FIREFLY SPECIES FACT SHEET:
Southwest synchronous firefly (*Photinus knulli*)

A Southwest synchronous firefly from Tumacácori National Historical Park, AZ (Tony Palmer, iNaturalist, CC BY-NC).

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Xerces Society for Invertebrate Conservation

Scientific Name:

Photinus knulli Green, 1956
Phylum: Arthropoda
Class: Insecta
Order: Coleoptera
Family: Lampyridae
Subfamily: Lampyrinae
Tribe: Lucidotini
(ITIS 2023)

Synonyms: None

Common Names:

Southwest synchronous firefly, Fall Southwest firefly

Conservation Statuses:

Global Status: G2G3 – Imperiled (last reviewed 6 January 2022)
National Status (United States): NNR – Nation Not Ranked
State Statuses: SNR – State Not Ranked (AZ)
(Walker & Cicero 2022b)

Federal Status (United States): None
IUCN Red List: Vulnerable (Fallon et al. 2021; Walker & Cicero 2022a)

Technical Description:

Adult: The technical description for this species is based largely on Green (1956). However, because his description was based on just two specimens (one male and one female), very little intraspecific variation is reflected. *Photinus knulli* belongs to the *P. consanguineous* group of Green's Division II of North American *Photinus*, whose members are characterized by the following traits of the aedeagus: lateral lobes short and stout, not descending, and inner margins separated throughout, or touching only beyond the tip of the median lobe (Green 1956). Other members of this group include *Photinus indictus*, *P. lineellus*, *P. ignitus, and*, *P. consanguineous*, although none of these species are sympatric with *P. knulli* (Green 1956). *P. knulli* differs from all other members of the *P. consanguineus* group by its distinctive male genitalia which, while maintaining the group's conserved genital appearance, presents a distinctive shape as can be seen in Figure 16 of Green (1956:599).

Adult male and female *P. knulli* specimens range in length from 5-8 mm (Green 1956; Buschman 2016). Both sexes are winged (Green 1956; Cicero 1983). Green (1956:599) describes the adult male as having a pronotum with irregular median dark vitta reaching the base but not the apex; a pale piceous scutellum; piceous elytra with a pale border; and large eyes (although the female's eyes are slightly smaller) (Figures 1 and 2). Other key diagnostic features of the species include a pronotum with rounded hind

angles and black side markings, simple tarsal claws, and its geographic location (Green 1956; Walker 2024; see Distribution section). It is unlikely that this species will be misidentified, as it is the only *Photinus* species recorded from southern Arizona, and one of only two flashing species known from the area (the other being the Southwest spring firefly, *Bicellonycha wickershamorum*, which is active at a slightly different time of year [although there is some overlap], is different in appearance and flash pattern, and is known to co-occur at only two sites).

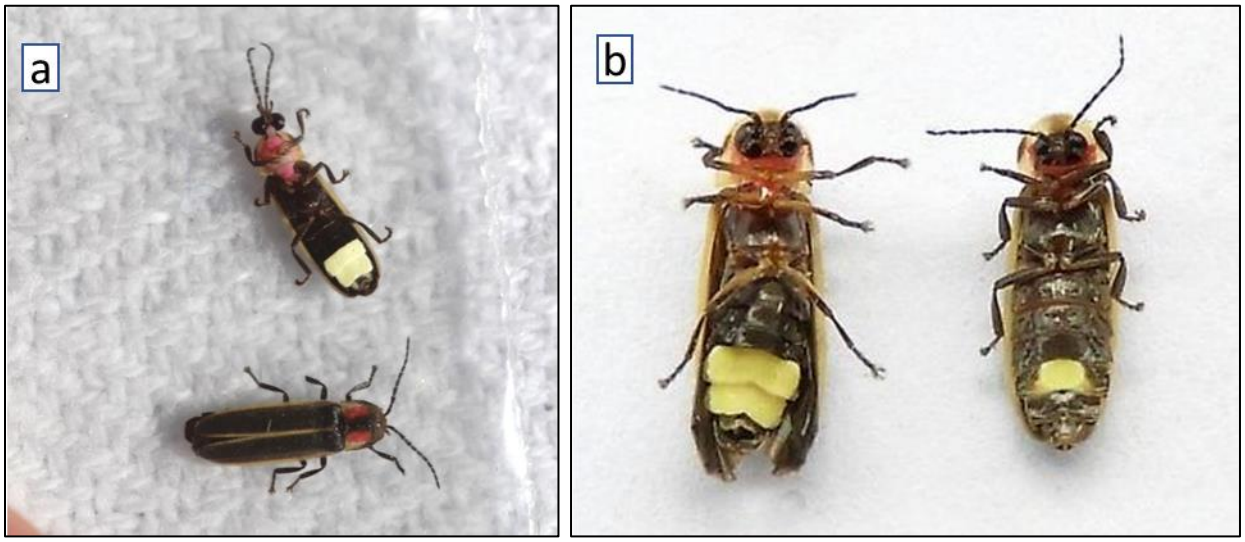

Figure 1. (a) Dorsal and ventral views of an adult male Southwest synchronous firefly (Tony Palmer, iNaturalist, CC BY-NC, original photo brightened and cropped for use). (b) Ventral view of adult male (left) and adult female (right). Note the much smaller lantern on the female and the smaller eyes (Jim Eckert, BugGuide, CC, original photo cropped).

