



## ARTICLE

# Butterfly Diversity on a Southeast Florida Military Base Located within an Urban Matrix

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### ABSTRACT

South Florida is a renowned 'hotspot' for rare and endemic taxa, with insects and plants found in few other ecosystems. Specialized species evolved in Florida's stochastic climate, adapting to seasonal drought and flooding, hurricanes and high-wind tropical storms. As human population growth and development increased, and natural ecosystems disappeared, or became increasingly degraded, at-risk taxa now face additional threats, such as urban pesticide use and fragmented remnant habitats. The ability of species to adapt to these changing ecological factors is one of the dynamics that either impacts their fitness to greater survival or drives extirpation or extinction. Butterflies are native indicator species that can be used to document environmental conditions affecting many other taxa. Butterfly surveys were conducted over 16 months on an active military air reserve base located within a mosaic of densely populated urban, commercial, industrial, residential, and agricultural matrices in Homestead, southeast Florida. Butterfly species richness, abundance and diversity were documented, providing valuable base-line data for on-going butterfly monitoring, and the importance of this site's relatively healthy remnant ecosystems was evidenced by the supporting host plants for 20 migratory butterflies in 40 species. In addition, the air reserve base acts as refugia for many rare, endangered, and threatened federal and state-listed plants as well.

## 1. Introduction

Southeast Florida is a recognized 'hotspot' for biodiversity<sup>[1]</sup>, home to endemic rare plants and animals found nowhere else in the world, many of which are located in globally endangered ecosystems such as globally endangered pine rocklands<sup>[2]</sup> and tropical hardwood hammocks<sup>[3]</sup>. Even as human-tolerant and

still common wildlife such as raccoons and opossums are squeezed into decreasing suitable habitat fragments within urban matrices, the less-mobile, once-abundant species, including small invertebrates, may become extirpated or extinct<sup>[4-12]</sup>. Remaining islands of natural ecosystems are often infested with non-native, invasive plant and animal species which exacerbate the ability of native wildlife to survive<sup>[5,7,9,11-17]</sup>. In addition, these fragments of remnant

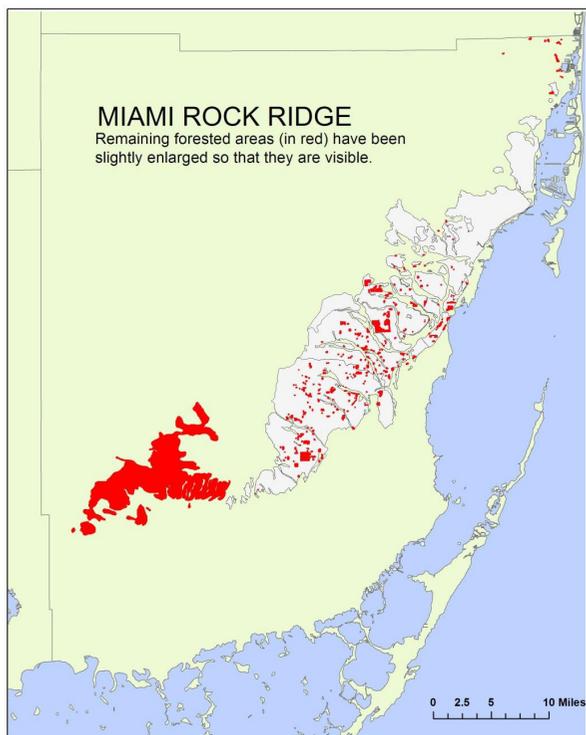
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habitat are usually surrounded by unsuitable, hostile environment with little safe connectivity between extant parcels [11,18-22]. The original pine rockland habitat, dominated by slash pines (*Pinus elliottii* var. *densa*) and rare endemic plants [23-26] has been reduced to less than 1.5% (Figure 1). Isolated safe haven areas (refugia) are often in danger of being lost to further commercial development, or agricultural areas, affecting population size, survival and dispersal capabilities [7,11,12,16,27-30].



FAIRCHILD TROPICAL BOTANIC GARDEN

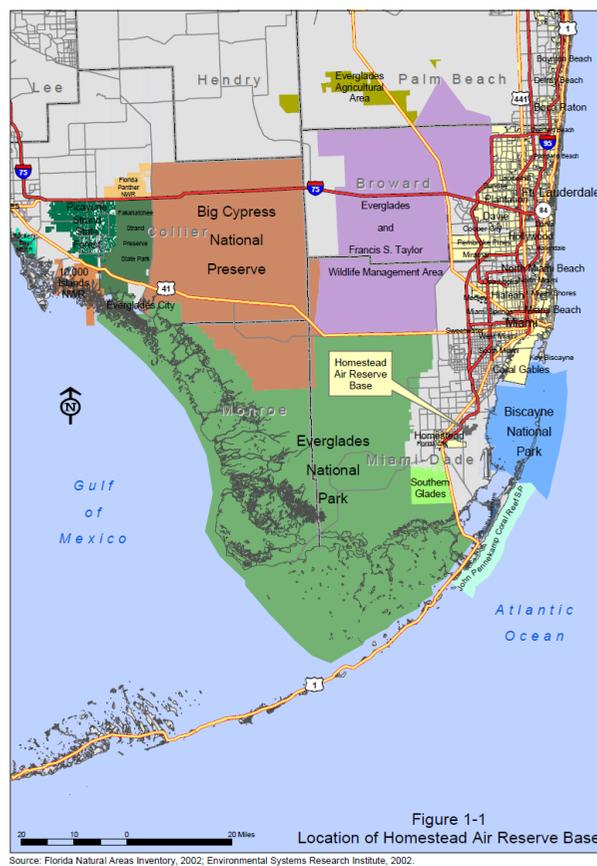
**Figure 1.** Remnant pine rockland areas remaining in Miami-Dade County are colored red; light gray outlines indicate original range

Source: Fairchild Tropical Botanic Garden.

