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NOTES ON THE STATUS AND ECOLOGY OF *STRYMON ACIS BARTRAMI* (LYCAENIDAE) IN EVERGLADES NATIONAL PARK

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ABSTRACT. A 10-year survey was conducted within the pine rocklands of Everglades National Park to study the status, phenology and natural history of *Strymon acis bartrami* (W. Huntington and Comstock). The response of populations of this species to prescribed fires and hurricane activity within the Everglades was also noted. *Strymon a. bartrami* (n = 77 adults) was encountered throughout the survey, most often in the spring, but was generally uncommon. The species was slow to re-colonize recently burned pine rocklands. However, prescribed fires conducted in a cyclic pattern as well as near appropriate hostplant-bearing refugia may have aided *S. a. bartrami* in post-burn re-establishment. In addition, the species appeared to recover quickly after hurricane events in the Everglades.

Additional key words: prescribed fire, phenology, conservation, hurricanes

Strymon acis bartrami (W. Huntington & Comstock) (Lycaenidae) (Fig. 1) has historically occurred throughout the pine rocklands of southern Florida and the lower Florida Keys (Baggett 1982; Minno & Emmel 1993; Smith *et al*. 1994; Salvato & Hennessey 2004), where it is endemic. However, due to extensive habitat loss across much of its former range, this species is now restricted to the pine rocklands within and adjacent to Everglades National Park (Fig. 2) as well as to Big Pine Key, which is part of the National Key Deer Refuge (NKDR) in the lower Florida Keys.

In addition to habitat loss, use of chemical adulticides for mosquito control and suppression of natural fire regimes have been suggested as primary factors that have influenced the decline of *S. a. bartrami* (Hennessey & Habeck 1991; Hennessey *et al*. 1992; Emmel *et al*. 1995; Schwarz *et al*. 1996; Salvato 1999, 2001).

In the Everglades, where the threat of further habitat loss or use of chemical pesticides is reduced, the role and frequency of fire remains a critical factor influencing populations of *S. a. bartrami* (Salvato 1999; Salvato & Hennessey 2004). Historically, periodic lightning-induced fires were a vital component in maintaining native vegetation within the pine rockland ecosystem (Loope & Dunevitz 1981; Slocum *et al*. 2003), including *Croton linearis* Jacq. (Euphorbiaceae), the only known hostplant for *S. a. bartrami*. While prescribed fire had been employed as a management tool in the Everglades for several decades, it was only towards the end of the twentieth century that these protocols were adapted to best mimic the timing of lightning-ignited fires and their role in natural histories of various pine rockland species.

Strymon a. bartrami is rarely found farther than 5 m from the hostplant (Schwartz 1987; Worth *et al*. 1996; Salvato & Salvato 2008) and is generally thought to have limited dispersal abilities preventing the species from escaping fire events (Salvato & Hennessey 2004). Kwilosz & Knutson (1999) found that, while fire

FIG. 1. *S. a. bartrami* at gate 4 in Long Pine Key on 22 November 2003 (Photo: H. L. Salvato).

improves habitat, it also temporarily suppresses resident butterfly populations. Swengel (1996) and Swengel & Swengel (2001, 2007) indicated that many specialist insects have a negative short-term response to fires because they must rebuild their populations from unburned areas. Therefore, when large or entire tracts of *C. linearis*-bearing pine rocklands are burned the *S. a. bartrami* populations that occurred within them may be either extirpated or only slowly re-colonized from adjacent areas (Lenczewski 1980; Salvato & Hennessey 2004).

Salvato & Salvato (2007) discussed the influence of hurricane and tropical storm activity on several butterfly species within coastal portions of southern Florida. These studies indicated that species richness and abundance returned to pre-storm levels within one year after the disturbances. However, the potential influence of tropical storms on pine rockland species such as *S. a. bartrami* has never been evaluated.

This paper describes our ongoing population monitoring of *S. a. bartrami* within Everglades National Park and examines phenology, natural history, and response to hurricane activity, as well as the possible influence of prescribed fires on the abundance of this species.

