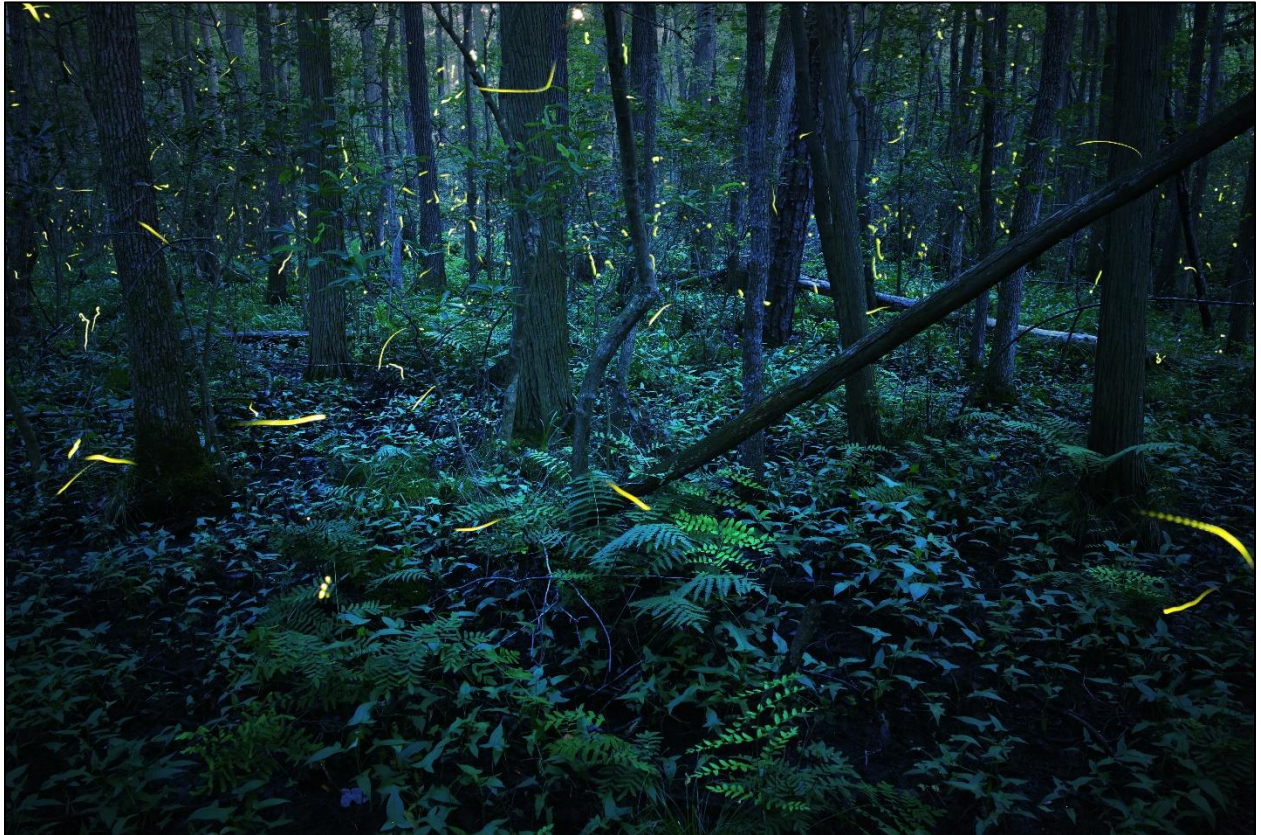


# **FIREFLY SPECIES FACT SHEET:** **Mysterious lantern firefly (*Photuris mysticalampas*)**



*Long-exposure image of mysterious lantern firefly flash patterns in Delaware (Radim Schreiber).*

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**Xerces Society for Invertebrate Conservation**



**Scientific Name:**

*Photuris mysticalampas* Heckscher, 2013

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Lampyridae

Subfamily: Photurinae

Tribe: Photurini

(ITIS 2023)

