mowed every 7 days (every week)
- Mowed every 12 to 14 days (every 2 weeks)
- Mowed every 18 to 21 days (every 3 weeks)

The scientists also sampled flowering plants and bees at each lawn 5 times per year, for a total of 10 times per lawn.

All sampling took place before mowing. They identified and counted flowering plants, then added them up to calculate each lawns' total **floral** abundance.

To sample bees, the scientists strategically placed 30 plastic pan traps filled with soapy water across each lawn to catch the greatest number of bees (figure 11). They left the pan traps on each lawn for 24 hours. Because pan traps often collected mostly small bees, the scientists also swept each yard with hand nets for 15 minutes to catch larger bees. They followed a standard process (figure 12) while sweeping with the hand net. The scientists brought the collected bees to a lab to wash, pin, identify, and label them, and then entered the information into a database (figure 13).

Figure 10. The scientists mowed each lawn with a basic lawn mower. Photo courtesy of Susannah Lerman, USDA Forest Service.

Figure 11. Scientists left pan traps, like these colored bowls, on the lawns to collect bees for identification.

Photo courtesy of Michelle Andrews.

Figure 12. A hand net (also called an aerial net) is lightweight; has a long, thin handle; sometimes a flexible hoop; and a soft bag. These nets are ideal for collecting delicate specimens, including many pollinators like bees, moths, or butterflies. Scientists typically use this type of net to "scoop" insects from the air or off a plant, but they can also "pancake" the nets flat against the ground to catch insects on or near the ground.

Photo courtesy of Michelle Andrews.

(A)

Figure 13. The scientists identified and pinned all the bees they collected. Identifying and pinning the bees enabled the scientists to visualize the different bee species that might be impacted by changing how people mow lawns.

Photo courtesy of Michelle Andrews.

Reflection Section

Why do you think the scientists sampled the lawns multiple times over 2 years?

Explain in your own words why the scientists used multiple techniques to sample bees from the lawns. Can you think of another way to identify and count bees? If so, how would you do it?

Findings

After 2 years of lawn mowing and 10 sampling events per lawn, the scientists collected a total of 4,587 bees. They identified a total of 93 bee species on the lawns and an additional 8 species as part of another study, for a total of 101 species. This represents about 25 percent of bee species recorded in Massachusetts. Of those 93 species identified in the lawn mowing study, 10 species accounted for 78 percent of all 4,587 bees identified. The sweat bee (figure 14) was the most common type of bee found, accounting for 42 percent of all bees collected. During the same 2-year period, the scientists identified 54 different flowering plants and found another 11 unidentifiable plants.

Number Crunch

Sweat bees accounted for 42 percent of all 4,587 bees collected. How many bees from the total were sweat bees?

Figure 14. Sweat bees are a diverse group of bees. Some species are blue or green in color, like this green metallic sweat bee. As the name suggests, these bees are attracted to human sweat, which they eat for salt. Luckily, they are not aggressive toward humans unless they feel threatened.

Photo courtesy of Wayne Boo, U.S. Geological Survey Bee Monitoring and Inventory Lab, Flickr.

The lawns with the greatest diversity of bee species were those that scientists mowed weekly (table 1). However, these lawns also had many single captures. Single captures are bee species from which scientists only captured one bee over the course of the entire study, rather than bees that scientists caught frequently and in high numbers. The lawns that had the greatest number of bees were those that scientists mowed once every 12 to 14 days (every 2 weeks). The scientists found that lawns mowed every 18 to 21 days (every 3 weeks) had significantly higher grass and 2½ times more flowers.

Lastly, the scientists found that yard characteristics, such as lawn size or tree **canopy** cover, did not impact the abundance of bees or flowering plants.

