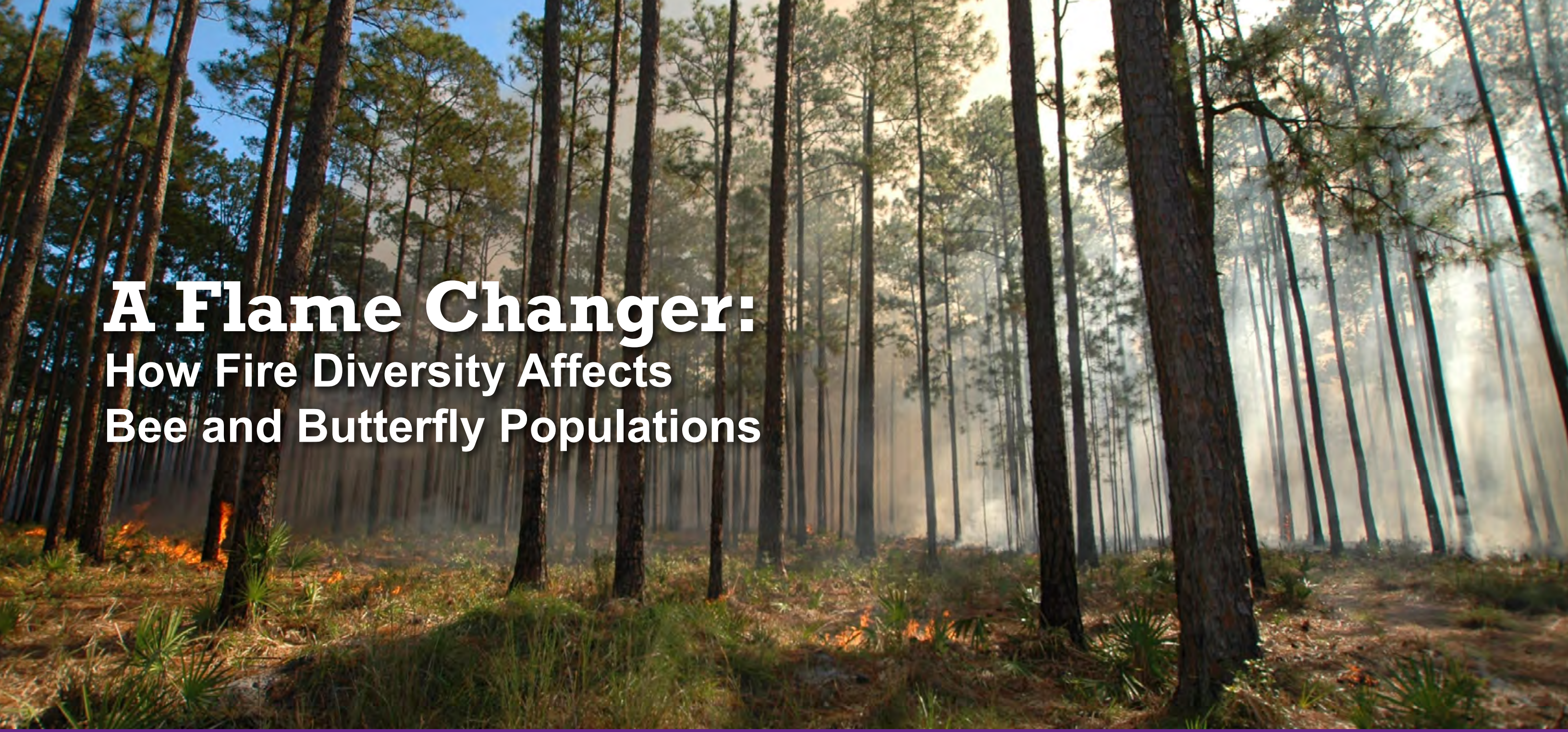


A Flame Changer:
How Fire Diversity Affects Bee and Butterfly Populations

MEET THE SCIENTISTS!

