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Western Prairie Fringed Orchid Management, Ecology, and Decline at Mormon Island

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Abstract

The western prairie fringed orchid (*Platanthera praeclara* Sheviak & M. L. Bowles; WPFO) was first detected in a vegetative state on Mormon Island in 1978 and identification was confirmed following a mass flowering event in 1982. From a high count of ~60 plants the WPFO slowly declined and has not been observed since 2000 despite flowering season surveys conducted in 15 of the last 20 years. We explore the natural history of the WPFO in the contexts of Mormon Island to establish potential causes for its apparent disappearance and evaluate the possibility it persists in some capacity. Our investigation of secondary data suggests the Mormon Island vegetation community remains relatively intact, including species associated with WPFO occurrence. Examination of the ranges of known and potential WPFO pollinators suggests that *Sphinx drupiferarum*, *Eumorpha achemon*, and *Hyles lineata* were the most likely pollinators at Mormon Island, and recent observations of these species indicate pollinator decline may not have been a primary factor in WPFO disappearance locally. Research demonstrates individual WPFOs can occasionally live for decades, are able to survive underground as rhizomes for periods of time, and often present above ground as just 1–3 leaves during the growing season. Additionally, the seeds may persist in the soil for a substantial period of time. The WPFO appears to tolerate a reasonably wide range of habitat conditions and management regimes but may require a relatively narrow range of circumstances to flower *en masse*, including above average spring precipitation in subsequent years. Mass flowering events may also be stimulated by early spring burns that precede above ground vegetative growth and subsequent rest during the growing season, but research is equivocal. Though factors such as inbreeding depression and herbicide overspray could have potentially impacted the population, based on local conditions we suggest the WPFO may persist on Mormon Island in a reduced capacity. We recommend the continuation of growing season surveys and experimentation with multi-year management strategies that could stimulate growth and flowering.

Keywords: Western prairie fringed orchid, *Platanthera praeclara*, Management, Pollination, Ecology, Central Platte River Valley, Sphingidae

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Introduction and History

The western prairie fringed orchid (*Platanthera praeclara* Sheviak & M. L. Bowles; WPFO) was first located in a vegetative state in field number four at Mormon Island, Hall County, Nebraska (currently Northwest Mormon management unit; **Figure 1**), during initial inventory surveys in 1978, but identification remained unconfirmed until 1982 when over 50 predominantly flowering plants were discovered in the same general area (Currier 1982, 1984, Nagel and Kolstad 1987). The approximate location of notable clusters of WPFO included the southwest portion of the Northwest Mormon pasture, with smaller concentrations to the east within the southern half of the same management unit (Figure 1). Given concerns regarding the potential impacts of grazing, exclosures were placed around some concentrations for research purposes in the early 1980s (approximately 40.795460°N, -98.435211°W and 40.796549°N, -98.432704°W, respectively; Figure 1). Annual survey data is not available from 1983 to 1990, but Armstrong et al. (2017) reports a high count of 60 plants from this Hall County population during that time period. The USFWS began assisting with WPFO surveys shortly after the species was listed as Threatened under the Endangered Species Act in 1989 (USFWS 1989). Surveys generally consisted of multiple biologists walking east–west transects spaced about 5 m apart until the majority of the survey area had been visually assessed for WPFOs, with extra attention paid to areas surrounding the exclosures where the highest densities had once been (Crane Trust & USFWS unpublished data). Data from 1991 to 2000 demonstrates a steady decline in species

