

## **STATUS OF THE SPECIES - Bartram’s scrub-hairstreak butterfly (*Strymon acis bartrami*)**

**Legal Status** - The U.S. Fish and Wildlife Service (Service) listed the Bartram’s scrub-hairstreak butterfly as an endangered species under the Endangered Species Act of 1973, as amended (Act) (87 Stat. 884; 16 U.S.C. 1531 et seq.) on August 12, 2014 (79 FR 47221). Critical habitat was designated at the same time on August 12, 2014 (79 FR 47179) within Miami-Dade and Monroe Counties.

The Service first recognized the Bartram’s scrub-hairstreak as a candidate in 1984 and later removed it from the list in 1996 because there was not sufficient information on the subspecies’ biological vulnerability and threats to support issuance of a proposed rule. In 2006, the Service recognized the Bartram’s scrub-hairstreak as a candidate species, with a Listing Priority Number of 3 (threat is imminent) and subsequently listed the species on August 12, 2014. Throughout this timeframe the Service has worked closely with scientific experts, land managers, and stakeholders to implement actions that will help ensure survival and long-term recovery of the subspecies.

The Bartram’s scrub-hairstreak is not currently listed by the State of Florida as a protected species under Chapter 68A-27, Rules Relating to Endangered or Threatened Species.

### **Species Description**

#### *Appearance/Morphology*

The Bartram’s scrub-hairstreak is a small butterfly approximately 25 millimeters [mm; 1 inch (in)] in length with a forewing length of 10.0 to 12.5 mm (0.4 to 0.5 in) and has an appearance characteristic of the genus (*i.e.*, dark gray-colored on the upper (open) wings, light gray-colored under (closed) wings, small size, body shape, distinctive white barring or dots on underwings, and tailed hindwings) (Pyle 1981, Opler and Krizek 1984, Minno and Emmel 1993).

#### *Taxonomy*

The Bartram’s scrub-hairstreak butterfly (*Strymon acis bartrami*) was first described by Comstock and Huntington in 1943. Seven subspecies of *Strymon acis* have been described (Smith *et al.* 1994). Smith *et al.* (1994) indicated that perhaps no other butterfly in the West Indies has evolved as many distinct island subspecies as *S. acis*. Each group of Antillean islands appears to have its own particular set of *S. acis* hairstreaks, and these have been classified into two separate groups. The Type A subspecies are larger, darker colored and are found in the more southeastern Antillean islands. The Type B subspecies, to which the Bartram’s scrub-hairstreak belongs, are smaller, more surface-grey colored.

The Integrated Taxonomic Information System (2015) uses the name *Strymon acis bartrami* and indicates that this subspecies’ taxonomic standing is valid. FNAI (2015) uses the same name *S. a. bartrami*.

## Life History

As with the Florida leafwing, pineland croton is the only known hostplant for the Bartram’s scrub-hairstreak (Minno and Emmel 1993, Smith *et al.* 1994). However, other related scrub-hairstreak species, such as the Martial scrub-hairstreak (*Strymon martialis*), while having preference for bay cedar as a larval hostplant, have recently been documented using nickerbean (*Caesalpinia spp.*) in the Florida Keys (Daniels *et al.* 2005). Similarly, the mallow scrub-hairstreak (*Strymon istapa*) has also been shown to use a variety of host sources in southern Florida. While the Bartram’s scrub-hairstreak has been consistently documented to use pineland croton, further natural history studies may indicate the subspecies’ use of additional pine rockland plants for larval development.

The Bartram’s scrub-hairstreak is rarely encountered more than 5 meters [m; 16.4 feet (ft)] from its host plant–pine rockland interface (Schwartz 1987, Worth *et al.* 1996, Salvato and Salvato 2008). Worth *et al.* (1996) and Salvato and Hennessey (2004) indicate that the Bartram’s scrub-hairstreak may have limited dispersal abilities. However, while the hairstreak is often described as sedentary, the need to evade natural disturbance (fires, storms) and subsequently recolonize suggests that adult hairstreaks, perhaps as a function of age, sex, or density, are adapted for effective dispersal throughout the pine rockland habitat and associated ecosystems. Eggs are laid singly on the flowering racemes of pineland croton (Worth *et al.*, 1996, Salvato and Hennessey 2004). Hennessey and Habeck (1991) observed a female oviposit three eggs over the course of 5 minutes. This long duration of oviposition likely enables females to serve as one of the major pollinating species for the host plant (Salvato 2003). First and second instars remain well camouflaged amongst the white croton flowers, while the greenish later stages occur more on the leaves.

The Bartram’s scrub-hairstreak is most often observed visiting pineland croton flowers for nectar, but has also been observed using the flowers of other species, including: pine acacia (*Acacia pinetorum*), Spanish needles, saw palmetto (*Serenoa repens*), button sage (*Lantana involucrata*), Bloggett’s swallowwort (*Cynanchum blodgettii*), Everglades Key false buttonwood (*Spermacoce terminalis*), locustberry (*Byrsonima lucida*), and starrush whitetop (*Rhynchospora colorata*) (Minno and Emmel 1993, Worth *et al.* 1996, Calhoun *et al.* 2000, Salvato and Hennessey 2004, Salvato and Salvato 2008, Anderson 2010).

The Bartram’s scrub-hairstreak has been observed during every month on Big Pine Key and in Everglades National Park (ENP); however, the exact number of broods appears to vary sporadically from year to year (Salvato and Hennessey 2004, Salvato and Salvato 2010a). Salvato and Salvato (2010b) indicated the hairstreak is most abundant in the spring and early summer, throughout its range. However, on Big Pine Key, the subspecies is often uncommon during the fall and early winter (Salvato 1999, Anderson and Henry 2015, Salvato 2015).

## Habitat

The Bartram’s scrub-hairstreak occurs only within pine rocklands, specifically those that retain the subspecies’ only known larval hostplant, pineland croton.

Once occurring throughout the pine rocklands of the lower Florida Keys (Dickson 1955, Hennessey and Habeck 1991, Salvato 1999), pineland croton now occurs only on Big Pine Key. The last reports of the hostplant from other keys were from No Name and Little Pine Keys (Carlson et al. 1993; Hennessey and Habeck 1991). Recent surveys of relict pine rockland habitat throughout the Lower Keys by Salvato (1999) and Salvato and Salvato (2010b) failed to locate the plant on any island other than Big Pine Key. Big Pine Key retains the largest undisturbed tracts of pine rockland habitat in the keys (Zhong *et al.* 2010, Roberts 2012).