◄ **MICHAEL ULYSHEN, Entomologist**

My favorite science experience was collecting insects in French Guiana (gē **a** nə) while I was in graduate school. French Guiana is a small South American country north of Brazil. To attract insects at night, we set up bright lights on remote roads surrounded by rainforest. An unbelievable number and variety of insects were drawn to the light, including *Titanus giganteus*, which is considered the largest beetle species in the world!

My most memorable experience was when the noisy generator, which was powering our lights, ran out of gas. My ability to see insects (or anything else!) was suddenly replaced by the ability to hear the forest. I could hear the flapping sounds of countless bats as they flew around me to catch the insects that had been attracted by the light.

Glossary words are in **bold** and are defined on page 28.

◀ **CONOR FAIR, Entomologist**

I enjoy my field research because I have the opportunity to observe the natural beauty of the field sites. Field work can often be physically demanding, but finding time to enjoy these moments makes it all worth it.

◀ **SCOTT POKSWINSKI, Botanist**

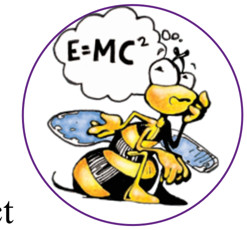
My favorite science experience was working on large-scale research burns. First of all, it is a blast to see the work of managing prescribed fire on a large scale, and I really enjoyed working with scientists of other disciplines, including physicists, meteorologists, biologists, and chemists. You learn to see fire and its effects differently when you see it through the eyes of scientists in other disciplines.

What Kinds of Scientists Did This Research?

Botanist: This scientist studies plants.

Entomologist: This scientist studies insects.

Thinking About Science



The scientists in this study wanted to collect samples of the different bees and butterflies living in the study area. Because the scientists could not collect every bee and butterfly that lived there, they designed a method to collect bees and butterflies that would represent the whole population. The scientists decided to use pan traps, which are shallow bowls filled with soapy water, to collect the pollinators (**figure 1**). They used yellow, blue, and white bowls and put those bowls on wire stands so they stood above the ground. Why do you think the scientists chose this method?

The scientists chose this method because of earlier research on different ways to collect pollinator samples. Most scientific research builds on the findings of earlier research. In this case, other scientists had tested what kinds of traps were best at catching pollinators, what color pan traps were best, which traps were best in which types of environments, and whether ground traps or **elevated** traps were better. The scientists in this study used this previous research to choose the best method to collect the data they needed for their experiment.

Figure 1. Scientists in this study chose yellow, blue, and white disposable bowls to use as their pan traps. Why do you think scientists chose these bright colors to attract pollinators?

Thinking About the Environment

Diversity can be important to an ecosystem. Biodiversity is the existence of different kinds of plants and animals in an environment. Habitat diversity is the existence of different types of habitat in an environment. Scientists **hypothesize** that the more habitat diversity there is in a given environment, the more biodiversity there will be in that environment, too. Why do you think this might or might not be the case?

Think about a typical preschool or kindergarten classroom. Often, these classrooms have a variety of centers that children can visit. These classrooms might include a center for dress-up, one with a play kitchen, one with blocks, and another with art supplies. The more centers there are, the fewer children there may be at each center. Also, children may be more likely to find something they enjoy doing when they can choose from a variety of centers to visit.

Like centers in a classroom, many different types of habitat in an environment mean that each species may find its own **niche** in the environment. They may not have to compete with as many other plants or animals to occupy that space. The environment can support many kinds of plants and animals in finding food and shelter (**figure 2**).

Another reason more habitat diversity can lead to more biodiversity is that diverse habitats can provide **refuge** when other places in that environment are damaged, changed, or difficult to reach. In the classroom centers example, if the kitchen center is broken and children cannot play there anymore, other centers are available where the children can play. In an ecosystem, if one habitat is damaged by something like a fire, other places in that ecosystem may be available where animals can seek refuge and find food and water.

Fire can also be an important source of habitat diversity. Fire can burn with different temperatures, in different locations, and at different times. This fire diversity can lead to habitat diversity. You will read more about fire diversity in the following study. Scientists in this study wanted to know how habitat diversity, largely created by fire diversity, impacts pollinator diversity.