Figure 2. Close-up of *P. knulli's* pronotum, displaying the rounded hind angles and irregular median dark vitta meeting the base, but diffusing without reaching the apex (Salvador Vitanza, BugGuide, permission granted for use).

Immature: Although they have been collected and studied (Cicero 1983), the immature stages of this particular firefly have not been formally described. *Photinus* larvae are generally somewhat cigar-shaped and are known to live in the soil, feeding on earthworms and other soft-bodied invertebrates (Lloyd 2012). Furthermore, all known firefly larvae, including those of the Southwest synchronous firefly, are bioluminescent (Cicero 1983; Lloyd 2018), an adaptation thought to warn potential predators that they are distasteful (Lewis 2016). Because the only other Photinine fireflies known from southern Arizona are *Pyropyga* and *Ellychnia*—both of which have known representative larvae that are distinct from *Photinus*—larvae identified as *Photinus* are likely to be *P. knulli* (e.g., see Figure 3).

Figure 3. *P. knulli* larva, found under a rock at Tumacácori National Historical Park (Tony Palmer, iNaturalist, CC BY-NC).

Life History:

Flash behavior and phenology

Flash pattern and activity period can be used as distinguishing features from other fireflies, such as *Bicellonycha wickershamorum*, should observations be conducted in an area where both species are sympatric. Both male and female Southwest synchronous fireflies flash, and are active after the onset of monsoon rains, typically in July and August but sometimes into September (Cicero 1983; Buschman 2016). Courtship activity begins approximately 35–120 minutes after sunset. The male flash displays are composed of quick triplet yellow flashes emitted over the course of about one second and repeated every three to five seconds, although flash patterns consisting of just two or up to four or five flashes can be observed (Sarfati et al. 2022; Figure 4). Female responses are typically composed of a single flash, but can be extremely varied, ranging from short pulses to long, continuous glows (Cicero 1983).

Figure 4. The characteristic triplet flash pattern of the Southwest synchronous firefly at Tumacácori National Historical Park, AZ (Julius Schlosburg).

True to its name, the Southwest synchronous firefly is one of only three firefly species in the US known to synchronize its flashes (Sarfati et al. 2022). The other two species, the snappy sync (*Photuris frontalis*) and the synchronous firefly (*Photinus carolinus*), both occur in the East, making *P. knulli* the sole western representative of this specialized behavior. Initially recorded through detailed visual observations in the 1980s (Cicero 1983), the synchronous nature of *P. knulli*'s flashes has now been verified by statistical analyses of high-resolution stereoscopic video recordings (Sarfati et al. 2022). Firefly synchronization typically involves coordinated, rhythmic flashing by groups of male fireflies. In the East, this synchronization can produce spectacular displays in which huge numbers of males start and stop their courtship flashes at the same time (Copeland & Moiseff 1994). Because high degrees of synchronization are reached only at high flashing densities, and populations of the Southwest synchronous firefly do not appear to be very large, courtship displays do not attain synchronicity at every site or even in every season (Cicero 1983; Copeland & Moiseff 1994; Sarfati et al. 2022).

The Southwest synchronous firefly is unique in that it is the only North American firefly known for its lekking behavior, in which males congregate and display in summer gathering areas ("lek arenas") (Cicero 1983). This lekking behavior, which is detailed at length in Cicero (1983), is summarized in Walker and Cicero (2022a):

> "By the second week of August, the [courtship] activity is peaking, and a large number of males are seen displaying from leks, generally about 5 m^2 in size, nightly. The display behavior is very complex and involves several "anchor males" displaying characteristic triplet flashes (three consecutive quick flashes within a second) from the ground, while other "patrolling males" venture out along an established flyway, which, in the premiere study at least, was a straight line about a kilometer in length (Cicero 1983). While patrolling, males fly a couple meters off the ground and emit triplet flashes about every six seconds. They often fly in schools of up to seven and emit triplet flashes in synchrony with each other. After patrolling for about an hour, males circle back toward the base arena where the "anchor males" are still on the ground, flashing (Cicero 1983). Males that locate the lek by passing over it and seeing activity below, will land and join in, while others that do not relocate it will form satellite leks."

Thus far, lekking has been observed only at Peña Blanca over the two years of Cicero's study (1982 and 1983)(Cicero 1983). Site visits in 2022 and 2023 revealed strong reduction of population size at this site, possibly attributable to climate, and no indication of stable lek formation (Cicero pers. obs. 2022, 2023). While this unusual lekking behavior is indicative of the species, its occurrence appears to be dependent on reaching a certain density threshold, so not all courtship displays will result in lekking or synchrony.