On peninsular Florida the largest remaining stands of pine rockland habitat occur within the Long Pine Key region of ENP (Service 1999). The current distribution and abundance of pineland croton across all extant pine rockland habitat fragments within Miami-Dade County, outside of ENP, is not fully known. Geographic information system analysis conducted by the Service using data collected by The Institute for Regional Conservation (IRC) in 2004, indicated that 77 pine rockland habitat fragments (totaling 516 hectares [ha; 370 acres (ac)] in Miami-Dade County, contained pineland croton (IRC 2006). More recently, in 2012, the Service funded Fairchild Tropical Botanic Gardens (FTBG) to conduct extensive surveys of Miami-Dade pine rockland habitat fragments to determine current pineland croton abundance and distribution. Pineland croton populations were encountered at 11 of the 13 locations surveyed, the largest occurring at Navy Wells Pineland Preserve and the Richmond Pine Rocklands, with each site retaining more than 21,000 individual plants (Maschinski *et al.* 2013).

Adult butterflies will also make use of rockland hammock and hydric pine flatwood vegetation when interspersed within the pine rockland-bearing regions discussed above.

## **Distribution**

### *Historical Range*

The Bartram’s scrub-hairstreak is endemic to south Florida including the lower Florida Keys. The butterfly was locally common within pine rockland habitat that once occurred within Miami-Dade and Monroe Counties and were less common and sporadic within croton-bearing pinelands in Collier, Palm Beach, and Broward Counties (Kimball 1965, Baggett 1982, Schwartz 1987, Hennessey and Habeck 1991, Minno and Emmel 1994, Smith *et al.* 1994, Emmel *et al.* 1995, Worth *et al.* 1996, Schwarz *et al.* 1996, Salvato and Hennessey 2004).

### *Current Range*

Populations of the Bartram’s scrub-hairstreak have become increasingly localized as pine rockland habitat has been lost or altered through anthropogenic activity (Baggett 1982, Hennessey and Habeck 1991, Schwarz *et al.* 1996, Salvato and Hennessey 2004, Salvato and Salvato 2010a). Recent surveys and natural history studies (Salvato 1999, 2001, 2003, Salvato and Hennessey 2004, Minno and Minno 2009, Salvato and Salvato 2010b, Anderson 2012a, Land 2012, Maschinski et al. 2013, Cook 2013) indicate that the Bartram’s scrub-hairstreak is extant on Big Pine Key (Monroe County), in the Long Pine Key Region of ENP, and locally

within pine rockland habitat fragments on mainland Miami-Dade County, particularly those adjacent to ENP, such as Navy Wells Pineland Preserve and the Richmond Pine Rocklands.

### **Population Dynamics**

In ENP, Salvato and Salvato (2010a) and Salvato (2015) have encountered as many as 6.3 adult Bartram’s scrub-hairstreaks per ha (2.5 per ac) annually from 1999 to 2015, based on monthly surveys in Long Pine Key. Ongoing surveys conducted by ENP staff from 2005 to present have encountered a total of approximately 24 and 30 hairstreak adults and larvae, respectively, throughout Long Pine Key (Land 2012; Sadle 2013).

Additional pine rockland habitat fragments within Miami-Dade County that are known to maintain small, localized populations of pineland croton and sporadic occurrences of Bartram’s scrub-hairstreak, based on limited survey work, include: Navy Wells Pineland Preserve, Camp Owaissa Bauer (owned and managed by Miami-Dade County), and several parcels within the Richmond Pine Rocklands, including: Larry and Penny Thompson Memorial Park, Zoo Miami Preserve, Martinez Pineland Park, and U.S. Coast Guard lands in Homestead (Minno and Minno 2009, Possley 2010). Adult butterflies have also been observed within Zoo Miami (Cook 2013).

In the lower Florida Keys ongoing surveys by Salvato (2015) indicate the average number of adult Bartram’s scrub-hairstreaks recorded annually on Big Pine Key has declined considerably, from a high of 19.3 per ha (7.7 per ac) in 1999, to a low of less than 1 per ha (0.3 per ac) in 2011, based on monthly (1999–2006) or quarterly (2007 to 2012) surveys.

Since early 2012, North Carolina State University (NCSU) personnel have collaborated with the Service on techniques to improve detection probabilities, estimate abundances, and measure vegetation characteristics associated with butterfly populations on the National Key Deer Refuge (NKDR) (Henry and Haddad 2013). These studies have documented a mean monthly count across sites ranging from 0.0 to  $2.8 \pm 0.33$  adult Bartram’s scrub-hairstreaks per ha (Anderson 2012b). During 2013, using these survey techniques, NKDR documented a peak abundance of 159 adults in the early summer months (Anderson 2014).

There were few or no observations of the Bartram’s scrub-hairstreak on Big Pine Key in 2014 (n = 0) and 2015 (n = 1), by NKDR staff or Salvato (Salvato 2015, Breaux 2015).

**Critical Habitat** – Critical habitat was designated in Miami-Dade and Monroe Counties, consisting of 4,670 hectares (11,539 acres) in seven units. Five of the seven critical habitat units are currently occupied by the Bartram’s scrub-hairstreak (79 FR 47179).

The following are the physical and biological features (PBFs) found in occupied habitats that are essential to the conservation of Bartram’s scrub-hairstreak:

1. Pine rockland habitats and associated rockland hammock and hydric pine flatwoods that are at least 7 ha (18 ac) in size and are located no more than 5 km (3 miles) apart to allow for habitat connectivity.

2. Pine rockland and associated rockland hammocks and hydric pine flatwoods, specifically those containing pineland croton and other herbaceous vegetation typical of these plant communities.
3. Absence of pesticide in the pine rocklands, and associated rockland hammock and hydric pine flatwood communities or in low enough quantities that is not detrimental to the butterfly.
4. Pine rockland and associated rockland hammocks and hydric pine flatwoods, specifically those containing pineland croton and other herbaceous vegetation typical of these plant communities.
5. Disturbance regimes, natural or prescribed to mimic natural disturbances such as fire, to be a PBF for this subspecies.

Based on our current knowledge of the PBFs and habitat characteristics required to sustain the butterfly’s life-history processes, the primary constituent elements (PCEs) for the Bartram’s scrub-hairstreak critical habitat are:

1. Pine rockland habitat, and in some instances, associated rockland hammocks and hydric pine flatwoods.
  - (a) Pine rockland habitat contains:
    - i. Open canopy, semi-open subcanopy, and understory;
    - ii. Substrate of oolitic limestone rock; and
    - iii. A plant community of predominately native vegetation.
  - (b) Rockland hammock habitat associated with the pine rocklands contains:
    - i. Canopy gaps and edges with an open to semi-open canopy, subcanopy, and understory;
    - ii. Substrate with a thin layer of highly organic soil covering limestone or organic matter that accumulates on top of the underlying limestone rock; and;
    - iii. A plant community of predominately native vegetation.
  - (c) Hydric pine flatwood habitat associated with the pine rocklands contains:
    - i. Open canopy with a sparse or absent subcanopy, and dense understory;
    - ii. Substrate with a thin layer of poorly drained sands and organic materials that accumulates on top of the underlying limestone or calcareous rock; and
    - iii. A plant community of predominately native vegetation.
2. Competitive nonnative plant species in quantities low enough to have minimal effect on survival of Bartram’s scrub-hairstreak butterfly.

