Florida Leafwing Butterfly
(*Anaea troglodyta floridalis*)

Status Review:
Summary and Evaluation

Photo credit: Holly L. Salvato

U.S. Fish and Wildlife Service
Southeast Region
Florida Ecological Services Field Office
Vero Beach, Florida

August 2023

STATUS REVIEW
Florida leafwing butterfly (*Anaea troglodyta floridalis*)

GENERAL INFORMATION

Current Classification: Endangered

Lead Field Office: Florida Ecological Services Field Office, Shawn Christopherson, (772) 469-4336

Contributing Authors: Amanda Van Buskirk and Seth Carey, University of Georgia; Lesny Avila, Georgia Gwinnett College; and Mark Salvato, Service, Retired

Reviewers:
Lead Regional Office: Atlanta Regional Office, Carrie Straight (404) 679-7226.

Date of original listing: September 11, 2014 (79 FR 47221; August 12, 2014), and correction in amendatory language published (79 FR 49023; August 19, 2014).

Critical Habitat:

FR notice: 79 FR 47180
Date designated: August 12, 2014 (Service 2014a)

Approximately 4,273 hectares (ha) (10,561 acres (ac)) have been designated for the Florida leafwing (79 FR 47179). The critical habitat is located in Miami-Dade and Monroe Counties. Critical habitat includes four units three of which are currently unoccupied.

Methodology used to complete the review. In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service (Service) evaluated the biology, habitat, and threats of the Florida leafwing butterfly (hereafter, Florida leafwing or leafwing) to inform this status review. A notice of the initiation of this 5-year review was published by the Service in the Federal Register (84 FR 28850) on June 20, 2019, and a 60-day comment period was opened. One comment was received from the public. We evaluated and incorporated comments as appropriate in this review.

In conducting this 5-year review, the Service relied on the best available information pertaining to historical and current distributions, life history, ecology, and habitat of this species. The primary sources of information used in this review were published survey data and reports, unpublished data from the Service and partners, and personal communication with recognized experts.

FR Notice citation announcing the species is under active review:
June 20, 2019 (84 FR 28850)

Species' Recovery Priority Number at start of 5-year review (48 FR 43098):
6C, which indicates that this is a subspecies that has a high degree of threat and low recovery potential. The "C" indicates the recovery is, or may be, in conflict with construction or other development projects or other forms of economic activity.

Review History: This is the first 5-year status review for this species

REVIEW ANALYSIS

Listed Entity

Taxonomy and nomenclature
Anaea troglodyta floridalis is still considered a valid subspecies as indicated by Integrated Taxonomic Information System (ITIS 2023). We are not aware of any changes to the taxonomy of this entity, and it is still considered valid by the Service.

Distinct Population Segment (DPS)
The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing of a DPS to only vertebrate species. Because the species under review is not a vertebrate, the DPS policy is not applicable.

Recovery Criteria

Recovery Plan or Outline
There is no recovery plan or outlines available for this species.

Biology and Habitat Summary

A detailed review of the species biology and habitat information can be found in the final listing rule (Service 2014b). The Florida leafwing occurs only within pine rocklands, specifically those that retain the subspecies only known larval hostplant, pineland croton (sometimes referred to as the wooly croton) (*Croton linearis*). Adult butterflies will also make use of rockland hammock and hydric pine flatwood vegetation when interspersed within the pine rockland habitat.

Current Distribution. The endemic Florida leafwing is currently restricted to the Long Pine Key region of Everglades National Park (ENP) (Figure 1). Historically, the Florida leafwing was locally common throughout the pine rocklands of Miami-Dade County, as well as Big Pine Key (including National Key Deer Refuge (NKDR)) within the lower Florida Keys (Monroe County), while only sporadically occurring as strays in Collier, Palm Beach, and Broward Counties (Figure 2). The subspecies is sporadically encountered (as strays) within the pine rockland fragments adjacent to ENP (Salvato and Salvato 2010a). However,

breeding Florida leafwing populations have not been documented in pine rockland fragments adjacent to ENP for at least the past 30 years.

Historically, pineland croton may have occurred throughout the pine rocklands of the lower Florida Keys (Hennessey and Habeck 1991), however, for at least the past 30 years it has only been documented on Big Pine Key. More recently, Possley *et al*. (2016) conducted extensive surveys of pine rockland fragments within the two core Miami-Dade pine rockland areas outside of the Everglades in order to determine current pineland croton abundance and distribution. Pineland croton populations were encountered at 9 of the 10 locations surveyed, the largest occurring at Navy Wells Pineland Preserve and the Richmond Pine Rocklands, with each site retaining 14,483 and 30,902 individual plants, respectively (Maschinski *et al*. 2013; Possley *et al*. 2016).