Developed arenas invite increased use of pesticides and non-native vegetation, and vast agricultural monocultures not only use potentially harmful agrochemicals, insecticides and herbicides [15,31-35] but also heavy machinery that further degrades the soil structure and native vegetation (including removal of “weeds” that act as host plants for insect larvae and nectar sources for adult insects) [36]. In addition, South Florida agricultural lands consist of “rock-plowed” limestone outcrop, a process developed in the 1950’s to make use of the substrate called “Miami oolite” [37] for agriculture. Many butterfly species that inhabit this unique environment are endemic to southeast Florida and are often rare or localized [8,22,38-40]. Four species are considered endangered by the United States Fish and Wildlife

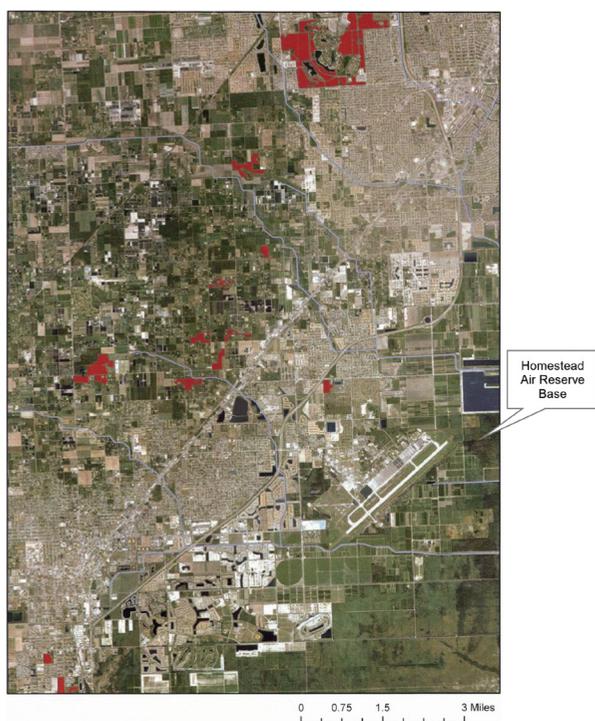
Service [41]: Bartram’s scrub-hairstreak (*Strymon acis bartramii*), Schaus swallowtail (*Heraclides aristodemus ponceanus*), Florida leafwing (*Anaea troglodyta florida-lis*) and Miami blue (*Cyclargus thomasi bethunebakeri*) [42]. Three additional species of butterflies in south Florida are protected by the Florida Wildlife Conservation Commission [43] and 26 are considered “imperiled” in south Florida by the State of Florida’s Imperiled Butterfly Work Group, a subset of the Florida Wildlife Conservation Commission [43], which was formed in 2008 to study declining lepidoptera. Two species are now considered extinct, zestos skipper (*Epargyreus zestos oberon*) and Meske’s rockland grass skipper (*Hesperia meskei pinocayo*) [43].

Surveys of butterfly populations have been used as an important monitoring protocol for ecological and biodiversity indicators for many years [12,39,44-48]. Our butterfly surveys show that the butterflies and plant species listed by the USFWS or FWC as endangered or threatened have safe refugia on the Homestead Air Reserve Base (HARB) (Figure 2); it is also valuable conservation data, strengthening long-term data collection that has been done in the Homestead area in nearby critical butterfly units [49] (Figure 3).



**Figure 2.** Homestead Air Reserve Base and surrounding matrices, located in southeast Florida

Source: Florida Natural Areas Inventory, 2002. Environmental Systems Research Institute 2002.



**Figure 3.** Critical butterfly habitat units (in red) located within proximity of Homestead Air Reserve Base

Source: M. Andrejko

## 2. Location and Description of Survey Units

Homestead Air Reserve Base (HARB) is an active military base located in southern Miami-Dade County, in Homestead, Florida (25° 29' 9.752", -80° 23' 27.298"). The base is located approximately 20 miles south-southwest of the city of Miami and about 1.5 miles inland from Biscayne National Park and the Atlantic Ocean (Figure 1). HARB is nestled within densely populated urban, commercial, industrial, residential, and agricultural matrices. The surrounding natural areas include globally endangered pine rockland fragments, fresh-water marshes containing low-lying herbaceous plants, coastal beaches with heavily used public and commercial boating facilities, tropical hardwood hammock fragments, mining operations, industrial complexes and derelict abandoned properties (Figure 2). Agricultural fields are the predominant landscape interspersed with residential, commercial and industrial facilities (such as limestone and sand mining). Critical butterfly habitat units, protected natural areas owned and maintained by Miami-Dade County, or in some cases by private landowners, are located south, west, and north of the airbase<sup>[40,50]</sup> (Figure 3).

HARB currently contains 1,943 acres; numerous ownership changes since the 1940's and a number of powerful hurricanes have caused significant damage over the years,

reducing the original base acreage by nearly half. Large portions were sold or transferred as excess property after Hurricane Andrew in 1992<sup>[51]</sup>. The areas within the base are divided into fourteen "Land Management Units"<sup>[51]</sup> (Table 1); 1,000 acres are described as "heavily modified pine rockland habitat"<sup>[51]</sup>. The airfield itself covers 945.3 acres, nearly half of the remaining land area. Most of the units were either off-limits for surveys because of concern for safety, such as ordnance storage, or because of military practices, such as training sessions or other air force activities. Some 'units' actually consist of parking lots and administration buildings and were therefore not suitable for butterfly occupancy. There is a mosaic of non-native vegetation, native endangered or threatened plants, grasslands, globally threatened pine rocklands, as well as old partially developed or damaged derelict areas. A lake and wetlands were not surveyed but are part of the off-limit areas to the southeast (runway area).

**Table 1.** Land management units identified on the base: (Integrated Natural Resources Management plan for Homestead Air Reserve Base, Homestead, Florida Volume 1, July 2009.)

Land Management Unit	Acreage
Boundary Canal	40,400 linear ft.
Administrative and Industrial Support	334.3 acres
Airfield Area	945.3 acres
Grenade Range and Reserves Area	116.6 acres
Hush House Area	30.6 acres
Munitions Area	122.0 acres
Northeast Grasslands	50.5 acres
Operable Unit (OU)-2 acre	21.1 acres
Phantom Lake (including old Grenade Range)	93.8 acres
Remnant Pine Rockland	5.1 acres
SOCSouth	14.0 acres
Southeast Triangle	51.9 acres
Southwest Clear Zone	57.0 acres
Twin Lakes and Wetland Fringe	40.8 acres
Wetland marsh	34.7 acres

