

# NATURE ILLUMINATED

## The Fireflies of Elkmont

by Amanda Womac

For one week in early summer, thousands of people travel to Elkmont in Great Smoky Mountains National Park to witness the enchanting spectacle of synchronous fireflies. Lynn Faust, a biologist known as the “firefly lady” helped discover this unique display. Using a chemical reaction called bioluminescence, the fireflies perform a mesmerizing mating ritual. These fireflies, however, face threats such as habitat destruction and light pollution. Scientists with the park and Discover Life in America are working to educate park visitors about the critical role fireflies play in our ecosystem and the steps each person can take to ensure these unique critters are around for future generations.

Image by Radim Schreiber









**DEEP IN THE WOODS** on a warm summer evening, a species of beetle signals its mate with a unique flash pattern in Great Smoky Mountains National Park. Synchronous fireflies (*Photinus carolinus*), or lightning bugs as some Appalachian natives know them, are one of at least 19 species of fireflies in the park and one of the few species in North America with synchronized flashing light patterns.

Becky Nichols, a park entomologist, first learned about the synchronous fireflies in 1998 shortly after she started

Above: A female common eastern firefly (*Photinus pyralis*) signals to a mate. The Smokies are home to at least 19 different firefly species, each utilizing a different flash pattern to attract mates. Photo by Radim Schreiber.

Left: Park volunteers assist with the trolley route that shuttles visitors to Elkmont during the synchronous firefly event. Photo by Warren Bielenberg

working in the park. "The fireflies were well known by the local community at Elkmont when people still lived in the area," says Nichols. "It was quite amazing to see the display for the first time with just a handful of other local people who knew about it."

The early summer lightshow is now a tourist attraction. People from all over the world travel to the park for one week in early June each year to experience the magic these Appalachian lightning bugs offer. At first, people flocked to Elmont by the hundreds—parking their cars on the side of the road and trampling through the forest to find their perfect viewing spot.

"There were too many vehicles trying to come in and out of the relatively small area; cars would be parked in precarious places, headlights and flashlights were interrupting the flashing behavior, and people were going off trail, endangering themselves and likely stepping on the female and larval fireflies," says Nichols. "In 2006, we began shuttling people to the site, so the event is much more controlled now. Disturbance to the fireflies is minimized and the visitor experience is much improved."



Park officials close the road into Elkmont for the viewing period and, during the eight-night event, between 800 and 1,000 people view the synchronous fireflies each night. In order to streamline the ticket application process, park officials implemented a lottery system in 2015. Each year, in mid- to late-April, dates for the synchronous firefly display are announced on the park website, social media channels, and through a press release. The lottery opens for four days, which allows applicants to enter their information and choose two preferred dates to attend the event. When the application period ends, a computer chooses names randomly and winners are notified within 10 days.

"In 2019, there were nearly 29,000 applicants vying for the 1,800 tickets available," says Nichols.

## DETERMINING PEAK DISPLAY PERIOD

Lynn Faust grew up spending her summers at a family cabin in Elkmont. "As a child, I was no different from any other East Tennessee child, chasing lightning bugs at sunset, wondering at their funny smell and bright colors and magical flashes," she says. "We enjoyed the wonderful light show from our big, screened-in porch each summer. We talked about them and their beautiful synchrony and waves on the hillside and understood this particular pattern was not in the valley at our homes in Knoxville."

When the park took her family cabin in Elkmont in 1992, Faust was determined to learn more about the synchronous fireflies. She began her journey that has taken her all over the United States, Canada, Central and South America, Asia and Europe conducting research projects, participating in symposiums, and delivering talks about fireflies.

"Like everyone initially, my family and I thought lightning bugs were all the same," says Faust. "Now I know better!"