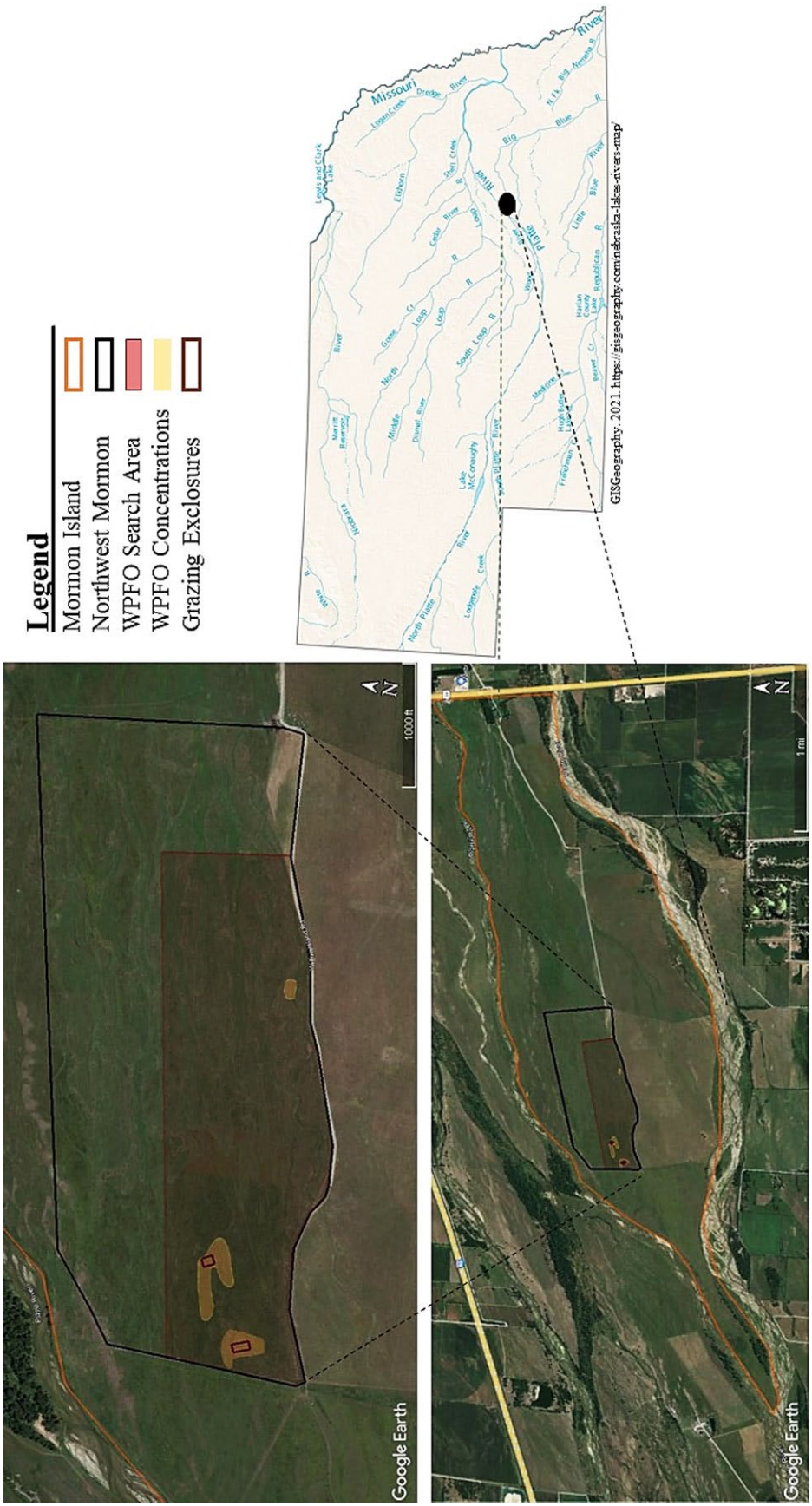

Figure 1. Map delineating the historic distribution of the western prairie fringed orchid (*Platanthera praeclara*; WPFO) on Mormon Island, Hall County, Nebraska. WPFOs were detected from 1978–2000 (yellow-filled polygons indicate concentrations derived from unpublished reports). Map also includes grazing exclosures (brown rectangles) used to assess the impacts of management on WPFO persistence, the annual search area surveyed from 1991–2000, 2002–2004, and 2010–2021 (red-filled polygon), the Northwest Mormon pasture (syn. field no. 4; black outline), Mormon Island (orange outline), and the location of Mormon Island within the state of Nebraska (Image sources: Google 2021, GISGeography 2021)

abundance, with 8-12 plants detected annually from 1991 to 1995 and only 1-4 plants detected between 1996 and 2000, which was the last time the WPFO was positively identified at Mormon Island despite continued summer surveys for the species from 2002 to 2004 and from 2010 to 2021 (Crane Trust & USFWS unpublished data). To provide insight into why the WPFO apparently disappeared from Mormon Island and determine if there is a chance it still persists undetected, we examined the natural history of the WPFO in the contexts of Mormon Island using secondary data sources.