3. The presence of the butterfly’s hostplant, pineland croton, in sufficient abundance for larval recruitment, development, and food resources, and for adult butterfly nectar source and reproduction;
4. A dynamic natural disturbance regime or one that artificially duplicates natural ecological processes (e.g., fire, hurricanes, or other weather events) that maintains the pine rockland habitat and associated plant community.
5. Pine rockland habitat and associated plant community that allow for connectivity and are sufficient in size to sustain viable populations of Bartram’s scrub hairstreak butterfly.
6. Pine rockland habitat with levels of pesticide low enough to have minimal effect on the survival of the butterfly or its ability to occupy the habitat.

## **Threats**

### *Habitat Loss*

The Bartram’s scrub-hairstreak has experienced substantial destruction, modification, and curtailment of its habitat and range. The pine rockland community of south Florida, on which the butterfly and its’ hostplant depend, is critically imperiled globally (FNAI 2015). Destruction of the pine rockland habitat for economic development has reduced this habitat community by 98 percent on mainland south Florida outside of ENP (O’Brien 1998). However, any unknown extant populations of the butterfly or suitable habitat that may occur on private land or non-conservation public land, such as within the Richmond Pine Rocklands, are vulnerable to habitat loss.

Similarly, most of the pine rockland habitat within the Florida Keys have been impacted or destroyed for residential and commercial development (Hodges and Bradley 2006). All vacant land in the Florida Keys is projected to be developed, including lands currently inaccessible for development, such as islands not attached to the Overseas Highway (US 1) (Zwick and Carr 2006). During 2006, Monroe County implemented a Habitat Conservation Plan (HCP) for Big Pine and No Name Keys. Subsequently, development on these islands has to meet the requirements of the HCP with the resulting pace of development changed accordingly. Furthermore, in order to fulfill the HCP’s mitigation a requirement, Monroe County has been actively acquiring parcels of high-quality habitat for listed species and managing them for conservation, including pine rockland habitat occupied by the Bartram’s scrub-hairstreak on Big Pine Key. However, land development pressure and habitat losses may resume when the HCP expires in 2023. If the HCP is not renewed, residential or commercial development could increase to pre-HCP levels. Consequently, remaining extant Bartram’s scrub-hairstreak and pine rockland habitat fragments could be at risk to habitat loss and modification.

### *Fire Management*

The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Salvato and Salvato 2010a, 2010c). Historically, lightning-induced fires were a vital component in maintaining native vegetation within the pine rockland ecosystem, including pineland croton (Loope and Dunevitz 1981, Slocum *et al.* 2003, Snyder *et al.* 2005, Salvato and Salvato 2010a). Resprouting after burns is the primary mechanism allowing for the persistence of perennial shrubs, including pineland croton, in pine habitat (Olson and Platt 1995). Without fire, successional climax from tropical pineland to hardwood hammock is rapid, and displacement of native species by invasive nonnative plants often occurs.

Cyclic and alternating treatment of burn units may benefit the Bartram’s scrub-hairstreak throughout Long Pine Key (Salvato and Salvato 2010a). The influence of prescribed burns on the status and distribution of the Bartram’s scrub-hairstreak and pineland croton is being evaluated. The Bartram’s scrub-hairstreak is rarely encountered more than 5 m (16.4 ft) from its hostplant (Schwartz 1987, Worth *et al.* 1996, Salvato and Salvato 2008). Salvato and Hennessey (2004) and Salvato and Salvato (2010a) indicate that, if the Bartram’s scrub-hairstreak is unable to disperse adequately during fire events, then only adults at the periphery of burned areas are likely to escape to adjacent pine rockland habitat. Ideally, as a result of cyclic burns and multiyear treatment intervals, the Bartram’s scrub-hairstreaks will move from burned locations to adjacent refugia (i.e., unburned areas of croton hostplant) and then back to the recently burned area in numbers equal to or greater than before the fire. Over the past decade, the Bartram’s scrub-hairstreak appears to have benefited from prescribed burns within Long Pine Key, with population densities greater than those recorded in any previous studies (Salvato and Salvato 2010a), and this trend has continued subsequently (Land 2011, 2012a, Salvato 2012).

Outside of ENP, Miami-Dade County has implemented various conservation measures, such as burning in a mosaic pattern and on a small scale, during prescribed burns in order to protect the butterflies (Maguire 2010). Miami-Dade County Parks and Recreation staff has burned several of their conservation lands on a fire-return interval of approximately 3 to 7 years. As a result, the Bartram’s scrub-hairstreak has retained populations within many of these County-managed conservation lands.

Recent natural or prescribed burn activity on Big Pine Key and adjacent islands within NKDR appears to be insufficient to prevent loss of pine rockland habitat (Carlson *et al.* 1993, Bergh and Wisby 1996, O’Brien 1998, Snyder *et al.* 2005, Bradley and Saha 2009, Saha *et al.* 2011). As a result, many of the pine rockland habitat parcels, across NKDR are being compromised by succession to hardwood hammock (Bradley and Saha 2009, Saha *et al.* 2011). Pineland croton, which was historically documented from No Name and Little Pine Keys (Dickson 1955, Hennessey and Habeck 1991, Carlson *et al.* 1993), is now absent from these locations (Emmel *et al.* 1995, Salvato and Salvato 2010b).

Fire management of pine rockland habitat in NKDR is hampered by the pattern of land ownership and development; residential and commercial properties are embedded within or in close proximity to pine rockland habitat (Snyder *et al.* 2005, Anderson 2012a). As a result, hand

or mechanical vegetation management may be necessary at select locations on Big Pine Key (Emmel *et al.* 1995, Minno 2009, Service 2010) to maintain or restore pine rocklands. However, mechanical treatments may not provide the same ecological benefits as fire, therefore NKDR continues to focus efforts on conducting prescribed burns where possible (Anderson 2012a).

### *Climate Change and Sea Level Rise*

Climatic changes, including sea level rise, are major threats to south Florida, and to the Bartram’s scrub-hairstreak. The Service used various model scenarios developed at Massachusetts Institute of Technology, in combination with extant and historical Bartram’s scrub-hairstreak occurrences and remaining hostplant-bearing pine rockland habitat to predict what may occur to the butterfly and its habitat.