## 3. Descriptions of Survey Areas

### Pine Rockland Unit and Sample Site #7

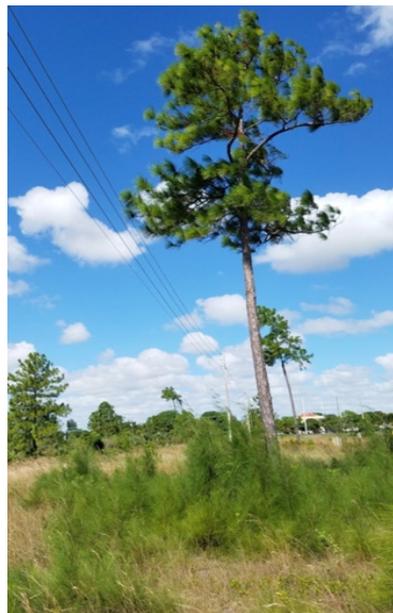
On-going restoration at this northwest HARB pine rockland unit consisting of 5.1 acres was occurring as invasive non-native trees and exotic herbaceous vegetation were removed. The site contains mature and seedling Florida slash pine trees (*Pinus elliottii* var. *densa*), a species particular to south Miami-Dade and the Caribbean known for its extremely hard wood and high-leaved growth habit, due to being fire-adapted. The nutrient-poor limestone substrate in the rocklands has little soil or organic matter,

and the pines grow slowly, making the wood dense and hard. Other native trees in the pineland area included Florida trema (*Trema micranthum*), the state-listed threatened West Indian lilac (*Miconia bicolor*) and the state tree, cabbage palm (*Sabal palmetto*). Herbaceous plants include the state-endangered pineland jacquemontia (*Jacquemontia curtsii*) and locustberry (*Byrsonima lucida*) (Figure 4).



**Figure 4.** Remnant pine rockland area; this site has more understory vegetation than regularly fire-maintained pine rockland areas (Copyright: Koi)

Sample Site #7, a small subset of approximately 2 acres located directly to the east of the pineland, consists of a few scattered mature and young Florida slash pines, and low-lying herbaceous native vegetation such as porterweed (*Stachytarpheta jamaicensis*), Spanish needle (*Bidens alba* var. *radiata*), and creeping ticktrefoil (*Desmodium incanum*). The federally endangered sandflax, (*Linum arenicola*), and the state-listed endangered quailberry (*Crossopetalum ilicifolium*) are also located here (Figure 5).



**Figure 5.** Sample site 7 contains a ruderal field with scattered non-native Australian pine seedlings (now destroyed) and native slash pine trees and seedlings. (Copyright: Abbott)

### 3.1 Boundary Canal Unit

The Boundary Canal unit consists of 40,400 linear feet (7.8 miles) of deep channels dug into the limestone substrate, which contain fresh water with high visibility except for a few areas polluted with urban trash that gets flushed into the canal from surrounding matrices. It harbors both native and non-native fish, and occasional ducks and wading birds, as well as numerous non-native reptiles. Fresh-water canals such as these are known to provide habitat for the Miami cave crayfish, *Procambus milleri*<sup>[52]</sup>, a federally endangered species<sup>[43]</sup>.

Weedy non-native tree seedlings and mature trees, primarily the exotic non-native Australian pine (*Casuarina equisetifolia*), line the edges of the canals. Native shrubs, such as myrsine (*Myrsine floridana*), and cocoplum (*Chrysobalanus icaco*), grow along the banks. Maintenance protocol at the base periodically sprays herbicide along the canal edges, causing temporary die-back of all vegetation. The Boundary Canal is shaded by the Australian pine trees and non-native Brazilian pepper (*Schinus terebinthifolius*) on the northwest and south routes and has grassy banks on the western route (Figure 6).



**Figure 6.** The southwestern edge of the boundary canal unit has a grassy bank with scattered trees along the canal, lined with non-native Australian pine and Brazilian-pepper on the eastern edge (Copyright: Abbott)

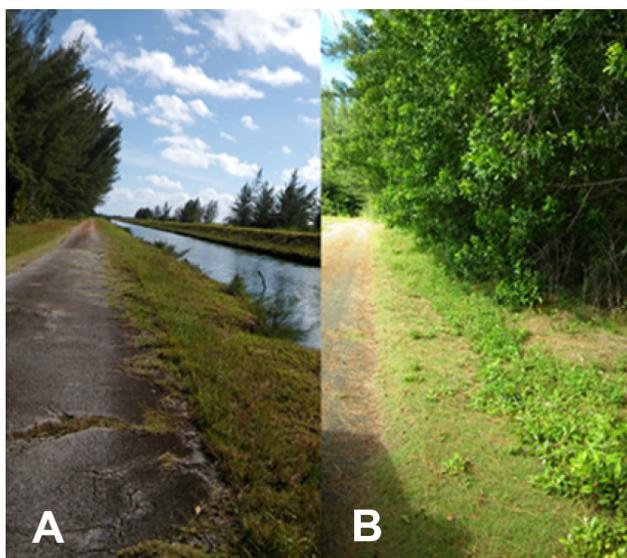
### 3.2 Grenade Range and Reserves Unit

A grenade range and reserves area, still used for military practices, consists of 116.6 acres of open mowed and unmowed grasslands, and thin sand-soils lying on limestone outcrop. There is a rich variety of both native and non-native trees and vegetation. Native plants found include passionvine (*Passiflora suberosa*), porterweed, marlberry (*Ardisia escallonioides*), and sandflax (*Linum arenicola*). There are sunny open areas of native and non-native grassy fields, both mowed and unmowed. Native herbs in this unit include passionvine, Spanish needles, pencil-flowers (*Stylosanthes hamata*) and native milkweed (*As-*

*clepius suberosa*), and the federally endangered Small's milkpea (*Galactia smallii*). There are also burned out vehicles and other blockades from military practices on this location, but we did not monitor near these artifacts. Non-native Australian pine and Brazilian pepper trees are mixed among native trees such as gumbo limbo (*Bursera simaruba*), poisonwood (*Metopium toxiferum*) and willow bastic (*Dipholis salicifolia*) (Figures 7 and 8).



**Figure 7.** The practice Grenade Range and Reserves Area consisted of mowed and unmown areas, as well as the derelict vehicles used in military training sessions (Copyright: Koi)



**Figure 8.** The edge of the Boundary Canal northwest perimeter has a narrow grassy edge, shaded by a mix of non-native Australian pine and Brazilian-pepper trees; the semi-shaded understory contained abundant weedy nectar and host plant resources. A. Facing the canal looking west. B. Facing the trees looking east (Copyright: Koi)

### 3.3 Special Operations South (SOCSouth)

This 14-acre area consists of a mosaic of remnant derelict road fragments, tropical hardwood hammock, restored

pine rockland, and weedy un-mowed fields. It contains twenty-six federal- and state-listed trees such as silver palm (*Coccothrinax argentata*), and Bahama senna (*Senna mexicana* var. *chapmanii*). Some areas are densely overgrown and heavily shaded with native plants such as the semi-invasive jack-in-the-bush (*Chromolaena odorata*), an excellent nectar source for both butterflies and moths, as well as bees, beetles and other beneficial insects. Herbaceous vegetation such as the federally endangered sandflax, and Small's milkpea are found here as is the state-listed endangered pineland clustervine (*Jacquemontia curtsii*). The area has a wide variety of small native shrubs, including beautyberry (*Callicarpa americana*), saltbush (*Baccharis halimifolia*), native trees such as wild tamarind (*Lysiloma latisiliquum*) and royal palm (*Roystonea elata*). Florida state-listed ground-covering herbs such as wild potato morning glory (*Ipomoea microdactyla*), Bahama ladderbrake (*Pteris bahamensis*) and pineland lantana (*Lantana depressa*). On-going non-native plant removal also occurred at this location, to remove heavy infestation of Brazilian pepper and Burma reed (*Neyraudia reynaudiana*) (Figure 9).