Figure 2. This forest habitat may not look especially diverse, but ecosystems like this one are home to a rich diversity of plants and animals. The trees, grasses, and even the soil are important habitats for different species. Longleaf pine forests, like the one in this photo, provide habitats for over 600 species of plants and animals, 29 of which are endangered or threatened.

Introduction

The Coastal Plain of the southeastern United States has one of the highest fire frequencies in North America (**figure 3**). Many more fires start in this region every year than in the Western United States. Before humans began **suppressing** wildland fires, many of these landscapes burned regularly. These fires supported healthy and diverse ecosystems. Fire would start from a lightning strike or be intentionally set by humans who understood its benefits and behavior, and the fire would spread until it ran out of fuel or was put out by rain or another water source. These fires would clear away shrubs, grasses, other plants, and fallen trees and branches, resulting in an open forest landscape. An open forest is characterized by widely spaced trees and a low or absent understory of shorter plants. Some plants even need fire to grow. For these species, fire can remove competing plants, stimulate growth, or cause seeds to sprout.

After many years of preventing or putting out all fires in wildland areas, more and more people are beginning to understand how some fires can be good for the ecosystem. Land managers use

Figure 3. A coastal plain is a relatively flat, low-lying area that borders an ocean. In the United States, the southeastern Coastal Plain borders the Atlantic Ocean and the Gulf of Mexico. Do you live close to or in the southeastern Coastal Plain?

prescribed fire to help keep forests healthy and prevent large, destructive wildfires. A prescribed fire, also known as a prescribed burn, is the controlled use of fire under specific weather conditions to restore health to an ecosystem that depends on fire. A prescribed burn is conducted by trained professionals who consider many factors before starting a fire (**figure 4**).

Areas that experience fire can experience a variety of fire conditions, even in places where most of the fires are prescribed. Within a forest, one area can burn every year, while another place in that same forest may go several years between fires. One area may burn in the early spring while another area burns later in the fall. One area may experience a severe crown fire that destroys many trees while another

Figure 4. A forester uses a drip torch to light surface fuels like grasses when performing a prescribed burn.

Fun Fact!

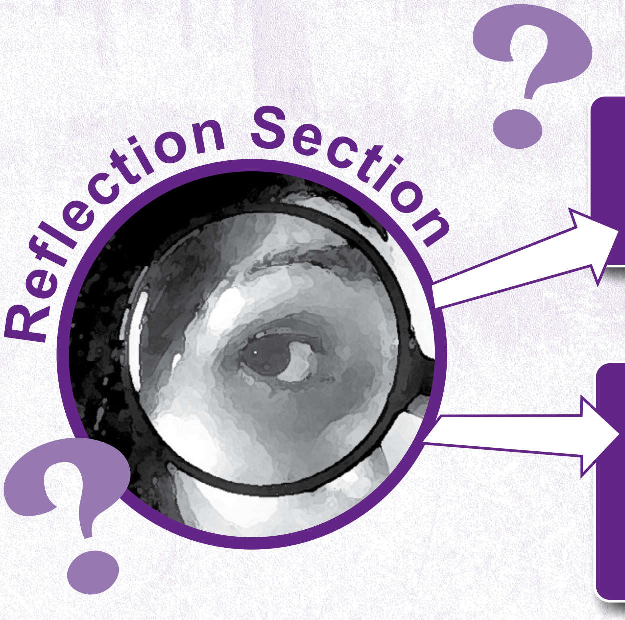
The prefix "pyro" comes from the Greek word "pyr" and means "fire." The same prefix is used in the word "pyrotechnics," which is another word for fireworks. Can you think of any other words that contain the prefix pyro-?

area experiences a less destructive ground fire (see “Fuels and Fire” sidebar). The variety of fires in an area is known as pyrodiversity (**pī** rō də **vər** sə tē).

Scientists hypothesize that pyrodiversity may lead to biodiversity in an ecosystem. If different parts of a forest burn at different times and at different intensities, plants may grow back at different rates. Different plants may grow in different areas. The diversity of plants may result in a diversity of animals who rely on those different plants for food.