In the best-case scenario, which assumes low sea level rise, high financial resources, proactive planning, and only trending population growth, analyses suggest that the Big Pine Key population of the Bartram’s scrub-hairstreak may be lost or greatly reduced. Based upon the above assumptions, extant Bartram’s scrub-hairstreak populations on Big Pine Key and Long Pine Key appear to be most susceptible for future losses, with losses attributed to increases in sea level and human population. In the worst-case scenario, which assumes high sea level rise, low financial resources, a ‘business as usual’ approach to planning, and a doubling of human population, the habitat at Big Pine Key and Long Pine Key may be lost. This habitat loss would result in the complete extirpation of the hairstreak from these regions. Under the worst-case scenario, pine rockland habitat would remain within both Navy Wells and the Richmond Pine Rocklands, both of which currently retain Bartram’s scrub-hairstreak populations.

### *Collection*

Rare and endangered butterflies are often subject to collection by enthusiasts, before and sometimes after they receive regulatory protection. Such collecting has been hypothesized as contributing to the decline or extirpation of some species (Mattoni 1992) and has been identified as a threat to the Bartram’s scrub-hairstreak.

In the past, when the Bartram’s scrub-hairstreak was widespread on Big Pine Key and throughout southern Miami-Dade County, collecting likely exerted little pressure on butterfly populations. At present, even limited collection from the small, remaining populations could have deleterious effects on reproductive and genetic viability and thus could contribute to their eventual extinction.

There is evidence of interest in the collecting, as well as proposed commercial sale, of the Bartram’s scrub-hairstreak. Salvato (2011) has been contacted by several individuals requesting specimens of the Bartram’s scrub-hairstreak, as well as information regarding locations where the butterfly may be collected in the field. In addition, multiple websites offer or have offered specimens of south Florida butterflies for sale that are candidates for listing under the Act (Minno 2009, Nagano 2011, Olle 2011). Until recently, one website offered Bartram’s scrub-hairstreak specimens for €10.00 (\$13). It is unclear from where the specimens originated or

when they were collected, but this butterfly is now mainly restricted to conservation lands where collection is prohibited, therefore, it is possible that some specimens are being poached. Salvato (2012) observed several individuals collecting butterflies at Navy Wells during 2005, including times when Bartram’s scrub-hairstreak was present at this site. Alternatively, Calhoun (2013) suggests that many specimens of the Bartram’s scrub-hairstreak offered from sale online or elsewhere may come from older collections, as opposed to from poaching activities on conservation lands.

### *Scientific Research*

Some techniques (*e.g.*, capture, handling) used to research or monitor the Bartram’s scrub-hairstreak have the potential to cause harm to individuals or habitat. Visual surveys, transect counts, and netting for identification purposes have been performed during scientific research and conservation efforts with the potential to disturb or injure individuals or damage habitat. Mark–recapture, a common method used to determine population size, has been used by some researchers to monitor Bartram’s scrub-hairstreak populations (Emmel *et al.* 1995, Salvato 1999). While mark–recapture may be preferable to other sampling estimates (*e.g.*, count-based transects) in obtaining demographic data, such techniques may also result in deleterious impacts to captured butterflies (Mallet *et al.* 1987, Murphy 1988, Haddad *et al.* 2008). Murphy (1988) and Mattoni *et al.* (2001) indicated that studies on various lycaenids (hairstreaks and blues) have demonstrated mortality and altered behavior as a result of marking. Emmel *et al.* (1995) conducted mark–recapture studies on the hairstreak and noted no detrimental effects. In addition several individuals were re-encountered (recaptured) during the days following marking. However, researchers currently studying the populations of the endangered Miami blue (*Cyclargus thomasi bethunebakeri*) in the Florida Keys have opted not to use mark–release–recapture techniques due to the potential for damage to this small, fragile lycaenid (Haddad and Wilson 2011).

### *Disease or Predation*

Native parasites and predators have been documented to impact Bartram’s scrub-hairstreaks. Hennessey and Habeck (1991) collected an older Bartram’s scrub-hairstreak larva on Big Pine Key from which a single braconid wasp emerged during pupation. During 2010, Salvato *et al.* (2012) encountered a Bartram’s scrub-hairstreak larva within Long Pine Key that had been parasitized by *C. scutellaris*. These are the only known records for a larval parasitoid on this butterfly. Tracking the fate of hairstreak pupae is extremely difficult because they pupate in the ground litter (Worth *et al.* 1996). Collection of other parasitized Bartram’s scrub-hairstreak larvae is needed to determine the influence of parasitism on its early stages (Salvato and Hennessey 2004). Many immature lycaenids, including those of the Miami blue, demonstrate a symbiotic relationship with ants (Saarinen and Daniels 2006, Trager and Daniels 2009, Daniels 2013), as a strategy to ward off predation. However, no such symbiotic relationship between Bartram’s scrub-hairstreak larvae and ants has been documented (Salvato 1999).

Salvato and Salvato (2010c) observed erythraeid larval mite parasites on an adult Bartram’s scrub-hairstreak in Long Pine Key. Although mite predation on butterflies is rarely fatal (Treat

1975), the role of parasitism by mites in the natural history of the hairstreak requires further study. Salvato and Salvato (2008) have observed dragonflies (Odonata) preying on adult Bartram’s scrub-hairstreaks. Crab spiders, orb weavers, ants, and a number of other predators identified as mortality factors for the leafwing have also been frequently observed on pineland croton during Bartram’s scrub-hairstreak surveys and may also prey on adults and larvae (Salvato and Hennessey 2004, Salvato 2012). NKDR biologists have witnessed nonnative Cuban anoles (*Anolis equestris*) attempting to prey on adult Bartram’s scrub-hairstreaks (Anderson 2013). Minno and Minno (2009) also cite nonnative predators such as ants as a major threat to Bartram’s scrub-hairstreaks.

#### *Inadequacy of Existing Regulatory Mechanisms*

Federal - The apparent online sale of the butterflies suggests that collection could be occurring from locations such as the ENP. National Park Service (NPS) regulations at 36 CFR 2.1 and 2.2 prohibit visitors from harming or removing wildlife, listed or otherwise, from ENP. In addition, NPS regulation 36 CFR 2.5 prohibits visitors from conducting research or collecting specimens without a permit. Insufficient implementation or enforcement of regulations on NPS land is a potential threat to the Bartram’s scrub-hairstreak.

#### *Effects of Few, Small Populations and Isolation*

The Bartram’s scrub-hairstreak is vulnerable to extinction due to their severely reduced range, reduced population size, lack of metapopulation structure, few remaining populations, and relative isolation. Annual abundance and number of broods of Bartram’s scrub-hairstreak vary considerably from year-to-year, and among extant populations, based on a variety of ecological factors. Overall the Bartram’s scrub-hairstreak population is estimated to range from several hundred or fewer at any given time.