At first, Faust traveled 120 miles round-trip from her Knoxville home to Elkmont late at night to determine if the synchronous fireflies had started emerging. When she began working with film crews and other researchers, however, she



**The peak display period for the synchronous fireflies in the Smokies is determined by calculating "degree days," which is essentially a measure of maximum and minimum air and soil temperature data from the Elkmont site. Temperature determines the rate of development for the larval stage.**

Top: Faust stands on the porch of Spring Cottage, the (now demolished) cabin in Elkmont where she first fell in love with synchronous fireflies. Photo by Gavin Thurston.  
Above: Faust uses a data logger to record ground temperatures necessary for predicting peak firefly activity. Photo by Tom Uhlman/The Park Scientist/[marykaycarson.com](http://marykaycarson.com)





## CAPTURING THE MAGIC

It started with a vision of a firefly glowing on a blade of grass with the full moon lighting it from behind. Radim Schreiber had no idea how he would take the photograph since camera technology had not yet advanced enough, but he knew it was something he wanted to do. Digital photography progressed and Schreiber's vision became a reality. In 2011, "Amber Firefly" (above) won the Smithsonian magazine photo contest in the Natural World division.

Four years later, he won in the Altered Images category of the Smithsonian magazine photo contest for his photo of the synchronous fireflies in Great Smoky Mountains National Park. Schreiber has won national and international photography competitions, including the 2008 and 2009 Picture Sustainability photo contest hosted by the Rainforest Alliance and the 2010 Galapagos Conservancy photography contest.

"I spent a lot of time between classes in college taking photos of insects—grasshoppers, praying mantis, butterflies—and discovered a whole new world in the grass," says Schreiber. "I got excited about the macro-photography of insects."

By 2015, Schreiber had started photographing fireflies fulltime. In the beginning, he wondered: How do they light up? How do the light organs work and what do look like up close? As he spent more time with the creatures, he began to enjoy just being in their presence.

"I started having a magical night experience and felt connected with nature," says Schreiber. "I was in awe. I felt joy and lightness in the dark. It's fascinating to me."

Growing up in the Czech Republic, Schreiber did not have a childhood experience of fireflies. He thinks the ones in the United States are so unique and interesting that they should not be taken for granted. "Lots of people have beautiful memories from their childhood of catching fireflies in jars," says Schreiber. "I enjoy helping people reconnect to those memories."

Schreiber's book, *Firefly Experience*, is available in visitor center bookstores in Great Smoky Mountains National Park and online at [smokiesinformation.org](http://smokiesinformation.org) and [fireflyexperience.org](http://fireflyexperience.org), where you can learn more about his work and view videos from his experiences.

needed a better process. Faust used phenology—the study of seasonal changes in nature, specifically plants and animals—and began tracking which plants began to bloom and what insects emerged in the woods around her Knoxville home at the same time *P. carolinus* began coming out.

"When we had the cabin, we had simply enjoyed the light show each summer with little attention paid to exactly when it occurred," says Faust. "As a researcher, I needed to first understand their entire lifespan and the fact there is an actual peak. No one knew this at the time."

In addition to phenology, Faust used records from thousands of pages of her own field notes and historical weather records of rainfall, temperature, snow and other weather events. By 1993, Faust, Jonathan Cope-land and Andrew Moiseff, two other scientists who study synchrony, had acquired a research permit to observe the fireflies. In order for fireflies to be considered synchronous, their flashing must be rhythmic, repetitive and show a tendency for unison. After observing the Elkmont fireflies, they determined that *P. carolinus* fit the bill. Until they published their research, only a handful of reports of synchronous fireflies existed in North America.

The peak display period for the synchronous fireflies in the Smokies is determined by calculating "degree days," which is essentially a measure of maximum and minimum air and soil temperature data from the Elkmont site. Temperature determines the rate of development for the larval stage. The degree-day method is used to predict the emergence of a variety of species of insects.

"We all understand the concept of 'early spring' and 'late spring,'" says Faust. "That is all degree days are—they measure the accumulated heat of the season. The warmer it is, the faster or sooner the insects emerge."

Faust and colleague Paul Weston developed the degree-day formula for the synchronous fireflies in 2009 and Nichols has used it ever since to set shuttle dates for the synchronous firefly show. "After calculating the degree days up until a certain point, we can then project further based on predicted temperatures, to arrive at the date range when the peak display will likely occur," says Nichols.

Over the years, synchronous fireflies have peaked as early as mid-May and sometimes later in June. The 29-year-average peak at Elkmont, however, occurs approximately June 6–9.