METHODS

A survey transect was established at the gate 4 nature trail in the Long Pine Key (LPK) portion of Everglades National Park and monitored on one sampling date a month from January 1999 to December 2008 following the parameters outlined in Hennessey & Habeck (1991) and Salvato (1999). The transect was 400 m long and 5 m wide (0.2 ha) and occurred within pine rockland habitat with evenly distributed amounts of hostplant. To determine *S. a. bartrami* distribution in LPK additional, similarly proportioned transects (n = 3) were established during 2004 in areas where the species had been historically reported (gates 2, 8 and 10) (Fig. 3). These additional transects were monitored on one sampling date a month from 2004 to 2008. The status and natural history of another imperiled pine rockland

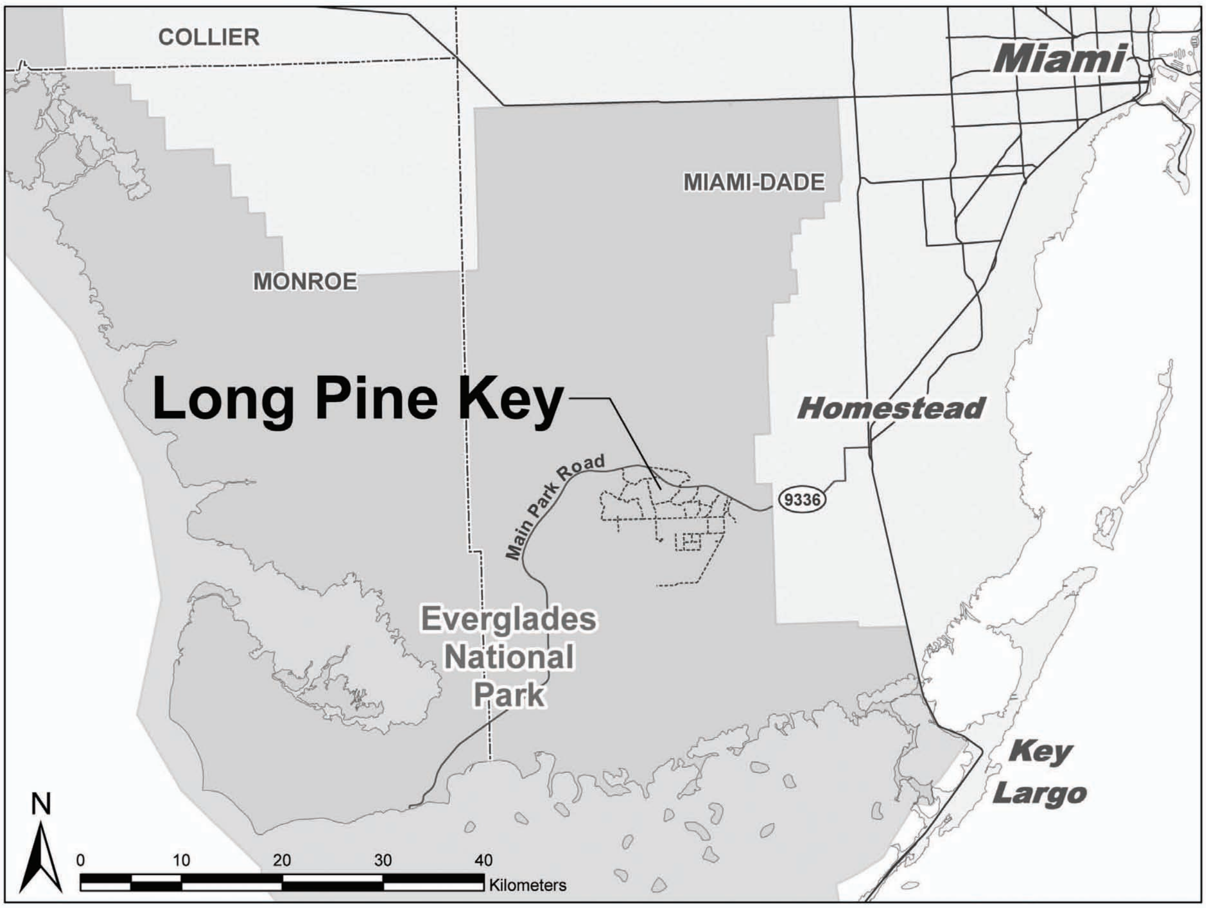

FIG. 2. Location of Long Pine Key within Everglades National Park (Park area and boundaries are indicated by shaded coloring) and southern Florida.

butterfly, *Anaea troglodyta floridalis* F. Johnson & Comstock, was also studied during this survey and these data are discussed elsewhere (Salvato & Salvato 2010).

Sampling dates occurred on warm, clear days when temperatures were considered sufficient for butterflies to be active. Adult butterfly abundance was determined on each monthly sampling date by recording the number of butterflies observed. Monthly visits to transects occurred at approximately four-week intervals which reduced the likelihood of encountering the same individuals on consecutive sampling dates. During 1999 to 2003 each monthly sampling date included approximately three to four hours of field time (between 08:00–12:00 h) at gate 4. From 2004 onward field time increased to approximately 9 hours (between 08:00– 17:00 h) on each monthly sampling date to accommodate the additional study sites at gates 2, 8 and 10.

Surveying transects on a monthly basis provided a standardized method for monitoring *S. a. bartrami* over the study period. Throughout the 10-year duration of this survey we attempted to choose sampling dates under appropriate weather conditions for *S. a. bartrami* to be active. However, these studies only provided a general estimate of *S. a. bartrami* abundance during this time frame. Additional sampling dates may have reflected a different level of abundance at the various survey sites.