Losses in Bartram’s scrub-hairstreak genetic diversity may have already occurred (Salvato 2012). The Bartram’s scrub-hairstreak has been extirpated from several locations where they were previously recorded (Baggett 1982; Salvato and Hennessey 2004). The Bartram’s scrub-hairstreak is extant within ENP, Navy Wells, Camp Owaissa Bauer, Richmond Pine Rocklands, as well as on Big Pine Key (Baggett 1982, Smith *et al.* 1994, Salvato and Salvato 2010a). However, given the possible limited dispersal abilities of this butterfly, the distance between these sites, (Worth *et al.* 1996, Salvato and Hennessey 2004) and their fragmentation, it is unlikely there is any genetic exchange between locations.

#### *Environmental Stochasticity*

The climate of southern Florida and the Florida Keys is driven by a combination of local, regional, and global events, regimes, and oscillations. According to the Florida Climate Center, Florida is by far the most vulnerable State in the United States to hurricanes and tropical storms.

The Bartram’s scrub-hairstreak has adapted over time to the influence of tropical storms and other forms of adverse weather conditions (Minno and Emmel 1994, Salvato and Salvato 2007).

However, given the substantial reduction in the historical range of this butterfly in the past 50 years, the threat and impact of tropical storms and hurricanes on the remaining population is much greater than when the subspecies distribution was more widespread (Salvato and Salvato 2010a).

During late October 2005, Hurricane Wilma caused substantial damage to the pine rockland habitat of northwestern Big Pine Key (Salvato and Salvato 2010b), specifically within the Watson Hammock region of NKDR, the historical stronghold for the Bartram’s scrub-hairstreak on the island. In historical instances when Bartram’s scrub-hairstreak population numbers were larger on Big Pine Key, such as following Hurricane Georges in 1998, the subspecies appeared able to recover soon after a storm. In ENP, the butterfly was minimally affected by the 2005 hurricane season (Salvato and Salvato 2010a). However, given its substantial decline on Big Pine Key, it is possible that the impact of Wilma has served to further hinder and reduce extant populations of the butterfly on the island.

Environmental factors have likely impacted the Bartram’s scrub-hairstreak and the pine rockland habitat within the subspecies historical and current range. For example, unusually cold temperatures were encountered throughout southern Florida during the winters of 2009 and 2010. Sadle (2009) noted frost damage on pineland croton at ENP on Long Pine Key in late 2009, but observed living larvae earlier that year, when temperatures were at or barely above freezing (2.2 °C; 36 °F) and frost was on the ground. Frost in winter 2010 resulted in substantial dieback of native plants, including damage and widespread defoliation of the pineland croton in Long Pine Key (Hallac *et al.* 2010). Sadle (2011) suggested that frost damage may produce similar effects to loss of aboveground plant parts that results from fire. It is not clear what the short- or long-term impacts of prolonged cold periods may be on hairstreak populations; however, it is likely that prolonged cold periods have some negative impacts on both the Bartram’s scrub-hairstreak and pineland croton (Hallac *et al.* 2010, Sadle 2010, Land 2010).

### *Pesticides*

Efforts to control salt marsh mosquitoes (*Aedes taeniorhynchus*) among others, have increased as human activity and population have increased in south Florida. To control mosquito populations, second-generation organophosphate (naled) and pyrethroid (permethrin) adulticides are applied using both aerial and ground-based methods by mosquito control districts throughout south Florida. The use of such pesticides to control mosquitoes presents a potential risk to non-target species, including the Bartram’s scrub-hairstreak.

The Long Pine Key region of ENP is not treated with pesticides for mosquito control. Outside of the ENP, occupied butterfly habitat within Miami-Dade County remains vulnerable to the effects of adulticide applications. However, use of mosquito control pesticides within Miami-Dade County pine rockland habitat areas is limited.

On Big Pine Key, Salvato (2001) and Hennessey *et al.* (1992) suggested declines in populations of the Bartram’s scrub-hairstreak were partly attributable to mosquito control chemical applications. Specifically, Salvato (2001) noted that butterflies, such as the Bartram’s scrub-

hairstreak, were particularly vulnerable to truck applications based on their tendency to roost within low-lying vegetation (including along roadsides), an area with maximal exposure to ground-based treatments.

Miami-Dade County and the Florida Key Mosquito Control District coordinate annually with the Service in order avoid or minimize any impacts to pine rockland and butterfly habitat. In addition, extensive no spray and buffer zones have been established around Bartram’s scrub-hairstreak critical habitat both on Big Pine Key and throughout Miami-Dade County.

### **Ongoing Conservation Efforts**

For almost 10 years, the Service has engaged the State of Florida (Florida Fish and Wildlife Conservation Commission [FWC]), conservation organizations (North American Butterfly Association), ENP, and researchers from the University of Florida (UF), NCSU, and FTBG to locate extant populations of the Bartram’s scrub-hairstreak, and its hostplant, pineland croton, to identify remaining suitable habitat.

To date, collaborative research, monitoring and recovery efforts for the Bartram’s scrub-hairstreak have focused largely on 1) conducting comprehensive surveys of historic locations for presence or absence of the Bartram’s scrub-hairstreak and pineland croton; 2) establishing fire management and other restoration plans to include conservation measures for the subspecies, pineland croton and the pine rockland habitat; 3) evaluating techniques to accurately estimate abundance and distribution of extant butterfly populations and their hostplants within the pine rocklands; 4) expanding the buffer and no-spray zones on Big Pine Key (including within NKDR) to prevent adverse impacts to the butterfly and its habitat; 5) evaluating the influence of pesticide applications on imperiled butterfly populations; and 6) increasing public awareness of this endangered butterfly.

The NPS revised General Management Plan (GMP) for ENP (NPS 2015), serves to protect, restore, and maintain natural and cultural resources at the ecosystem level. Although the GMP is not regulatory, and its implementation is not mandatory, the GMP identifies conservation measures for the Bartram’s scrub-hairstreak and more broadly, pine rockland habitat.

The ENP began to monitor populations of the Bartram’s scrub-hairstreak shortly after the subspecies was reinstated as a candidate in 2006. ENP continues to actively monitor populations of the Bartram’s scrub-hairstreak, as well as to map pineland croton abundance and distribution. The NPS and the Service have actively coordinated on prescribed burn treatments in ENP since 2006. In 2015, ENP updated their GMP and Fire Management Plan and these revisions included extensive conservation measures for the Bartram’s scrub-hairstreak, and pine rocklands, in general.

The comprehensive conservation plan (CCP) for the Lower Florida Keys National Wildlife Refuges (NKDR, Key West National Wildlife Refuge, and Great White Heron National Wildlife Refuge) provides a description of the environment and priority resource issues that were considered in developing the objectives and strategies that guide management over the next 15

years. The CCP promotes the enhancement of wildlife populations by maintaining and enhancing a diversity and abundance of habitats for native plants and animals, especially imperiled species that are found only in the Florida Keys. The CCP also provides for obtaining baseline data and monitoring indicator species to detect changes in ecosystem diversity and integrity related to climate change. In the Lower Key Refuges, CCP management objective 11 provides specifically for maintaining and restoring butterfly populations of special conservation concern, including the Bartram’s scrub-hairstreak.