In 2017, Faust's nearly 30 years of firefly curiosity culminated in the first-ever comprehensive firefly field guide for the eastern half of the United States and Canada. *Fireflies, Glow-worms, and Lightning Bugs: Identification and Natural History of the Fireflies of the Eastern and Central United States and Canada* contains more than 70 species



of fireflies, including historical backgrounds, a chart documenting the flash patterns of individual species, and photos that illustrate distinguishing physical characteristics of these captivating insects.

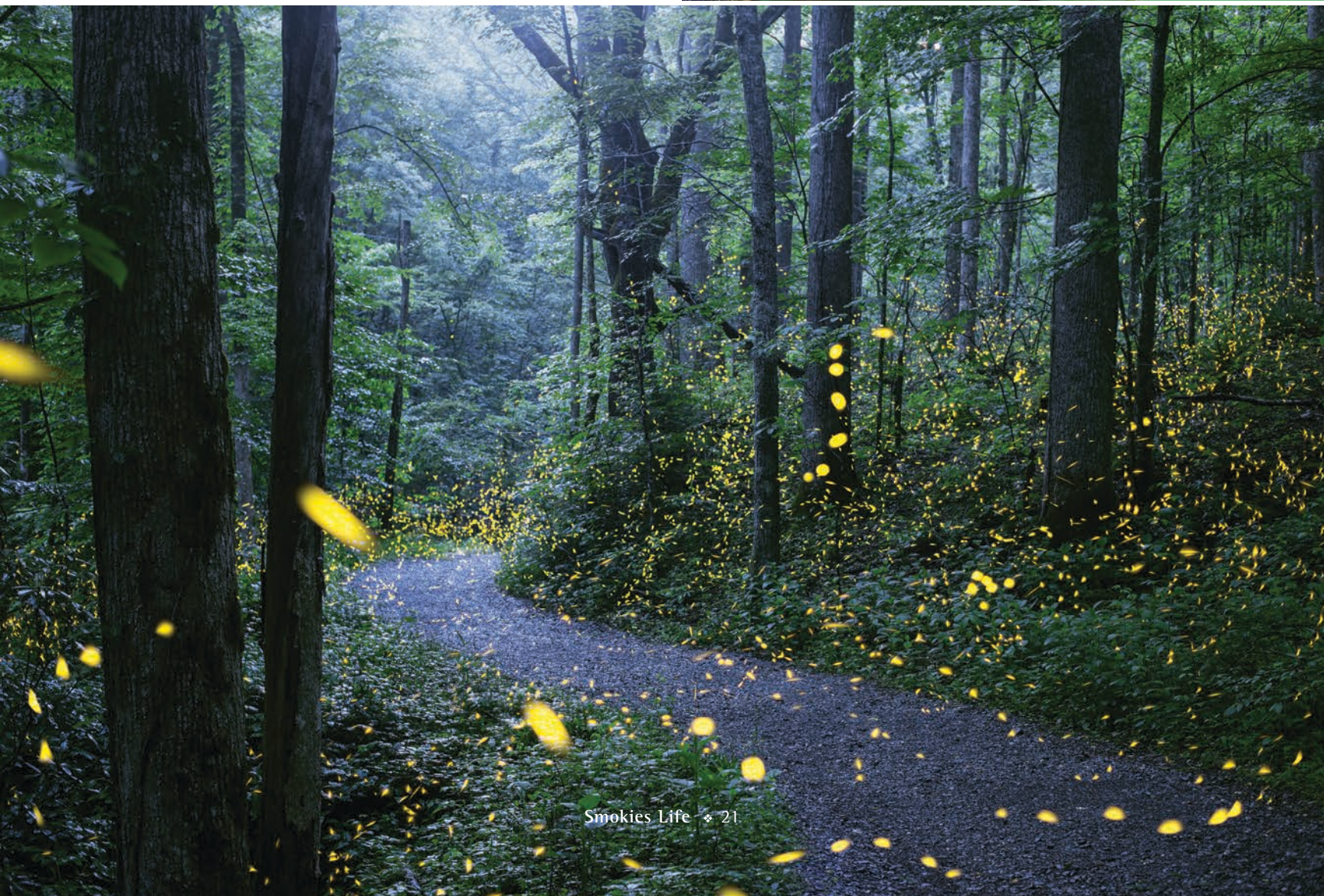
## THE SCIENCE OF FIREFLIES

While the flicker of a firefly in the night sky can seem like magic, it all comes down to a chemical reaction. The basic ingredients are oxygen, calcium and an energy-carrying molecule called adenosine triphosphate. Mix in the light-emitting chemical compound luciferin and combine all the ingredients in the presence of the bioluminescent enzyme luciferase, and the result is bioluminescence—a light produced by fireflies, marine animals, fungi and bacteria. This light, however, does not release heat like a light bulb. Fireflies produce a cold light and astonishingly do not lose much energy during the process.