Synonyms: None

**Common Names:**

Mysterious lantern firefly, mystical lantern firefly

**Taxonomic Note:**

This species' name comes from the Latin "mystica," meaning mystical or mysterious, and "lampas," meaning flame or lantern. This is inspired by the males' surreal courtship display; their prolonged greenish flashes appear like distant torches, signaling slowly on and off through the dense forest understory. The mysterious lantern firefly was first recognized as a distinct taxon in 2005 and later formally described by Christopher M. Heckscher in 2013 (Heckscher 2013; ITIS 2023). Unlike other species of *Photuris*, which are difficult to distinguish from one another morphologically, *P. mysticalampas* has morphological characters—a small, oval-shaped body when viewed from above and densely pubescent elytra—that clearly distinguish it from other species within its range (Heckscher 2013; Lloyd 2018). The oval body outline is rather pronounced, with a large width-to-length ratio; other *Photuris* species in the area have a slenderer body shape (Heckscher 2013).

**Conservation Status:**

Global Status: G1G2 – Critically Imperiled (last reviewed 23 December 2021)

National Status (United States): NNR

State Statuses: SNR – State Not Ranked (DE)  
(NatureServe 2023)

Federal Status (United States): Petitioned for listing, awaiting 90-day finding (Geest et al. 2023)

IUCN Red List: Endangered (Fallon & Heckscher 2021; Fallon et al. 2021)

Species of Greatest Conservation Need (Tier 1): Delaware (Delaware Division of Fish and Wildlife 2015)

**Technical Description:**

Adult: The mysterious lantern firefly is a member of the *Photuris versicolor* complex. Adults of most species within this group exhibit the following characteristics: humpback posture; long legs; red, yellow, and black protonota; and pronotal markings in the shape of an arrow, T, or anchor (Faust 2017; Figure

1). The elytra are striped. Dissection of adult male genitalia, which can often help with species-level identification in morphologically similar species, does not yield enough differentiation in this group to confidently assign identifications.

While mysterious lantern fireflies are similar in appearance to other sympatric *Photuris* fireflies, including *P. pensylvanica*, *P. hebes*, *P. eliza*, and *P. sheckscheri*, they can be distinguished from these other species by their small oval-shaped bodies, dense elytral pubescence, specific habitat association, and unique flash pattern (Heckscher 2013; Lloyd 2018). At 8.2-10.55 mm in length, adults are considered small for the *Photuris* genus (Heckscher 2013). The elytra (modified, hardened forewings found in beetles) range from light brown to gray and the thorax is typically brown (Heckscher 2013).



Figure 1. Dorsal (left) and ventral (right) images of an adult male mysterious lantern firefly, *Photuris mysticalampas* ([aaronr/iNaturalist](#), CC BY-NC)

**Immature:** The immature life stages of the mysterious lantern firefly have not been described. However, all known firefly larvae are bioluminescent (Lloyd 2018), an adaptation thought to warn potential predators that they are distasteful (Lewis 2016), and the same is likely true of this species.

### **Life History:**

#### *Flash behavior and phenology*

Flash pattern and activity period can be used as distinguishing features from other fireflies in the area. Both male and female mysterious lantern fireflies flash, and can be found flying from mid-June into late July (Heckscher 2013; NatureServe 2023). Courtship flashes are unique to each firefly species; this species is characterized by a single prolonged flash, appearing more green than yellow (Heckscher 2013). Males exhibit a single flash that lasts usually between 0.4-0.8 seconds, every 3-7 seconds (Heckscher 2013). However, sometimes the signal can exceed 1.0 second and the interval between