Dispersal capacity

The dispersal capacity of the Southwest synchronous firefly is unknown. In general, fireflies are thought to be weak fliers that 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). Because *P. knulli* has occasionally been observed in canyons without permanent water sources, or in irrigated areas such as farms and golf courses, it is suspected that this species is capable of flying relatively long distances (Walker & Cicero 2022a). Gravid adult females, however, are incapable of flight, and the subterranean larvae further limit the species' dispersal capacity (Cicero 1983).

Life cycle

As with all beetles, the Southwest synchronous firefly has a holometabolous life cycle, meaning it undergoes four life stages: egg, larva, pupa, and adult. While life stage lengths are not known for this species, in general, fireflies spend two to three weeks as eggs, which then hatch into larvae (Faust 2017). The larval stage is the longest; fireflies spend the majority of their lifetimes (1-2 years) as larvae, undergoing 4-7 growth stages called instars (Faust 2017; Lloyd 2018). The larvae will then pupate and remain dormant for one to three weeks, before emerging as an adult. In *P. knulli*, larvae are subterranean, and pupae are also found underground (Cicero 1983). Males begin eclosing from their pupal cases in late July or early August, after the monsoon rains have started (Cicero 1983). Adult females begin to emerge about three days after the first males eclose (Cicero 1983). At sites with high enough densities of males, lekking behavior ensues. Courtship takes place over several weeks, typically influenced by monsoon rain patterns and moon cycles. Once mated, gravid females are unable to fly, and thus remain at the lekking arenas to lay eggs and start the cycle anew (Cicero 1983).

Diet

The larval diet of this species has not been recorded, but other *Photinus* larvae feed on earthworms and other soft bodied invertebrates at or below the soil surface (Buschman & Faust 2014). Adults are typically not known to feed, although some species have been documented consuming plant material including berries, milkweed nectar, and apple slices (Buschman 1984; Faust 2017).

Range, Distribution, and Abundance:

Type Locality: Nogales, AZ (Green 1956)

Range: The Southwest synchronous firefly is known from south central and south eastern Arizona and the extreme northeast of Sonora, Mexico (Walker & Cicero 2022a).

Distribution:

Photinus knulli has been recorded from approximately a dozen localities scattered across southeast Arizona (Pima, Santa Cruz, and Cochise Counties) and northern Sonora, Mexico (Green 1956; BugGuide 2023a; GBIF.Org 2023; The Xerces Society 2023; iNaturalist 2024; Table 2; Figure 5). Because the population from Guadalupe Canyon is on the Arizona-New Mexico border, it is likely this species also occurs in New Mexico. However, its distribution appears to be centered on the Santa Cruz River and its tributaries in Pima and Santa Cruz Counties, Arizona (Walker & Cicero 2022a). In Sonora, this species is reported from just one locality, in Cajón Bonito canyon (J. Cicero pers. comm. 2023). It is unclear if all of these observed localities represent breeding populations. Cicero notes that males of this species may "drift" to other locations beyond the core breeding areas, but are unlikely to persist or establish leks due to the lack of permanent water; such individuals have been observed in the Tucson, Santa Rita, and Catalina Mountains (BugGuide 2023b; Table 2).

Table 1. All known localities of the Southwest synchronous firefly (*P. knulli*), with dates of observation. Sites that are suspected to be ephemeral are preceded by an asterisk.

Country	State	County	Locality	Month(s)	Year(s)	Reference(s)
USA	Arizona	Santa Cruz	Nogales	Aug	1953	Green 1956; GBIF 2023
USA	Arizona	Cochise	Guadalupe Canyon	Unknown	Unknown	J. Cicero pers. comm. 2024
Mexico	Sonora	N/A	Cajón Bonito, Sierra San Luis	Jul	2003	J. Cicero pers. comm. 2023
USA	Arizona	Santa Cruz	*Madera Canyon, Coronado National Forest (NF)	Aug	2018, 2021	BugGuide 2023; iNaturalist 2024
USA	Arizona	Pima	*Florida Canyon Road, Santa Rita Mtns	Aug	2021	GBIF 2023
USA	Arizona	Pima	*West Branch of the Santa Cruz River, Tucson	Aug	2022	Xerces Society 2023
USA	Arizona	Santa Cruz	Sonoita Creek, Blue Heaven Road, Patagonia	Jul	2022	GBIF 2023