The Service at NKDR also began to monitor populations of the Bartram’s scrub-hairstreak shortly after the subspecies was reinstated as a candidate. The NKDR continues to actively monitor extant Bartram’s scrub-hairstreak populations, as well as to map pineland croton abundance and distribution on Big Pine Key. Starting in 2012, NCSU personnel have collaborated with the Service on techniques to improve detection probabilities, estimate abundances, and measure vegetation characteristics associated with butterfly populations, including the Bartram’s scrub-hairstreak and pineland croton, on the NKDR.

The NKDR has attempted to increase the density of pineland croton across the refuge through the use of prescribed burns. They have also provided refugia (*i.e.*, unburned areas of croton hostplant) and maintained appropriate corridors for butterflies during prescribed burns. Prescribed burn implementation in NKDR has been hampered largely due to a shortage of resources, technical challenges, and expense of conducting prescribed burns in a matrix of public and private ownership. Given the difficulties in prescribed burn implementation on Big Pine Key, other options (such as habitat enhancement through mechanical clearing) have been explored to increase and maintain pineland croton abundance and distribution across the NKDR for extant Bartram’s scrub-hairstreak.

Miami-Dade County and the Florida Key Mosquito Control District coordinate annually with the Service in order avoid or minimize any impacts to pine rocklands and butterfly habitat. In addition, extensive no spray and buffer zones have been established around Bartram’s scrub-hairstreak critical habitat both on Big Pine Key and throughout Miami-Dade County.

In 2013, FTBG, with funding from the Service, conducted extensive surveys of remaining pine rockland habitat fragments throughout Miami-Dade County in order to determine current pineland croton abundance and distribution. These data assisted the Service in designating critical habitat for the Bartram’s scrub-hairstreak.

FTBG, with the support of various Federal, State, local, and nonprofit organizations, has established the “Connect to Protect Network.” The objective of this program is to encourage widespread participation of citizens to create corridors of healthy pine rocklands by planting stepping-stone gardens and rights-of-way with native pine rockland species, and restoring isolated pine rockland fragments. By doing this, FTBG hopes to increase the probability that pollinators can find and transport seeds and pollen across developed areas that separate pine rocklands fragments to improve gene flow between fragmented plant populations and increase the likelihood that these species will persist over the long term. Although this project may serve as a valuable component toward the conservation of pine rockland species, it is dependent on

continual funding, as well as participation from private landowners, both of which may vary through time.

### **Literature Cited**

- Anderson, C. 2010. Personal communication. Email to Paula Halupa (comments on Bartram’s hairstreak species assessment). U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. February 10, 2010.
- Anderson, C. 2012a. Personal communication. Email to Paula Halupa (comments on Bartram’s hairstreak species assessment). U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. February 16, 2012.
- Anderson, C. 2012b. Presentation Record. Presentation at the Imperiled Butterfly Working Group Meeting. U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. October 4, 2012.
- Anderson, C. 2013. Personal communication. Email to Mark Salvato (comments on the draft Florida leafwing and Bartram’s scrub-hairstreak listing package). U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. April 1, 2013.
- Anderson, C. 2014. Presentation Record. Presentation at the Imperiled Butterfly Working Group Meeting. U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. January 23, 2014.
- Anderson, C., and E. Henry. 2015. Synthesis of Research, Monitoring, Management of the Bartram’s Hairstreak in the National Key Deer Refuge 2009-2014. Final Report. U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida.
- Baggett, H.D. 1982. Order Lepidoptera. In R. Franz (ed.), *Invertebrates*. In P.C. Pritchard (ed.) *Rare and Endangered Biota of Florida*. Vol. 6. *Invertebrates*, 78-81. University Press, Gainesville, Florida.
- Bergh, C., and J. Wisby. 1996. *Fire history of the lower Keys pine rocklands*. Nature Conservancy (publishers). Key West, Florida.
- Bradley, K.A., and S. Saha. 2009. Post-hurricane responses of rare plant species and vegetation of pine rocklands in the Lower Florida Keys. Report submitted to U.S. Fish and Wildlife Service, Big Pine Key, Florida. The Institute for Regional Conservation. Miami, Florida.

- Breaux, D. 2015. Personal communication. Email to Multiple regarding the Intra-Service Section & form for burning on NKDR. U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. September 23, 2015.
- Calhoun, J.V., J.R. Slotten, and M.H. Salvato. 2000. The rise and fall of tropical blues in Florida: *Cyclargus ammon* and *Cyclargus thomasi bethunebakeri* (Lepidoptera: Lycaenidae). *Holarctic Lepidoptera* 7(1):13-20.
- Calhoun, J.V. 2013. Personal communication. Comments on the proposal to designate critical habitat for the Florida leafwing and Bartram’s scrub-hairstreak butterflies. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida. October 14, 2013.
- Carlson, P.C., G.W. Tanner, J.M. Wood, and S.R. Humphrey. 1993. Fires in Key deer habitat improves browse, prevents succession, and preserves endemic herbs. *Journal of Wildlife Management* 57: 914-928.
- Comstock, W. P. and E. I. Huntington. 1943. Lycaenidae of the Antilles. *Annals of the New York Academy of Science*. 45:49-130.
- Cook, D. 2013. Personal communication. Comments on the proposal to designate critical habitat for the Florida leafwing and Bartram’s scrub-hairstreak butterflies. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida. October 14, 2013.
- Daniels, J.C., J. A., Pence and T.C. Emmel. 2005. A new hostplant record for *Strymon martialis* (Lycaenidae: Theclinae) in the Florida Keys. *Journal of the Lepidopterists’ Society*. 59: 174-175.
- Daniels, J.C. 2013. Presentation Record. Presentation at the Imperiled Butterfly Working Group Meeting. University of Florida. Gainesville, Florida. August 15, 2013.
- Dickson, J.D. 1955. An ecological study of the Key deer. Florida Game and Freshwater Fish Commission. Pittmann-Robertson Project Technical Bulletin 3.
- Emmel, T.C., R.A. Worth, and K. Schwarz. 1995. The relationships between host plant and habitat for the distribution of three potentially endangered south Florida butterfly species. Report to the National Biological Survey.
- Florida Natural Areas Inventory. 2015. FNAI Element Tracking Summary. Tallahassee, Florida. September 28, 2015. <http://www.fnai.org/bioticssearch.cfm> [Accessed: September 28, 2015].
- Haddad, N. and J. Wilson. 2011. Preliminary observations of Miami blue butterfly (*Cyclargus thomasi bethunebakeri*). June 19, 2011. North Carolina State University. Raleigh, North Carolina.