signals can be longer than 7 seconds (Heckscher 2013). The flash is considered to be of medium luminescence for a *Photuris* species (Heckscher 2013). Occasionally, females will give short weak flashes when signaling to males, and when males approach a female, a trembling green flash may be given (Heckscher 2013). Adults emerge 30-40 minutes after sunset from thick sphagnum hummocks and can remain active until past midnight (Heckscher 2013; Faust 2017), with males patrolling the understory at low levels (<2m) (Heckscher 2013). Similarly, females remain low (<1m) on vegetation when signaling to males (Heckscher 2013). Female flash patterns can be difficult to ascertain due to the aggressive mimicry utilized by some female *Photuris*. This behavior, in which adult females mimic the female flash patterns of other firefly species (including those of *Photinus*, *Pyraclomena*, and *Photuris*), attracts males which are then eaten by the females. In doing this, female *Photuris* fireflies sequester protective toxins, called lucibufagins, which are produced by other firefly species and can be passed on to their offspring.

#### *Dispersal capacity*

Fireflies are weak fliers and rarely disperse beyond the habitat in which they were born (Lewis 2016), although some species, such as *Photinus signaticollis*, are capable of dispersing across large distances (Koken et al. 2022). Although *Photuris* fireflies in general may have greater dispersal capacity than other firefly genera due to their larger size, the smaller mysterious lantern firefly has not been found outside of wetland borders (C. Heckscher pers. obs.), indicating that individual fireflies of this species rarely disperse beyond their specialized habitat.

#### *Life cycle*

The mysterious lantern firefly is a beetle with a holometabolous life cycle, meaning it undergoes four stages of life: egg, larva, pupa, and adult. After mating, females lay their eggs in moist soil, duff, leaf litter, or rotting wood. *Photuris versicolor* complex females, such as those of this species, typically lay an average of 28 eggs, deposited singly or in batches over the course of several days to weeks (Faust 2017; Lloyd 2018). Two to three weeks later, these eggs hatch into grub-like beetle larvae that live in leaf litter, underground, or in rotting wood (Faust 2017). In northern latitudes, such as the Mid-Atlantic where this species occurs, larvae become inactive underground during the winter months. Fireflies spend the majority of their lifetime (1-2 years) as larvae, undergoing 4-7 growth stages called instars (Faust 2017; Lloyd 2018). Although rarely seen, the intermittent glows of foraging *Photuris* can sometimes be seen on dark nights in fall and spring. When fully grown, larvae pupate in constructed chambers under the soil surface or rotting logs and emerge as adults a few weeks later in late spring or early summer (Bauer et al. 2013; Faust 2017; Lloyd 2018). Adult *Photuris* typically live 3-4 weeks and are active after dark during the summer months (Faust 2017); all known observations of the mysterious lantern firefly have occurred in June and July (Heckscher 2013; Faust 2017; Firefly Atlas 2022).

#### *Diet*

The specific diet of larval mysterious lantern fireflies is unknown, but other larvae in the *Photuris* genus are generalist predators consuming worms, slugs, snails, and other soft-bodied invertebrates (Buschman

1984; Faust 2017). Adult fireflies typically do not eat, with the exception of *Photuris* spp. females (including those of *P. mysticalampas*) that will mimic other fireflies, to lure them in as prey (Faust 2017). These females will then sequester protective toxins called lucibufagins that they have acquired from their prey and pass these toxins on to their young as a protective measure (Faust 2017). Some adult firefly species have also been observed consuming plant material including berries, milkweed nectar, and apple slices (Buschman 1984; Faust 2017).

**Range, Distribution, and Abundance:**

Type Locality: USA: DEL, Sussex Co., Nanticoke Wildlife Area, Phillips Landing Trail, Atlantic white cedar (*Chamaecyparis thyoides*) swamp (Heckscher 2013)

Range: The mysterious lantern firefly occurs on the Delmarva Peninsula of Delaware and Maryland, along the Atlantic coast of the US.

Distribution: This firefly has only been documented from six sites on federal, state, and private lands in Sussex County, DE, and Worcester County, MD (Figure 2). Five of the six sites are located within approximately 14 miles of each other in one contiguous riverine floodplain system along the Maryland-Delaware border. The sixth, disjunct site, is located nearly 18 miles away to the northeast along the Atlantic coast in the Prime Hook National Wildlife Refuge in Delaware.