Country	State	County	Locality	Month(s)	Year(s)	Reference(s)
USA	Arizona	Pima	I-19, Canoa Ranch Rest Area	Jul, Aug, Sep	2009, 2021, 2022	BugGuide 2023; GBIF 2023
USA	Arizona	Santa Cruz	Sycamore Canyon, Coronado NF	Aug	2021, 2022	GBIF 2023; Xerces Society 2023
USA	Arizona	Pima	Buenos Aires NWF Arivaca Trail Parking Lot	Jul, Aug	2021, 2023	Xerces Society 2023
USA	Arizona	Santa Cruz	Peña Blanca Canyon, Coronado NF	Jul, Aug, Sep	2013, 2022, 2023	BugGuide 2023; GBIF 2023; Xerces Society 2023
USA	Arizona	Santa Cruz	Tumacácori National Historical Park	Jul, Aug	2016, 2021, 2022, 2023	GBIF 2023; Xerces Society 2023
USA	Arizona	Santa Cruz	Patagonia	Aug	2023	iNaturalist 2024

Documented

The Southwest synchronous firefly has been documented from the following public lands in southern Arizona (note that some sites may not be accessible after dark):

- Buenos Aires National Wildlife Refuge, Arivaca
- Canoa Ranch Rest Area off I-19, Green Valley
- Coronado National Forest (Madera Canyon, Peña Blanca Canyon, Sabino Canyon, Sycamore Canyon)
- Tumacácori National Historical Park, Tumacácori-Carmen

Suspected

The distribution limits of this species are not well understood, and it is possible it is more widespread in appropriate habitats throughout southern Arizona, including some of the following areas:

- Sierrita Mountains, Pima County
- Tanque Verde Wash, Pima County (anecdotal sightings reported, but may represent drifter males)
- Marsh Station, Vail, Pima County
- Southern edge of the Santa Rita Mountains, Santa Cruz County
- Rock Corral Canyon, Tumacácori Mountains, Santa Cruz County
- Saguaro National Park (Chiminea Canyon, Rincon Creek)
- Additional areas along the Santa Cruz and its tributaries in Tucson

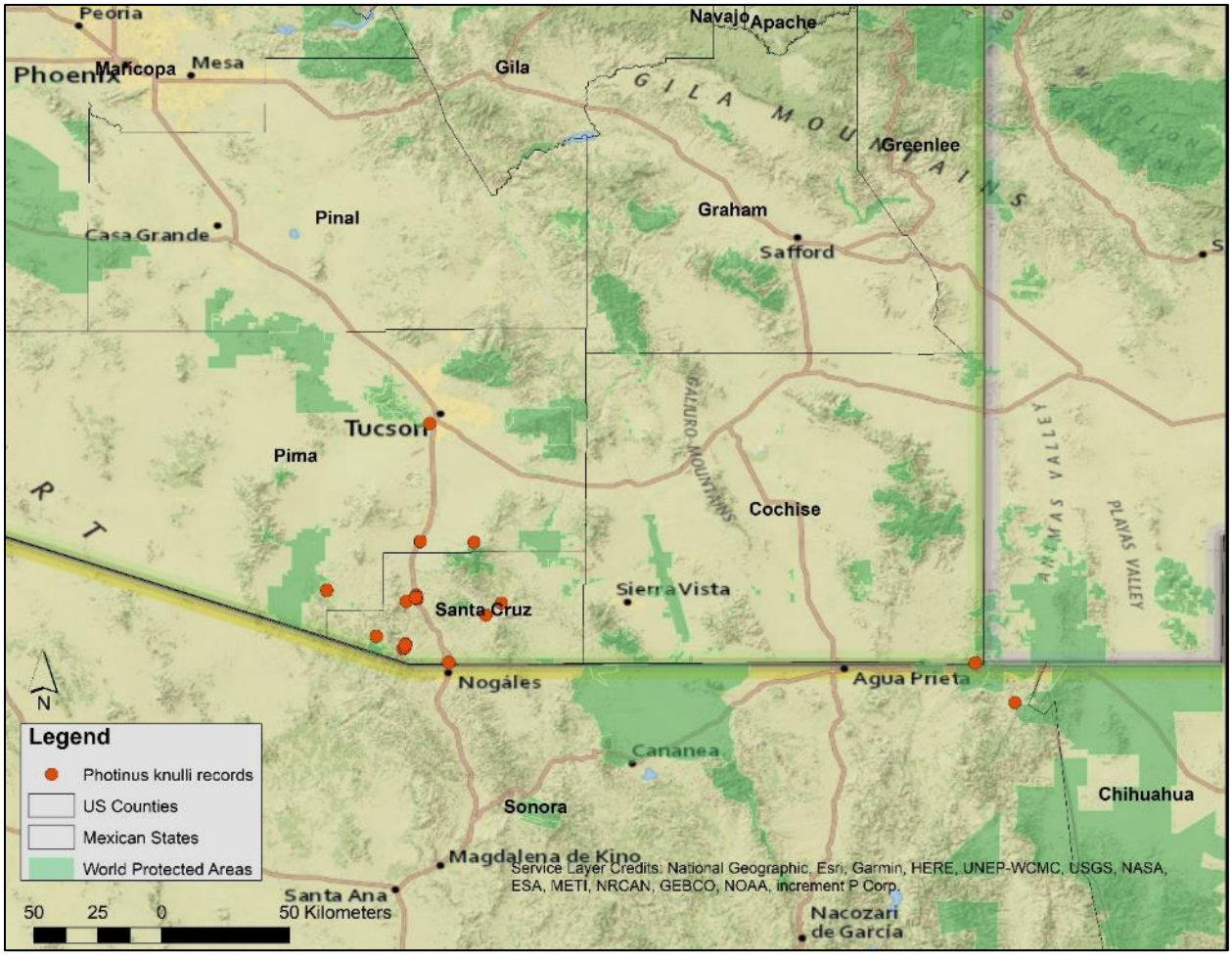

Figure 5. Known distribution of the Southwest synchronous firefly in southern Arizona and northern Mexico.