**Figure 9.** Weedy un-mown fields surrounded by shrubs and slash pines dominate SOCSouth; scattered sections of old pavement are also located in this unit (Copyright: Koi)

## 4. Materials and Methods

Nine standard “Pollard Walk”<sup>[44]</sup> surveys were conducted in four diverse ecosystems located on the base to document butterfly species between 09-May-2015 and 30-December-2016. Pollard walks are used throughout the world to assess butterfly populations, and primarily consist of slowly walking along pre-determined set transects or routes in the chosen site, noting butterfly species within five meters on three sides (left, right and above). Care was taken to avoid double-counting as the insects flew and close-focus binoculars were used to identify species; species were photographed whenever possible. Walks sometimes had to be cancelled because of military exercises,

heavy tropical storms, or restoration work, which accounts for the unevenness of the surveys.

Richness and diversity was determined using Shannon-Weiner Diversity Index, and Simpson Dominance Index, as well as the Equitability Index, and skewness was established via Kurtosis. Identification was done by an entomologist (one of the authors, SK), aided when necessary with photographic records from a university website<sup>[53]</sup> and a field guide<sup>[54]</sup>.

### 5. Butterfly Survey Results

Forty species of butterflies were counted, in seven families, for a total of 2,128 individuals in the nine Pollard Walks (Table 2). We recorded 469 individuals in the pine-land and Sample Site #7 (Figure 10), 1,425 individuals in the Canal and Grenade Range (Figure 11), and 234 individuals in SOCSouth (Figure 12). (Boundary Canal and Grenade Range were counted as one unit because they are contiguous in the actual landscape.)

**Table 2.** Butterflies observed at Homestead Air Reserve Baser by standard Pollard Walks from 9 May 2015 to 30 Dec. 2016, migratory status and host plants on base

Common Name	Scientific Name	Migratory	Hostplant(s)
Giant swallowtail	<i>Papilio cressphon-tes</i>	Yes	Wild Lime ( <i>Zanthoxylum fagara</i> ); Other citrus in surrounding matrix
Great southern white	<i>Ascia monuste</i>	Yes	Peppergrass ( <i>Lepidium virginicum</i> ); Other mustards in surrounding matrix Chapman's Wild Sensitive Plant ( <i>Senna mexicana var. chapmanii</i> )
Pink-spot sulphur	<i>Aphrissa neleis</i>	Yes	Wild tamarind ( <i>Lysiloma latisiliquum</i> ); Sabcicu ( <i>L. sabcicu</i> )
Cloudless sulphur	<i>Phoebis sennae</i>	Yes	Deering Partridge Pea ( <i>Chamaecrista deeringiana</i> ); Sensitive Pea ( <i>C. nictitans var. aspera</i> )
Orange-barred sulphur	<i>Phoebis philea</i>	Yes	False Tamarind ( <i>Lysiloma latisiliquum</i> )
Large orange sulphur	<i>Phoebis agarithe</i>	Yes	Beggarweed ( <i>Desmodium incanum</i> ); Threeflower Ticktrefoil ( <i>D. triflorum</i> )
Little yellow	<i>Pyrisitia lisa</i>	Yes	Chapman's Wild Sensitive Plant ( <i>Senna mexicana var. chapmanii</i> )
Barred yellow	<i>Eurema दौरا</i>	Yes	Partridge Pea ( <i>Chamaecrista fasciculata</i> ); Deering Partridge Pea ( <i>C. deeringiana</i> )
Dainty sulphur	<i>Nathalis iole</i>	Yes	Spanish Needles ( <i>Bidens alba var. radiata</i> ); Cheesytoes ( <i>Stylosanthes hamata</i> )
Martial scrub hairstreak	<i>Strymon martialis</i>	No	Florida trema ( <i>Trema micranthrum</i> ) Common Fanpetals ( <i>Sida acuta</i> ); Elliott's Fanpetals ( <i>S. elliottii</i> )
Mallow scrub hairstreak	<i>Strymon istapa</i>	No	Sleepy Morning ( <i>Waltheria indica</i> )