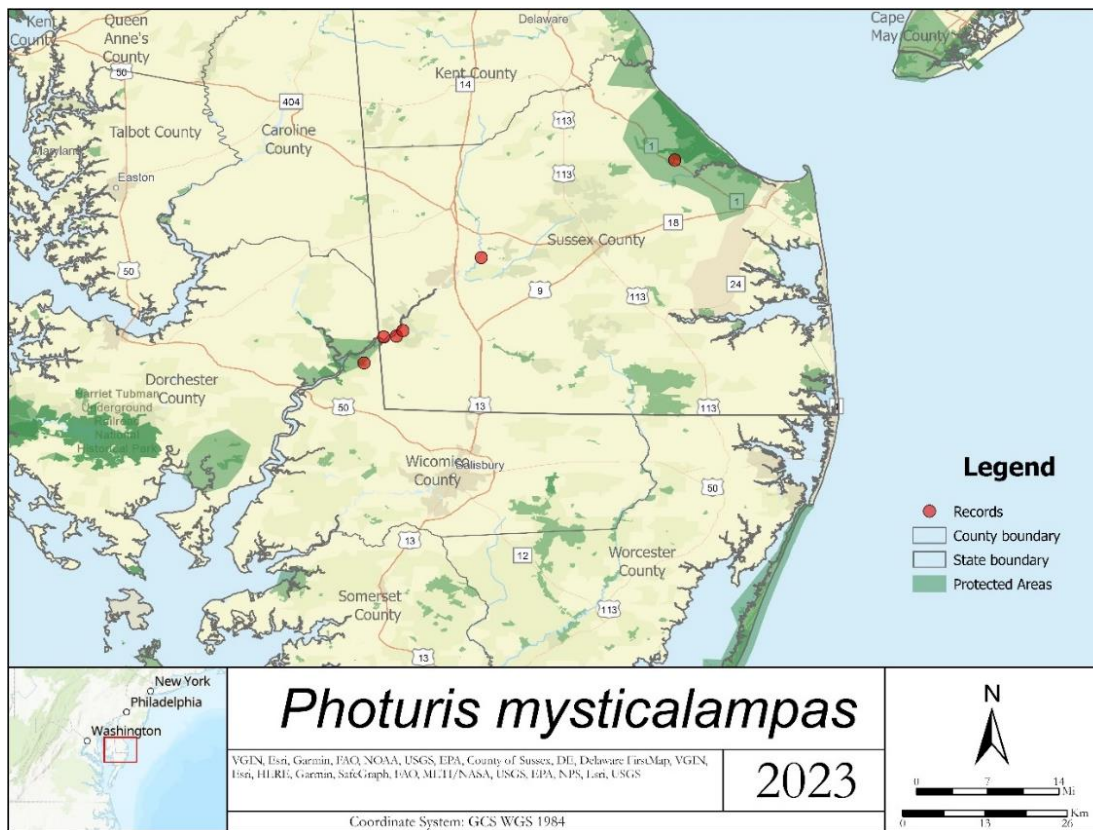


Figure 2. Map of known mysterious lantern firefly distribution in Maryland and Delaware, USA (excerpted from Geest et al. 2023).

### *Documented*

This species has been documented from two private Nature Conservancy preserves in Maryland and Delaware and the following public lands:

- Nanticoke State Wildlife Area, Sussex County, DE
- Prime Hook National Wildlife Refuge, Sussex County, DE

### *Suspected*

Although not yet documented from these sites, the mysterious lantern firefly is may occur in the following areas, given the availability of appropriate habitat within or adjacent to the species' known range:

- Nassawango Creek Preserve, MD (The Nature Conservancy)
- Pocomoke River State Park, MD (Maryland Division of Parks and Recreation)
- James Branch Nature Preserve, Sussex County, DE (Delaware Division of Parks and Recreation)
- Redden State Forest, Sussex County, DE (Delaware Forest Service)
- Belleplain State Forest, Cape May County, NJ (New Jersey State Park Service)
- Great Dismal Swamp National Wildlife Refuge, VA (US Fish and Wildlife Service)

Other palustrine forests of good ecological quality in coastal Virginia and North Carolina would also be ideal areas to target for surveys.

