



Jewels of the Night: Conservation of Fireflies in the U.S. and Canada

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NRCS Conservation Series
Webinar

October 22, 2019

2:00 – 3:00 p.m. ET

Photo: Synchronous fireflies (*Photinus carolinus*) in Great Smoky Mountains National Park, Radim Schreiber / fireflyexperience.org.



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The Xerces Society for Invertebrate Conservation

The Xerces Society is a science-based nonprofit organization that engages in education, outreach, applied research, policy, and restoration to protect invertebrates and their habitats.



Xerces blue butterfly (*Glaucopsyche xerces*), the first U.S. butterfly to go extinct due to human activities

Headquarters in Portland, Oregon, with regional offices coast to coast

Three main programs:

- Pollinator Conservation
- Endangered Species
- Pesticide Reduction

Photos: 2018 Xerces staff by Matthew Shepherd / Xerces Society. Blue butterfly by Dana Ross.

Webinar Moderator and Presenter





Thank You



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Thank you to the NRCS and National Technology Support Centers (and Candy Thomas in particular) for hosting this webinar and to Xerces Society members for funding our firefly conservation work.

We are grateful to our conservation guideline coauthors (Sarah Hoyle, Sara Lewis, Avalon Owens, Eric Lee-Mäder, Scott Hoffman Black, and Sarina Jepsen) who helped us develop the recommendations provided in this presentation. We also express our sincere thanks to the many researchers whose studies, advice, and data have helped shape our firefly conservation efforts.

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Webinar outline



Firefly distribution and life history

- Distribution
- Life cycle, courtship, feeding, and habitat associations



Population status and threats

- What do we know about the status of fireflies?
- Potential drivers of decline



Value for farm management

- Food web
- Watershed protection



Recommendations for conservation

- Actions for farms
- Other considerations

What are fireflies?

Fireflies, which are also called lightningbugs and glow-worms, are beetles in the family Lampyridae.

Fireflies are found on every continent except Antarctica. Over 2,000 species have been described worldwide.



Pyropyga sp. in Rock Creek Park, Washington, DC, Katja Schulz / Flickr.



Fireflies of the U.S. & Canada

- 20 genera
- 168 species, 2 subspecies



Photo: *Photinus pyralis* on basil. Radim Schreiber / fireflyexperience.org

Bottom: *Lucidota atra* by Katja Schulz/Flickr. Top: *Microphotus angustus* by Ken-ichi Ueda/Flickr.