Pyrodiversity may also allow animals to seek shelter in unburned places during a fire. Many studies have been conducted on how pyrodiversity affects plants and animals, but fewer studies have been done on how pyrodiversity affects insects, and specifically pollinators.

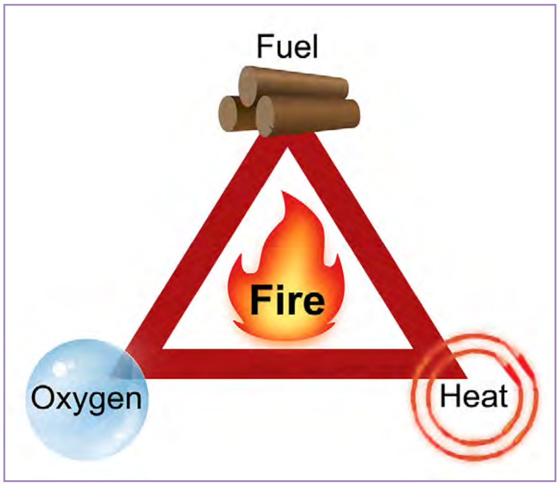
The scientists in this study wanted to know how pyrodiversity affects bee and butterfly numbers and diversity in an open pine forest in Florida that experiences regular prescribed burns.



In your own words, explain what pyrodiversity is.

What did the scientists in this study want to know? Write your answer in the form of a question.

Fuels and Fire



Fire needs heat, oxygen, and fuel to burn. Forests contain many different fuel sources. Grass, leaves, needles, shrubs, trees, and fallen limbs are some of the fuels in a forest. Two of the elements that determine what kind of fire burns in a forest are the type and placement of the fuel.

Below are three types of fire that occur in a forest:

Ground Fire

These fires burn **organic** matter at the soil level, like roots or rotting branches that are in the soil. These fires don't have much flame; they **smolder** instead.

Surface Fire

These fires burn the plant material above the ground, like grasses and shrubs, leaves and pine needles, and branches that have fallen.

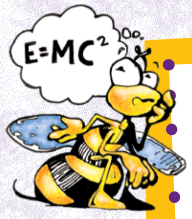
Crown Fire

These fires burn the tops, or crowns, of trees. Crown fires tend to be the most intense fires and are the hardest to contain.

Methods

The scientists conducted their study at Tall Timbers Research Station (TTRS) in Florida. The research station has many burn units. A burn unit is a section of the property that is managed by prescribed burns. The research station manages these burn units for research purposes and for **conservation**. Prescribed burns occur from the late winter to the early summer. Some burn units are burned every year, but most units are burned every 2 years. The frequent burns result in open stands of loblolly pines (**figure 5**). An open stand is characterized by widely spaced trees and a low or absent understory of shorter plants. These open stands are much like the open stands of longleaf pine that used to grow in this region before farming and logging changed the ecosystem. Because of the frequent burns, fires in this region are typically low-severity surface fires. A low-severity fire is a fire with a limited effect on trees, understory plants, and the soil. In a low-severity fire, fewer than 30 percent of the trees are killed.

Figure 5. The burn units at Tall Timbers Research Station that burn regularly are characterized by open forests of loblolly pines. These open forest ecosystems are rich in biodiversity and support many species of plants and animals. You can read more about a similar open forest ecosystem, that of the longleaf pine, in "Knock on Wood," another *Natural Inquirer* monograph.



Number Crunch

The research area for this study at Tall Timbers Research Station (TTRS) was approximately 1,100 hectares. How many acres is the research area?

(Hint: 1 hectare = 2.47 acres)

Scientists in this study selected 26 sampling locations within TTRS (**figure 6**). At each sampling location, they placed a row of three bowls (one yellow, one blue, and one white), each 5 meters apart (see “Thinking About Science” on page 16). The bowls were filled with soapy water to trap insect pollinators and were held 30 centimeters above the ground on wire stands. The bowls were used for 3 days each month from February to September in 2017. Scientists collected and identified each captured bee and butterfly.