Vegetative Associations and Habitat

Currier (1982) indicated that sedges (*Carex* spp.), rushes (*Juncus* spp.), prairie cordgrass (*Spartina pectinata*), ironweed (*Vernonia fasciculata*), asters (*Symphyotrichum* spp.), and mints (*Lamiaceae* spp.) represented community correlates of the WPFO at Mormon Island within the Central Platte River Valley (CPRV). Currier (1982) also noted that WPFOs occurred in poorly drained soils at the site. Bray and Wilson (1991) indicated that WPFOs were growing in-between swales dominated by *Carex* spp. and mesic flats dominated by slimstem reedgrass (*Calamagrostis stricta*) on Mormon Island in 1991. Bray and Wilson (1991) indicate the WPFO prefers sub-surface moisture but can tolerate up to 1 month of inundation and suggest that the species occupies the transition zone between wet and dry areas. I interpret this as zones of temporary or seasonal inundation, at the drier end of the wet meadow continuum (See Kantrud et al. 1989, Brinley Buckley et al. 2021). Wolken et al. (2001) indicated that WPFOs occupied swales with higher moisture content within 10 cm of the soil surface compared to unoccupied swales at Sheyenne National Grassland (SNG) in North Dakota. Wolken et al. (2001) additionally found that Baltic rush (*Juncus arcticus balticus*) as well as marsh hedge nettle (*Stachys palustris*) were positively associated with and predictive of WPFO occurrence. Relatedly, Sieg and King (1995) suggested WPFO occurrence was associated with *C. stricta* and *J. a. balticus* cover and was positively correlated with soil moisture at SNG. Despite the apparent local disappearance of the WPFO, the Northwest Mormon pasture vegetation community has remained very similar to that described by Currier (1982). *C. stricta*, *S. pectinata*, *V. fasciculata*, sedges (*C. pellita*, *C. emoryi*, *C. crawei*), rushes (*J. dudleyi*, *J. a. balticus*, *J. torreyi*), asters (*S. praealtum*, *S. lanceolatum, S. ericoides*), and mints (*Lycopus americanus*, *L. asper*, *Mentha arvensis*) remain relatively abundant and widespread (Crane Trust unpublished data, Caven and Wiese *In Review*), including several species associated with WPFO occurrence. This indicates that the disappearance of WPFO is not likely the result of a drastic shift in the local herbaceous plant community or the conditions that support it.

Management Considerations

When ~50 WPFOs were originally found on Mormon Island during late June of 1982, the site had been burned on 9 April 1982 and grazing was deferred until 15 July 1982 (Currier 1982, 1984). Currier (1982) speculated that fire may have a positive impact on WPFOs. Sheviak and Bowles (1986) similarly suggested that mass flowering events may be fire and/or moisture induced. Bleho et al. (2015) also indicated that periodic burning may be beneficial to the WPFO whereas severe grazing may be detrimental. Relatedly, Warner Alexander et al. (2010) found that WPFO seeds continue to mature from August to September and suggested that mowing, haying, and grazing should be deferred until after mid-September to promote maximum seed dispersal and establishment. Bleho et al. (2015) suggests a fire return interval of 2-3 years to promote WPFO occurrence. As Bridges et al. (2019) notes, fires increase calcium, magnesium and phosphorus availability in the soil, which may influence WPFO growth and flowering patterns (Wolken et al. 2001). However, Bjugstad-Porter (1993) found no impact of fire on WPFO flowering or growth, and Morrison et al. (2015) suggested fire may reduce plant height. Though the WPFO rhizome can survive overwinter even after a year when it did not produce an above ground shoot, repeated damage to standing vegetation from inappropriately timed intensive management (grazing, haying, or burning) across multiple growing seasons may lead to individual plant mortality and population declines as emerging shoots contain the apical meristem (Sheviak and Bowles 1986, Anderson and Smith 2020). However, it is of note that the population at Mormon Island persisted until at minimum the early 2000s despite season long cattle (*Bos taurus*) grazing at the site from the early 1900s until the late 1970s (Currier 1982, Bray and Wilson 1991, USFWS 2018). Moreover, historic records indicate that the CPRV was an important seasonal movement corridor for bison (*Bison bison bison*) before widespread European settlement, and therefore this area likely experienced periodically intensive grazing for thousands of years (Hart 2001).