Fulvous hair-streak	<i>Electros-trymon angelia</i>	No	Brazilian-pepper ( <i>Schinus terebinthifolius</i> )
Gray hair-streak	<i>Strymon melinus</i>	No	Common Fanpetals ( <i>Sida acuta</i> ); Elliott's Fanpetals ( <i>S. elliottii</i> )
			Lead Tree ( <i>Leucaena leucocephala</i> ) Buttonwood ( <i>Conocarpus erectus</i> ); polyphagous*
Cassius blue	<i>Leptotes cassius</i>	No	Downy milkpea ( <i>Galactia volubilis</i> ); Small's Milkpea ( <i>G. smallii</i> )
			False Tamarind ( <i>Lysiloma latisiliquum</i> )
Ceraunus blue	<i>Hemiargus ceraunus</i>	No	Sensitive Pea ( <i>Chamaecrista nictitans var. aspera</i> ); Partridge Pea ( <i>C. deeringiana</i> )
Zebra heliconian	<i>Heliconius charithonia</i>	No	Corkystem passionvine ( <i>Passiflora suberosa</i> )
Julia heliconian	<i>Dryas iulia</i>	No	Corkystem passionvine ( <i>Passiflora suberosa</i> )
Gulf fritillary	<i>Agraulis vanillae</i>	Yes	Corkystem passionvine ( <i>Passiflora suberosa</i> )
Variiegated fritillary	<i>Euptoieta claudia</i>	Yes	Sand Flax ( <i>Linum arenicola</i> ); Everglades Flax ( <i>L. carteri</i> )
Pearl crescent	<i>Phyciodes tharos</i>	No	Scaleleaf Aster ( <i>Symphotrichum adnatum</i> )
Phaon crescent	<i>Phyciodes phaon</i>	Yes	Turkey Tangle Fogfruit ( <i>Phyla nodiflora</i> ); Southern Fogfruit ( <i>P. stoechadifolia</i> )
Buckeye, tropical	<i>Junonia zonalis (=genoveva)</i>	No	Blue Porterweed ( <i>Stachytarpheta jamaicensis</i> )
Buckeye, common	<i>Junonia coenia</i>	Yes	False Foxglove ( <i>Agalinis fasciculata</i> ); Sand Flax ( <i>Linum arenicola</i> ) (?)**
White peacock	<i>Anartia jatrophe</i>	Semi	Turkey Tangle Fogfruit ( <i>Phyla nodiflora</i> ); Southern Fogfruit ( <i>P. stoechadifolia</i> )
			Herb-of-Grace ( <i>Bacopa monnieri</i> )
Ruddy daggerwing	<i>Marpesia petreus</i>	Yes	Strangler fig ( <i>Ficus aurea</i> ); Laurel Fig ( <i>F. microcarpa</i> )
Monarch	<i>Danaus plexippus</i>	Yes	Scarlet Milkweed ( <i>Asclepias curassavica</i> )
Queen	<i>Danaus gilippus</i>	Semi	Scarlet Milkweed ( <i>Asclepias curassavica</i> )
Long-tailed skipper	<i>Urbanus proteus</i>	Yes	Beggarweed ( <i>Desmodium incanum</i> ); Threeflower Ticktrefoil ( <i>D. triflorum</i> ); polyphagous*
Dorantes longtail	<i>Urbanus dorantes</i>	Semi	Beggarweed ( <i>Desmodium incanum</i> ); Threeflower Ticktrefoil ( <i>D. triflorum</i> ); polyphagous*
Horace's duskywing	<i>Erynnis horatius</i>	No	Oak species ( <i>Quercus</i> sp.)
Tropical checkered skipper	<i>Pyrgus oileus</i>	No	Common Fanpetals ( <i>Sida acuta</i> ); Elliott's Fanpetals ( <i>S. elliottii</i> )
Neamathla skipper	<i>Nastra neamathla</i>	No	Bluestem grass ( <i>Andropogon</i> sp.)

Three-spotted skipper	<i>Cymaenes tripuncta</i>	No	Guinea Grass ( <i>Panicum maximum</i> )
Clouded skipper	<i>Lerema accius</i>	Yes	Saint Augustine Grass ( <i>Stenotaphrum secundatum</i> )
Southern skipperling	<i>Copaeodes minimus</i>	No	Bermuda grass ( <i>Cynoden dactylon</i> )
Least skipper	<i>Ancyloxypha numitor</i>	No	Giant Cutgrass ( <i>Zizaniopsis milia- cea</i> )
Sachem skipper	<i>Atalopedes campestris</i>	Yes	Bermuda grass ( <i>Cynoden dactylon</i> ); Saint Augustine Grass ( <i>Stenotaphrum secundatum</i> )
Fiery skipper	<i>Hylephila phyleus</i>	Yes	Bermuda grass ( <i>Cynoden dactylon</i> ); Saint Augustine Grass ( <i>Stenotaphrum secundatum</i> )
Baracoa skipper	<i>Polites baracoa</i>	No	Grass sp.; polyphagous*
Southern broken-dash	<i>Wallengrenia otho</i>	No	Saint Augustine Grass ( <i>Stenotaphrum secundatum</i> ); Thin paspalum ( <i>Paspalum setaceum</i> )

Notes: \*Polyphagous refers to a wide variety of food plants; most common host plants are listed but these may not be the only host plants used by the species. \*\*Lineria is the usual hostplant; Linum may be as well based on chemical composition comparisons<sup>[79-81]</sup>.

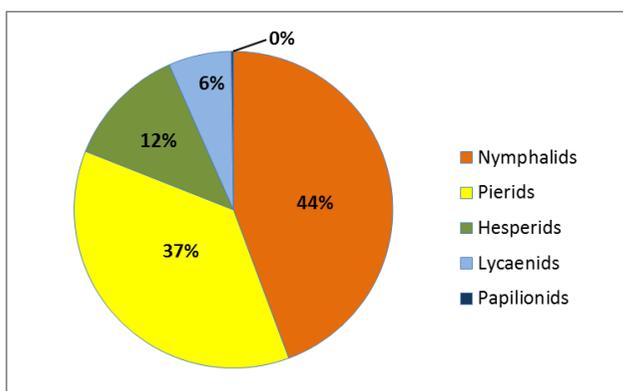


Figure 10. Pine Rockland Unit and Sample Area #7 were dominated by Nymphalids and Pierids, with a few Lycaenids and only one sighting of a Papilionid, which accounted for less than 0.002% of the total individuals observed and is represented by 0% on the graph

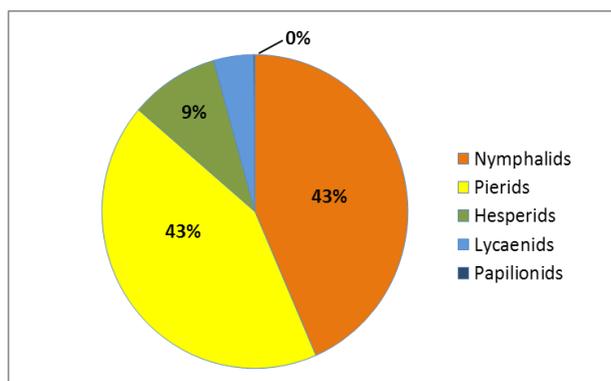


Figure 11. Species distribution in the practice Grenade Range and Boundary Canal Unit was dominated by the Nymphalid and Pierid families

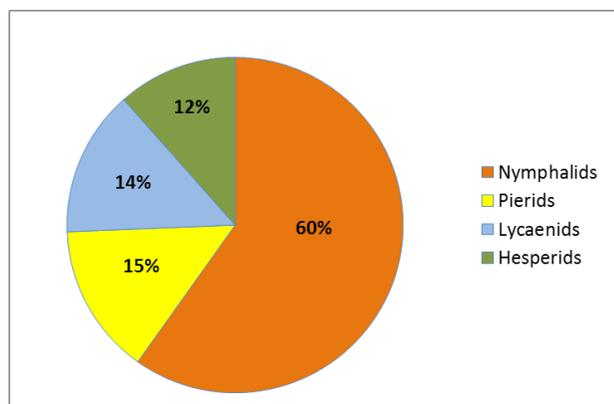


Figure 12. SOCSouth butterfly distribution was dominated by butterflies in the Nymphalid family and had more Lycaenids than any other habitat on the base

The least represented species were swallowtails (Papilionid family), with only three individuals in one species, the giant swallowtail (*Papilio cresphontes*), which was also only seen in one count (Figure 13). There were seven species and 816 individuals of “whites and yellows” (Pierid family) counted, the most abundant being barred yellow (*Eurema daira*), which accounted for 79% of the Pierids and 30% of all species. Dainty sulphurs (*Nathalis iole*) were the second most abundant in the family, accounting for 9% of all of the Pierids. Other species observed were great southern white (*Ascia monuste*), large orange sulphur (*Phoebis agarithe*), little yellow (*Eurema lisa*), and orange-barred sulphur (*Phoebis philea*) (Figure 13).