Fire plays a vital role in maintaining native vegetation in pine rocklands, including benefiting the pineland croton, which the Florida leafwing depends on to complete its lifecycle (Salvato and Salvato 2010a, and references therein). In the Everglades, prescribed fire was returned to Long Pine Key in early 2016, after several years of limited or sporadic burn treatments. Pineland croton returned at 3 to 6-months post-burn, and the leafwing appeared to be recolonizing burned areas (Sadle, pers. comm. 2017; Salvato and Salvato 2019). Pineland croton and the leafwing also appeared to recover following large-scale wildfires that occurred in spring and summer 2016 (Sadle, pers. comm. 2017, 2018; Salvato and Salvato 2019) and again following uncontained prescribed fires in in 2018 and 2022. Surveys conducted by Salvato and Salvato (2019) from 1997 to 2018 have recorded an average abundance of 6.6 adult Florida leafwings per ha (2.6 per ac) within Long Pine Key. Concurrent surveys conducted by ENP staff from 2013 through 2022 have encountered a total of approximately 43 and 631 leafwing adults and larvae, respectively, throughout Long Pine Key (Sadle, pers. comm. 2017; Land, pers. comm. 2022). In general, the size of the extant population within Long Pine Key fluctuates considerably from year-to-year based upon seasonal and other factors but is estimated to be in the hundreds at any given time. However, the number of observations by ENP staff during surveys from 2019 through 2022 suggest the population fluctuations are currently on a declining trend. Continued monitoring of the Florida leafwing population and the butterfly's response to management activities within Long Pine Key is exceptionally important.

Figure 1. Long Pine Key, Everglades National Park, Florida.

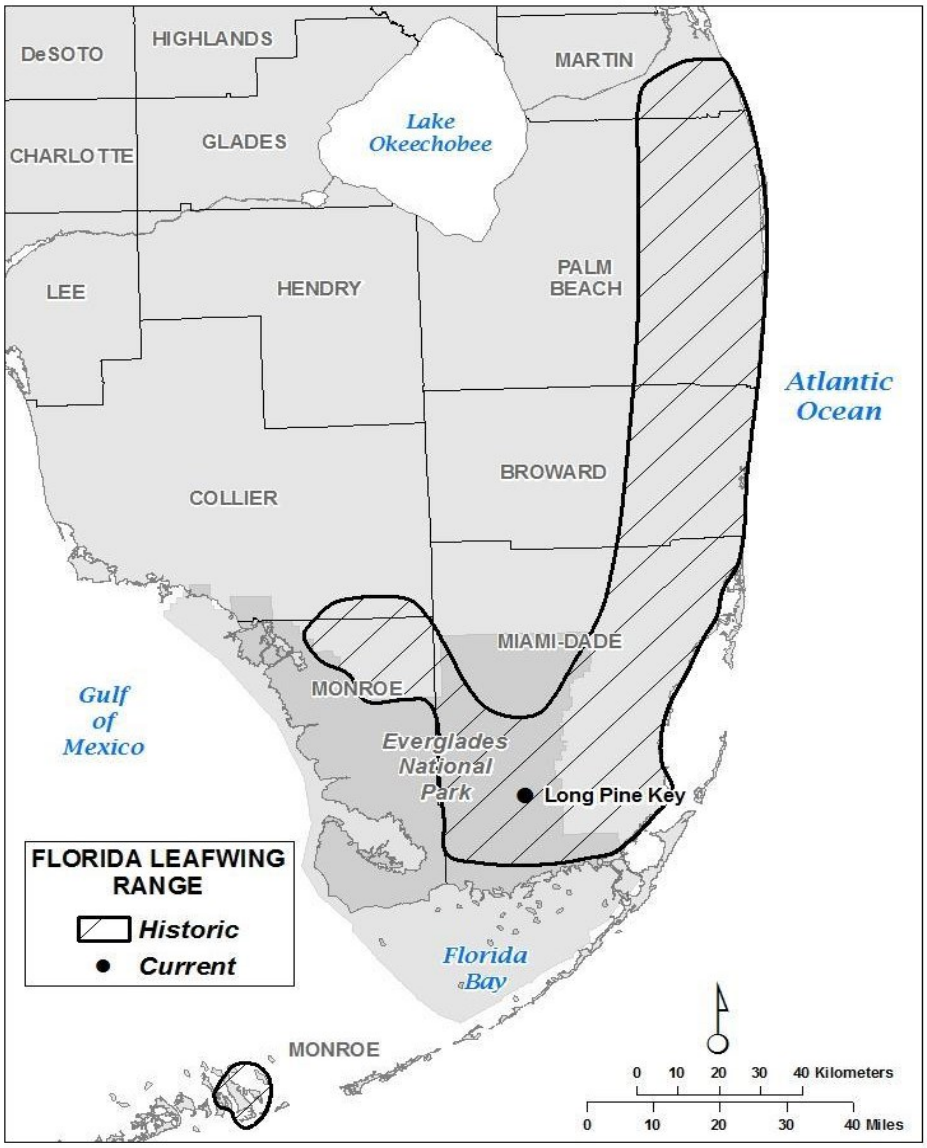

Figure 2. Historic and current range of Florida leafwing butterfly in Florida.

Threats (Five-Factor Analysis) Summary

The status of a species is determined from an assessment of factors specified in section 4 (a)(1) of the Act. The threats to the species are those that were discussed in the final listing rule (Service 2014a, 2014b) and are summarized below.