Abundance:

Detailed data on abundance are not available for this species. Buschman (2016) notes they can occur in large numbers along permanent streams. During field observations in Peña Blanca Canyon, Coronado National Forest, AZ, in the 1980s, Cicero (1983) reported that during the observed peak of the flight, there were thousands in the canyon, and about 200 actually on the ground in the lek arena during the peak of sampling. However, more recent survey efforts from 2021 - 2023 indicate that the species may not be as abundant as it once was, at least in Peña Blanca Canyon (Sarfati et al. 2022). This site is believed to have been the largest observed population before fireflies were reported from Tumacácori National Historical Park (J. Cicero pers. obs.; T. Palmer pers. obs.).

Habitat Associations:

The habitat needs of the Southwest synchronous firefly are not well delineated, although in general, the species is typically found in riparian areas, dry desert washes, and canyon arroyos near permanent water sources (Cicero 1983; Buschman 2016; Walker & Cicero 2022a; Walker 2024; Figure 6). In Peña Blanca Canyon, where Cicero

(1983) observed the mating displays and lek arenas of this species, the habitat is oak woodland in “two broad, converging canyon washes, and their respective banks of firm ground that follow along the canyon walls.” Nearby Sycamore Canyon is also oak woodland. Populations at Tumacácori are found in a cottonwood riparian community surrounded by mesquite/acacia thorn scrub. Larvae and pupae of this species can be found in the same habitat as the adults, and have been found at night by overturning large rocks where the species is known to occur (Cicero 1983; T. Palmer pers. obs. 2022). Given the handful of observations from areas without permanent water sources, more research is needed to understand the dispersal behavior and habitat requirements of this species. Surveyors have observed this firefly in some surprising locations in recent years, including a heavily degraded site along the West Branch of the Santa Cruz River in urban Tucson (The Xerces Society 2023).