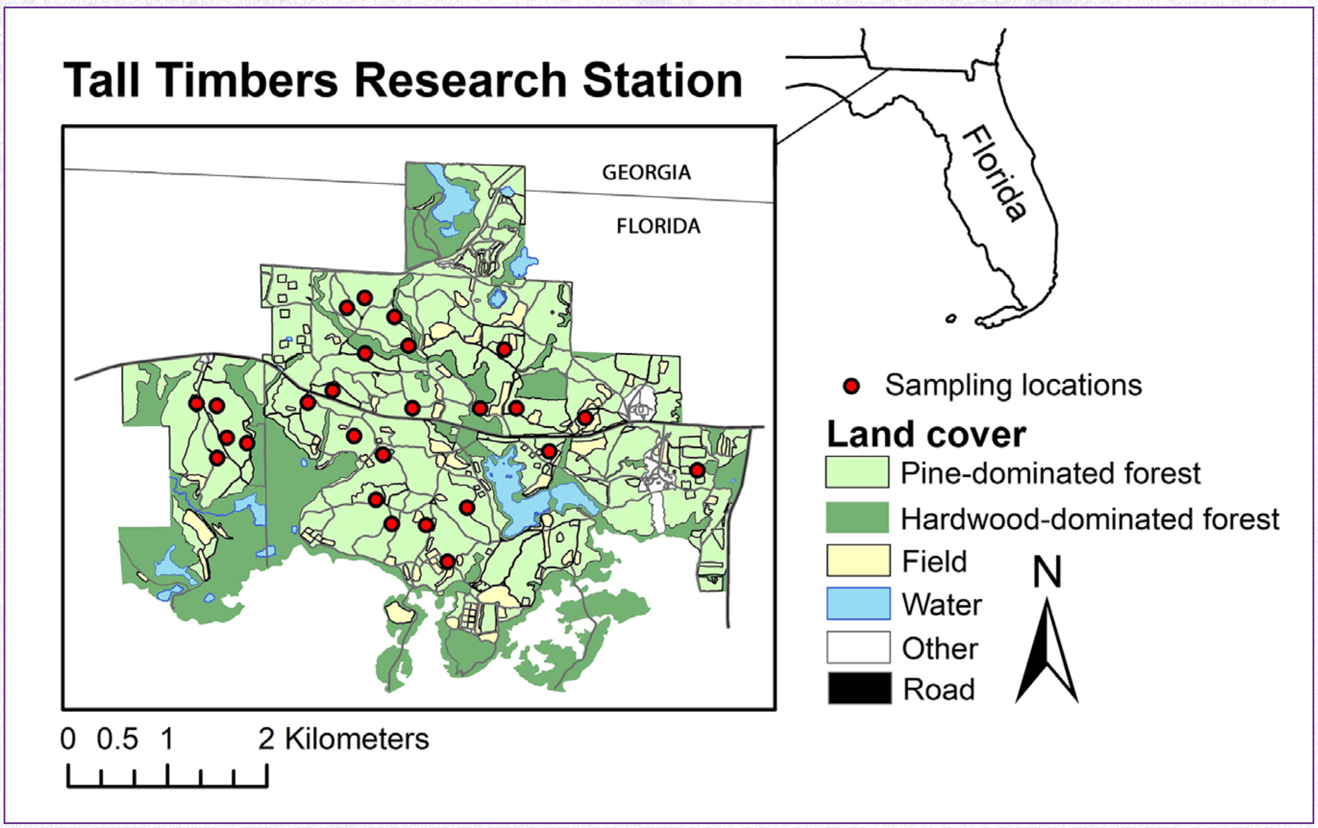


Figure 6. At Tall Timbers Research Station, scientists focused on areas with pine-dominated forests that were at least 250 meters away from the research station’s property boundaries and major waterbodies. Within those areas, the scientists randomly selected 26 sampling locations with a wide range of fire histories.

Figure 7. Scientists wanted to determine the canopy openness over each sampling location. Photo **A** is an example of a more open canopy with fewer branches or leaves covering the sky, while Photo **B** shows a more closed canopy.