On the same dates *C. linearis* (n = 100) was inspected at the gate 4 transect to monitor for larval activity. Fresh growth and flowers of *C. linearis* were examined for early instar *S. a. bartrami* larvae, while mature parts of the hostplant were searched for older larvae. Approximately one hour was spent inspecting *C. linearis* for *S. a. bartrami* larvae at gate 4 during every sampling date. *Croton linearis* was not monitored as extensively for larvae on the remaining transects, but larval activity, when observed at these locations, was noted. We attempted to determine the fate of larval development on subsequent sampling dates by examining the plants on or near where larvae had been observed during prior visits.

On several occasions throughout the study, prescribed burns were administered on all or part of select study sites. In such instances *C. linearis* was monitored to note general recovery time post-burn as well as duration until *S. a. bartrami* returned to the study site. In addition, adult *S. a. bartrami* abundance within the gate 4 study area was evaluated during the six months preceding and following burn events. A paired t-test (one-tailed) was used to compare overall *S. a. bartrami* abundance pre- and post-burn following prescribed fires at gate 4. This analysis allowed for small sample sizes of *S. a. bartrami* abundance, with unequal variances, to be examined before and after fire events at the same site on different years.

Following hurricanes Irene (1999), Katrina (2005) and Wilma (2005) we monitored the response of *S. a. bartrami* to storm influence.

RESULTS

Table 1 indicates the number of adult *S. a. bartrami* observed during 1999 to 2008 at Long Pine Key at gate 4, based on monthly surveys. Only one adult was observed during 1999 (9 March) (Salvato 2003). In subsequent years between one (2008) and 15 (2006) adults were observed annually.

A total of 55 adult *S. a. bartrami* was recorded at gate 4 over the 10-year survey period. Table 1 summarizes our observations of the species (n = 22) at gates 2, 8 and 10 during 2004 to 2008. Adults were observed during every month of the year, but the majority of observations occurred from March to June (Table 2), suggesting the species reaches peak abundance in LPK during spring.

TABLE 1. Total number of adult S. a. bartrami observed annually during 1999 to 2008 in Long Pine Key at gates 2, 4, 8 and 10, based on 12 months of sampling each year. NA indicates that data was not collected at this location during this period.