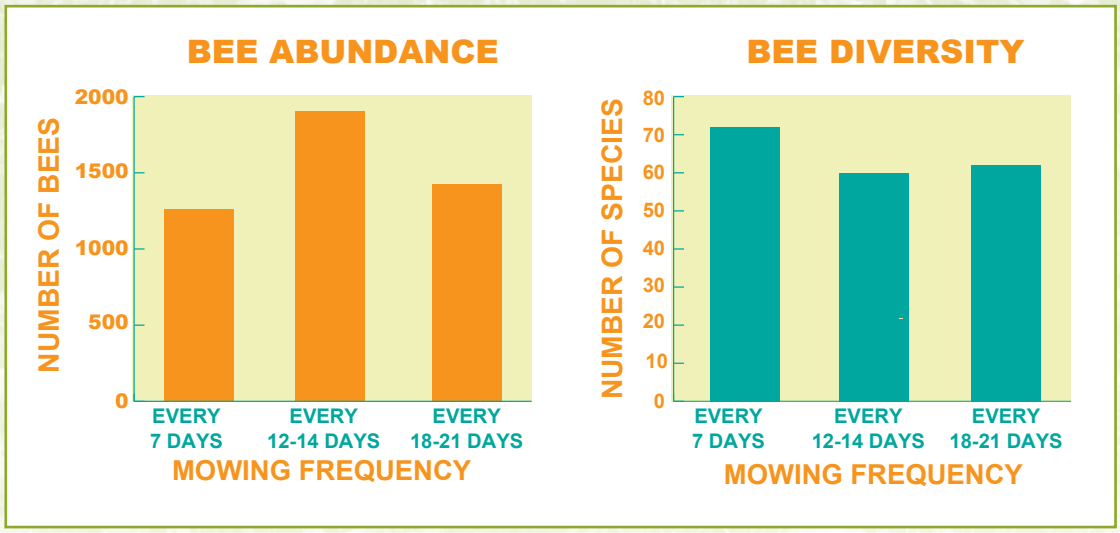


Table 1. Those lawns mowed once every 7 days had a high diversity of bee species, but fewer total bees. Lawns mowed in the other regimes had a lower diversity of bee species, but more total bees.

The scientists found that lawns mowed every 18 to 21 days had the most flowering plants. Does this result surprise you? Why or why not?

Review table 1. Based on these results, which mowing regime would you choose if you were managing a lawn for bees? Why?

Discussion

The scientists believe the results of the study partially supported their hypothesis. Although lawns do not have the same habitat quality as a native habitat, people can manage lawns to provide more resources for bees. The scientists suggest a "lazy lawnmower" approach of mowing less frequently, with every 2 weeks as the sweet spot. Less frequent lawn mowing results in the growth of more flowering plants and increases the abundance of bees. Although the study results indicated a lower diversity of bee species when mowing less, the scientists believe a lower diversity of species would not impact the role of bees in the ecosystem.

These findings are important, as lawns are common across the United States. Those who have lawns in urban, suburban, and even rural areas can actively add flowers to gardens to attract bees. Even those without specially designed gardens can support bees by managing lawns to encourage **spontaneous** flower growth.

The scientists recognized that these results are limited because they include only one city from one region of the United States. Additionally, there may be barriers to acceptance of the "lazy lawnmower" approach. For one, many people simply prefer a tidy lawn that is easy to care for. The scientists also recognize that certain laws in some parts of the country prevent lawns with taller plants. However, the scientists believe the "lazy lawnmower" approach to lawn management is an easy and inexpensive method for improving urban and suburban areas for bees.

Reflection Section

In your own words, explain the "lazy lawnmower" approach to lawn management.

Why do the scientists support the "lazy lawnmower" approach for lawn management?

The scientists note some possible issues with the "lazy lawnmower" approach. In your own words, what are those issues? Are there other issues? If so, what do you believe would be an issue?

At the beginning of this article, we posed two questions:

1. What is a question you want to investigate using the scientific process?
2. What tools or technologies could you use to test your question?

Take a moment to think through your answers to these two questions. Share your answers with a classmate or with your whole class. Create a class list of questions that the class would like to investigate.

Adapted from Lerman, S., et al. 2018. To Mow or to Mow Less: Lawn mowing frequency affects bee abundance and diversity suburban yards. Biological Conservation. 221:160-174. https://www.fs.fed.us/nrs/pubs/jrnl/2018/nrs_2018_Lerman_001.pdf.