Scientists also collected plant data at each sampling location. They marked a 10-meter square around each sampling location. Inside that square, they gathered data on plant height, the amount of bare ground, and the number of plant species present. They also took a picture of the sky above each bowl at each sampling site to measure the amount of **canopy** cover in that area (**figure 7**).

Because TTRS has been used for research on prescribed fire for over 100 years, the scientists had a lot of data about the fires at TTRS. They looked at circular areas with a radius of 250 meters around each sampling location (**figure 8**). They gathered fire history data from 2007 to 2017 for each of the circles. The scientists recorded how many different fires occurred at the location, how big the fires were, and how often they occurred. They also recorded the percentage of area burned at each sampling site in 2017, the year the pollinator samples were collected.

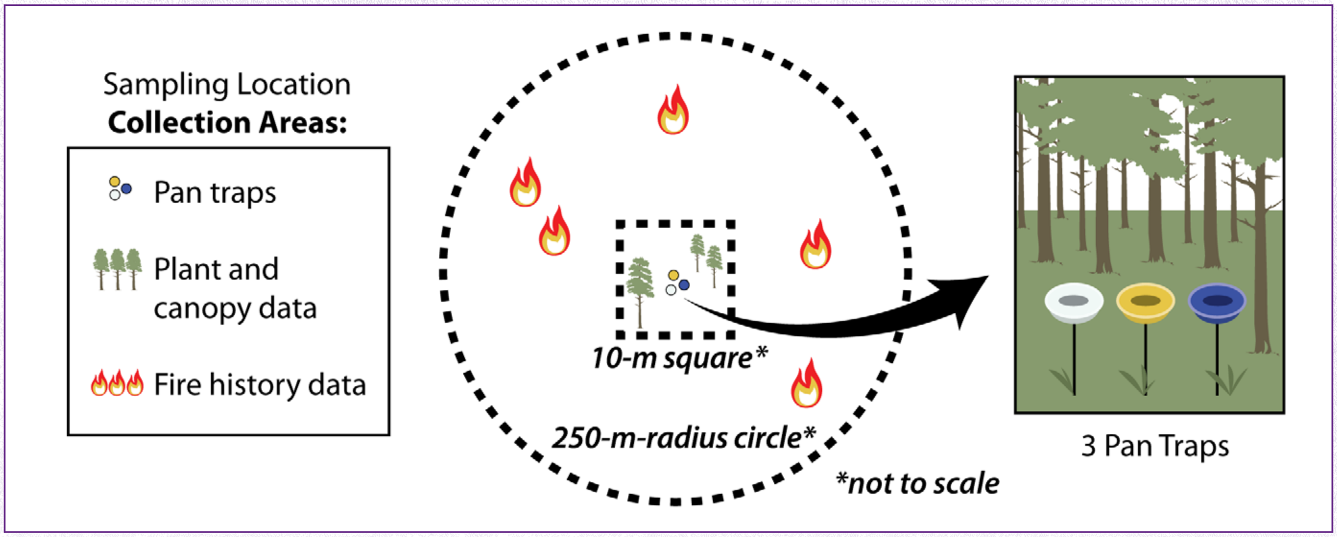


Figure 8. Each of the 26 sampling locations was made up of 3 areas for data collection. Three pan traps were placed at the center of the sampling location. A 10-meter square was marked around the traps to collect plant and canopy data. A 250-meter-radius circle, with the pan traps as the center point, was marked on a map to collect fire history data.

Why do you think scientists used three different colors of pan traps?

How did conducting this research at a research station help the scientists?

Findings

The scientists collected 3,735 bees of 70 different species and 371 butterflies of 30 different species. When the scientists analyzed the data, they found that, in general, sampling locations that experienced greater pyrodiversity had more diverse and abundant bees and butterflies. While this finding was true for most of the bee and butterfly species they sampled, a few species of bees declined in number in areas with greater pyrodiversity.

The same was true of sampling locations that had more area that burned in 2017. In general, the locations with more burned area in 2017 had a greater number of bees and butterflies than other locations (**figure 9**). However, some individual species of bees showed a decline in numbers in areas with recent burns.