Phenology and Persistence

Currier (1982) suggested that WPFO flowered from the last two weeks of June to the first two weeks of July at Mormon Island. Bray and Wilson (1991) noted 7 flowers in bloom or bud at Mormon Island on 17 June 1991 as well as 1 in bloom and "several" in bud on 12 June at Nine-Mile Prairie near Lincoln, NE. Siege and King (1995) noted that just a small fraction of individual WPFO plants persisted vegetatively above ground, whether blooming or not, for more than a few years. Tracking 160 plants marked in 1987, Siege and King (1995) found that only 2 presented above ground in all 8 of the subsequent years (1.3%). Just 16 plants (10.0%) were detected above ground in 5 or more years of the 8-year study (Siege and King 1995). The longest time period a plant was recorded being dormant and then reappearing above ground was 3 years and plants regularly reappeared vegetatively as only a couple leaves. Smith (2012) notes that in Minnesota plants regularly present as just 1–3 leaves during the growing season without flowering. Siege and King (1995) use their data to suggest that the WPFO may not be as long lived as previous researchers have speculated. However, Sather and Anderson (2012) documented individual plants persisting as long as 25 years with periods of dormancy in Minnesota. Sheviak and Bowles (1986) emphasize that WPFO mass flowering events have been noted following "several-year periods" of seeming absence and suggest that drastic fluctuations in above ground abundance are reflective of the species' adaptations to recurrent drought. It is unclear how long WPFO seeds remain viable in the soil, but researchers have speculated based on the species' life history and the seed bank present at some occupied sites that it may be a relatively long period of time (Hof 1999). Theoretically, long-term seed viability should buffer the species from catastrophic losses, so research that helps improve these estimates is highly important (Hof 1999).

WPFO seedling establishment and growth is dependent on mycorrhizal fungi (MF), however, this relationship is not fully understood (Sharma et al. 2003, Kaur et al. 2019). Though a whole host of MF taxa have been associated with WPFO sites, a particular taxon of Ceratobasidiaceae, *Ceratorhiza* spp., has been linked to increased seedling establishment and growth and was found to be present at WPFO sites across the species' range (Sharma et al. 2003, Kaur et al. 2019). Zettler and Piskin (2011) indicate that the closely related Eastern Prairie Fringed Orchid (*Platanthera leucophaea*) also appears to depend on *Ceratorhiza* spp. for mycotrophic requirements. Although this MF taxon was generally absent from sites without WPFO, it was found in bulk soil samples collected in Nebraska and Iowa (Kaur et al. 2019). Additionally, Kaur et al. (2019) found that levels of relevant MF taxa in area soils influenced those recovered from WPFO roots. Research indicates that soil MF communities are actually more stable than cooccurring bacterial communities and are largely driven by plant community composition (Hannula et al. 2019). The fact the vegetation community remains largely intact at Mormon Island may indicate that associated MF taxa linked to WPFO establishment also remain. However, future research is needed to confirm the presence of relevant *Ceratorhiza* spp. (Kaur et al. 2019).