Abundance: Detailed data on abundance are not available. This species has a very small range and is known from only six sites in two counties (Geest et al. 2023). Given the patchy distribution of its forested peatland habitat, it is likely that population connectivity is low. Where the species does occur, it can be locally abundant; Faust (2017) notes that “large groups of over one hundred males drift as they silently display...”

### **Habitat Associations:**

*Photuris mysticalampas* is a habitat specialist associated with swampy (palustrine) forested wetlands. Although most freshwater wetlands on the Delmarva Peninsula are categorized as palustrine forested (Tiner 2001), this species is only found in high quality forested peatland floodplains, where Atlantic white cedar (*Chamaecyparis thyoides*) is often codominant (Heckscher 2013; Faust 2017; Fallon & Heckscher 2021). Deep peat with sphagnum hummocks and dense vegetation appears to be an important habitat feature for this species (C. Heckscher pers. comm. 2022.; Figure 3). Larvae may be restricted to these areas, and adults can be seen emerging from sphagnum hummocks at dusk (NatureServe 2023).



Figure 3. Forested wetland habitats of the mysterious lantern firefly (Candace Fallon/Xerces Society). Note the sphagnum mats in the photo on the left, and the dense vegetation in the photo on the right.

Atlantic white cedar swamps are found in a narrow band along the eastern coastline and Gulf Coast, occurring patchily from Maine to Mississippi (Laderman 1989). On the Delmarva Peninsula, these swamps are found only on the Atlantic Coastal Plain, where they serve as coastal buffer zones and flood control areas, and provide a haven for other rare and imperiled species like Hessel’s hairstreak (*Callophrys hesseli*) and the bald cypress sphinx moth (*Isoparce cupressi*). Atlantic white cedar swamps are characterized by slightly elevated hummocks, where the trees grow, surrounded by hollows that are typically filled with darkly tannic freshwater throughout the growing season (Environmental Protection Agency 2016). Soils are acidic with high levels of organic matter and are characterized by hydrophilic and often rare and unusual plant species (Environmental Protection Agency 2016). Sphagnum mats are common, and can often be found growing over the roots of the cedars (Environmental Protection Agency 2016).

Other firefly species known to co-occur with the mysterious lantern firefly include *Photuris lucicrescens*, *Photuris hebes*, *Photuris pensylvanica*, and *Photinus pyralis* (Heckscher 2013; Firefly Atlas 2022).

### **Threats:**

The mysterious lantern firefly is imperiled by multiple threats including habitat fragmentation, pesticide use, climate change (including sea level rise), small population size, recreation, invasive species, and a lack of protective regulatory mechanisms, among other factors. While this species has been recorded on federal, state, and private conservation lands, there are no species-specific management activities focused on its protection. Additionally, the passive protection allotted from these managed areas cannot protect this species from new and emerging threats including sea level rise and increased frequency and severity of storms that can destroy or degrade the forested peatlands upon which this firefly depends.

While the mysterious lantern firefly has been found in non-tidal cedar swamps, many of the Nanticoke sites in which it is found are tidal freshwater peatlands, which are threatened by sea level rise. The rate of sea level rise on the Delmarva Peninsula is three or four times higher than the global average, with a rise of between 0.5 and 1.5 m expected by the year 2100. This would inundate most mysterious lantern firefly habitats, which are less than 1 meter above the current sea level. As a result, vast portions of the coast are vulnerable to higher storm surges, increased incidence of flooding, and deterioration of beaches and wetland habitats (Sallenger et al. 2012). Given this species' association with tidal freshwater floodplains that occur less than 1 m above sea level (Heckscher 2013), this predicted rise and associated storm surges would completely inundate most of the habitats that *Photuris mysticalampas* currently utilizes.