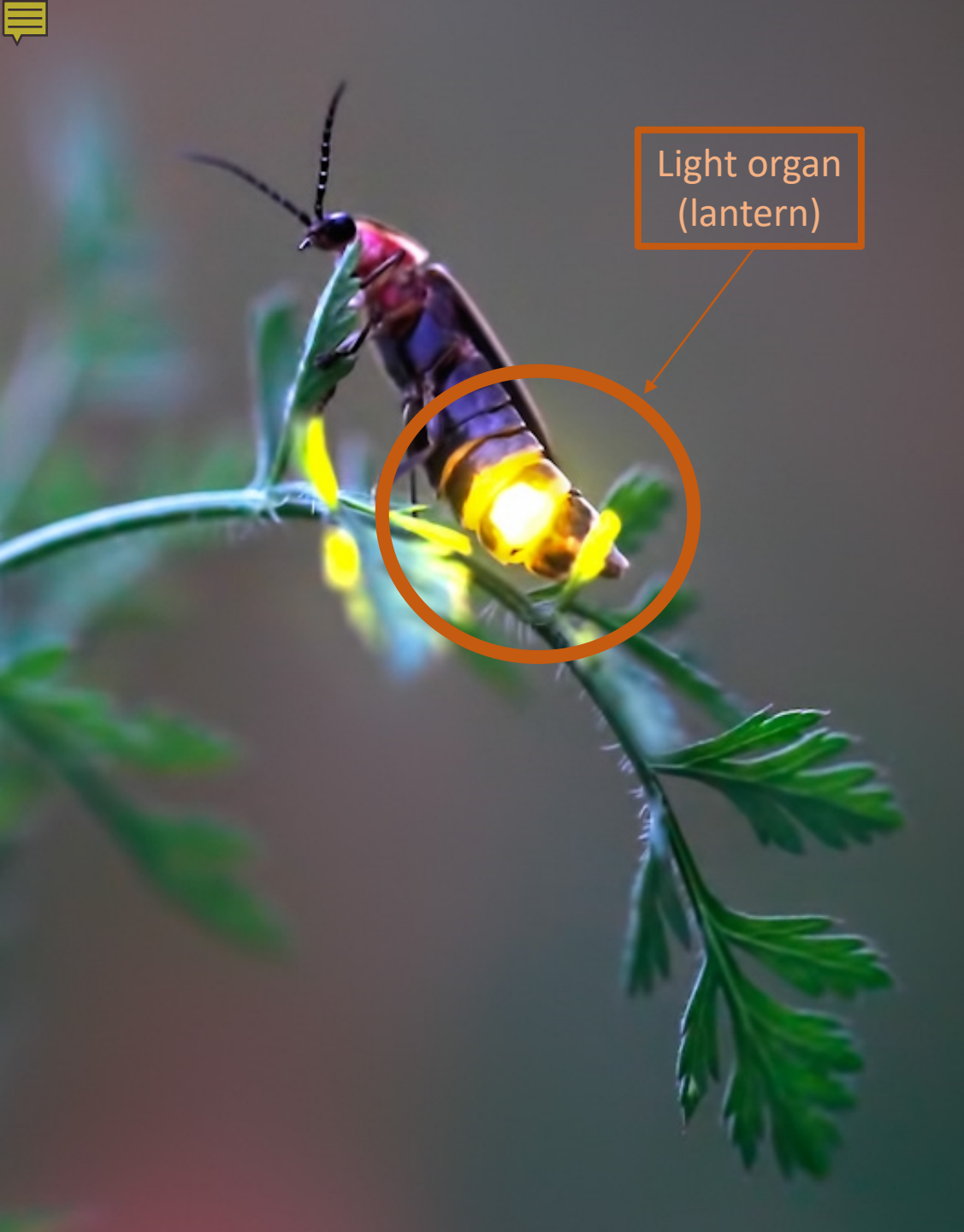
Firefly Life Cycle

- Fireflies undergo complete metamorphosis.
- Larvae and pupae of many species live underground. Some species pupate on the sides of trees.
- Females of most glowing species are flightless and live underground.
- Larval diet consists primarily of soft-bodied invertebrates such as snails, slugs, and earthworms.
- Most species require moisture of some kind and are found in riparian or wetland habitats.



Photo by Heinz Albers/Wikimedia Commons.

Bioluminescence



All firefly species create light via a biochemical reaction that takes place inside larval and adult light organs (called lanterns).

- Although not all adults produce light, larvae do.

How is the light produced?

- The firefly luciferase enzyme allows its substrate, known as luciferin, to interact with oxygen and the chemical ATP to produce a photon of light.

Different species will emit different colors (wavelengths) of light varying from green to yellow to red.

Photo: Radim Schreiber / fireflyexperience.org

Adult Courtship

Fireflies that Flash

- *Photinus*—includes our synchronous fireflies
- *Pyractomena*
- *Photuris*
- *Micronaspis*
- *Bicellonycha*
- *Aspisoma*



Fireflies that use Pheromones

- *Ellychnia*
- *Lucidota*
- *Pyropyga*
- *Paraphausis*
- *Pterotus*
- Others

Fireflies that Glow

- *Pleotomus*
- *Microphotus*
- *Pleotomodes*
- *Phausis*



Photos from left: *Photuris* sp. by Warren Lynn/Flickr, *Microphotus* sp. by Ken-Ichi Ueda/Flickr, *Pterotus* sp. by Ed Sullivan/Bugguide.

Adult Feeding

As a general rule, fireflies only eat in their larval stage. However, there are some exceptions to this.

- Females of some *Photuris* species mimic the flash of other fireflies to lure in males for dinner.
- Other species have been documented nectaring on flowers including milkweed, goldenrod, and aster.
- Maple sap may be used as a secondary moisture source by some species.



Photo: *Photuris* female eating another firefly, Joyce Gross.

Habitat Associations

Fireflies are associated with a wide variety of habitats, from broadleaf deciduous forests to tidal marshes and desert river canyons. Some species are also found in agricultural fields and residential lawns.



Photos (clockwise from top left): Tumbling Run, Flickr; Justin Meissen, Flickr; Nicholas A. Tonelli, Flickr; Emily May; Laura Richardson, Flickr; Arizona Traveler, Flickr; Jennifer Hopwood, Xerces Society; John Griffiths, Flickr.



What is the status of fireflies in the U.S. and Canada?

“Are fireflies disappearing? No one knows for sure, but based on anecdotal evidence firefly populations appear to be fading, with fewer seen every summer.”

Scientific American 2010 (*Only you can help prevent firefly extinction*)

“We have no definitive proof,” says biologist Ben Pfeiffer, founder of Firefly.org, “but there is a broad consensus that fireflies are in trouble...”

NFWF 2017 (*Bringing Back the Light*)

Potential Causes of Decline

Threats to fireflies are thought to include:

- Habitat degradation and loss
- Pesticide use
- Poor water quality
- Light pollution
- Over-collection for medical research
- Invasive species (incl. fire ants, grasses)
- Climate change (incl. drought and rising sea levels)

In addition, events such as hurricanes, floods, and wildfires can further stress populations that are already at risk. Introduced nematodes and other biological controls may also be an issue. Firefly tourism can negatively impact sensitive habitats.

Impacts to larval habitat may be especially critical. Fireflies spend most of their lives in the larval stage—sometimes up to 2 years—whereas adults may live for only a few weeks.

Bottom; Bethany Beach development by Emily May. Top: Light pollution in CA by Mike Knell/Flickr.



Fireflies at Risk



Photo: California pink glow-worm, *Microphotus angustus*. u_phantasticus, iNaturalist.

Certain life history traits may make some species more vulnerable than others:

- Require true dark for mating displays
- Flightless females
- Highly restricted range
- Dependence on at-risk habitat type



Value of Fireflies

Aesthetic, ecological, medical

Fireflies as Pest Management

- Only ~2% of insect species are pests
- \$4.5 - \$12 billion annual value of natural pest suppression by insects
- Many dwell at or beneath the soil surface

Fireflies are voracious predators of soft-bodied invertebrates such as snails and slugs, making them valuable predators of crop and garden pests.