Area	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Gate 2	NA	NA	NA	NA	NA	2	5	6	4	0
Gate 4	1	6	6	5	3	9	6	15	3	1
Gate 8	NA	NA	NA	NA	NA	0	0	0	1	4
Gate 10	NA	NA	NA	NA	NA	0	0	0	0	0

TABLE 2. The mean number (± standard deviation) of adult S. a. bartrami observed monthly during 1999 to 2008 in Long Pine Key at gate 4 only, based on 12 months of sampling each year.

Month	Mean	Std. Deviation
January	0.3	0.483
February	0.4	0.516
March	0.7	0.675
April	1.0	1.491
May	1.4	1.647
June	0.9	1.101
July	0.2	0.422
August	0.2	0.422
September	0.3	0.483
October	0.2	0.422
November	0.5	0.707
December	0.3	0.483

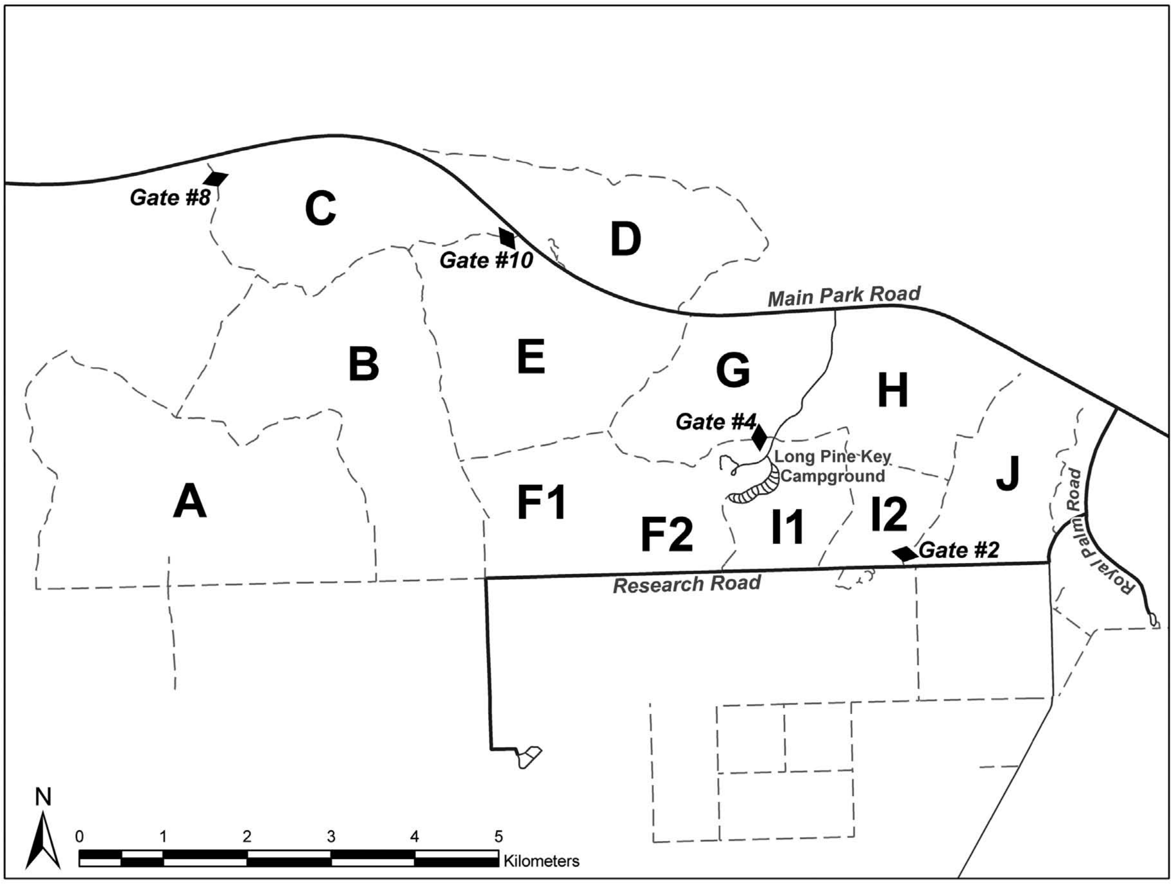

FIG. 3. Locations of the study areas at gates 2, 4, 8 and 10 and the burn units within Long Pine Key.