THE BEE FREQUENCY

GLOSSARY

abundance (ə **bən** dən(t)s): A degree of plentifulness.

anther (**an(t)** thər): On the male flower, the part of the flower that contains pollen.

canopy (**ka** nə pē): (1) Anything that covers like a roof; (2) On a tree, the area of leaves that cover the ground.

cross-pollinate (**krȯs pä** lə nāt): To pollinate (a flower or plant) with pollen from another flower or plant.

fertilization (**fər** tə lə **zā** shən): The joining of an egg cell and a sperm cell (pollen in a plant) to form the first stage of an embryo (a seed in a plant).

floral (**flȯr** əl): Of, relating to, or depicting flowers.

hypothesize (hī **pä** thə **sīz**): (1) To propose an explanation in light of known facts; (2) To make an assumption to test its logical consequences.

nectar (**nek** tər): In botany, a liquid made by the flowers of plants.

oligolege (ə **lē** gə lāj): Pollinator species which requires the pollen of a particular plant for development and survival.

parasitic (per ə **si** tik): Relating to or having the habit of a parasite.

pollen (**pä** lən): Particles containing genetic material for reproduction of plants.

pollinator (**pä** lə nā tər): An agent (such as an insect) that pollinates flowers.

regime (rā **zhēm**): A regular pattern of occurrence or action.

stigma (**stig** mə): On the female flower, the sticky knob which collects pollen from pollinators.

urban heat island effect (**ər** bən **hēt ī** lənd ē **fekt**): An urban area that is significantly warmer than its surrounding rural areas due to human activities.

Accented syllables are in **bold**. Marks and definitions are from https://www.merriam-webster.com. Definitions are limited to the word's meaning in the article.

CITIZEN SCIENCE CONNECTIONS

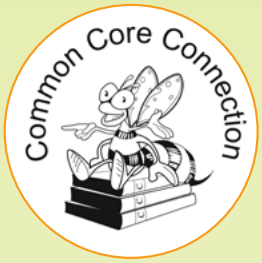
Imagine hiking through your favorite park with a hand net in search of bumble bees, scanning your backyard for hummingbirds with a pair of binoculars, or teaming up with your classmates to track butterfly migration. With citizen science, it's possible to get real, hands-on experience doing science with real scientists.

Citizen science is a collection of scientific data by individuals who are not professional scientists. For instance, people who participate in Bumble Bee Watch (http://www.bumblebeewatch.org) photograph bumble bees that they find anywhere in the United States and use a phone app to upload the images to a database. Those photographs, along with information about where the photographer found the bumble bee, help scientists understand more about conserving these small but important pollinators.

There are many projects focused on pollinators that enable people to become a citizen scientist. With the Great Sunflower Project (http://www.greatsunflower.org), people can plant a sunflower and record pollinators that visit the flower. They can also track down ladybugs, photograph them, and submit the images to scientists participating in the Lost Ladybug Project (http://www.lostladybug.org).

Scientists need your help to learn more about the environment. To learn more about citizen science and about how to get involved, visit CitizenScience.gov (https://www.citizenscience.gov/) or get a free copy of the *Natural Inquirer* Citizen Science edition (http://www.naturalinquirer.org/Citizen-Science-i-71.html).

FACTivity



Time Needed

- One class period

Materials

- Roll of paper towels
- Markers
- Plastic bowls
- Construction paper (optional)
- Snack food with sticky residue like cheese doodles/puffs or something similar
- Individually wrapped candy (enough for three pieces per student)

FACTivity **Background**

In "The Bee Frequency," you learned that pollinators need certain habitat qualities to thrive. In the case of bees, they used lawns with food resources available (in the form of flowering plants) more frequently than lawns without food resources available. Flowering plants contain the nectar that pollinators need to survive.

In the "Welcome to" section of this monograph, you learned that pollinators carry pollen from flower to flower without knowing they are helping the pollination process. Pollen, which humans often associate with allergies, is very sticky, and it coats the pollinating insects as they move from flower to flower. In this FACTivity, we'll demonstrate the pollination process, and will see how effectively pollinators can move pollen between flowers.

FACTivity **Methods**

Your teacher will first have all students wash their hands thoroughly. Then your teacher will divide your class into groups of three students. The teacher will then provide you and each student in your group with a paper towel and a marker. Use the marker to draw a big flower on your paper towel.

Next, your teacher will place a bowl of snack food in front of your group which has a dust or residue. You will notice that the bowl has some additions that make it look like a flower. Your teacher will have placed nine pieces of candy in the bottom of each bowl. The candy represents the nectar that you, a pollinator, are in search of for food.

Taking turns, each student in your group will reach into the bowl to grab one piece of candy. After each turn, you will all wipe your hands clean on your paper towel flowers. Each student in your group should go three times, and each student should end up with three pieces of candy.