Photo: *Lampyris noctiluca* (European glow-worm) by Katja Schulz / Flickr.

Fireflies as Prey



Photo: Firefly trapped in a spider's web, Frank Starmer/Flickr.

Spider food

Spiders are the best-documented invertebrate predators of fireflies.

Other invertebrate predators include assassin bugs and hangingflies.

Vertebrate predators are less common.

Value to Other Wildlife

Firefly habitat

Firefly habitats are compatible with the needs of other wildlife



Protecting, restoring, and enhancing habitat for fireflies can benefit many other species and promote overall soil and watershed health.

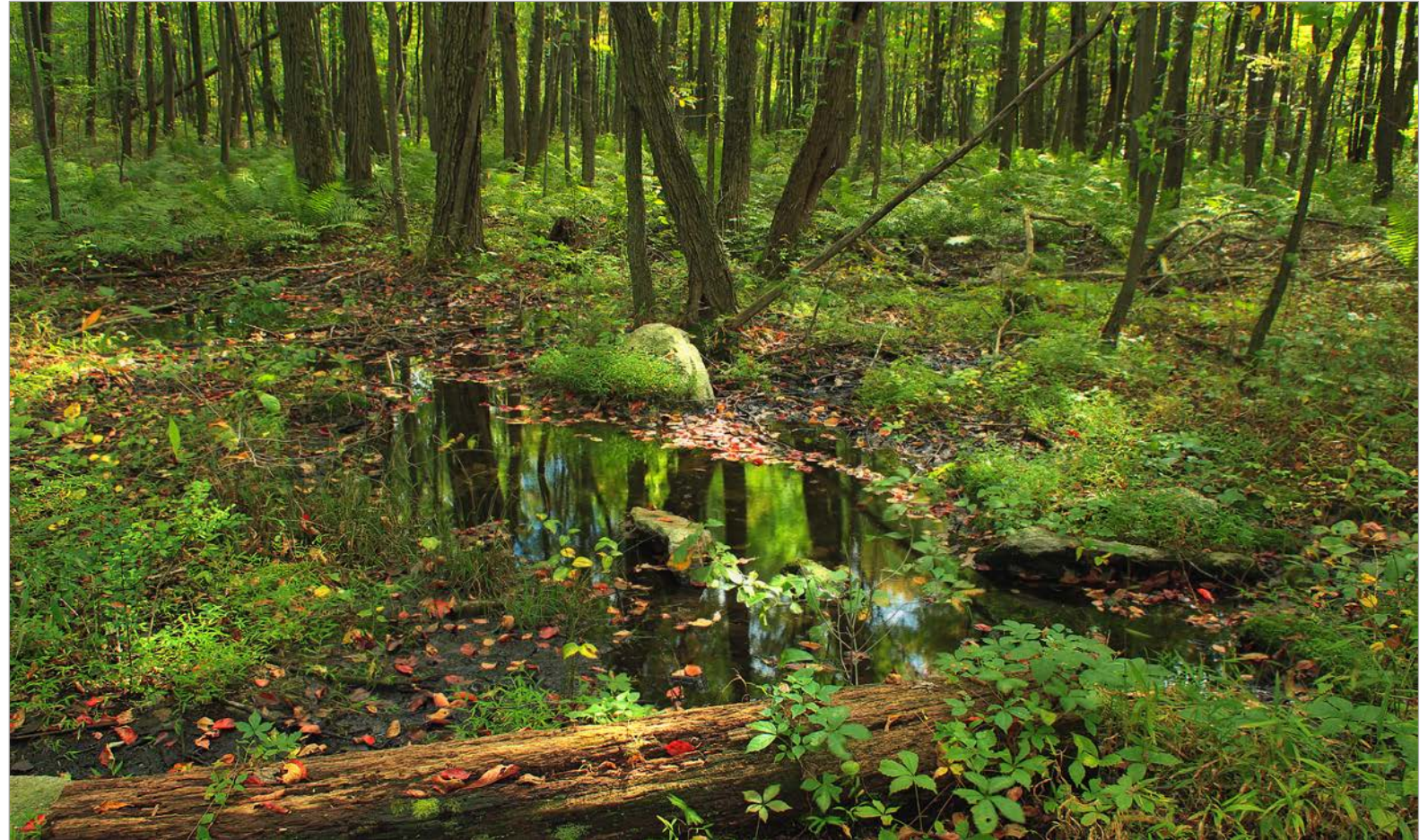


Photo: Nicholas A. Tonelli/Flickr

Conservation Recommendations



Photo: The blue ghost firefly, *Phausis reticulata*, in an Atlantic white cedar forest in Delaware.
Radim Schreiber / fireflyexperience.org

What do fireflies need?

In addition to protection from pesticides and other negative influences on their habitat, fireflies need four primary things.

Moisture

To prevent desiccation of fireflies and their prey



Food

Including soft-bodied invertebrates like snails, slugs, and earthworms



Shelter

Leaf litter, underground burrows, and native vegetation



Dark nights

For species active after dark



Photos from left: Justin Wheeler, Heinz Albers/Wikimedia Commons, Sarah Foltz Jordan/Xerces, Radim Schreiber/fireflyexperience.org



Photo: *Photinus pyralis* by Katja Schulz, Flickr.