Other potential threats to this species include light pollution and predation by predatory conspecifics such as *Photuris pensylvanica* and *P. lucicrescens*. Adults are active in full darkness, displaying from thirty to forty minutes after sunset to past midnight (Faust 2017). Increased light pollution associated with development has been shown to adversely impact mating success of nocturnal firefly species like *Photuris mysticalampas*, which require dark conditions for courtship displays (Owens & Lewis 2018; Lewis et al. 2020).

### **Conservation Considerations:**

Although this firefly is listed as a Tier One Species of Greatest Conservation Need in Delaware (Delaware Division of Fish and Wildlife 2015) and all known sites where it occurs are considered protected areas (Heckscher 2013; Protected Planet 2023), there are no specific conservation measures in place to protect it. Given this species' habitat associations and the fact that it may be dependent on cool groundwater seepage from surrounding uplands (C. Heckscher pers. obs.), protection of forested buffers along occupied floodplain corridors is recommended. Continued inventory of peatland floodplain forest is needed in the Nanticoke watershed in Delaware and Maryland and in other areas of the Delmarva Peninsula. This species has not been found in similar habitat in New Jersey or in areas just north and south of the known localities in Delaware and Maryland (Firefly Atlas 2022; NatureServe 2023); however, given the limited nature of these surveys, further inventory work in these areas is warranted.



## *Research needs*

Despite recent work to assess the mysterious lantern firefly's conservation status and compile a comprehensive database of known occurrence records, our understanding of this species' distribution, abundance, and population trends is incomplete or lacking, which hinders our ability to effectively conserve the species. Basic details regarding this firefly's life history, microhabitat requirements, and vulnerability to various threats are also largely unknown, further impeding conservation efforts. Work by Heckscher (2013) to describe the species and define its habitat associations and distribution in the Mid-Atlantic formed an initial foundation, and recent (2022) surveys by Xerces Society biologists have further illuminated the range of the species. However, there remain critical data gaps that must be addressed to inform conservation efforts for the mysterious lantern firefly, including:

### *Natural history*

- What is the larval diet? Are they generalists or specialists?
- What microhabitat features are important to adults? To the larvae?
- What habitat associations and factors affect the persistence of *P. mysticalampas* populations within forested peatlands?

### *Species range and distribution*

- What is the full extent of this species' range?
- Does this species occur elsewhere on the Delmarva Peninsula or in adjacent states?
- What can species distribution modeling tell us about focusing future survey efforts?
- Can we use occupancy modeling to determine the survey- and site-level variables that influence the detection and presence of fireflies at known sites?
- What is the dispersal capacity of this species?

### *Population size, trends, and abundance*

- What are the global and local population sizes and trends for this species?
- What monitoring protocols and/or programs do we need to develop to answer this question?
- What is the most reliable index of abundance for this species?
- What is the geographic pattern of genetic differentiation?

### *Threats*

- To what extent do known threats impact the species?
- Can we model the impacts of sea level rise and other climate change impacts on their populations? What about the impacts of increasing development and light pollution?

### *Conservation impacts*

- How do different management activities impact adult firefly populations?
- How do different management activities impact immature firefly populations?
- How can we use this information to guide conservation and restoration activities?

### *Inventory and monitoring*

In addition to addressing data gaps, continued surveys of high quality forested peatlands are needed to determine the full extent of this species' range (Heckscher 2013). This firefly may occur in appropriate habitat elsewhere in Delaware and Maryland, as well as New Jersey, eastern Virginia, and eastern North Carolina. As core sites for this species are discovered, land managers could work to establish long-term monitoring programs to better understand population size, dynamics, and trends.