Factor A. Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat Loss: The Florida leafwing 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 2010;

2019). Between the early 1900s and 1996, this habitat in Miami-Dade County had been reduced by almost 90% (Kernan and Bradley 1996). The largest remaining intact pine rockland (approximately 2,313 ha [5,716 ac]) is Long Pine Key in ENP, which managed for conservation and retains the only extant Florida leafwing population.

Outside of the Everglades, suitable habitat that remains for the Florida leafwing is threatened by habitat loss and degradation, and these threats are expected to accelerate with increased development along the Miami Rock Ridge and in the Florida Keys. Any suitable habitat that may occur on non-conservation public or private land, are vulnerable to habitat loss directly from development or indirectly by lack of management.

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 on Big Pine and No Name Keys. In November 2022, the HCP was renewed and remains valid until June 30, 2026. Land development pressure and habitat losses may resume should the HCP expire in 2026.

Fire Management: The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Salvato and Salvato 2010a, 2010b). Without fire, successional climax from tropical pineland to hardwood hammock is rapid, and displacement of native species by invasive nonnative plants often occurs. Surveys conducted shortly after burns often found adult leafwings actively exploring the recently burned locations in search of new hostplant growth (Salvato and Salvato 2008, 2010a, 2019; Land, pers. comm. 2010, 2012; Sadle, pers. comm. 2017, 2018).

Outside of ENP, Miami-Dade County has implemented various conservation measures, such as burning in a mosaic pattern and on a small scale to protect listed pine rockland species (Maguire Miami-Dade County], pers. comm. 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. However, implementation of a prescribed fire program in Miami-Dade County has been hampered by a shortage of resources, and by logistical difficulties and public concern related to burning next to residential areas.

Natural or prescribed burn activity on Big Pine Key and adjacent islands within National Key Deer Refuge (NKDR) appears to be insufficient to prevent loss of pine rockland habitat, resulting in conversion to habitats not conducive to pineland croton (Carlson *et al.* 1993; Bergh and Wisby 1996; O'Brien 1998; Snyder *et al.* 2005; Bradley and Saha 2009; Saha *et al*. 2011; Bradley *et al*. 2013).

In areas where fire may be limited, Kalasz (pers. comm. 2019) and Salvato (2019) indicated that restoration studies on Big Pine Key that employ a combination of mechanical treatments and subsequent prescribed burns, have resulted in substantial pineland croton resurgence within the pine rocklands.

Climate Change and Sea Level Rise (SLR): Climatic changes, including SLR and shifts in seasonal precipitation, temperature, and storm cycles, are major threats to south Florida, the Florida leafwing and the pine rocklands. National Oceanographic and Atmospheric Administration (Sweet *et al.* 2022) and other studies (Park and Sweet 2015; University of Florida Geoplan 2015; Rahmstorf *et al*. 2015; The Nature Conservancy 2011; Zhang *et al*. 2011; Vargas-Moreno and Flaxman 2010 [Massachusetts Institute of Technology and GeoAdaptive, Inc.]) have developed scenarios that range from 1 foot to 8 feet of SLR by 2100. Based on this, areas supporting the leafwing will become partially or completely inundated (i.e., under water) at some point during this century. For example, approximately 75 percent of land mass in the Florida Keys is predicted to be inundated at 1.9 ft (0.59 m) of sea level rise (The Nature Conservancy 2011) and 94 percent of the Keys would be inundated at 5.9 ft (1.8 m) of sea level rise (Zhang et al. 2011). Benedict *et al*. (2018) conducted an interagency evaluation of the influence of SLR and climate change to listed species and habitats throughout the Florida Keys, including Florida leafwing. Using the same modeling and analyses outlined in Miller and Traxler (2019), Benedict *et al*. (2018) concluded the leafwing and pine rockland habitats would be lost from Big Pine, No Name and Little Pines Keys, at 2-feet of SLR. However, decades prior to surface inundation, pine rocklands will undergo vegetation shifts triggered by changes to hydrology (wetter), salinity (higher), and more frequent storm surge and king tide events (pulse events causing massive erosion and salinization of soils) (Saha *et al*. 2011; Bradley *et al*. 2013). In other words, pine rocklands will convert to mangroves earlier than expected due to root zone inundation from salt water.

Hydrology and Everglades Restoration: Hydrology is a key ecosystem component that affects plant distribution and viability (Gann *et al*. 2006), including pineland croton. While projects designed to restore the historical hydrology of the Everglades and other natural systems in southern Florida, such as the Comprehensive Everglades Restoration Plan (CERP) are beneficial to the Everglades ecosystem, some may produce collateral impacts to extant pine rockland and associated habitats within the region through inundation or increased hydroperiods. The effects of changes in regional hydrology through restoration may have impacts on pine rocklands. Sadle (pers. comm. 2012) suggested various CERP projects (such as C-111 spreader canal; L-31N seepage barrier), specifically the operation of pumps and associated detention areas along the ENP boundary, may influence (through excessive water discharges) select portions of eastern Long Pine Key. Increased and longer-duration hydroperiods within the pine rockland habitats where the last extant population of the leafwing occurs may lead to a reduction in the amount of suitable habitat, a potential reduction in the area occupied and a reduction in the number of individuals found in ENP. It is unclear to what extent this may occur, if at all. In an effort to establish a baseline assessment of future hydrologic modifications, long term monitoring transects and plots for several listed species were established in Long Pine Key between 2003 and 2008 (Gann 2015).