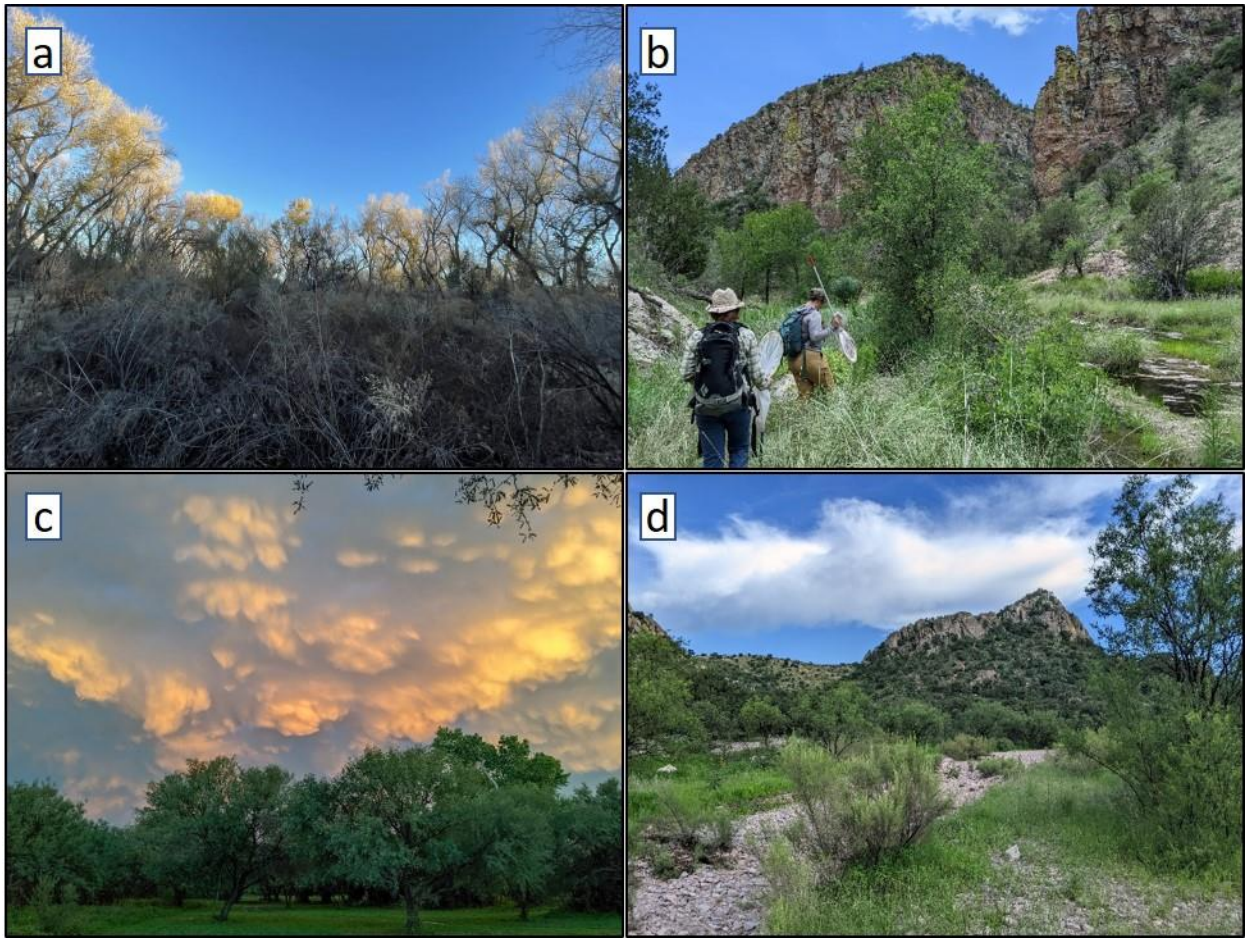

Figure 6. The Southwest synchronous firefly can be found in riparian areas, desert washes, and canyon arroyos. (a) Habitat near the Santa Cruz River, Tumacácori National Historical Park, AZ, as seen in winter (Tony Palmer). (b) Sycamore Canyon, Coronado National Forest, AZ, where surveyors found a Southwest synchronous firefly resting on vegetation by day (Candace Fallon/Xerces Society). (c) Irrigated orchard habitat under monsoon skies at Tumacácori National Historical Park, AZ (Candace Fallon/Xerces Society). (d) A dry gravel bed running through firefly habitat at Peña Blanca Canyon, Coronado National Forest, AZ (Candace Fallon/Xerces Society).

Threats:

Documented threats to the Southwest synchronous firefly include habitat loss and fragmentation from livestock grazing, residential development, water diversion, mining, and other landscape modifications

for agriculture and pasturing (Walker & Cicero 2022a). Researchers predict that the quality of this species' habitats will continue to decline within its known range due to climate change and associated drought, which can cause drying of permanent rivers and nearby ephemeral habitats upon which this species depends (Walker & Cicero 2022a). More localized threats such as trampling by cattle, water and light pollution, declines in local food sources, pesticide use, off-road vehicle use (Figure 7), and other intrusive recreational or tourist activities are also potential drivers of decline. Larvae are particularly at risk of trampling and other habitat degradations, as they live in the soil, have limited dispersal abilities, and tend to be concentrated in areas of suitable habitat (Cicero 1983).

Figure 7. A large grassy area just to the west of the lekking arena at Peña Blanca Canyon, Coronado National Forest, AZ, where tire tracks are visible. Off-road vehicle usage through occupied areas like these can be particularly detrimental to immature life stages of fireflies. (Candace Fallon/Xerces Society).

Because of its congregating behavior, this firefly is especially vulnerable to extinction due to human-caused habitat modification and drought. Entire populations can also be wiped out by stochastic events like floods. While floods can be catastrophic, fireflies do require moist conditions throughout their lifecycle and are often found in proximity to water (Evans et al. 2019). Loss of water sources could lead to increased firefly mortality due to desiccation or a reduction in larval food sources (Lewis et al. 2020).

Drought is already suspected to be driving declines in populations of the Southwest synchronous firefly. For example, in the summer of 2020, the monsoon rains were far below average, and *P. knulli* was not observed at three out of five historic sites (Walker & Cicero 2022a).

Artificial light at night (also known as light pollution or ALAN) can interfere with the behavior of nocturnal fireflies because it constitutes noise which, like the moon, can suppress the visual cues needed to take flight and recognize luminescence of their conspecifics. If bright enough, ALAN can also swamp out their optical physiology such that they may actually be blind to their surroundings (Owens & Lewis 2018; Lewis et al. 2020). Because the Southwest synchronous firefly begins its courtship displays after full darkness, it is likely more vulnerable to light pollution, especially in populations in closer proximity to urban areas such as Tucson, Patagonia, and Green Valley (Figure 8).