Note: Please do not eat any snack food or candy until after the activity, or until your teacher gives you permission to eat the items.

As a class, compare the paper towel flowers that you used to wipe your hands between turns. What happened to the snack food residue on your hands after each turn reaching for a piece of candy? Considering that the bowl was a flower and each of your paper towels was also a flower, how does this activity imitate pollination? What role did each person in your group play in the pollination process?

Pollen is sticky, just like the snack food dust/residue that covered your hands as you searched for your candy in the bowl. It sticks to pollinators who bring it to other flowers in their search for food (nectar). They do not transfer pollen on purpose, however; they are just searching for food as they visit flowers. This is similar to your actions in this activity; you weren't looking to collect snack food dust/residue, but it stuck to you as you searched for pieces of candy.

Natural Inquirer Connections

You may want to reference this *Natural Inquirer* article for additional information and FACTivities:

- For more information about ecosystem services, read the *Natural Inquirer* Ecosystem Services edition.
- For more information about pollinator habitat, read "That's A Humdinger!" in the Animals and Ecosystems of the Southwestern United States *Investi-gator or* "Treasure Islands" in the *Natural Inquirer* Hawai'i-Pacific Islands edition.
- For more information about citizen science, read the *Natural Inquirer* Citizen Science edition.

This article, along with others, can be found at: http://www.naturalinquirer.org/all-issues.html.

If you are a trained Project Learning Tree educator, you may use "Charting Diversity" as an additional resource.

WEB RESOURCES

USDA Forest Service: Pollinators
https://www.fs.fed.us/wildflowers/pollinators/

USDA Forest Service:
Want to help bees? Take a break from lawn mowing
https://www.fs.usda.gov/features/want-help-bees-take-break-lawn-mowing

Pollinators Live
https://pollinatorlive.pwnet.org/index.php

USDA Forest Service: Gardening for Pollinators
https://www.fs.fed.us/wildflowers/pollinators/gardening.shtml

USDA Forest Service: Inside Agroforestry—Learn How You Can Use Agroforestry to Help Pollinators
https://www.fs.usda.gov/nac/assets/documents/insideagroforestry/IA_vol23issue2_pollinators.pdf

USDA Forest Service: Forest Service is Aflutter with Native Plant and Pollinator Gardens
https://www.usda.gov/media/blog/2013/06/17/forest-service-aflutter-native-plant-and-pollinator-gardens

The Xerces Society for Invertebrate Conservation
http://www.xerces.org/

Project Learning Tree: Pollinators: Why They're Important and How Schools Can Help
https://www.plt.org/educator-tips/pollinators-how-schools-can-help/

National Environmental Education Foundation:
Create a Place for Pollinators
https://www.neefusa.org/nature/plants-and-animals/create-place-pollinators

THE BEE FREQUENCY
MAKE A PHRASE

Common Core Connection

Draw a line from each word in column one to the word in column two that creates a phrase used in The Bee Frequency monograph.

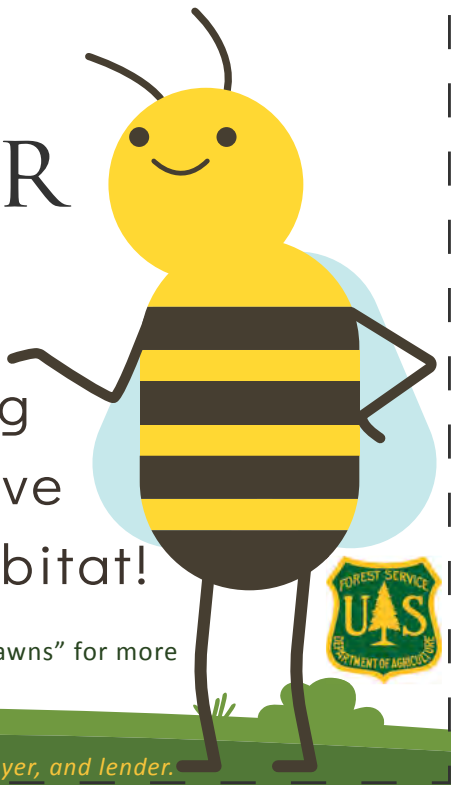
Flowering	Abundance
Hand	Bee
Mowing	Regime
Bee	Lawnmower
Lazy	Trap
Sweat	Plants
Pan	Net

Here is a sign you can cut out and display so that more people can learn about this research!