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

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; Seidl 1999) and has been identified as a threat to the Florida leafwing.

There is evidence of interest in the collecting, as well as proposed commercial sale, of the Florida leafwing. Salvato (2019) has also been contacted by several individuals requesting specimens of the Florida leafwing, 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 (Service 2014b). Until 2015, websites offered male and female Florida leafwing specimens for €110.00 and €60.00 (euros), respectively (approximately $144 and $78). It is unclear from where the specimens originated or when they were collected. Given that the only known leafwing population occurs entirely within protected Federal lands, it is possible that some specimens are being poached. Alternatively, Calhoun (2013) suggests that many specimens of the Florida leafwing offered from sale online or elsewhere may come from older collections, as opposed to from poaching activities on conservation lands.

In the past, when the Florida leafwing 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.

Scientific Research: Some techniques (e.g., capture, handling) used to research or monitor the leafwing 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 Florida leafwing 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 when used in a proper design on appropriate species, such techniques may also result in deleterious impacts to captured butterflies (Mallet *et al.* 1987; Murphy 1988; Haddad *et al.* 2008). Salvato (2019) ceased using mark–recapture shortly after initiating his long-term leafwing studies when he realized how much the tagging altered from the butterflies' cryptic (camouflage) underside as individuals alit (rested) on pineland foliage. Conversely, Emmel *et al.* (1995) conducted mark–recapture studies on the leafwing and noted no detrimental effects.

Factor C: Disease or Predation

Predation: A number of predators have been documented to impact the Florida leafwing throughout its life cycle. Common predators to leafwings and other butterflies include native and non-native ants (e.g.,Family Formicidae*, Pseudomyrmex pallidus*, *P. gracilis, and P. planatus*) (Matteson 1930, Hennessey and Habeck 1991, Cannon 2006, Salvato *et al*. 2016, Clayborn and Koptur 2017).

Additional predators of immature Florida leafwings include spiders (Rutkowski 1971; Glassberg *et al.* 2000; Salvato and Salvato 2010c, 2011, 2019), ambush bugs (Salvato and

Salvato 2008), and possibly mites (Salvato and Salvato 2019). Salvato and Salvato (2019) have examined the bite marks on wings of numerous adults in the field suggesting a variety of birds and lizards are among the predators of the adults.

Parasitism: A number of parasites have been documented to impact Florida leafwings throughout their life cycle. Hennessey and Habeck (1991), Salvato and Hennessey (2003) and Salvato and Salvato (2022) noted that leafwing egg mortality within ENP and Big Pine Key from trichogrammid wasp (*Trichogramma* sp.) parasitism ranged from 70 to 100 percent. Salvato and Salvato (2019, 2022) continually encounter leafwing eggs that have been attacked by trichogrammid wasps, suggesting this wasp remains a consistent parasitoid for the leafwing and other endangered pine rockland butterflies (Salvato *et al*. 2018) within ENP.

Researchers have also documented larvae have also been been parasitized by *Chetogena scutellaris*, which has been documented resulting in a range of mortality to those infected (Hennessey and Habeck 1991, Salvato *et al*. 2009, Salvato *et al*. 2009; Salvato and Salvato 2010a, Salvato and Salvato 2019).

Salvato *et al*. (2008) observed a biting-midge, *Forcipomyia* (*Microhelea*) *fuliginosa* (Diptera: Ceratopogonidae), feeding on a young Florida leafwing larva within ENP. Studies of *F*. (*M*.) *fuliginosa* and a second biting midge *F*. (*M*.) *eriophora* (Salvato *et al*. 2012) indicate they consistently parasitize leafwing larvae within Long Pine Key throughout their development.

Disease: Fungal pathogens have been documented to contribute to mortality of immature leafwings (Salvato and Salvato 2012; Sadle 2013, pers. comm.).

In general, immature life-stages of lepidoptera, especially eggs and early instars, are particularly vulnerable and mortality is often high but can vary widely (Hermann et al. 2019; Zalucki et al. 2002). Salvato and Salvato (2019) and Sadle (pers. comm. 2017a) have monitored Florida leafwing immature development in the field for several years at Long Pine Key. To date these studies have measured mortality rates of more than 70 percent for immature leafwing, individuals dying from various parasites, predators, and other factors such as fungal pathogens (Salvato and Salvato 2019; Sadle, pers. comm. 2017). While this level of mortality is generally consistent within other lepidoptera, compounded with the other threats leafwings face, mortality from predators, pathogens, and parasitoids can have significant effects on generational survival, especially within small or declining populations.