Figure 4 shows adult *S. a. bartrami* abundance at gate 4 during the six-month periods preceding and following the six prescribed fire events administered during the study period. Similar *S. a. bartrami* abundance was observed at gate 4 before and after four of the six burn events. As a result, although more adults were observed prior to prescribed burns (n = 29, mean = 4.833) than after the fires (n = 4, mean = 0.667), this difference was not significant (t-test; t = 1.7885, p = 0.0669).

Several adult *S. a. bartrami* observations at gate 4 in early 2000 (n = 6) (following Hurricane Irene in October 1999) and early 2006 (n = 15) (after Hurricane Katrina in August 2005 and Hurricane Wilma in October 2005) suggested that this species can recover quickly from the influence of storm activity.

Only four *S. a. bartrami* larvae were encountered during this study, three at gate 4 (May 1999, March 2003 and April 2006) and one at gate 8 (December 2007). The cryptic nature of the larvae made them difficult to locate and it is likely that a considerable number of individuals were overlooked during our surveys.

DISCUSSION

The population status of *S. a. bartrami* within the Everglades has varied in the literature for several decades. Lenczewski (1980) indicated that while the species was encountered consistently within the pine rocklands of Long Pine Key during the early 1970s, it appeared to have been extirpated in the Everglades later that decade. However, subsequent surveys by Hennessey & Habeck (1991) and Emmel *et al*. (1995) found the species in low numbers. Salvato (2001) was unable to find *S. a. bartrami* within LPK during an intensive survey in 1997–98, but did ultimately encounter the species in 1999 at gate 4 at the onset of this study (Salvato 2003). During the present survey, the species was observed throughout the year, most frequently during the winter and spring across LPK, but never abundantly.

Salvato & Hennessey (2004) suggested that *S. a. bartrami* may have historically been more common within the Everglades due to the influence of a natural fire regime that maintained a widespread distribution of *C. linearis*. Natural fires in the pine rocklands are

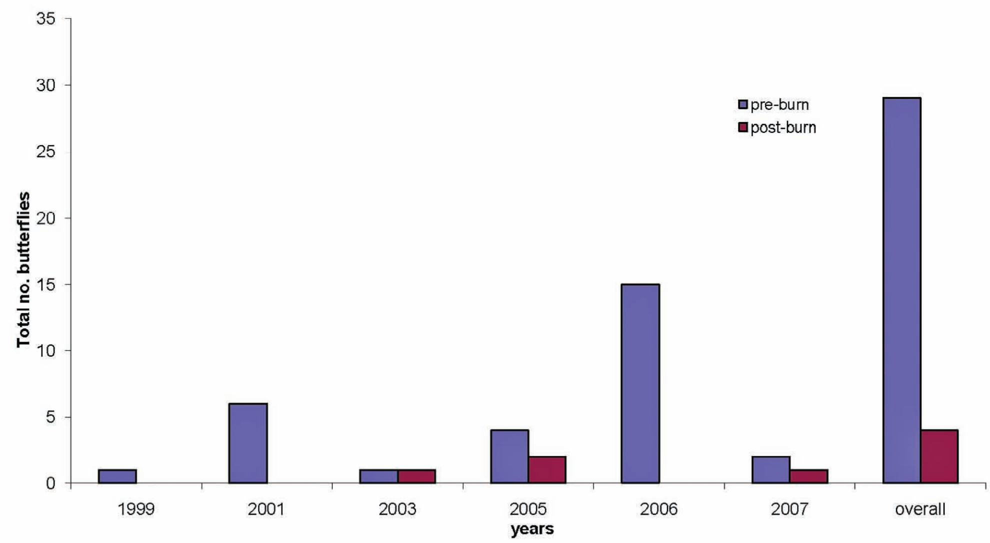

FIG. 4. Indicates the total number of adult *S. a. bartrami* observed at gate 4 of Long Pine Key within the six months preceding and following prescribed burn events.