LAZY LAWN MOWER ALERT:

We're mowing less to improve pollinator habitat!

Scan or visit www.nrs.fs.fed.us and search "Bees and Lawns" for more information.



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THE BEE FREQUENCY

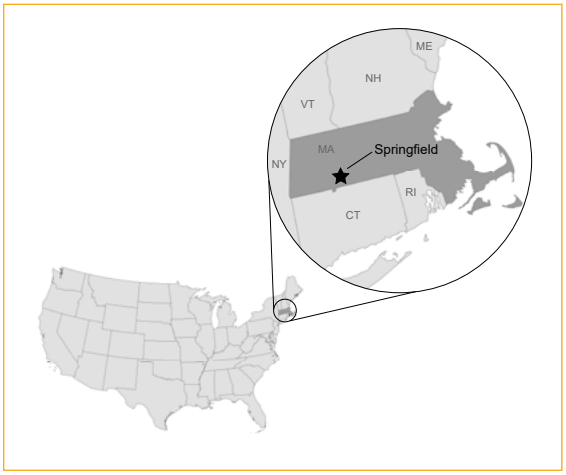
eyeChallenge

Each of the following images represents something from the article. Explain what each of these images represents. You may write your explanation or hold a class discussion. If you write your explanation, use complete sentences, proper spelling and grammar, and appropriate punctuation.

Photo courtesy of Babs McDonald.

Photo courtesy of Susannah Lerman, USDA Forest Service.

Photo courtesy of Wayne Boo, U.S. Geological Survey Bee Monitoring and Inventory Lab, Flickr.



Map by Carey Burda.

Photo courtesy of Michelle Andrews.

Photo courtesy of Jessica Nickelsen and Babs McDonald.

National Education Standards

For more detailed correlations of this *Natural Inquirer* Monograph to National Education Standards, visit the *Natural Inquirer* website (http://www.naturalinquirer.org).

National Science Education Standards Addressed In This Article

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Structure and function in living systems
- Regulation and Behavior
- Populations and Ecosystems
- Diversity and adaptations of organisms
- Populations, Resources, and Environments
- Science as a human endeavor
- Nature of Science
- History of Science

Social Studies Education Standards Addressed In This Article

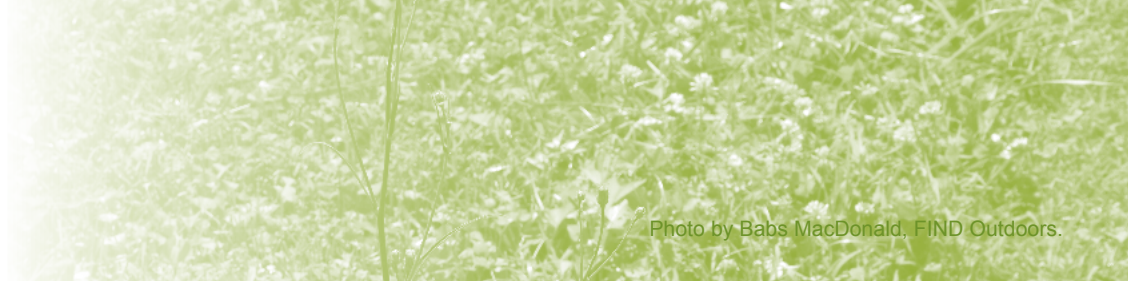
- People, Places, and Environments
- Science, Technology, and Society

Common Core Education Standards Addressed in This Article

- Key Ideas and Details
  - CCSS.ELA-Literacy.RST.6-8.1
  - CCSS.ELA-Literacy.RST.6-8.2
  - CCSS.ELA-Literacy.RST.6-8.3
- Craft and Structure
  - CCSS.ELA-Literacy.RST.6-8.4
  - CCSS.ELA-Literacy.RST.6-8.5
  - CCSS.ELA-Literacy.RST.6-8.6
- Integration of Knowledge and Ideas
  - CCSS.ELA-Literacy.RST.6-8.7
  - CCSS.ELA-Literacy.RST.6-8.8
  - CCSS.ELA-Literacy.RST.6-8.9