Factor D: Inadequacy of Existing Regulatory Mechanisms

Federal: Existing Federal regulatory mechanisms that provide some protection for the Florida leafwing include: (1) the National Park Service Organic Act and its implementing regulations; (2) the National Wildlife Refuge System Administration Act (16 U.S.C. 668dd–ee) as amended, and the Refuge Recreation Act (16 U.S. C. 460k–460k-4) and their implementing regulations.

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. The apparent online sale of the butterflies may suggest that poaching could be occurring in ENP, the only extant population. Therefore, insufficient implementation or enforcement could be a threat to the butterfly in the future if it continues to decline in numbers.

Although the species is not known to currently occur in any National Wildlife Refuges, Special Use Permits (SUPs) are issued by the Refuges as authorized by the National Wildlife Refuge System Administration Act (16 U.S. C. 668dd–ee) as amended, and the Refuge Recreation Act. The Service's Florida Ecological Services Office and NKDR coordinate annually on potential impacts to the Florida leafwing prior to issuance of an SUP to the Florida Keys Mosquito Control District (FKMCD) (see Factor E—Pesticides, below). In addition, the Comprehensive Conservation Plans for the Lower Key Refuges provides specifically for maintaining and restoring butterfly populations within NKDR, including the Florida leafwing (Service 2009).

State: The Florida leafwing is currently not listed by the State of Florida as a protected species under Chapter 68A-27, Rules Relating to Endangered or Threatened Species, so there are no existing State regulations designated to protect the subspecies. However, all State-owned property and resources are generally protected from harm in Chapter 62D–2.013(2), and animals are specifically protected from unauthorized collection in Chapter 62D–2.013(5) of the Florida Statutes.

Local: Under Miami-Dade County ordinance (Section 26-1), a permit is required to conduct scientific research (Rule 9) on county environmental lands. In addition, Rule 8 of this ordinance provides for the preservation of habitat within County parks or areas operated by the Parks and Recreation Department. We have no information to suggest that other counties within the range of the leafwing have regulatory mechanisms that provide any protections for the butterfly.

Despite existing regulatory mechanisms, the Florida leafwing has declined due to the effects of a wide array of threats. Based on our analysis of the best available information, we find that existing regulatory measures, due to a variety of constraints, do not work as designed, and, therefore, the existing regulatory mechanisms are inadequate to address threats to the subspecies throughout all of its range.

Factor E: Other Natural or Manmade Factors Affecting its Continued Existence

Effects of Few, Small Populations and Isolation: The Florida leafwing 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 within the extant Florida leafwing population at Long Pine Key varies considerably from year-to-year, based on a variety of ecological factors. The leafwing has been extirpated from several locations where they were previously recorded (Baggett 1982; Salvato and Hennessey 2003). Because of these extirpations and low population numbers, losses in Florida leafwing genetic diversity may have already occurred (Salvato 2019).

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 Florida leafwing 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; 2010c).

During late October 2005, Hurricane Wilma caused substantial damage to the pine rocklands of northwestern Big Pine Key (Salvato and Salvato 2010b), specifically within the Watson Hammock region of NKDR, the historical stronghold for the Florida leafwing on the island. In historical instances when leafwing population numbers were larger on Big Pine, such as following Hurricane Georges in 1998, these butterflies appeared able to recover soon after a storm (Salvato and Salvato 2010b). In ENP, where leafwing densities remain stable, the butterfly was minimally affected by the 2005 hurricane season (Salvato and Salvato 2010a). However, for the leafwing, given its substantial decline on Big Pine Key prior to Wilma, it is possible that the impact of this storm served to further hinder and reduce extant populations of the butterfly on the island (Salvato and Salvato 2010b).

Other environmental factors have likely impacted both butterflies and their habitat within their historical and current ranges like cold temperatures resulting in frost on pineland croton likely reducing survival of larval leafwings (Service 2014a and references therein). It is not clear what the short- or long-term impacts of prolonged cold periods may be on leafwing populations; however, it is likely that prolonged cold periods have some negative impacts on butterfly and pineland croton (Sadle 2010, pers. comm.; Land, pers. comm. 2010).

Pesticides: Efforts to control salt marsh mosquitoes, *Aedes taeniorhynchus*, among other mosquito species, 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 Florida leafwing. The Long Pine Key region of Everglades National Park, however, is not treated with pesticides for mosquito control. Outside of the Everglades, unoccupied butterfly habitat within Miami-Dade County and on Big Pine Key remains vulnerable to the effects of adulticide applications. However, use of mosquito control pesticides within Miami-Dade County pine rockland areas is limited.

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 Florida leafwing critical habitat both on Big Pine Key and throughout Miami-Dade County.