Hydrology and Emergence

Bray and Wilson (1991) suggest that the previous year's moisture conditions may be important to ultimately growing a flowering stalk. Bleho et al. (2015) similarly indicates that hydrological and climatological conditions during the previous growing season and potentially winter may be important predictors of WPFO emergence in addition to wet springs during the flowering year. Sieg and King (1995) likewise found that both the current and previous growing seasons' moisture regimes may be important to WPFO reproduction and thus population persistence. Morrison et al. (2015) suggests that precipitation during the previous summer (June-July) supports bud and root system growth and that a certain threshold of spring precipitation (April-May) may also be needed to promote above ground emergence and flowering. Currier (1982, 1984) considered it "exceptionally" wet in 1982 when WPFO was first confirmed on Mormon Island, however, based on streamflow (1934-2020; USGS, Grand Island) and precipitation data (1893-2020; NOAA, Minden) 1982 was just slightly above average regarding moisture level. Mean annual precipitation was 24.5 in. from 1893 to 2020 and was 32.7 in. in 1981 (which may prep the plant for flowering; Bray and Wilson 1991) and 30.0 in. in 1982. It is of note that rainfall in May *was* exceptional in both 1981 and 1982, which totaled 7.8 in. and 7.3 in., respectively (mean = 4.1 in 1893-2020). However, mean annual streamflow (mean = 1,554 cfs, 1934-2020; USGS), which drives wet meadow inundation (Brinley Buckley et al. 2021), was actually below average in 1981 (895 cfs) and 1982 (1,104 cfs). Moreover, May flows were even further below average during those years (1981 = 733 cfs,

1982 =1,015 cfs, mean = 2,122 cfs, 1934-2020; USGS). In this sense, hydrological conditions in 1982 were not exceptionally wet, considering periods of regional record for precipitation (1893-2020) and streamflow (1934-2020), but 1982 did have above average May precipitation as did 1981.

Pollination

Some angiosperms have very exclusive plant-pollinator relationships (e.g., *Yucca elata* – *Tegeticula yuccasella*), while other flowering plant species rely on a wide range of mechanisms and wildlife species for pollination (*Helianthus annuus* – *Bombus* spp., *Apis mellifera*, & wind; Neff and Simpson 1990, Landry 2010, Pellissier et al. 2010). Though the WPFO lies somewhere between these two typologies, it requires the effective pollinator to have relatively specific morphometric characteristics (Sheviak and Bowles 1986, Cuthrell 1994, Westwood and Borkowsky 2004). To date only sphinx moths (Sphingidae) have been suggested as effective pollinators of WPFO, though other species have been documented exploiting the species' nectar resources without effectively pollinating it, including several bee species that apparently puncture the nectar spur (*Bombus* spp., *Apis mellifera*; Phillips 2003, Travers et al. 2011, Fox et al. 2015).

The number of sphinx moths that can successfully pollinate WPFO is constrained by both proboscis length and eye width (Sheviak and Bowles 1986, Cuthrell 1994, Westwood and Borkowsky 2004). The sphinx moth's eyes need to be wide enough apart that they come into contact with the viscidia that hold the pollinia (pollen sacs) when the head of the moth enters the flower, as in addition to the proboscis they are the only portion of the moth's body to which pollinia will adhere (Sheviak and Bowles 1986, Cuthrell 1994, Westwood and Borkowsky 2004). The viscidia are placed about 6-7 mm apart in WPFO and the moths that have been noted as effective pollinators via observations of pollinia attachment have mean distances across their outer eye margins ranging from 4.9 to 6.6 mm (Sheviak and Bowles 1986, Cuthrell 1994, Westwood and Borkowsky 2004, Fox 2008). The WPFO has a 50 mm long spur at the base of its flower that generally fills with 10-30 mm of nectar and therefore provides energy resources to sphinx moths (Sphingidae) with proboscis lengths ≥20 mm (Sheviak and Bowles 1986, Cuthrell 1994, Phillips 2003, Westwood and Borkowsky 2004). However, those species with proboscis lengths significantly exceeding 50 mm can actually serve as nectar robbers because they can drain the floral spur without coming into contact with the viscidia (e.g., *Manduca quinquemaculata, Agrius cingulata*; Sheviak and Bowles 1986, Fox et al. 2015). Known and potential pollinators of WPFO collectively have an average proboscis length of 35.4 ±1.9 mm (**Table 1**; Gregory 1964, Cuthrell 1994, Westwood and Borkowsky 2004, Travers et al. 2011). About 86% of these species include Nebraska within a portion of their range and about 57% have distributions extending into the CPRV (Table 1; Messenger 1997, Lotts et al. 2021).