- Haddad, N.M., B. Hudgens, C. Damiani, K. Gross, D. Kuefler, and K. Pollock. 2008. Determining optimal population monitoring for rare butterflies. *Conservation Biology* 22(4):929–940.
- Hallac, D., J. Kline, J. Sadle, O. Bass, T. Ziegler, and S. Snow. 2010. Preliminary effects of the January 2010 cold weather on flora and fauna in Everglades National Park. Biological Resources Branch, South Florida Natural Resources Center, Everglades and Dry Tortugas National Parks, Homestead, Florida. February 2, 2010.
- Hennessey, M.K. and D.H. Habeck. 1991. Effects of mosquito adulticiding on populations of non-target, terrestrial arthropods in the Florida Keys. Final report of research results. Submitted on February 1, 1991 to U.S. Fish and Wildlife Service and University of Florida Cooperative Wildlife Research Unit. United States Department of Agriculture - Agricultural Research Service; Miami, Florida.
- Hennessey, M.K., H.N. Nigg, and D.H. Habeck. 1992. Mosquito (Diptera: Culicidae) adulticide drift into wildlife refuges of the Florida Keys. *Environmental Entomology* 21(4):715-721.
- Henry and Haddad, 2013. Using mechanical disturbance to restore Bartram’s scrub-hairstreak habitat. Research proposal to the Service. North Carolina State University. Raleigh, North Carolina. 8 pp.
- Hodges, S.R., and K.A. Bradley. 2006. Distribution and population size of five candidate plant taxa in the Florida Keys: *Argythamnia blodgettii*, *Chamaecrista lineata* var. *keyensis*, *Indigofera mucronata* var. *keyensis*, *Linum arenicola*, and *Sideroxylon reclinatum* subsp. *austrorfloridense*. The Institute for Regional Conservation. Final Report Contract Number 401815G011. Miami, Florida.
- Integrated Taxonomic Information System. 2015. ITIS standard report page: *Anaea troglodyta floridalis* <http://www.itis.gov/servlet/SingleRpt/SingleRpt>. [Accessed September 28, 2015].
- The Institute for Regional Conservation. 2006. Plant lists of Natural Forest Communities in Miami-Dade County, exclusive of Everglades National Park. Prepared in cooperation with U.S. Fish and Wildlife Service, Vero Beach, FL. Project funded under a Memorandum of Agreement between Miami-Dade County and the U.S. Fish and Wildlife Service.
- Kimball, C. P. 1965. The Lepidoptera of Florida, an annotated checklist. Arthropods of Florida and Neighboring Land Areas. Vol. 1. Gainesville: Div. Plant Indus., Fla. Dept. Agric. 363 pp, 26 pl.

- Land, A. 2010. Personal communication. Email to Paula Halupa (comments on species assessment). Everglades National Park Fire Effects. Everglades National Park. Homestead, Florida. January 22, 2010.
- Land, A. 2011. Personal communication. Email to Paula Halupa (comments on species assessment). Everglades National Park Fire Effects. Everglades National Park. Homestead, Florida. February 2, 2011.
- Land, A. 2012. Personal communication. Email to Mark Salvato. Everglades National Park Fire Effects. Everglades National Park. Homestead, Florida. August 9, 2012.
- Loope, L.L., and V.L. Dunevitz. 1981. Impact of fire exclusion and invasion of *Schinus terebinthifolius* on limestone rockland pine forests of southeastern Florida. South Florida Resource Center. Report T-645, National Park Service. Everglades National Park, Homestead, Florida.
- Maguire, J. 2010. Personal communication. Email to Mark Salvato, Miami-Dade Parks and Recreation Department, Miami, FL. April 28, 2010.
- Maschinski, J., S. Hodges, E.B. Magnaghi, and J. Possley. 2013. Survey and Mapping of the Distribution of Pineland Croton (*Croton linearis*) in Pine Rocklands in Miami-Dade County. Final Report. Fairchild Tropical Botanic Garden, Coral Gables, Florida
- Mallet, J., J.T. Longino, D. Murawski, A. Murawski, and A. Simpson de Gamboa. 1987. Handling effects in *Heliconius*: where do all the butterflies go? *Journal of Animal Ecology* 56:377-386.
- Mattoni, R. 1992. Rediscovery of the endangered Palos Verdes blue, *Glaucopsyche lygdamus paloverdesensis* Perkins and Emmel (Lycaenidae). *Journal of Research on the Lepidoptera* 31: 180-194.
- Mattoni, R., T. Longcore, C. Zonneveld, and V. Novotny. 2001. Analysis of transect counts to monitor population size in endangered insects. The case of the El Segundo blue butterfly, *Euphilotes bernardino allyni*. *Journal of Insect Conservation* 5:197–206.
- Minno, M. 2009. Personal communication. Email to Paula Halupa. Eco-Cognizant, Inc. Gainesville, Florida. February 16, 2009.
- Minno, M.C., and T.C. Emmel. 1993. *Butterflies of the Florida Keys*. Scientific Publishers, Inc., Gainesville, Florida.
- Minno, M.C. and T.C. Emmel. 1994. Schaus swallowtail – *Papilio aristodemus ponceanus* Schaus. Species of Special Concern. Family Papilionidae. Pages 668-671 in M. Deyrup and R. Franz, editors. *Rare and Endangered Biota of Florida, Vol. IV, Invertebrates*. University Press; Gainesville, Florida.

- Minno, M. C. and M. Minno. 2009. A plan to conserve rare butterflies in the Florida Keys. Final report to the Florida Keys Mosquito Control District. 1993 pp.
- Murphy, D.D. 1988. Are we studying our endangered butterflies to death? *Journal of Research on the Lepidoptera* 26(1-4):236-239.
- Nagano, C. 2011. Personal communication. Email to Dana Hartley. Sacramento, California. February 23, 2011.
- National Park Service. 2015. Everglades National Park Final General Management Plan. Volumes 1-2. August 2015. U.S. Department of the Interior, National Park Service, Everglades National Park, Homestead, Florida.
- O’Brien, J.J. 1998. The distribution and habitat preferences of rare *Galactia* species (Fabaceae) and *Chamaesyce deltoidea* subspecies (Euphorbiaceae) native to southern Florida pine rockland. *Natural Areas Journal* 18:208–222.
- Olle, D. 2011. Personal communication. Email to Robert Westphal. North American Butterfly Association. Coral Gables, Florida. July 28, 2011.
- Olson, M.S., and W.J. Platt. 1995. Effects of habitat and growing season fires on resprouting of shrubs in longleaf pine savannas. *Vegetatio* 119:101-118.
- Opler, P.A., and G.O. Krizek. 1984. *Butterflies east of the Great Plains*. The John Hopkins University Press, Baltimore, Maryland.
- Possley, J. 2010. Personal communication. Email to Paula Halupa. Fairchild Tropical Botanic Garden. Coral Gables, Florida. December 27, 2010.
- Pyle, R.M. 1981. *The Audubon Society field guide to North American butterflies*. Alfred A. Knopf, New York.
- Roberts, M. 2012. Personal communication. Email to Mark Salvato. Monroe County Growth Management. Marathon, Florida. November 27, 2012.
- Saarinen, E.V. and J.C. Daniels. 2006. Miami blue butterfly larvae (Lepidoptera: Lycaenidae) and ants (Hymenoptera: Formicidae): new information on the symbionts of an endangered taxon. *Florida Entomologist* 89(1):69-74.
- Sadle, J. 2009. Personal communication. Email to Marc Minno. Everglades National Park. Homestead, Florida. March 9, 2009.
- Sadle, J. 2010. Personal communication. Email to Paula Halupa. Everglades National Park. Homestead, Florida. January 28, 2010.