Synthesis

The Florida leafwing butterfly is currently restricted to select pine rockland habitat fragments harboring its only known host plant, pineland croton, in Long Pine Key, Miami-Dade County in south Florida. The species is considered extirpated from the remainder of its historical range. The primary threats to the Florida leafwing include habitat destruction and fragmentation, including climate change, lack of adequate fire management, poaching, parasitism, predation, disease (fungal pathogens), effects from small population size, restricted range, catastrophic environmental events, and influence of chemical pesticides used for mosquito control. The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management. The Florida leafwing remains stable and protected from habitat loss and impacts from mosquito spraying within the Long Pine Key region of Everglades National Park. However, outside of the Everglades, suitable habitat that remains for the Florida leafwing is threatened by habitat loss and degradation, and these threats are expected to accelerate with increased development along the Miami Rock Ridge. Updated predictions for sea level rise in South Florida continue to indicate that areas supporting the Florida leafwing and its habitat will likely undergo vegetation shifts or become partially or completely inundated. Additionally, Florida leafwing appears to be vulnerable to extinction due to retaining a single, localized population that varies in annual abundance. Consequently, at present, the Florida leafwing butterfly continues to meet the definition of endangered.

RECOMMENDED FUTURE ACTIVITIES

Recovery Activities

This species does not have a final recovery plan. In the course of this status review, we have identified the following potential recovery activities which are included below:

- Protect, restore, and manage remnant pine rocklands and associated habitats to increase functionality and connectivity throughout the leafwings range to aid in butterfly dispersal between larger occupied fragments and conservation lands Florida.
- Develop and expand partnerships to acquire and protect larger tracts of degraded or historic pine rocklands.
- Continue to work with the NPS, Miami-Dade and Monroe Counties and other partners to facilitate prescribed fire in pine rockland sites to establish consistent fire-return-intervals (3 to 7 years)
- Continue to coordinate with Mosquito Control Districts in south Florida to evaluate the impacts of pesticide applications, and establish effective no-spray zones, maintain adequate buffer zones, and reduce application dosage and extent of drift, where applicable.
- Conduct management activities to control nonnative parasitoids, and predators (e.g., fire ants) of the Florida leafwing.
- Enhance enforcement of poaching laws to limit illegal collection of the species.

Monitoring / Research Activities

- Work with partners to continue to:
  - Expand monitoring efforts of the Florida leafwing population and the butterfly's response to management activities within Long Pine Key, ENP.
  - Evaluate mechanisms to restore long-disturbed sites within the historic range of the Florida leafwing, including pine rocklands that have been converted to other uses (*e.g.*, agriculture, development).
  - Evaluate the potential effects towards the pine rocklands and listed species within resulting from changes in regional hydrology from Everglades restoration in Everglades National Park.
  - Conduct studies to address Florida leafwing natural history and ecological requirements.
  - Evaluate the genetic viability of the Florida leafwing within ENP, as well as that of pineland croton throughout Miami-Dade and Monroe Counties.
  - Conduct research on Florida leafwing ecology and habitat requirements, as well as developing reintroduction protocols, are recovery priorities for the subspecies.

REFERENCES

Anderson, C. 2012. 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.

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.

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. March 5, 2009. 31 pp.

Bradley, K.A., C. Anderson and S. Saha. 2013. Fire, Hurricanes, and Long-term Change in the Pine Rockland Forests of the National Key Deer Refuge. Report submitted to U.S. Fish and Wildlife Service, Big Pine Key, Florida. The Institute for Regional Conservation. Miami, Florida. March 5, 2009. 56 pp.

Benedict, L., B. Glazer, S. Traxler, C. Bergh, B. Stys, and J. Evans. 2018. Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for Threatened and Endangered Species. A Project Report for USFWS Cooperative Agreement F16AC01213. 152.

Bergh, C. and J. Wisby. 1996. Fire history of the lower Keys pine rocklands. Nature Conservancy (publishers). Key West, Florida.

Calhoun, J.V. 2013. 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.

Cannon, P. 2006. Bahamian swallowtails in the United States. American Butterflies 14:4-15.

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.

Clayborn, J. and S. Koptur. 2017. Mortal combat between ants and caterpillars: an ominous threat to the endangered Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*) in the Florida Keys, USA. Journal of Insect Conservation 21: 689-702.

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 (FNAI). 2010. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, Florida.

Florida Natural Areas Inventory (FNAI). 2019. FNAI Element Tracking Summary. Tallahassee, Florida. http://www.fnai.org/bioticssearch.cfm [Accessed: April 19, 2019].

Gann, G.D., K.N. Hines, E.V. Grahl, and S.W. Woodmansee. 2006. Rare plant monitoring and restoration on Long Pine Key, Everglades National Park. Year End Report, YEAR 3, Cooperative Agreement #H5284-03-0044. Submitted by The Institute for Regional Conservation, Miami, Florida to Everglades National Park, Homestead, Florida.

Gann, G.D. 2015. Vascular Plant Species of Management Concern in Everglades National Park. Final Report. Submitted by The Institute for Regional Conservation, Miami, Florida to Everglades National Park, Homestead, Florida.

Glassberg, J., M.C. Minno, and J.V. Calhoun. 2000. Butterflies through binoculars. Oxford University Press, New York.

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.