Examining the ranges of known WPFO pollinators and the regional availability of larval host plants suggests that *Sphinx drupiferarum* (wild cherry sphinx), *Eumorpha achemon* (achemon sphinx), and *Hyles lineata* (white-lined sphinx) would be the most likely local pollinators of the WPFO in the CPRV. Historic records exist for *S. drupiferarum* about 50 km (31 mi.) west of Mormon Island near Prairie Center, Nebraska, just north of the CPRV (Lotts et al. 2021). This species is considered relatively uncommon but demonstrably secure within its range (Lotts et al. 2021). Recent distributional records exist within the CPRV for both *E. achemon* (verified photo from 09/16/2014 near Odessa, NE; 70 km/44 mi. W of Mormon Island; Lotts et al. 2021) and *H. lineata* (photo from 09/09/2018 on Shoemaker Island, Hall County, NE; 5 km/3 mi W. of Mormon Island; Crane Trust unpublished data, Lotts et al. 2021). *E. achemon* and *H. lineata* are also considered secure but occasionally rare within their range (Lotts et al. 2021).

Sphinx drupiferarum and *Eumorpha achemon* appear to be particularly effective WPFO pollinators (Cuthrell 1994, Westwood and Borkowsky 2004). Westwood and Borkowsky (2004) noted four *S. drupiferarum* carrying between 3 and 11 pollinia on their eyes. Similarly, Cuthrell (1994) noted a *S. drupiferarum* carrying 19 and an *E. achemon* carrying 17 total pollinia on their compound eyes. It is of note that all of these prospective pollinators either exclusively or occasionally use woody species as larval host plants (Table 1; Messenger 1997, Lotts et al. 2021) and the Crane Trust has worked to clear woody species from Mormon Island for the benefit of Whooping Cranes, Sandhill Cranes, and grassland birds (Pfeiffer and Currier 2005). However, sphinx moths have relatively strong dispersal capabilities and can therefore facilitate genetic exchange across isolated plant populations (Skogen et al. 2019). Consequently, it is unlikely that restoration efforts decreasing local larval host plant abundance precluded pollinators from accessing WPFOs at Mormon Island. Nonetheless, there is a possibility that pollinator densities were

Table 1. Known and potential sphinx moth (Sphingidae) pollinators of the western prairie fringed orchid (WPFO; *Platanthera praeclara*), their proboscis lengths, whether species have been detected in Nebraska (NE) or in the Central Platte River Valley (CPRV), whether species are know to pollinate the WPFO via observations of pollinia transportation (Known) or suspected to pollinate it based on morphometric characteristics (Potential), identified larval host plants found in the CPRV, and finally the source suggesting each species as an effective pollinator.

Genus species	Common Name	Proboscis Length[1] (mm)		Range[2]		Pollinator Status	Larval Host(s)[2]	Source[3]
		$\bar{x}$	*se/range*	*NE*	*CPRV*			
Lintneria eremitus	hermit sphinx	39.92	0.41	No	No	Known	*Monarda* spp., *Mentha* spp., *Lycopis* spp.	Fox et al. 2015
Hyles euphorbiae	spurge hawkmoth	25.52	0.23	Yes	Edge	Known	*Euphorbia* spp.	Fox et al. 2015
Hyles gallii	bedstraw hawkmoth	33.50	0.96	Yes	No	Known	*Galium* spp., Salix spp.	Westwood & Borkowsky 2004
Sphinx drupiferarum	wild cherry sphinx	38.40	0.97	Yes	Yes	Known	*Prunus americana, Celtis occidentalis*	Westwood & Borkowsky 2004
Eumorpha achemon	achemon sphinx	38.45	36.7-40.2	Yes	Yes	Known	*Vitis* spp.	Cuthrell 1994
Hyles lineata	white-lined sphinx	38.00	25.0-48.0	Yes	Yes	Known	*Mirabilis* spp., *Oenothera* spp., *Ulmus* spp.	Travers et al. 2011; Fox 2008
Sphinx kalmiae	laurel sphinx	33.64	1.31	Yes	No	Potential	*Fraxinus* spp., *Populus* spp.	Sheviak and Bowles 1986
Summaries	**-**	**35.35**	**1.89**	**85.7%**	**57.1%**	**-**	**-**	**-**