important in regulating and maintaining the herbaceous layer, including *C. linearis* (Loope & Dunevitz 1981; Carlson *et al*. 1993; Bergh & Wisby 1996; Slocum *et al*. 2003). Since 1989, LPK fire management staff have ignited prescribed fires on a cyclic basis to best mimic those historically initiated by lightning strikes (Slocum *et al*. 2003). While this policy has resulted in pine rockland restoration throughout much of LPK, including a resurgence in *C. linearis*, many populations of this hostplant remain fragmented throughout the Everglades. This has isolated *S. a. bartrami* populations (Salvato 1999), possibly presenting an obstacle towards re-colonization. Salvato & Hennessey (2004) indicated that *S. a. bartrami* appears to require continuous stands of *C. linearis*, based on its close association with this hostplant. In the lower Florida Keys, Salvato (1999, 2003) and MHS & HLS (unpublished data) reported finding *S. a. bartrami* reliably in areas of Big Pine Key within NKDR that maintained widespread *C. linearis*, but found the species to be less frequent where hostplant populations were small or fragmented.

At the onset of this survey we encountered *S. a. bartrami* consistently in low numbers at gate 4, an area in Long Pine Key where *C. linearis* is common and largely contiguous. During June 2001 much of our gate 4 study area in burn units F2 and G (see Fig. 3) was subjected to a prescribed burn (approximately 540 ha) and *S. a. bartrami* was not observed again at this location more than six months (Fig. 4).

Lenczewski (1980) and Salvato & Hennessey (2004) indicated that *S. a. bartrami* requires at least five months to re-colonize an area following a burn. However, in 2007 MHS & HLS (unpublished data) found that this species had successfully re-colonized prescribed burn areas of Navy Wells Pineland Preserve, an approximately 100-ha area consisting largely of relict pine rocklands adjacent to the Everglades, within only three to four months of the fires. The small sizes of these prescribed fires (5 and 11 ha, respectively) and availability of *C. linearis* adjacent to the burn sites may have aided *S. a. bartrami* in re-establishing more quickly. By comparison burns in LPK during this study were often larger and not always near or containing appropriate hostplant-bearing refugia. Knight & Holt (2005) found insect abundance to be higher at the edges of burned areas bordered by refugia as compared to the interior of the treatment area. Swengel & Swengel (1996) reported that *Lycaeides melissa samuelis* Nabokov (Lycaenidae) responded favorably to fire management practices in central and northwestern Wisconsin when provided with unburned refugia for recolonization. Kwilosz & Knutson (1999) determined that while *L. m. samuelis* numbers dropped substantially within burned areas, overall population numbers remained unchanged due to recolonization of the area by individuals surviving within the refugia or returning from adjacent unburned units. Similarly, Panzer (2003) and Johnson *et al*. (2008) reported that many insects will successfully rebound in a burned location provided that enough individuals can re-colonize from adjacent areas. If *S. a. bartrami* is unable to disperse adequately during fire events then only adults at the periphery of burned areas are likely to escape to adjacent pine rocklands (Salvato & Hennessey 2004). Given the low numbers of *S. a. bartrami* found in this and other surveys, it is likely that only a small number of butterflies reach refugia during LPK burn events, thereby reducing the ability of the species to return and re-colonize in substantial numbers after a fire.