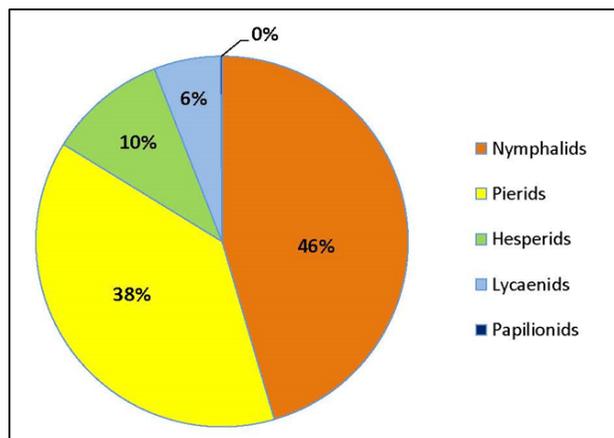


Figure 13. All butterfly families and abundance documented at Homestead Air Reserve Base counted by standard Pollard Walks from 9 May 2015 to 30 Dec. 2016. The Papilionid count consisted of only three individuals, which was less than 0.001% of the total individuals observed, statistically counted as “0%”

The very small butterflies known as “blues” accounted for 4% of all butterflies counted, in only two species, cer- anus blue (*Hemiargus ceraunus*) and cassius blue (*Lep-*

*totes cassius*). Although both species are common, both butterflies are listed as endangered by the federal government<sup>[42]</sup>, because of their similarity to the federally endangered Miami blue (*Cyclargus thomasi bethunebakerii*)<sup>[42]</sup>. Ceraunus blue was more common than cassius blue (Figure 13).

Only four species of “hairstreak” butterflies (Lycaenidae family), named for the tiny tail-like protrusions on their hindwings, were seen. Numbering just 20 individuals, they accounted for less than 1% of the butterfly species recorded. The most observed species was fulvous hairstreak (*Electrostrymon angelia*). There was only one each observed of mallow scrub-hairstreak (*Strymon istapa*), martial scrub-hairstreak (*Strymon martialis*), and gray hairstreak (*Strymon melinus*) (Figure 13).

The “Brushfoot” butterflies (Nymphalids) were the most abundant family observed at each survey, totaling 933 individuals in nine species. Gulf fritillary (*Agraulis vanillae*) butterflies accounted for 46% of all Nymphalids observed, and 34% of all butterflies observed, with 433 individuals. White peacocks (*Anartia jatrophae*) were the second most abundant.

We did not differentiate between the two possible Southeast Florida buckeye butterflies tropical buckeye (*Junonia zonalis*) and common buckeye (*J. coenia*) (see detailed note and citations regarding *Junonia* species and migration). Because buckeyes scatter quickly when approached, it was challenging to verify species consistently in the field. The majority were likely “tropical” as opposed to “common” because the host plant for the tropical buckeye, blue porterweed (*Stachytarpheta jamaicensis*), is abundant on the property. Tropical buckeyes do not migrate, but common buckeye does. However, they hybridize in locations where the migratory route of the common buckeye overlaps with the resident populations of the tropical species. For this reason, ‘buckeye’ species were counted as one group. (The third species, mangrove buckeyes (*J. evarete*) are not found on the base as there are no host plant mangroves on the surveyed property and this species does not migrate).

Zebra heliconian (*Heliconius charithonia*) was the next abundant species seen, and we also observed variegated fritillary (*Euptoieta claudia*), phaon crescent (*Phyciodes phaon*), julia heliconian (*Dryas iulia*), pearl crescent (*Phyciodes tharos*) and ruddy daggerwing (*Marpesia petreus*) (Figure 13).

There were 46 individuals counted in the milkweed butterfly family (Danaid), which are Nymphalids, 25 queens and 23 monarchs (Figure 13). No soldiers, the third Danaid species, were observed on base (pun intended)!

Skipper butterflies (Hesperiidae family) were much less abundant than expected given the profusion and diversity of graminoid species in the grassy fields on the air base, as many skippers are grass feeders. Fourteen species were observed, totaling 199 individuals. The most abundant species was baracoa skipper (*Polites Baracoa*), representing 31% of all skippers observed. Longtailed skippers (*Urbanus proteus*) were the next abundant, followed by the Dorantes skipper (*Urbanus dorantes*). We also recorded fiery skipper (*Hylephila phyleus*), clouded skipper (*Lerema accius*), three-spotted skipper (*Cymaenes tripunctus*), tropical checkered skipper (*Pyrgus oileus*), monk skipper (*Asbolis capucinus*), ocola skipper (*Panoquina ocola*), sachem skipper (*Atalopedes campestris*), southern broken-dash skipper (*Wallengrenia otho*), southern skipperling (*Copaodes minimus*), least skipper (*Ancyloxypha numitor*), neamathla skipper (*Nastra neamathla*), and palmetto skipper (*Euphyes arpa*) (Figure 13).

Shannon Diversity Index shows fairly high diversity (2.554) dominated by a few species (Simpson’s Index of Dominance: 0.8612). The species evenness was low (0.692), and the skewness/Kurtosis was high (3.697/14.308).

## 6. Discussion

Tracks of land protected from further development and alteration, such as HARB and other military and reserve bases, act as vital refugia for plant and animal taxa, as well as providing connectivity between remaining natural areas, even in heavily urbanized surrounding matrices<sup>[30,49,55]</sup>. However, the natural areas within these agricultural-urbanized matrices may ‘suffer from detrimental edge effects’<sup>[5-7,11,50,56]</sup>, primarily because the natural ‘edges’ or ecotones no longer exist and the biotic taxa that may have lived within the transition zone between ecosystems cannot adapt to the changes between a natural area and an artificial matrix. Butterflies and other insects often require specific elements in ‘landscape architecture’ as well as host plants and nectar resources in order to persist in a location<sup>[20,57]</sup>. In addition, fire-maintained ecosystems such as pine rocklands suffer from fire suppression in urban areas<sup>[50]</sup>.