Hermann S.L., C. Blackledge, N.L. Haan, A.T. Myers, and D.A. Landis. 2019. Predators of monarch butterfly eggs and neonate larvae are more diverse than previously recognized. Scientific Reports 9:1–9. https://doi.org/10.1038/s41598-019-50737-5.

Integrated Taxonomic Information System (ITIS). 2023. *Anaea troglodyta floridalis* F. Johnson and W. Comstock, 1941. www.itis.gov. Retrieved on May 23, 2023.

Kalasz. K. 2019. Personal communication. Email to Mark Salvato. U.S. Fish and Wildlife Service, Florida Ecological Services Office. Vero Beach, Florida. June 25, 2019.

Kernan, C. and K. Bradley. 1996. Conservation survey of *Linum arenicola* in Dade County, Florida. Fairchild Tropical Garden. Report to the U.S. Fish and Wildlife Service, Vero Beach, Florida.

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. 2012. Email to Mark Salvato. Everglades National Park Fire Effects. Everglades National Park. Homestead, Florida. August 9, 2012.

Land, A. 2022. Email to Shawn Christopherson. Butterfly Monitoring Project. Everglades National Park. Homestead, Florida. February 11, 2022.

Maguire, J. 2010. Email to Mark Salvato, Miami-Dade Parks and Recreation Department, Miami, FL. April 28, 2010.

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.

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.

Matteson, J.H. 1930. *Anaea portia* - the leaf-wing and a list of the Rhopalocera of Miami, Florida. American Nature Association, Nature Magazine. 16pp.

Mattoni, R. 1992. Rediscovery of the endangered Palos Verdes blue butterfly, *Glaucopsyche lygdamus palosverdesensis* (Lycaenidae). Journal of Research on the Lepidoptera. 31:180-194.

Miller, L. and S. Traxler. 2019. Sea level rise and future environmental trends - A 2019 best available science synthesis report. Case study - Big Pine Key, Florida. Unpublished technical report. Vero Beach, Florida.

Park, J. and W. Sweet. 2015. Accelerated Sea Level Rise and Florida Current Transport. Ocean Science 11:607–615

Possley J., S. Hodges, E. Magnaghi, and J. Maschinski. 2016. Distribution of *Croton linearis* in Miami-Dade County Preserves with Potential for Supporting the Federally Endangered Butterflies *Strymon acis bartrami* and *Anaea troglodyte floridalis*. Natural Areas Journal. 36: 81-87.

Rahmstorf, S., J.E. Box, G. Feulner, M.E. Mann, A. Robinson, S. Rutherford, and E.J. Schaffernicht. 2015. Exceptional twentieth-century slowdown in Atlantic Ocean overturning circulation. Nature Climate Change 5: 475–480.

Rutkowski, F. 1971. Notes on some South Florida Lepidoptera. Journal of the Lepidopterists' Society 25:137-139.

Sadle, J. 2010. Personal communication. Email to Paula Halupa. Everglades National Park. Homestead, Florida. January 28, 2010.

Sadle, J. 2012. Email to Mark Salvato. Everglades National Park. Homestead, Florida. December 5, 2012.

Sadle, J. 2013. Email to Mark Salvato. Everglades National Park. Homestead, Florida. February 5, 2013

Sadle, J. 2017. Personal communication. Email to Mark Salvato. Everglades National Park. Homestead, Florida. August 10, 2017.

Sadle, J. 2018. Personal communication. Email to Mark Salvato. Everglades National Park. Homestead, Florida. May 31, 2018.

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. 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. 2019. Observation record. U.S. Fish and Wildlife Service, South Florida Ecological Services Office. Vero Beach, Florida. 2019.Salvato, M.H. 2019a. Observation record. U.S. Fish and Wildlife Service, Florida Ecological Services Office. Vero Beach, Florida. 2019.

Salvato, M.H. and M.K. Hennessey. 2003. Notes on the historic range and natural history of *Anaea troglodyta floridalis*. Journal of the Lepidopterists' Society 57:243-249.

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 *Anaea troglodyta floridalis* in Everglades National Park. Journal of the Lepidopterists' Society 64: 91-97.

Salvato, M.H., and H.L. Salvato. 2010b. Notes on the status of *Anaea troglodyta floridalis* on Big Pine Key. News of the Lepidopterists' Societ 52: 139-140.

Salvato, M.H., and H.L. Salvato. 2010c. *Misumenops bellulus* (Araneae: Thomisidae) a predator of larval *Anaea troglodyta floridalis* (Nymphalidae). News of the Lepidopterists' Society 52: 6-8, 25.

Salvato, M.H., and H.L. Salvato. 2011. Orb spiders (*Neoscona* spp.): Predators of larval *Anaea troglodyta floridalis* (Nymphalidae). News of the Lepidopterists' Society 53: 103.

Salvato, M.H., and H.L. Salvato. 2012. Parasitism of the Florida leafwing and Bartram's hairstreak butterfly immature stages. Comprehensive Annual Report to Everglades National Park.

Salvato, M.H., and H.L. Salvato. 2019. Parasitism of the Florida leafwing and Bartram's hairstreak butterfly immature stages. Comprehensive Annual Report to Everglades National Park.