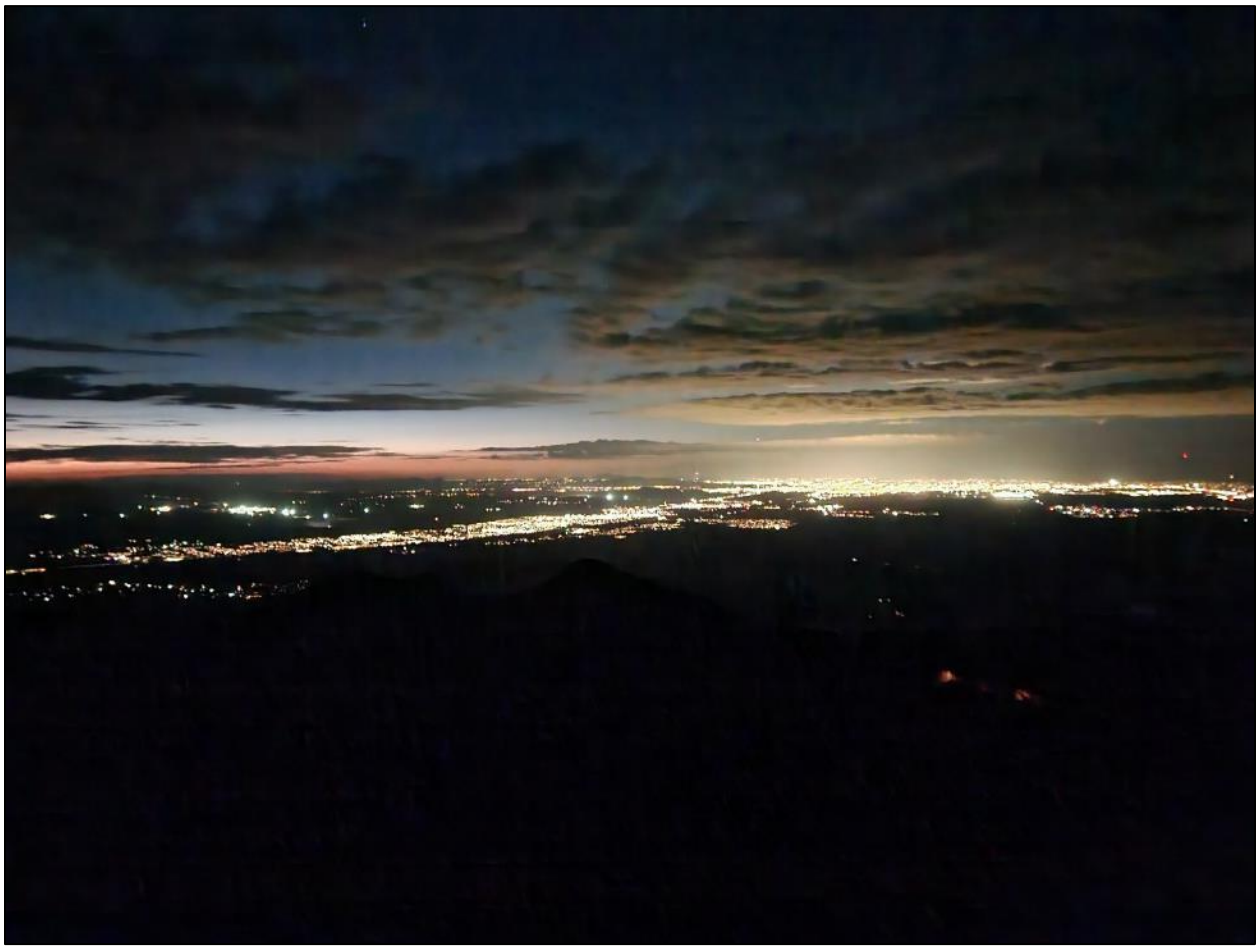

Figure 8. Artificial light at night as seen from the Whipple Observatory on Mt. Hopkins in the Santa Rita Mountains. The lights of Tucson can be seen on the horizon. (Joe Cicero).

Conservation Considerations:

The Southwest synchronous firefly is a rare desert riparian species documented from less than a dozen sites in Arizona and Mexico. This firefly is vulnerable to extinction because it is not known from very many localities, its population size is suspected to be small (especially compared to historic levels), and the species faces numerous threats to its persistence including habitat degradation, light pollution, and recreation. Small population sizes make this species particularly vulnerable to site-disturbing activities and stochastic events such as drought, fire, or flooding. The synchronizing displays put on by adult males may make this species attractive for public viewing, which also makes it more sensitive to trampling and other negative impacts from excessive visitation to sites. It is especially important to model responsible firefly viewing etiquette when surveying for this species or holding viewing events.

While this species occurs in at least one protected area (Tumacácori National Historical Park; UNEP-WCMC and IUCN 2024), there are no specific conservation measures in place to protect the firefly across its range or the habitats upon which it relies. However, entomologists at Tumacácori have already made significant progress in delineating firefly sites within the park, considering management and visitor impacts to fireflies and their habitat, educating the public about Arizona fireflies, and hosting well-managed firefly viewing events to share the wonder of these species while being considerate of their specific needs. Furthermore, the park's designation as an International Dark Sky Park in 2018 helps to ensure that night skies are kept dark enough for firefly courtship displays. However, recently proposed expansions in surrounding communities like Rio Rico threaten the area's dark skies, as development is likely to lead to increased light pollution.