Next Generation Science Standards Addressed In This Article

- Science and Engineering Practices
  - Asking Questions and Defining Problems
  - Planning and Carrying Out Investigations
  - Analyzing and Interpreting Data
  - Constructing Explanations and Designing Solutions
  - Engaging in Argument From Evidence
  - Obtaining, Evaluating, and Communicating Information
- Disciplinary Core Ideas
  - Life Science: LS1.A Structure and Function; LS1.B Growth and Development of Organisms; LS2.A Interdependent Relationships in Ecosystems; LS2.C Ecosystem Dynamics, Functioning, and Resilience; LS4.C Adaptation; LS4.D Biodiversity and Humans
  - Earth and Space Science: ESS3.A Natural Resources; ESS3.C Human Impacts on Earth Systems
- Crosscutting Concepts
  - Patterns
  - Cause and Effect
  - Scale, proportion, and quantity
  - Structure and Function
  - Stability and Change
  - Connections to Nature of Science
  - Connection to Engineering, Technology, and Applications of Science



What Is the Forest Service?

The Forest Service is part of the U.S. Department of Agriculture (USDA), and is made up of thousands of people who care for the Nation's forest lands. The Forest Service manages 154 national forests and 20 national grasslands. These are large areas of trees, streams, and grasslands. National forests are similar in some ways to national parks. Both are public lands, meaning they are owned by the public and managed for the public's use and benefit. Both national forests and national parks provide clean water, homes for the animals that live in the wild, and places for people to do fun things in the outdoors. National forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the Forest Service are scientists whose work this journal presents. Forest Service scientists work to solve problems and provide new information about natural resources so that we can ensure that our natural environment is healthy, now and into the future.

For more information, visit https://www.fs.usda.gov/

What Is FIND Outdoors?

Formerly the Cradle of Forestry in America Interpretive Association, FIND Outdoors is a 501(c)3 nonprofit organization based in Pisgah National Forest, North Carolina. We are the Southeast's leader in providing access to public lands, environmental education, recreation, and front-country camping experiences. We maintain and operate 21 recreation, education, and camping facilities across western NC, northern GA, and beyond—serving approximately 800,000 visitors each year with over 150 recreational and environmental education programs, special events and tours.

Our story is rooted in education about the **forest**.

Our passion is to help people become **inspired**.

Our goal is to help people connect with **nature**.

Our drive is to help people learn through **discovery**.

We help people...FIND Outdoors

We are…FIND Outdoors

For more information, visit http://www.goFINDoutdoors.org.

Who is Woodsy Owl?

Help us celebrate Woodsy Owl's 50th birthday! Woodsy Owl has been inviting children of all ages to explore and care for the natural environment since 1971. Woodsy Owl, in partnership with the *Natural Inquirer* program, helps introduce students to science and the natural world. In this monograph, students will learn about pollinators and how lawn mowing affects pollinator populations. Woodsy encourages students to listen to what scientists have to say, to see what scientists are studying, to ask questions, and to understand what scientists are discovering. Woodsy's motto is "Lend a Hand, Care for the Land!" As you read, look for ways that scientists lend a hand and care for the land too. Then think of ways you can lend a hand and care for the land too!

For more information, visit https://www.fs.usda.gov/main/conservationeducation/smokey-woodsy/woodsy-owl.

What is 4-H?

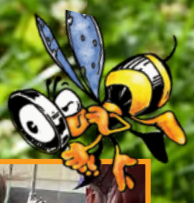
The 4-H Youth Development Program is the youth outreach program from the land-grant institutions' cooperative extension services and the U.S. Department of Agriculture. 4-H serves as a model program for the practice of positive youth development by creating positive learning experiences; positive relationships for and between youth and adults; positive, safe environments; and opportunities for positive risk taking.

For more information, visit https://nifa.usda.gov/program/4-h-positive-youth-development.

Student Editorial Review Boards

Mrs. Lauer's 8th grade
Living Environment class
Fredonia Middle School • New York
(pictured here)

Ms. Borger's 6A2 Global
Scholars Virtual Class
Altman MS 172
New York



Natural Inquirer
http://www.naturalinquirer.org

Forest Service Conservation Education
https://www.fs.usda.gov/conservationeducation

Woodsy Owl
https://www.fs.usda.gov/main/conservationeducation/smokey-woodsy/woodsy-owl

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Photo courtesy of Babs McDonald.