Salvato, M and H. Salvato. 2022. Notes on the Ecology of Immature *Anaea troglodyta floridalis*. News of the Lepidopterists' Society 64: 119-121

Salvato, M.H., H.L. Salvato, A. Land, and J. Sadle. 2016. *Pseudomyrmex* spp. ant (Hymenoptera: Formicidae) predation on *Anaea troglodyta floridalis* (Nymphalidae). Journal of the Lepidopterists' Society 70(1):, 76-78.

Salvato, M.H., H.L. Salvato, E.H. Henry, and B.D. Pluer. 2018. *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) an egg parasitoid of *Strymon acis bartrami* (Lycaenidae). Journal of the Lepidopterists' Society 72: 175-176.

Salvato, M.H., H.L. Salvato, and W.L. Grogan Jr. 2008. Forcipomyia (Microhelea) fuliginosa (Meigen)(Diptera: Ceratopogonidae), an ectoparasite of larval Anaea troglodyta floridalis (Nymphalidae). Journal of the Lepidopterists' Society. 62: 174-175.

Salvato, M.H., H.L. Salvato, and W.L. Grogan Jr. 2012. *Forcipomyia (Microhelea) eriophora* (Williston)(Diptera: Ceratopogonidae), an ectoparasite of larval *Anaea troglodyta floridalis* (Nymphalidae). Journal of the Lepidopterists' Society 66: 232-233.

Salvato, M.H., H.L. Salvato, and M.K. Hennessey. 2009. *Chetogena scutellaris* (Diptera: Tachinidae) and endoparasite of larval *Anaea troglodyta floridalis*. News of the Lepidopterists' Society. 51: 85, 101, 106.

Salvato, M.H., H.L. Salvato, A. Land, and J. Sadle. 2016. *Pseudomyrmex* spp. ant (Hymenoptera: Formicidae) predation on *Anaea troglodyta floridalis* (Nymphalidae). Journal of the Lepidopterists' Society.

Salvato, M.H., H.L. Salvato, E.H. Henry, and B.D. Pluer. 2018. *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) an egg parasitoid of *Strymon acis bartrami* (Lycaenidae). Journal of the Lepidopterists' Society.72: 175-176.

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. https://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=1001&context=sercrp

Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak. 2022. Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf

The Nature Conservancy. 2011. Initial estimates of the ecological and economic consequences of sea level rise on the Florida Keys through the year 2100. The Nature Conservancy, Arlington, Virginia.

University of Florida GeoPlan Center. 2015. Testing and Enhancement of the Florida Sea Level Scenario Sketch Planning Tool. Final Report. University of Florida GeoPlan Center Gainesville, Florida.

U.S. Fish and Wildlife Service (Service). 2014a. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Florida Leafwing and Bartram's Scrub-Hairstreak Butterflies. Federal Register 79: 47179-47220.

U.S. Fish and Wildlife Service (Service). 2014b. Endangered and Threatened Wildlife and Plants; Endangered Status for the Florida Leafwing and Bartram's Scrub-Hairstreak Butterflies. Federal Register 79: 47222-47244.

Vargas-Moreno, J.C and M. Flaxman. 2010. Addressing the challenges of climate change in the Greater Everglades landscape. Project Sheet, November 2010. Massachusetts Institute of Technology, Department of Urban Studies and Planning; Cambridge, Massachusetts.

Zhang, K., J. Dittmar, M. Ross, and C. Bergh. 2011. Assessment of sea level rise impacts on human population and real property in the Florida Keys. Climatic Change. DOI 10.1007/s10584-011-0080-2

Zalucki, M.P., A.R. Clarke, and S.B. Malcolm. 2002. Ecology and Behavior of First Instar Larval Lepidoptera. Annual Review of Entomology. Volume 47, 361–393. DOI 10.1146/annurev.ento.47.091201.145220.

RESULTS / APPROVALS

U.S. FISH AND WILDLIFE SERVICE
Status Review of Florida Leafwing Butterfly

Status Recommendation
On the basis of this review, we recommend the following status for this species. A 5-year review presents a recommendation of the species status. Any change to the status requires a separate rulemaking process that includes public review and comment, as defined in the Act.

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist *(Indicate reasons for delisting per 50 CFR 424.11)*:
____ *The species is extinct*
____ *The species does not meet the definition of an endangered or threatened species.*
____ *The listed entity does not meet the statutory definition of a species.*
_x__ No change needed

FIELD OFFICE APPROVAL:

Acting for **Division Manager, Classification and Recovery, Florida Ecological Services Field Office, U.S. Fish and Wildlife Service**

Approve NICOLE COLANGELO Digitally signed by NICOLE COLANGELO Date: 2023.08.18 14:45:23 -04'00'

LEAD REGIONAL OFFICE APPROVAL:

Acting for **Assistant Regional Director- Ecological Services, U.S. Fish and Wildlife Service**

Approve AARON VALENTA Digitally signed by AARON VALENTA Date: 2023.08.18 14:24:58 -04'00'