Do you have fireflies?

Determine if they are present at your site

When: Adults of most species are active during the summer, from June through August.

Where: Wetlands, forests, desert canyons, fields—anywhere with adequate moisture and food supplies.

How: Visual surveys for flashing and glowing species; sweep net surveys for day-active species.



Assessing your site

Do fireflies currently inhabit the site, or have they in the past?

Will restoring this site link existing populations?

Fireflies do not disperse very far, so keep in mind that newly created or restored sites may not immediately attract fireflies if they are not already present in your area.



Photo: Blue ghost firefly, *Phausis reiculata*, Blue Ridge Mountains, NC.
Radim Schreiber/fireflyexperience.org.



Habitat Protection

Actions for Working Lands



Key Actions for Protecting Fireflies

1

Protect fireflies and their habitat from ground disturbing activities

- Leave leaf litter and mulch
- Mow less often
- Exclude cattle from fragile areas
- Conduct activities on a rotational basis

2

Be conscientious about pesticide use

- Eliminate cosmetic uses
- Use within an IPM framework when needed

3

Monitor and control invasive weeds

- Use a scouting program for early detection
- Consider the needs of fireflies in any control methods that are utilized

4

Reduce light pollution

- When possible, eliminate artificial light at night
- Consider switching to motion detectors, changing your bulb color, or shielding the light so it targets a smaller area

Leave the Leaves!



Image: The Xerces Society

Overwintering is an essential component to invertebrate conservation that is often overlooked.

Leaves are natural fertilizers – leaving a thin layer is great for gardens and yards.

Leaves provide natural shelter for fireflies, bees, butterflies, moths, snails, etc.

Conservation
Practice Standard:
Mulching (484)

Leave Leaf Litter and Mulch

Leaf litter provides shelter and improves moisture content of the soil.

- Retain leaf litter when possible!
- Refrain from raking or leaf blowing.
- Consider using fallen leaves in place of wood mulch:
 - Add around newly planted habitats
 - Use as part of a weed mgmt. plan



Photo: Sarah Foltz Jordan/Xerces Society

Mow Less Often

Mower blades and ground trampling can directly kill fireflies, as both larvae and egg-laying females spend most of their time on the ground. Males use grasses and forbs as resting places.

- Allow grass to grow higher so fireflies have more places to hide and find shelter.
- If you do mow, set your mower height higher to leave a buffer between fireflies and the blade.
- Mow when fireflies are the least active, usually in the winter.

Weeds or natural habitat left unmown can provide valuable floral resources for pollinators, predators and parasitoids, shelter, habitat for spiders and for alternate prey, and refuge when crops are harvested.

Conservation Practice Standards: Upland Wildlife Habitat Management (645), Early Successional Habitat Development or Management (647)



Exclude Cattle from Fragile Areas



- Use fencing or other exclusions to keep cattle and other animals from destroying fragile wetland habitats used by fireflies, especially in the arid West.

Conservation Practice Standards: Fence (382), Wetland Wildlife Habitat Management (644). Supporting practices: Livestock Pipeline (516), Watering Facility (614).