### *Management actions*

The mysterious lantern firefly is known to occur in just six sites in Delaware and Maryland. Although all known sites where it occurs are considered protected areas (Protected Planet 2023), the passive protection afforded by such designations are inadequate to protect the species from extinction. Therefore, targeted protection and restoration of known habitats is crucial. Land managers can play a key role in ensuring that known and potential habitat is not disturbed by recreation, development, harmful pesticide applications, light pollution, or other management activities. Key actions that could help this firefly include:

- establishing and maintaining natural buffers around forested wetlands to maintain hydrology, protect groundwater, and reduce stormwater, pollution, and nutrient run-off
- rerouting roads and trails around sensitive habitat areas
- installing boardwalks or bridges if passage through the site is required
- removing or modifying artificial light sources such as streetlights that may be negatively impacting populations (e.g., using motion sensors on existing lights, or replacing bright LEDs with dim red bulbs that don't interfere with firefly flash communication)
- protecting occupied sites from excessive or unnecessary pesticide application
- removing invasive plants such as the common reed *Phragmites australis*, which may alter native plant communities and make them uninhabitable for fireflies,
- restoring natural hydrology by removing impoundments and ditches
- setting up long-term monitoring programs at a subset of occupied sites to gather baseline population data to better understand population trends and conservation status of this species over time, as well as insights into the impacts that various management activities have on firefly health and abundance.

## **Survey Protocol:**

### **Where:**

- Peatland forests in freshwater river floodplains along the Mid-Atlantic coast of the US (Delaware, Maryland, New Jersey, eastern Virginia, and eastern North Carolina). In particular, surveyors could focus on appropriate habitat in the Nanticoke River, Mispillion River, and Cedar Creek watersheds and headwaters of mill ponds. Atlantic white cedar and sphagnum moss are good vegetation indicators for appropriate habitat.
- Sites will likely be within protected areas, so permission to access them for surveys is especially important.

### **When:**

- Surveys should occur at night, after full darkness, from mid-June to late-July, peaking between 1500-1800 modified Growing Degree Days (mGDD)
- Air temperature should be at least 65° Fahrenheit (18° Celsius)
- Wind should be Beaufort wind scale 2 or lower (0-7 mph), if adults are targeted
- Moon phase should ideally be last quarter, waning crescent, new moon, or waxing crescent

### **How:**

- Review survey protocols and print data sheets from the Firefly Atlas ([www.fireflyatlas.org](http://www.fireflyatlas.org))
- If needed, secure the appropriate permits and/or site access permissions prior to conducting surveys
- Walk slowly through or along peatland forests looking for single, prolonged yellowish green glows, especially near small streams and sphagnum mats with dense vegetation
- In addition to flash pattern, this species can be distinguished by its hairy elytra and pale scutellum, coxae, and thorax. Its body has an oval shape when viewed from above.
- Consider recording observations using a voice memo app on a cell phone or a voice recorder, using the data sheet as a guide
- If permitted, net several individuals and take high quality dorsal and ventral photos, including a scale to show the length of the firefly. Photos will enable validation of species identification by a Firefly Atlas administrator or relevant species expert.
- Use artificial light sparingly to maintain night vision and avoid disturbing fireflies; a dim red headlamp or a flashlight wrapped in red cellophane can be used as needed to navigate the site
- Submit survey data and photographs to the Firefly Atlas (regardless of whether fireflies were observed)

## **Additional Resources:**

*Species-specific*

- Petition to list the mysterious lantern firefly as an endangered species under the US Endangered Species Act: <https://xerces.org/publications/policyposition-statements/petition-for-protection-of-mysterious-lantern-firefly-under>

#### *General conservation*

- Conserving the Jewels of the Night: Firefly-Friendly Lighting Practices : <https://xerces.org/publications/fact-sheets/firefly-friendly-lighting>
- Conserving the Jewels of the Night: Guidelines for Protecting Fireflies in the United States and Canada: <https://xerces.org/publications/guidelines/conserving-jewels-of-night>
- State of the Fireflies of the United States and Canada: Distributions, Threats, and Conservation Recommendations: <https://xerces.org/publications/scientific-reports/state-of-fireflies-of-united-states-and-canada>

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