Although the prescribed burns conducted within the gate 4 study area during 2001 were extensive, those conducted throughout the remainder of the survey period were done in an alternating pattern from year-to-year. This provided such species as *S. a. bartrami* with refugia of similar habitat adjacent to the burn locations. Following each of these subsequent burns, at least one side of our gate 4 study site (unit F2 or G) continued to maintain *C. linearis* for butterfly use until the entire area recovered. Possibly as a result of this cyclic burn pattern and continual access to *C. linearis* adult *S. a. bartrami* observations increased within gate 4 during 2004 and into early 2006. In the winter and spring of 2006, we recorded 15 adults within the northern half of gate 4, the greatest abundance noted for the species during this survey.

However, this increased abundance was short-lived. A prescribed burn (approximately 353 ha) was conducted during June 2005 within unit F2 on the southern side of the gate 4 study area. Post-burn recovery of *C. linearis* was slow and hampered by hurricane activity. At one-year post-burn, the hostplant was sparse within the southern portion of gate 4, but it remained abundant in unit G to the north, where the majority of the *S. a. bartrami* were observed. A prescribed burn (approximately 318 ha) was administered to unit G during July 2006. Following this burn *S. a. bartrami* abundance declined again at gate 4 for the remainder of the study (Table 1).

Strymon a. bartrami was encountered sporadically on a number of our other transects (gates 2 and 8) and elsewhere (gate 11) in LPK during the remaining years of this study. These are areas where the species was previously reported (Hennessey & Habeck 1991; Emmel *et al*. 1995) (Table 1). This suggests that while *S. a. bartrami* is largely uncommon in LPK, the species continues to be widespread. Although our studies focused largely on the relationship of *S. a. bartrami* and fire at gate 4, we also noted that the species responded favorably to a burn at gate 8 (around Pine Glades Lake) in 2005 and less so to a fire at gate 2 during 2007. The role and influence of prescribed fire on other *S. a. bartrami* population segments within the Park will require further evaluation.

Cyclic and alternating treatment of burn units may have benefited *S. a. bartrami* during much of the present study, both at gate 4 and perhaps elsewhere in LPK, yet this alone may not be sufficient to increase the species' numbers. Providing refugia directly within (as well as adjacent to) the treatment area during prescribed burn activities may substantially increase the potential for *S. a. bartrami* to re-colonize recently burned areas and allow the species to remain within or near the fire-treated pineland. Use of refugia, particularly within the most abundant segment of a specialist butterfly population, has proven successful in retaining or increasing the densities of several imperiled butterflies (Panzer 2002, 2003; Kwilosz & Knutson 1999; Swengel & Swengel 1996, 2007). In addition, Swengel & Swengel (2007) indicated that establishment of permanent, non-fire refugia, managed through the use of less intensive alternatives had numerous benefits for a variety of specialist arthropod groups. Emmel *et al*. (2005) and Schwarz *et al*. (1996) promoted the use of prescribed fire to maintain the pine rocklands for *S. a. bartrami* conservation, but suggested that in addition to the burns, select areas with large stands of *C. linearis* be maintained by hand clearing of dense understory growth.

Strymon a. bartrami was listed as a candidate species for Federal protection on 12 September 2006 based on the continued range-wide decline of the species within the United States. Given the imperiled status of *S. a. bartrami* in southern Florida, the conservation and protection of this species requires urgent attention from land managers.

In summary, to help reduce fragmentation of *S. a. bartrami* populations and limit obstacles toward the species re-colonization in LPK following burns, prescribed fire treatments in the pine rocklands should continue on a cyclic basis, and whenever possible be on a smaller scale than those done historically. Maintaining unburned patches of hostplant-bearing refugia within or adjacent to the treatment areas will likely also aid *S. a. bartrami* in reestablishment. Where feasible, over growth should be reduced through hand clearing or other less intensive means. In the absence of continued cyclic burn patterns, reductions in overall treatment scale, adequate refugia within burn-treated areas, or the application of other forms of adaptive management within the LPK fire regime, it is likely *S. a. bartrami* will continue to occur only in the low densities observed during the majority of this study.

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