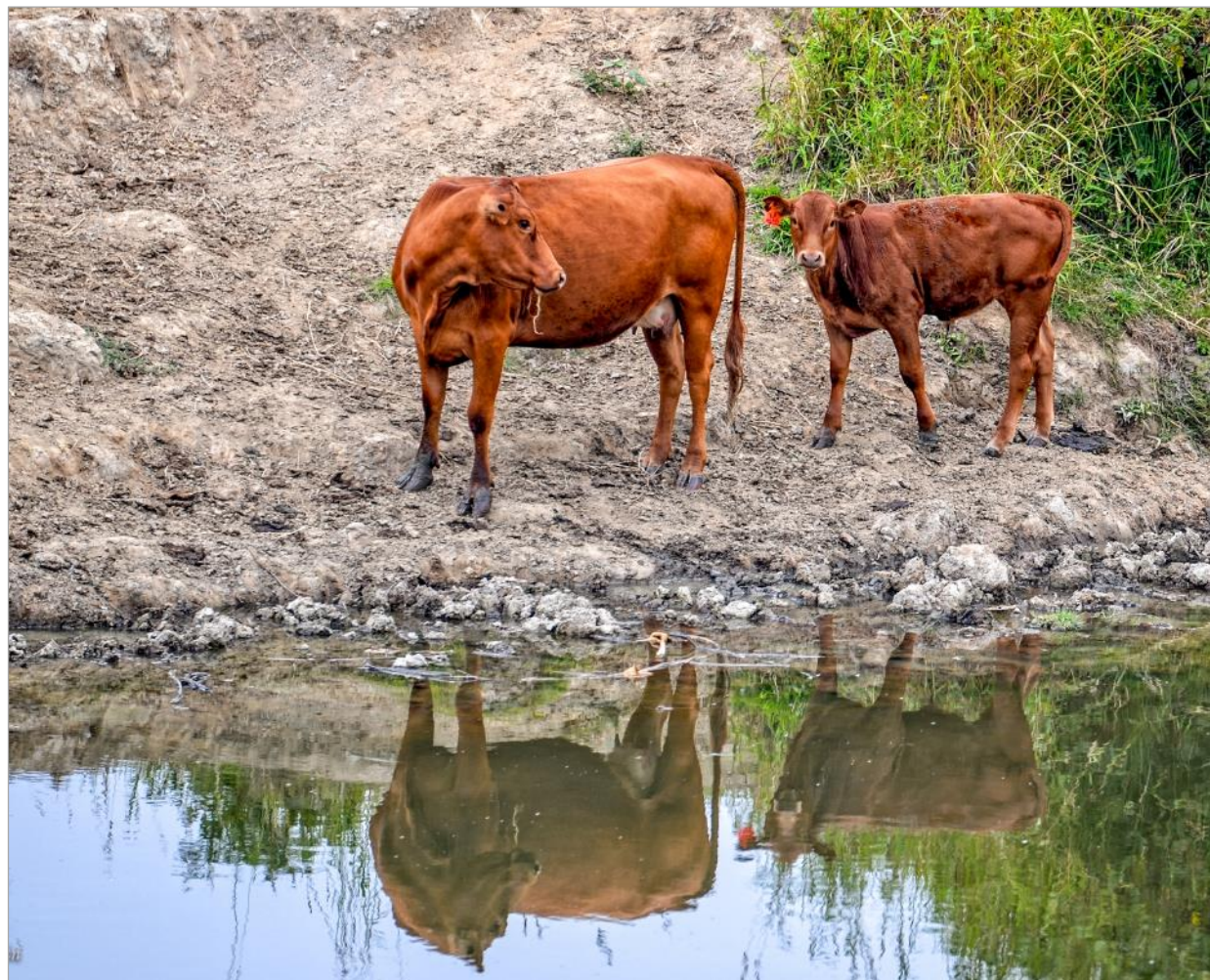


Photo: Stephen Curtin / Flickr



Conduct Activities on a Rotational Basis

Limit disturbance frequency and duration

In general, mowing, grazing, burning, disking are best at infrequent intervals

- Disturb no more than 1/3 of habitat area each year
- Time management actions for when they are most effective against target species, or during the dormant season
- For fireflies, dormancy of larvae and flightless females is most important—this is usually over the winter, although it may extend from late fall to early spring at higher latitudes

Conservation Practice Standards: Upland
Wildlife Habitat Management (645);
Prescribed Grazing (528)

Eliminate Cosmetic Use of Pesticides

- Eliminate all cosmetic or unnecessary pesticide use that is not responding to economic damage or a public health risk.
- If pesticides are used, work to minimize impacts to fireflies and their habitat.
- When managing weeds with herbicides, spot treat to minimize negative impacts to plants used by fireflies.



Photo: Apionid / Flickr

Address Pests with IPM

Use pesticides as a last resort

Reduce or eliminate pesticide use that can kill fireflies or their prey, or alter their habitat.

- Avoid broad-spectrum insecticide use, including all neonicotinoids, in and around firefly habitat.
- Minimize herbicide use in firefly habitat to avoid potential negative impacts.
- Reduce or eliminate potential for pesticide drift into firefly habitat.

If mosquitos are a concern, create an integrated mosquito-management plan. Only consider insecticides to reduce adult mosquitoes during a disease outbreak, and use them as a last resort in a manner that is as targeted as possible.

Conservation Practice Standard: Pest Management Conservation System (595)

Photo: US National Park Service

Understand impacts of chemical fertilizers



Photo: Candace Fallon, Xerces Society

Consider effects
on prey

Chemical fertilizers
(especially ammonia
based products), can
add salts to soil and
can kill firefly prey.

Monitor for and control invasive weeds

Use a scouting program

Identify and control invasive weeds before they overwhelm a site, potentially crowding out the diverse structural components fireflies need

Conservation Practice Standards: Herbaceous Weed Treatment (315), Brush Management (314)



Photo: Grand River Conservation Authority, Flickr

Reduce light pollution



Photo: Fireflies in the Catskills, Delaware County, NY, by [s58y](#) / Flickr.

Fireflies need dark nights

- More than 60% of invertebrates are nocturnal, which makes them more vulnerable to light pollution.
- More than three-quarters of firefly species in the United States and Canada are nocturnal or crepuscular (active at dusk), and these species rely on bioluminescent light signals to communicate.



Habitat Restoration

Considerations



Choosing a restoration site

Consider the basic needs of fireflies and determine whether your site is suitable.

- **Water availability.** One of the most important factors is the availability of moisture, which most firefly species and their prey need. Does your site have a perennial water source or moist, shady places that can support fireflies? If not, can you create a water source (e.g., a small pond or water feature)?
- **Distance from artificial light sources.** Dark nights are important for many species of fireflies. Is your restoration site adjacent to an area that is lit at night? If so, are there steps you can take to mitigate light pollution?
- **Exposure to pesticides.** While fireflies can be found in abundance in some agricultural areas, consider potential pesticide use and associated drift before restoring or creating sites within or adjacent to these areas.
- **Presence of invasive plants.** Are invasive plants present at your site? If so, identify replacement native plants that have similar structural value to the nonnative species and develop a restoration plan that reduces the impact of habitat conversion on fireflies by restoring only a third of the site in any given season.
- **Habitat types.** Fireflies are often associated with moist sites, such as wet meadows, riparian areas, and woodlands, although they can be found in a large variety of habitats, from old fields and urban lots to desert canyons and mangrove swamps. If possible, determine which species naturally occur in your county or region and focus on providing habitats those species are known to use.