1) Sources include Gregory (1964), Cuthrell (1994), Westwood and Borkowsky (2004);
2) Sources include Messenger (1997), Lotts et al. (2021);
3) "Sources" pertain to "Pollinator Status."

reduced near the WPFO population as a factor of the site's distance to larval host plants. If WPFO reemerges at Mormon Island, there may be technical approaches to increasing the probability of pollination (attraction via blacklight; Cuthrell 1994, Westwood and Borkowsky 2004). It is unlikely that an acute scarcity of potential pollinators is the key factor resulting in WPFO decline at Mormon Island.

Conclusions and Implications

WPFO mass flowering events can be relatively stochastic, with significant periods of time between them (Currier 1984, Sheviak and Bowles 1986). It is possible the WPFO has persisted on Mormon Island in a predominantly vegetative and below ground state, or in low numbers at unsuspected locations (Smith 2012). As Morrison et al (2015) notes abundance can be highly variable across years (annual range at Pipestone National Monument, MN = 0–722 from 1993 to 2012) and individual plants can remain dormant for multiple years (Siege and King 1995, Sather and Anderson 2012). Additionally, some researchers have suggested that seed may remain viable in the soil for an extended period of time, however, significant uncertainty surrounds this assumption (Hof et al. 1999). Additional positive signs indicating that Mormon Island's WPFO population may persist include our observation that the vegetative community remains largely intact, including several species associated with WPFO occurrence, indicating that habitat conditions have not changed drastically (Currier 1982, Sieg and King 1995). This may also indicate that the associated mycorrhizal fungi communities have been persevered, but future research should confirm the presence of *Ceratorhiza* spp. (Hannula et al. 2019, Kaur et al. 2019). Though the WPFO may be somewhat sensitive to intensive and persistent disturbance throughout the

growing season, its general resilience to a range of management strategies also provides an indication it may persist on Mormon Island (Currier 1982, Sheviak and Bowles 1986, Bjugstad-Porter 1993, Bleho et al. 2015). We recommend the continuation of annual walking transect visual surveys during the flowering period for the foreseeable future (mid-June through early July).

Nevertheless, if present, WPFO numbers are likely substantially reduced at Mormon Island compared to those from the early 1980s, considering our significant vegetation survey efforts from 2015–2020 (Caven and Wiese *In Review*) in addition to annual flowering season surveys from 2010–2021 (Crane Trust & USFWS unpublished data) failed to detect the WPFO. Inappropriate use of non-selective herbicides to control purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), and other exotic-invasive species can harm the WPFO, and this may have had a negative impact on Mormon Island's population (Kraemer and Alsum 2006). Caution should be employed when controlling exotic-invasive species within the historic WPFO range at Mormon Island and localized mechanical treatments may reduce potential impacts compared to blanket herbicide applications but more research is needed (Bjugstad-Porter 1993, Kraemer and Alsum 2006). Another potential cause for decline could be lowered reproductive success associated with inbreeding depression in smaller populations of the WPFO (Ross and Travers 2016). If continued search efforts ultimately confirm the absence of WPFO, Mormon Island could serve as an ideal experimental reintroduction site given its appropriate habitat features (Krupnick et al. 2013).

A review of the data relating to WPFOs in the CPRV and elsewhere indicates that resting a wet meadow pasture (e.g., Northwest Mormon) from grazing during a wet year, administering an early spring burn (late March to early April; before above ground WPFO growth begins) in a subsequent relatively wet year, and continued rest from grazing through the flowering period may be the best 2-year management approach to stimulating WPFO growth and flowering. However, planning such management in the right hydrological contexts poses several challenges and considerable uncertainty remains in the literature regarding the impacts of fire and grazing on the WPFO.

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