Additional conservation measures are needed across the species' range, most critical of which are increased survey efforts throughout southeastern Arizona and research to better understand the species' distribution, life history, and habitat associations. At existing sites, especially those at Tumacácori and Peña Blanca, site protection will be critical to this species' persistence, and long-term monitoring can help managers better understand the species' abundance and population trends, particularly in response to threats and management actions. Populations at several sites where this firefly historically occurred appear to be in decline or potentially extirpated. This includes Peña Blanca Canyon—which once supported thousands of Southwest synchronous fireflies but now supports many fewer—and Sabino Canyon, where a once-stable population appears to have been lost (J. Cicero pers. comm. 2023). While this firefly continues to be reported from the Tucson Mountains and Santa Catalina-Rincon Mountain foothills, there do not appear to be permanent breeding populations in these mountains, possibly due to lack of adequate moisture. Small observable numbers from Sycamore Canyon suggest that a core population occurs deeper in the canyon or in one of the side canyons of this drainage, and increased survey efforts could help to confirm this.

Research needs

Despite recent work to assess the Southwest synchronous firefly's conservation status and compile a comprehensive database of known occurrence records, our understanding of this species' distribution, abundance, and population trends is limited, which hinders our ability to effectively conserve the species (Walker & Cicero 2022a). Basic details regarding this firefly's life history, microhabitat

requirements, and vulnerability to various threats are also largely unknown, further impeding conservation efforts. Critical information gaps must be addressed to inform conservation efforts for the Southwest synchronous firefly, including:

Natural history

- Are the larvae dietary specialists or generalists? What species do they prey on?
    - Test preferences for snails, earthworms, other soft-bodied invertebrates
- What microhabitat features are important to adults? To the larvae?
    - Try to observe oviposition behavior
    - Try to observe the emergence of adults, to better understand the microhabitat of pupae
- How close in proximity must they be to permanent water for populations to persist?
- What habitat associations and factors affect the persistence of *P. knulli* populations?

Species range and distribution

- What is the full extent of this species' range?
- Which observations represent breeding populations, and which are a result of errant dispersers?
- Can we use species distribution models to better inform 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 (drought, flooding, trampling by cattle) impact the species?
    - To what extent can subterranean larvae survive flooding or streambed overflow onto otherwise stable shores that they rely on for maturation?
- Can we model the impacts of drought and other climate change impacts on their populations?

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 areas along permanent waterways are needed to determine the full extent of this species' range. This firefly may occur in appropriate habitat elsewhere in Arizona. 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. GoPro camera setups have been successfully used to record courtship behavior, species-specific flash patterns, and firefly densities in recent years , and ongoing work in this area may lead to novel methods of detecting new populations and assessing species abundance (Sarfati et al. 2020, 2022). Engaging volunteers or leveraging biologists who are already in the field for nocturnal survey work (such as for bats, owls, or amphibians) may help build extra capacity for survey and inventory work.

Management actions

The Southwest synchronous firefly has been documented from less than a dozen localities in the US, and it is unclear if all of these populations remain extant, or if some of these observations reflect errant individuals and nonbreeding populations. Targeted protection and restoration of habitats where the species is known to reproduce will be crucial for supporting its populations. Land managers can play a key role in ensuring that known and potential habitat is not disturbed by development, cattle grazing, harmful pesticide applications, light pollution, recreation, or other intrusive management activities. Key actions that might help this firefly include:

- establishing and maintaining natural buffers around riparian habitats to maintain hydrology, protect groundwater, and reduce stormwater, pollution, and nutrient run-off
- rerouting roads and trails around sensitive habitat areas
- fencing off sensitive marsh habitats and maintaining these fences to ensure cattle, ATVs, and recreationists are not finding ways through
- removing or modifying artificial light sources 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, which may alter native plant communities and make them uninhabitable for fireflies
- assessing the impacts of proposed dams and other water modifications (such as those associated with mining operations) that may negatively impact this species' habitat
- setting up long-term monitoring programs at extant 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:

- Riparian areas, desert washes, and canyon arroyos near permanent water sources in southern Arizona

When:

- Surveys should occur 35 to 120 minutes after sunset from July through early September, during the summer monsoon rain season
- Minimum air temperature for activity is not known, but 65° Fahrenheit (18° Celsius) is likely a good threshold
- Wind speed should be at Beaufort scale 2 or lower (0-7 mph) if adults are being 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)
- If needed, secure the appropriate permits and/or site access permissions prior to conducting surveys
- Walk slowly along marshy habitats in riparian areas with permanent water sources, looking for three quick yellow flashes given over one second and repeated every five to six seconds
- Diagnostic morphological features to look for include a small (5-8 mm), slender body; a pronotum with rounded hind angles; and simple tarsal claws
- 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

- Have You Seen this Rare Firefly? https://www.fireflyatlas.org/firefly-posters

- Guide to Fireflies of the Southwest, by Anna Walker https://www.fireflyatlas.org/learn/firefly-publications

Firefly 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

Acknowledgements:

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