There was a pronounced difference in the abundance of butterflies in the different units (Table 3). The highest number of species (34) and most individuals (1424) counted was in the Practice Grenade Range/Boundary Canal Unit, which had the most habitat diversity and greatest acreage. Weedy, overgrown, limestone outcrop areas such as the Pine Rockland and Sample Area 7 units hosted thirty species and we counted 469 individuals there. The lowest species count (29) and lower number of individuals

(243) counted was in the SOCSouth Unit, which at that time was still undergoing restoration efforts.

**Table 3.** Butterfly species abundance as observed in the units surveyed on Homestead Air Reserve Base

Common Name	Scientific Name	Pine Rockland/Sample Area 7	SOC-South	Practice Grenade Range/Boundary Canal
Giant swallowtail	<i>Papilio cresphontes</i>	1	-	2
Great southern white	<i>Ascia monuste</i>	2	-	24
Cloudless sulphur	<i>Phoebis sennae</i>	8	7	29
Orange-barrred sulphur	<i>Phoebis philea</i>	1	4	-
Large orange sulphur	<i>Phoebis agarithe</i>	1	4	7
Little yellow	<i>Pyrisitia lisa</i>	2	7	2
Barred yellow	<i>Eurema daira</i>	149	10	487
Dainty sulphur	<i>Nathalis iole</i>	9	2	60
Martial scrub-hair-streak	<i>Strymon martialis</i>	-	-	1
Mallow scrub-hair-streak	<i>Strymon istapa</i>	4	-	2
Fulvous hairstreak	<i>Electrostrymon angelia</i>	-	13	-
Gray hairstreak	<i>Strymon melinus</i>	-	1	-
Cassius blue	<i>Leptotes cassius</i>	1	8	18
Ceraunus blue	<i>Hemiargus ceraunus</i>	25	11	39
Zebra heliconian	<i>Heliconius charithonia</i>	4	6	53
Julia heliconian	<i>Dryas iulia</i>	2	-	7
Gulf fritillary	<i>Agraulis vanillae</i>	101	58	261
Variagated fritillary	<i>Euptoieta claudia</i>	11	18	3
Pearl crescent	<i>Phyciodes tharos</i>	-	3	1
Phaon crescent	<i>Phyciodes phaon</i>	3	1	29
Buckeye species	<i>Junonia sp.</i>	67	32	32
White peacock	<i>Anartia jatrophae</i>	12	7	203
Ruddy daggerwing	<i>Marpesia petreus</i>	-	2	1
Monarch	<i>Danaus plexippus</i>	2	3	18
Queen	<i>Danaus gilippus</i>	6	10	11
Long-tailed skipper	<i>Urbanus proteus</i>	1	6	48
Dorantes longtail	<i>Urbanus dorantes</i>	-	3	20

Tropical checkered-skipper	<i>Pyrgus oileus</i>	-	-	6
Neamathla skipper	<i>Nastra neamathla</i>	-	-	1
Three-spotted skipper	<i>Cybaeus tripunctus</i>	1	1	9
Clouded skipper	<i>Lerema accius</i>	6	-	5
Southern skipperling	<i>Copaeodes minimus</i>	1	-	1
Least skipper	<i>Ancyloxypha numitor</i>	2	-	7
Sachem skipper	<i>Atalopedes campestris</i>	-	4	1
Fiery skipper	<i>Hylephila phyleus</i>	8	1	4
Baracoa skipper	<i>Polites baracoa</i>	32	3	30
Southern broken-dash	<i>Wallengrenia otho</i>	2	2	-
Palmetto skipper	<i>Euphyes arpa</i>	1	-	-
Monk skipper	<i>Asbolis capucinus</i>	4	1	2
Ocola skipper	<i>Panoquina ocola</i>	-	6	-
<b>Total abundance</b>		469	234	1424
Total species		30	29	34

While many land managers must think in big pictures (saving biomes for bears or whales), the micro-scale at which many insects live is something often overlooked: even small tracts of land, if providing necessary elements for survival, may be important for the persistence of rare and endangered endemic taxa<sup>[17,19,20,22,30,49,56,57]</sup>. Fire-driven and fire-adapted pine rockland habitats may contain as many as 536 plant taxa<sup>[37,58,59]</sup> and even small isolated fragments may contain exceeding rare or threatened species<sup>[38,59,60]</sup>. This is true for the HARB pine rockland unit, which contains four Florida state endangered plants, and over fifty native plants. Only nine non-native plants were found in the small pineland, which have since been eradicated.

The hostplants (larval food plants) for all butterfly species observed are found on the base, with the exception of the recorded food for the palmetto skipper, saw palmetto (*Serenoa repens*), (Table 2). It is possible that the palmetto skipper is utilizing the other palm species located on the base, or saw palmetto located in nearby critical butterfly units (Figure 3). A wide variety of nectar sources is also site, providing continuous bloom<sup>[59,60]</sup> appropriate for the adults of all species (generally, small butterflies need small flowers and large butterflies need large flowers). Homestead is also a “low-income” community (per capita income is below \$18K)<sup>[61]</sup>, and there are many ‘less-manicured’ homes in the residential area,

which is beneficial for weedy overgrowth of nectar and host plants in the surrounding matrix. Although the agricultural fields surrounding the base may provide some additional host and nectar sources, pesticide and herbicide use is also frequent<sup>[6,35,50,62]</sup>. Florida has a year-round growing season.

HARB is located on the eastern coast of south Florida, along the “Atlantic Flyway,” where birds, dragonflies and butterflies follow the trade winds to aid in migrating south or north, depending on season, increasing its value as a stop-over site and refugia. One author (SK) witnessed mass migrations of checkered whites (*Pontia protodice*) and great southern whites flying through southern Homestead, ovipositing and mating on the abundant peppergrass (*Lepidium virginicum*) growing along the edges of the agricultural fields, and then saw the farm workers come out soon after to spray pesticide-herbicide to kill any and all butterflies, eggs and larvae. Simply converting to agricultural fields from original habitats is destructive to most butterfly assemblages, especially in tropical and neo-tropical regions<sup>[11,39,56]</sup>. The toxins from these anthropogenic chemicals are detrimental to development and survival of insect pest species in agricultural fields, but also affect non-target butterflies and beneficial insects<sup>[6,31-35,39,62]</sup>.