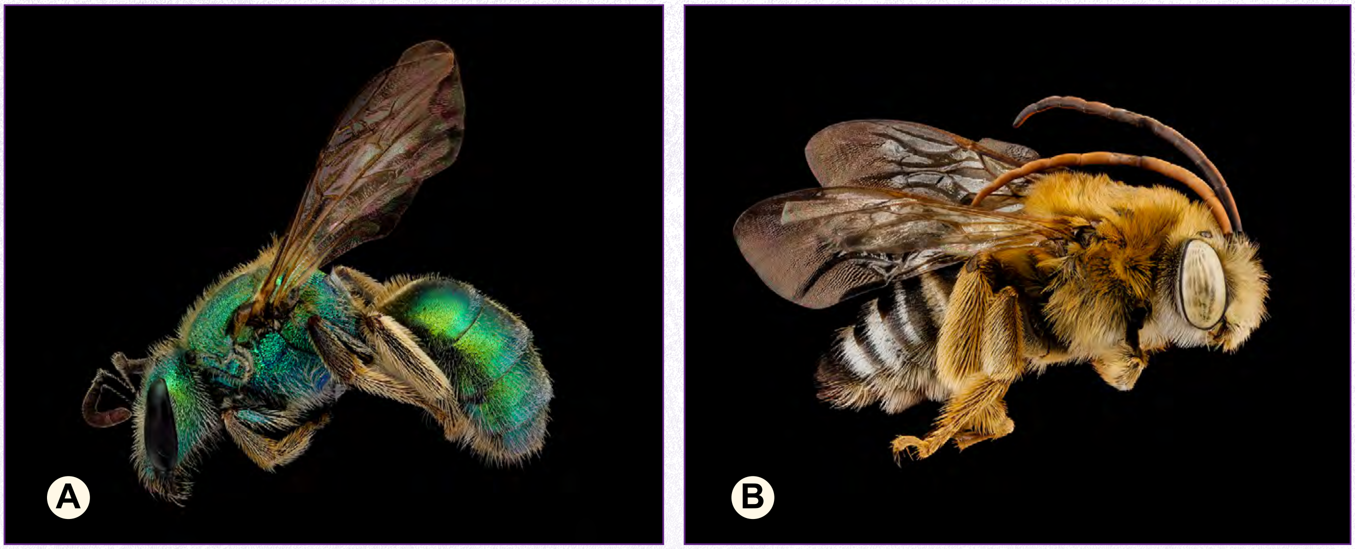
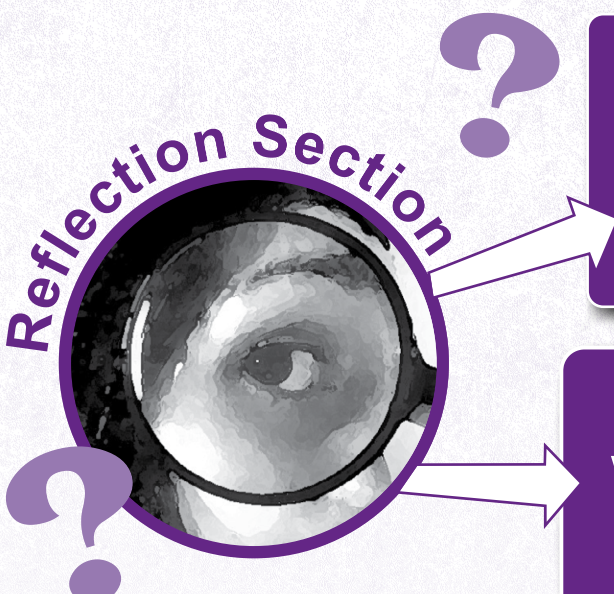


Figure 9. Two bee species, **(A)** the golden green sweat bee (*Augochlorella aurata*) and **(B)** the common long-horned bee (*Melissodes communis*), were more abundant in areas that burned more in 2017.

Areas that burned more frequently tended to have less bee and butterfly diversity and abundance, though butterflies seemed to be impacted more by more frequent fires (**figure 10**). However, not all species followed this general trend. Some species of bees declined in number when fires were more frequent, but the opposite was true of a few species as well. Those bees were present in greater numbers in areas with more frequent fires.