Fireflies light up primarily to communicate and attract a mate. The males produce a signature flash pattern only females of his own species can identify. During the firefly show at Elkmont, visitors look on while thousands of flying males flash a pattern of six quick light pulses followed by six seconds of darkness to court the females hidden in the leaf litter. When she makes her decision to choose a mate, the female firefly

sends a paler, short, simple and subtle response by pointing her abdomen toward her courting male. The synchronous courtship display continues for about two hours.

Synchronous fireflies like *Photinus carolinus* may fall victim to this *Photuris* firefly, a predatory female that specializes in mimicking other fireflies to lure in males and eat them, including her own males after mating. Below photo by Tom Uhlman/The Park Scientist/marykaycarson.com. Bottom photo by Radim Schreiber





"If you've ever been lucky enough to experience a peak night, you would understand why the synchronous firefly display is such a popular event," says Faust. "I think people love that it is a magical, beautiful display completely orchestrated by Mother Nature. Once someone has experienced it, they want to share it with a loved one the next year. I love seeing so many people leave the comfort and safety of their living room and electronic devices to come to the woods and relax in the dark, quietly anticipating the magical light show."

## ENVIRONMENTAL FACTORS

Environment plays a key role in the firefly show at Elkmont. *P. carolinus* prefers the stage for its courtship ritual humid, dark and clean—and Great Smoky Mountains National Park, which is similar to a temperate rain forest, is prime firefly real estate.

"Firefly larvae are predators and therefore need a diverse array of prey, which typically can be found in an undisturbed forest floor, but development has caused much of this type of habitat to disappear," says Nichols.

Habitat destruction is one of the greatest threats fireflies face in an increasingly developed world. The lifecycle of fireflies is a full year and much of it is spent in the larval stage. Once they mature into adults, they live for approximately 21 days.

Another threat to fireflies is light pollution. A successful courtship depends on a female being able to see the male's flash patterns. Too much human-caused light can disrupt their communication, which leads to lower reproduction success and declining numbers of fireflies worldwide.

"Lightning bugs are an indicator species, or a canary in a coal mine," says Faust. "If they begin to disappear from sites where they were previously abundant, something is very wrong. They are part of the wonderfully complex web of life in the Smokies."

## PRESERVING THE WONDER

Firefly populations are declining worldwide, but these charismatic creatures—a rare quality among insects—are an excellent example of a flagship species that can help educate people about the importance of a healthy ecosystem.

"Humans can help fireflies thrive by considering the habitats required for them to complete their lifecycle," says Nichols. "Minimal or no lighting at night will benefit not only fireflies, but other nocturnal animals as well. Also limit pesticides you use and always follow label directions to avoid harmful effects on non-target insects, such as fireflies and pollinators."



Fireflies may be the Smokies' most famous insect residents, but since the advent of the All Taxa Biodiversity Inventory, over 6,000 other insects have been cataloged in the park. Photo courtesy of DLiA

## TAKING COUNT

In 1998, a group of scientists with Discover Life in America (DLiA) began a journey to identify the estimated 60,000 to 80,000 species in the Great Smoky Mountains National Park through the All Taxa Biodiversity Inventory. To date, they have identified a total of 20,050 species in the park. Of those, 9,564 are new to the park and 1,006 are new to science.

The goal is simple. In order to be good stewards of our environment, we need to understand the web of biodiversity. How many species live in the park? What role do they play in maintaining the ecosystem of the park? How do they interact with each other? Before the ATBI, most of these questions were unanswered.

Although bears and elk are major tourism draws to the park, mammals make up only 2.5 percent of species in the park. Wildflowers and other plants contribute 13.5 percent, but insects, like the synchronous fireflies, spiders, lichen and fungi comprise 84 percent of the total diversity in the park. While they sometimes go unnoticed, these tiny organisms contribute to cru-

cial ecological functions in the Smokies.