Plant Selection

Considerations

Grasses. Tall grasses provide cover for larvae and their prey. They can also give female fireflies a better vantage point at night, when they crawl up to watch for males flashing overhead.

Flowering forbs. Although most adult fireflies do not feed, there are some reports of adults visiting flowers including aster, goldenrod, and common milkweed.

Providing a diversity of flowering plants throughout the growing season may benefit fireflies and can also increase the diversity of pollinators and other wildlife at your site.

Image: Danielle Lamberson Philipp, <https://grow.cals.wisc.edu>



Plant Selection

Shrubs. Brushy areas provide shelter and perches for fireflies, and they increase the diversity of vegetation heights available to them.

Trees. Tall trees adjacent to or within habitat can provide shade and shelter as well as mating display perches for species that signal from the canopy. Tree branches can also help block light pollution, increasing the darkness needed for bioluminescent communication.



Photo: *Pyralis farinalis* larva. Katja Schulz, Flickr



Watershed health

Protecting and restoring firefly habitat also contributes to watershed health:

- Protecting riparian areas helps reduce runoff, improve infiltration, and reduce nutrient loads entering waterways
- It provides habitat for pollinators and other wildlife that is especially important during periods of drought
- It helps reduce flooding



Resources

- Conservation guidelines
- Species identification
- Community science efforts
- Conservation biocontrol

Conserving the Jewels of the Night

Guidelines for Protecting Fireflies in the United States and Canada

Candace Fallon, Sarah Hoyle, Sara Lewis, Avalon Owens, Eric Lee-Mäder, Scott Hoffman Black, and Sarina Jepsen



Image from www.xerces.org

Conservation Guidelines

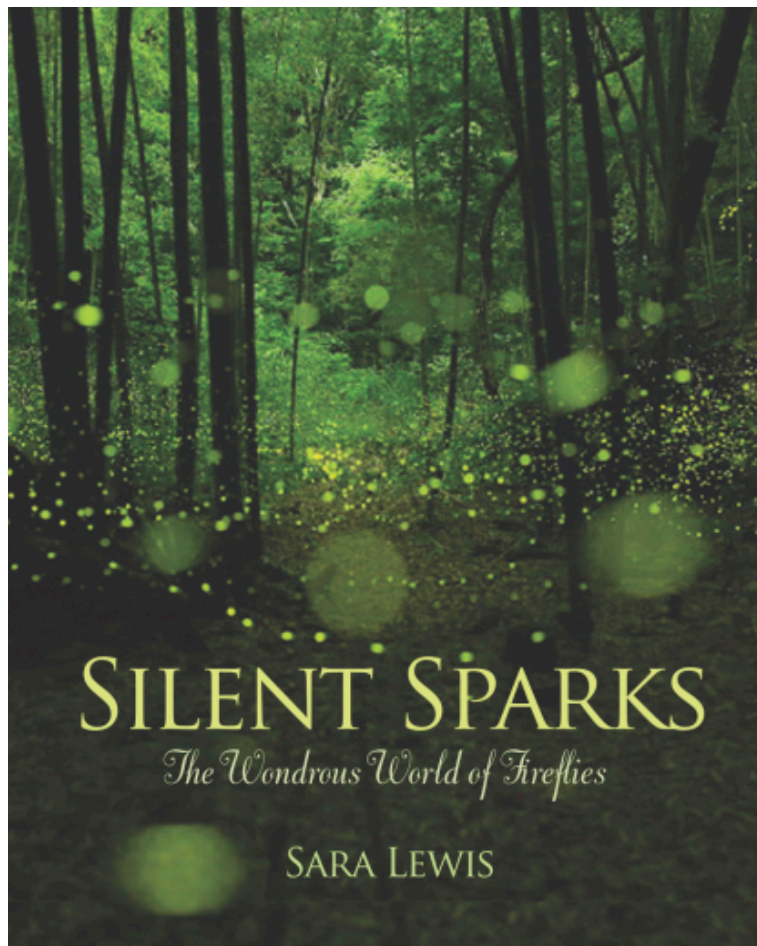
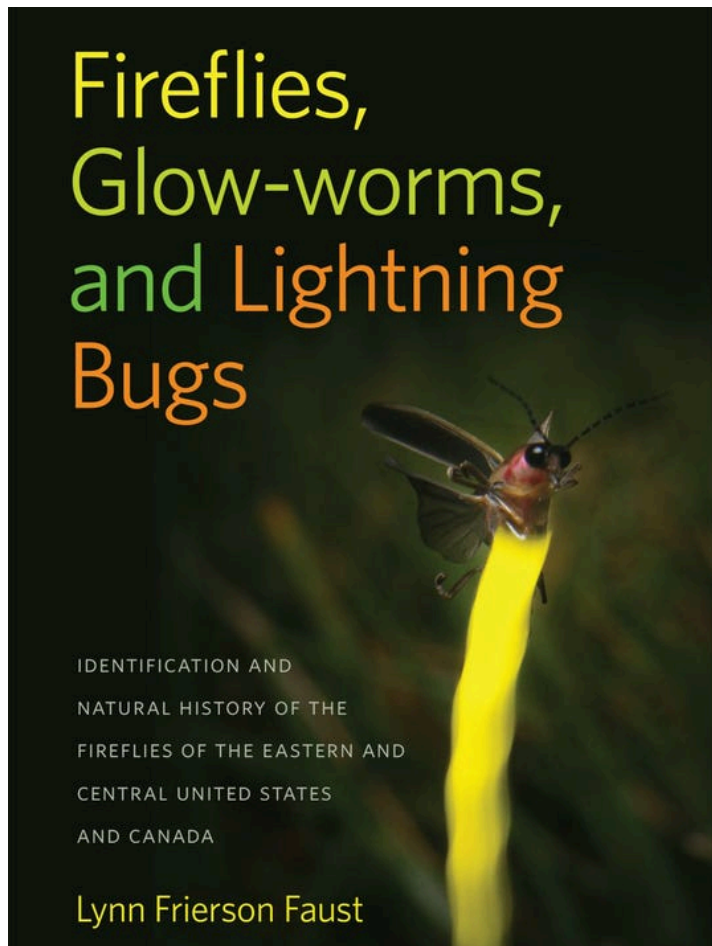
by The Xerces Society