- Sadle, J. 2013. Personal communication. Email to Mark Salvato. Everglades National Park. Homestead, Florida. February 5, 2013.
- Saha, S, K. Bradley, M. S. Ross, P. Hughes, T. Wilmers, P. L. Ruiz, and C. Bergh. 2011 . Hurricane effects on subtropical pine rocklands of the Florida Keys. *Climate Change*. 107: 169-184.
- Salvato, M.H. 2011. Observation record. U.S. Fish and Wildlife Service, South Florida Ecological Services Office. Vero Beach, Florida. 2011.
- Salvato, M.H. 2012. Observation record. U.S. Fish and Wildlife Service, South Florida Ecological Services Office. Vero Beach, Florida. 2012.
- Salvato, M.H. 2015. Observation record. U.S. Fish and Wildlife Service, South Florida Ecological Services Office. Vero Beach, Florida. 2015.
- Salvato, M.H. 1999. Factors influencing the declining populations of three butterfly species in South Florida and the lower Florida Keys. M.S. Thesis. University of Florida, Gainesville, Florida.
- Salvato, M.H. 2001. Influence of mosquito control chemicals on butterflies (Nymphalidae, Lycaenidae, Hesperiiidae) of the lower Florida Keys. *Journal of the Lepidopterists’ Society* 55(1):8-14.
- Salvato, M.H. 2003. Butterfly conservation and host plant fluctuations: the relationship between *Strymon acis bartrami* and *Anaea troglodyta floridalis* on *Croton linearis* in Florida (Lepidoptera: Lycaenidae and Nymphalidae). *Holarctic Lepidoptera* 10(1-2):53-57.
- Salvato, M.H. and M. K. Hennessey. 2004. Notes on the status, natural history and fire-related ecology of *Strymon acis bartrami* (Lycaenidae). *J. Lepid. Soc.* 58: 223-227.
- Salvato, M.H. and H.L. Salvato. 2007. The influence of hurricane and tropical storm activity on resident butterflies in the lower Florida Keys. *Journal of the Lepidopterists’ Society* 61(3):154-164.
- Salvato, M.H., and H.L. Salvato. 2008. Notes on the feeding ecology of *Strymon acis bartrami* and *Anaea troglodyta floridalis*. *Florida Scientist*. 71: 323-329.
- Salvato, M.H., and H.L. Salvato. 2010a. Notes on the status and ecology of *Strymon acis bartrami* in Everglades National Park. *Journal of the Lepidopterists’ Society*. 64: 154-160.
- Salvato, M.H., and H.L. Salvato. 2010b. Notes on the status of *Anaea troglodyta floridalis* on Big Pine Key. *News of the Lepidopterists’ Society*. 52: 139-140.

- Salvato, M.H., and H.L. Salvato. 2010c. Parasitic mite larvae (Acari) on adult *Strymon acis bartrami* (Lycaenidae). *News of the Lepidopterists’ Society*. 52: 71.
- Salvato, M.H., H.L. Salvato, and J.O. Stireman III. 2012 . *Chetogena scutellaris* (Diptera: Tachinidae) and endoparasite of larval *Strymon acis bartrami* (Lycaenidae). *Journal of the Lepidopterists’ Society*. 66: 113-114.
- Schwarz, K.A., R.A. Worth, and T.C. Emmel. 1996. Conservation of two threatened south Florida butterflies and their host plant (Lepidoptera: Lycaenidae, Nymphalidae). *Holarctic Lepidoptera* 3:59-61.
- Schwartz, A. 1987. The butterflies of the Lower Florida Keys. Milwaukee Public Museum, *Contributions in Biology and Geology* 73:1-34.
- Slocum, M.G., W.J. Platt, and H.C. Cooley. 2003. Effects of differences in prescribed fire regimes on patchiness and intensity of fires in subtropical savannas of Everglades National Park, Florida. *Restoration Ecology* 11:91-102.
- Smith, D.S., L.D. Miller, and J.Y. Miller. 1994. The butterflies of the West Indies and South Florida. Oxford University Press, New York.
- Snyder, J.R., M.S. Ross, S. Koptur, and J.P. Sah. 2005. Developing ecological criteria for prescribed fire in South Florida pine rockland ecosystems. USGS Open File Report OF 2006-1062.
- Trager, M.D. and J.C. Daniels. 2009. Ant tending of Miami blue butterfly larvae (Lepidoptera: Lycaenidae): partner diversity and effects on larval performance. *Florida Entomologist* 92(3):474-482.
- Treat, A. E. 1975. *Mites of Moths and Butterflies*. Cornell University Press. London, England. 362 pp.
- U.S. Fish and Wildlife Service. (Service) 1999. South Florida multi-species recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.
- U.S. Fish and Wildlife Service. (Service) 2010. National Key Deer Refuge-A desired future conditions for fire-maintained habitats. U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuge Complex. Big Pine Key, Florida. August 16-17, 2010.
- Worth, R.A., K.A. Schwarz, and T.C. Emmel. 1996. Notes on the biology of *Strymon acis bartrami* and *Anaea troglodyta floridalis* in south Florida. *Holarctic Lepidoptera* 3(2): 62-65.

- Zhong, H., L.J. Hribar, J.C. Daniels, M.A. Feken, C. Brock, and M.D. Trager. 2010. Aerial ultra-low-volume application of naled: impact on non-target imperiled butterfly larvae (*Cyclargus thomasi bethunebakeri*) and efficacy against adult mosquitoes (*Aedes taeniorhynchus*). *Environmental Entomology* 39(6):1961-1972.
- Zwick, P.D., and M.H. Carr. 2006. Florida 2060. A population distribution scenario for the State of Florida. A research project prepared for 1000 Friends of Florida. Prepared by the Geoplan Center at the University of Florida, Gainesville, Florida. 29 pp.