On the firefly front, scientists have identified 19 species in the park. In addition to research, DLiA organizers host an annual fundraiser event centered around the synchronous fireflies, blue ghost fireflies and other glowing creatures that live in the park.

"I think 'edu-tainment' is the word that best describes the event," says Will Kuhn, scientist with DLiA and National Science Foundation Postdoctoral Fellow at the University of Tennessee, Knoxville. "Participants learn all about fireflies and then have the opportunity to see them first-hand with a guided viewing. It's quite an experience. I particularly love seeing the expressions on the faces of people who have never seen this magical display before. It's one of my favorite parts of the job!"

DLiA also organizes educational programs for children and adults and provides internships and volunteer opportunities for people interested in learning more about biodiversity and the natural history of the park. Visit [dlia.org](http://dlia.org) to learn more.

Observing firefly health in the park is an important piece of the conservation puzzle. Will Kuhn, a scientist with Discover Life in America (DLiA) and National Science Foundation Postdoctoral Fellow at the University of Tennessee, Knoxville, helps monitor the synchronous firefly species and the blue ghost fireflies. He also works with researchers like Faust to conduct studies in the park.

"We manage the park's All Taxa Biodiversity Inventory, under which 10 species of fireflies have been added to the park's list since the project started in 1998," says Kuhn. "There are currently 19 firefly species known to occur in the park and another five or so that are likely to live here that we have not yet discovered."

Kuhn, who grew up in Texas, did not see many fireflies around his home. When he visited family in Nashville during the summer, he was overwhelmed by how many fireflies he saw. "I was captivated by their display as a kid and later, as an adult entomologist, came to the realization that the typical fireflies I was seeing were actually a number of different species," he says.

Kuhn and his colleagues at DLiA help promote the synchronous fireflies and educate the local community about the species as part of the rich biodiversity of the Smokies. They work with partners in the park and Great Smoky Mountains Association to educate park visitors about the fireflies of the Smokies and their place in the larger biosphere in Southern Appalachia.

"Nearly everyone in the United States—and probably most people across the world—have seen or heard of a firefly," says Kuhn. "Their bioluminescence is something we are drawn to, something of legend. And yet, it's surprising how poorly they are studied in terms of their biodiversity."

As the most visited national park in the country, the Smokies provide an opportunity for scientists like Faust, Nichols and Kuhn to educate millions of people around the world about the importance of fireflies and the role humans play in their conservation. Fireflies exist on every continent except Antarctica. There are an estimated 2,000 species worldwide and more than 125 species in North America.

"Any one of these species may be on the verge of extinction and we barely even know they exist, much less interact with the species around them and how key they might be for keeping their ecosystem in balance," says Kuhn. "In this sense, fireflies are the poster child for a wider problem in biodiversity. We need to know the organisms that inhabit this planet to know how they function as part of the bigger picture. Time is running out for many species as humans are causing irreversible damage to our ecosystem."

Every individual can take small steps right now to help the fireflies in their backyard. Turn off outdoor lighting

when they are not in use. Limit the use of pesticides and herbicides and consider leaving a portion of the backyard to nature to help create habitat for fireflies and other flora and fauna.

"Green spaces like city parks and nature centers play important roles in preserving our various firefly species," says Faust. "Our system of state and national parks is absolutely critical at every level in preserving our amazing diversity of life."

Faust, Nichols, Kuhn and others will continue their work to discover life in the Smokies and keep the firefly population thriving for future generations to experience the magic so many have come to love and cherish as part of a summer experience in the Smokies. ♦

## FIREFLY RESOURCES

- *Fireflies, Glow-worms, and Lightning Bugs: Identification and Natural History of the Fireflies of the Eastern and Central United States and Canada* by Lynn Faust
- [FireflyExperience.org](http://FireflyExperience.org) and *Firefly Experience*, fine art photography and book by Radim Schreiber
- *Mountain Nature: A Seasonal Natural History of the Southern Appalachians* and "Morphology and Behavior of *Phausis reticulata* (Blue Ghost Firefly)," *Journal of the NC Academy of Science*, 2004, by Jennifer Frick-Rupert, professor of biology and environmental science, Brevard College



Image by Radim Schreiber