Newly released!

Coauthored by biologists with the Xerces Society
and Tufts University

[https://xerces.org/publications/guidelines/
conserving-jewels-of-night](https://xerces.org/publications/guidelines/conserving-jewels-of-night)

Firefly ID Guides



Field Guide to Western North American Fireflies

By

Larry Buschman (March 2016 Draft)

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Images (from left): KnoxNews.com, SilentSparks.com, <https://entomology.k-state.edu/doc/WesternFireflies%20March%202016a.pdf>.

Community Science Efforts

Fireflyer's International Network: iNaturalist

Map of Observations

The screenshot shows the iNaturalist project page for "Fireflies of the USA and Canada". On the left is a map of North America with grey circles indicating observation locations. The main content area includes an "About" section with a description of the project and a "Recent Observations" gallery. The gallery contains four images of fireflies with their respective species names and observation times.

| Overview | 13,510 OBSERVATIONS | 74 SPECIES | 1,775 IDENTIFIERS | 6,702 OBSERVERS | Stats |
|----------|---------------------|------------|-------------------|-----------------|-------|
|----------|---------------------|------------|-------------------|-----------------|-------|

Recent Observations

- Winter Firefly *Eilychnia cornusca* 115 hours ago
- Genus *Photinus* 4 months ago
- Winter Firefly *Eilychnia cornusca* a day ago
- Genus *Pyraclomena* 2 days ago

Images from iNaturalist, <https://www.inaturalist.org/projects/fireflies-of-the-usa-and-canada>



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Community Science Efforts

Mass Audubon: Firefly Watch

Firefly Watch Citizen Science Project



Firefly Watch combines an annual summer evening ritual with scientific research. Join a network of citizen scientists around the country by observing your own backyard, and help scientists map fireflies.

Why Watch Fireflies?

Are firefly populations growing or shrinking, and what could lead to changes in their populations? Mass Audubon has teamed up with [researchers from Tufts University](#) to track the fate of these amazing insects.

With your help, we hope to learn about the geographic distribution of fireflies and what environmental factors impact their abundance.

FOR PROJECT PARTICIPANTS

[To Submit Observations](#)

[Log in to your account >](#)

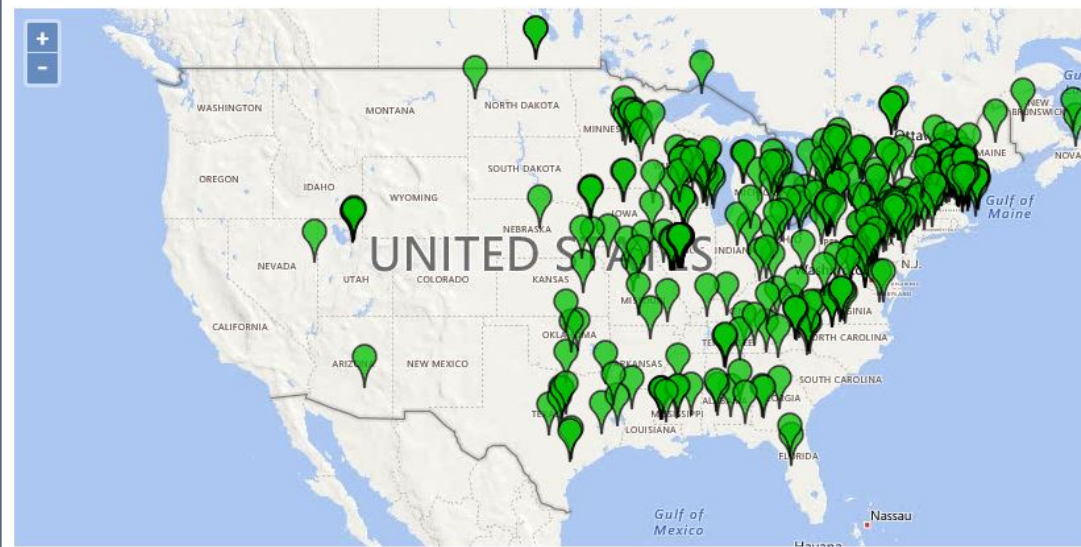
[Project FAQ](#)

Questions about the project? Explore our answers to some of the [most commonly asked questions](#).