Open canopy areas had higher numbers of bees. The number and variety of bees and butterflies varied with different amounts and kinds of plants growing at the sampling sites.

Figure 10. Two bee species, **(A)** the rugose-chested sweat bee (*Lasioglossum pectorale*) and **(B)** another sweat bee (*Augochloropsis sumptuosa*), had a strongly negative reaction to higher burn frequencies.



In general, which sampling locations had greater abundance and more diverse bee and butterfly species?

Sometimes not all species respond well to a management technique like fire. How would you decide if, when, or how often to use that technique?

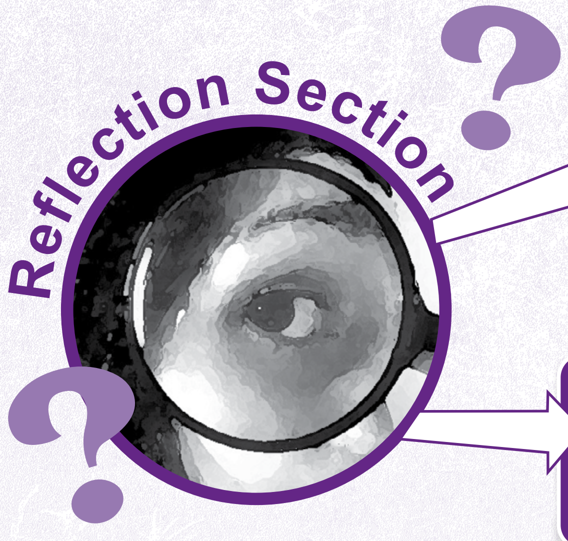
Discussion

In general, the scientists' findings strongly support the hypothesis that high pyrodiversity will contribute to high biodiversity for insect pollinators like bees and butterflies. Locations that experienced a variety of smaller burns on different burn schedules had a higher number of bees and butterflies as well as a greater variety of species.

This abundance and variety may be because these areas have more resources available that are close to the nesting sites of many of the bees. More bee and butterfly species may be successful in areas with varied burns because they may not have to travel very far to find a location in the forest that did not burn and has available food.

However, when fires were too frequent, bees and butterflies were less abundant and fewer species were present. When fires occur too frequently, flowering plants may not be able to grow enough between fires to provide food for pollinators. More frequent fires may destroy more plants that butterflies live on during their immature stages. Also, more frequent fires may not give pollinators enough time to rebuild nests and raise young before the next fire comes.

Even though bees and butterflies generally increased in abundance and diversity in areas with high pyrodiversity, some individual species did not. Because individual species were impacted differently by fire conditions, there may not be one fire management strategy that works for all bees and butterflies. In general, though, efforts to increase pyrodiversity will benefit the majority of insect pollinators like bees and butterflies.



Why might too-frequent fires in one location be a challenge for pollinators?

In your own words, explain the scientists' conclusion.

A FLAME CHANGER

GLOSSARY

canopy (**ka** nə pē): The uppermost spreading branchy layer of a forest.

conservation (kän sər **vā** shən): Planned management of a natural resource to prevent exploitation, destruction, or neglect.

elevated (**e** lə vā təd): Raised above the ground or other surface.

hypothesize (hī **pä** thə sīz): To make a tentative assumption in order to draw out and test its logical consequences.

niche (**nich**, **nēsh**, or **nish**): A habitat supplying the factors necessary for the existence of an organism or species.

organic (ȯr **ga** nik): Related to or coming from living organisms.

refuge (**re** fyüj): A place that provides shelter or protection.

smolder (**smōl** dər): To burn sluggishly, without flame, and often with much smoke.

suppress (sə **pres**): To inhibit the growth or development of.

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

Adapted from Ulyshen, M.D.; Hiers, J.K.; Pokswinksi, S.M.; Fair, C. 2022. Pyrodiversity promotes pollinator diversity in a fire-adapted landscape. Frontiers in Ecology and the Environment. 20(2): 78–83. https://www.fs.usda.gov/research/treesearch/64000.