Of the 40 butterfly species observed, half (50%) are long-distance migratory or at least exhibit a short distance but wide dispersal<sup>[63,64]</sup> (Table 2). Besides the well-known monarchs, great southern and checkered whites, and gulf fritillaries (so named because they migrate across the Gulf of Mexico), also migrate in swarms. Other butterflies migrate, but not long-distance, and some, such as the dainty sulphur, may disperse as far north as New York. Barred yellow, dainty sulphur, great southern whites, gulf fritillaries also exhibit periodic outbreaks or eruptions of large numbers of individuals, often during migratory or dispersal events<sup>[63,64]</sup>.

The giant swallowtails were seen in May, when the citrus trees were in heavy flower and new foliar growth. Three or more broods are known to occur in south Florida, and it is odd that we observed only these three swallowtails and no other swallowtail species. It may be that our surveys missed the main dispersal events for these butterflies.

The relative abundance of fulvous hairstreaks may be attributed to the remaining regrowth of its only host plant, the Brazilian pepper tree, one of the most aggressive non-native species on the base. The tree is ubiquitous throughout South Florida, even in areas that have undergone restoration work. A Caribbean species, fulvous hairstreak was first recorded in Florida in the early

1970's, arriving by unknown means; it is a rare example of a naturalized butterfly species that has benefitted from non-native plants. Invasive plants and animals have been associated with decreases in native species regardless of the ecosystems involved and non-native predators may also influence the survival of adults and offspring<sup>[8,10-17,50,65-67]</sup>.

It is also noteworthy to remember that less-optimal sites may act as “sinks” for some butterfly species, i.e., the primary host plant may not be available, so a female butterfly may choose inferior plants because that is all from which she has to choose at a remaining site<sup>[15,16,28-30,68]</sup>. In this scenario, the offspring may not survive, or may survive but not thrive, on the inferior or alternate host, causing the offspring to develop various inbred genetic faults or weakened immune systems, and/or the surviving adults may not be robust enough to mate and perpetuate the colony<sup>[15,19,27,29,30,68,69]</sup>. Because the butterflies are actually occupying a site is not always an indication that the site is “high-quality habitat”; it may be all that is left for them<sup>[9,11,16,17,30,67,68]</sup>.

For most butterfly species, we do not have the population viability analysis (PVA), which is how to determine if a colony is large enough to prevent collapse through genetic failure or food resource loss<sup>[30]</sup> and can calculate colony persistence for most animals. But what has been fairly well established is that habitat protection is of more importance and more telling for species survival than PVAs, because butterflies do not have the same kind of life history as mammals and avian species<sup>[30,40]</sup>. For example, Longcore and Osbourne<sup>[30]</sup> point out that a “molehill” may indeed be a “mountain” for animals that are the size of a dime or a quarter! Small urban preserves are increasingly valuable for the survival of rare plants and insects<sup>[16,17,30,40,49,66-68]</sup> and the risk of extinction increases with isolation from other sites<sup>[5,12,16,38,66]</sup> as well as connectivity between habitat patches and the surrounding matrix of those patches<sup>[6,16-18,66,70]</sup>.

We were surprised that we did not see the federally endangered Bartram's scrub-hairstreak, or Florida leafwing butterflies on the base, as there are thousands of their sole host plant, pineland croton (*Croton linearis*) on the surveyed sites. One author (SK) spoke to retired HARB military personnel at a butterfly conference in 2015 who mentioned that Bartram's used to be present on the airbase during the 1950's and 60's. Possible reasons for extirpation of the butterflies include the increasing isolation of this site from the other ‘critical butterfly units’ and pine rockland fragments in Homestead and south Miami-Dade County, because of increasing development of the surrounding matrix. In addition, HARB was heavily damaged

in Hurricane Andrew in 1992, and the presence of exotic animals and plants has exploded since then; there has been inconsistent maintenance over the years because of funding cuts and the absence of fire, as well as a number of smaller but damaging hurricanes.

Not all butterfly species are able to adapt to living in urban environments, although a few have managed to carve out a niche in domestic gardens and botanical reserves; the atala butterfly (*Eumaeus atala*), a former denizen of the disappearing pine rocklands, has made itself quite at home in private gardens since the 1980's with human assisted re-location programs<sup>[17,21,66,67,70,71]</sup>. It is unlikely that either Bartram's scrub-hairstreak or the Florida leafwing will take to living in metropolitan backyards, but one can hope that such an event will take place should they be provided with sufficient host plant, landscape architecture, and protection from urban pesticide use. In the meantime, HARB is acting as an important stop-over point and permanent refugia for butterflies and other migratory insects, such as dragonflies.

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### Note on *Junonia* species

We use the new species determination for the tropical buckeye as *Junonia zonalis*, according to genetic analysis of the genus by Lalonde<sup>[72-74]</sup>. In the recent past, Turner and Parnell<sup>[75]</sup> named the tropical buckeye as *Junonia genoveva* and the Mangrove Buckeye as *Junonia evarete*. There were no type specimens from the 1700's, only color illustrations in books published by Cramer<sup>[76]</sup>. Recent observations by Neild<sup>[77]</sup> reversed these names, but most scientists and older field guides stay with the descriptions made by Turner and Parnell<sup>[75]</sup>. Lalonde's seminal genetic work on the buckeye phylogeny is very valuable. It is known that the *Junonia* hybridize in South Florida and possibly elsewhere, complicating identification<sup>[72-74,76,78]</sup>.

### Declarations

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### Conflicts of Interest

The authors proclaim there are no conflicts of interest.

### Availability of Data and Material

All data and material are available via the Homestead Air Reserve Base archives or the Institute for Regional Conservation with Department of Defense release.

### Code Availability

Not applicable.

### Authors' Contributions

CVDH directed the study, SK designed and executed the surveys, CVDH and SK analyzed the data, SK wrote the manuscript and CVDH provided editorial advice.

### Ethics Approval

On behalf of, and having obtained permission from my co-author, I declare that:

(1) the material has not been published in whole or in part elsewhere except as an original biological report to the Homestead Air Reserve Base, Homestead, Florida;

(2) the paper is not currently being considered for publication elsewhere;

(3) both authors have been personally and actively involved in substantive work leading to the report, and will hold themselves jointly and individually responsible for its content;

(4) all relevant ethical safeguards have been met in relation to patient or subject protection, or animal experimentation.

### Consent to Participate

Not applicable.

### Consent for Publication

Permission to publish was granted by Timothy F. Norton, 482d Fighter Wing Public Affairs, Homestead Air Reserve Base, Homestead FL, on 11 Nov 2019. (786) 415-7330

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