2019 Project Data

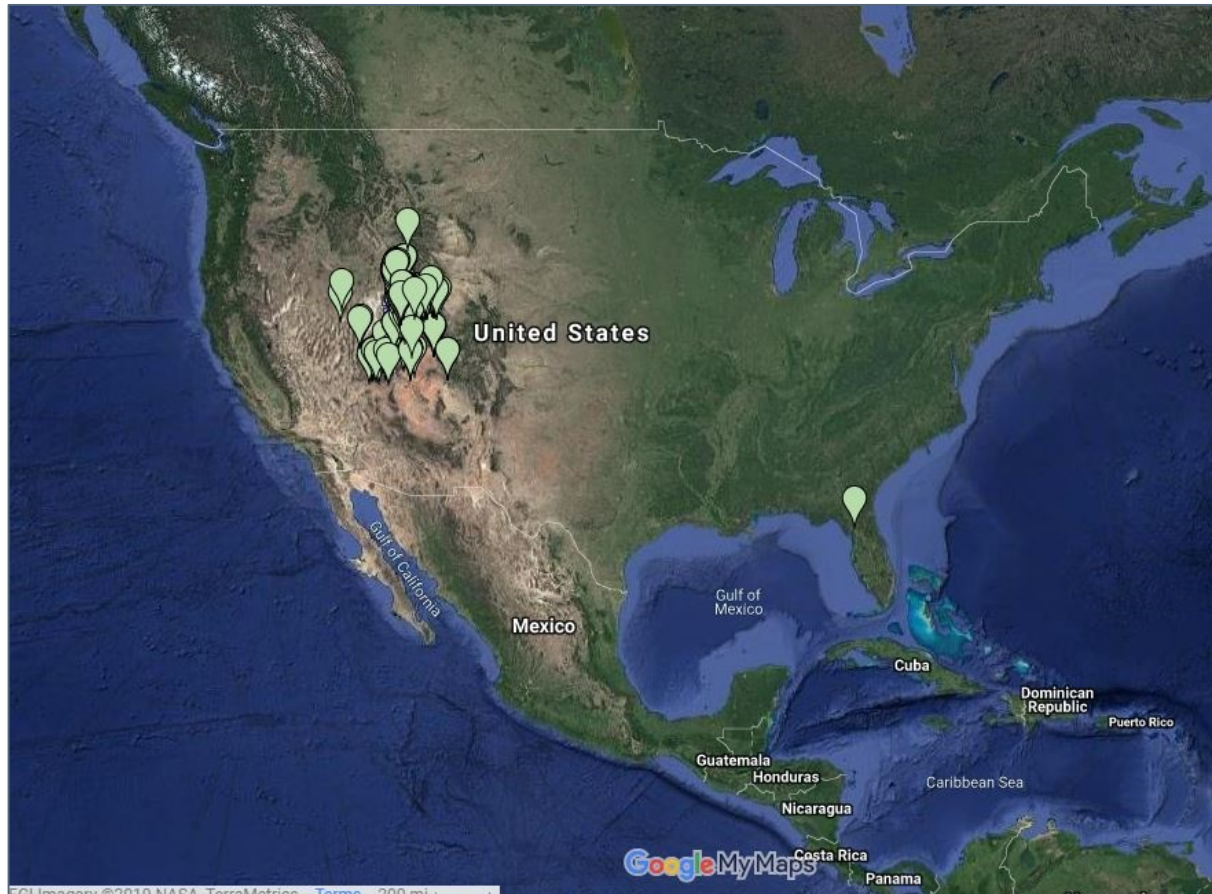
Explore the Data

The map below shows firefly observation data. **Click on an individual marker** to see a participant's first and last recorded observations at that location. See the *legend below the map for an explanation of the "fireflies seen" icons*.



Community Science Efforts

Natural History Museum of Utah: Western Firefly Project



Western Firefly Project: A Community Science Initiative

Did you know there are fireflies in Utah and other western states?

For many years, the Natural History Museum of Utah's entomologist Christy Bills had been hearing anecdotes from Utahns about occasional firefly sightings. The purpose of this project is to continue to find fireflies in the western U.S. in places where they are not expected to be.



The Natural History Museum of Utah has partnered with scientists at BYU to track their populations throughout Utah, using the help of citizen scientists. Geneticists at BYU are researching the relationships of various species and how the populations in Utah, that are separated by hundreds of miles and many geographical barriers, are related to the Eastern U.S. populations.

Project Background

Begun in 2014 as the Utah Firefly Citizen Science Project, the project is expanding to other western states in 2019.

Habitat Planning for Beneficial Insects

Guidelines for Conservation Biological Control

Jennifer Hopwood, Eric Lee-Mäder, Lora Morandin, Mace Vaughan,
Claire Kremen, Jessa Kay Cruz, James Eckberg, Sarah Foltz Jordan,
Kelly Gill, Thelma Heidel-Baker, and Sara Morris



Conservation Biocontrol

Guidelines

Check out our habitat planning guide for
beneficial insects at:

[https://xerces.org/habitat-planning-for-beneficial-
insects/](https://xerces.org/habitat-planning-for-beneficial-insects/)



Questions?

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