MIAMI BLUE BUTTERFLY MANAGEMENT PLAN

Cyclargus thomasi bethunebakeri

Adopted:
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Revised:
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FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION
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EXECUTIVE SUMMARY

The Miami blue is a small blue butterfly endemic to Florida. Primarily a south Florida coastal species, the Miami blue's distribution historically ranged as far north as Hillsborough County on the Gulf Coast and Volusia County on the Atlantic Coast. By the 1980s, the Miami blue was extirpated from mainland Florida and restricted to the Keys. After Hurricane Andrew in 1992, the butterfly was believed to be extirpated, only to be rediscovered in 1999 at a single colony of approximately 50 individuals in Bahia Honda State Park. In 2002, following an emergency petition, the Florida Fish and Wildlife Conservation Commission (FWC) listed the Miami blue as an endangered species. In 2003, the FWC prepared a biological status report that provided justification for the listing, and led to the approval of a Miami blue management plan. This document is a revision of the 2003 plan, updated to include new information and to adjust the conservation goal, objectives, actions, and implementation strategy.

The most exciting new information is that in 2006 the Miami blue was also discovered at the Key West National Wildlife Refuge by the U.S. Fish and Wildlife Service staff and volunteers. This increased the number of known metapopulations to two. Other updated information addresses attempts at captive propagation and reintroduction. In 2003, a captive propagation program was developed by the University of Florida and sponsored by the FWC and U.S. Fish and Wildlife Service. This program has been very successful at captive breeding Miami blues using stock from the Bahia Honda metapopulation. However, attempts at reintroducing captive-bred Miami blues to the wild have not been successful. Determining why reintroduction efforts have not succeeded is a research priority for the near future.

The conservation goal of this revised management plan is to secure multiple viable self-sustaining wild metapopulations of Miami blues throughout all or parts of its historic range so that it no longer requires listing. The conservation objectives for the Miami blue are: 1) maintain the two known existing metapopulations at Bahia Honda State Park and Key West National Wildlife Refuge; 2) establish a network of at least three additional viable self-sustaining metapopulations, with at least 50 adults each, in Monroe and Miami-Dade counties, allowing adequate connectivity for natural gene exchange within ten years; and 3) establish at least ten additional viable self-sustaining metapopulations, with at least 50 adults each, in the remainder of the historic range within 15 years, for a total of at least 15 metapopulations. Priority actions include: maintaining, protecting, and monitoring known populations; maintaining the captive population for reintroduction and research to reduce risk of extinction due to environmental catastrophe; establishing effective reintroduction techniques; identifying and securing sites for reintroduction; and establishing partnerships that lead to funding and logistical support for reintroduction, research, and public outreach to support Miami blue conservation.

MIAMI BLUE MANAGEMENT PLAN REVISION TEAM

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ACKNOWLEDGEMENTS

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Jaret Daniels, Marc Minno, Paula Halupa, and Anne Morkill submitted valuable information, tables and figures, references, and proposed edits to be considered for inclusion in the plan. Mark Salvato (USFWS) also provided written comments. Thanks are extended to the entire roster of participants of the key stakeholder meeting for their generous contribution of time, energy, and ideas for Miami blue conservation. The meeting was held January 21, 2010 in West Palm Beach and, in addition to FWC personnel, included:

Anne Morkill	USFWS, Florida Keys National Wildlife Refuges
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BHSP	Bahia Honda State Park
BNP	Biscayne National Park
CCAAs	Candidate Conservation Agreements with Assurances
DEP	Department of Environmental Protection
ENP	Everglades National Park
EQIP	Environmental Quality Incentives Program
FAC	Florida Administrative Code
FAMU	Florida A&M University
FCCMC	Florida Coordinating Council on Mosquito Control
FDACS	Florida Department of Agriculture and Consumer Services
FIU	Florida International University
FKMCD	Florida Keys Mosquito Control District
FWC	Florida Fish and Wildlife Conservation Commission
HCP	Habitat Conservation Plan
IBWG	Imperiled Butterfly Working Group
IPCC	Intergovernmental Panel on Climate Change
KWNWR	Key West National Wildlife Refuge
LIP	Landowner Incentive Program
NABA	North American Butterfly Association
NPS	National Park Service
PVA	Population Viability Analysis
UF	University of Florida
USCCSP	United States Climate Change Science Program
USFWS	United States Fish and Wildlife Service
WHIP	Wildlife Habitat Incentives Program

GLOSSARY

Area of Occupancy The geographic area inhabited by all individuals in a population. Typically, the amount of habitat in which individuals are known to occur.

Adulticide Pesticide used specifically to kill adult (flying) mosquitoes. Can be applied aerially or from the ground.

Augmentation Moving animals to supplement existing populations.

Extent of Occurrence The geographic area encompassing all locations of individuals of a species, including intervening areas of unoccupied habitat. Synonymous with range.

Extirpated Locally extinct. This refers to a species no longer present in this part of its natural range.

Historic Range The historic extent of occurrence of a species. For the Miami blue, the historic range includes previously occupied habitat from Hillsborough and Volusia counties south through the Florida Keys in Monroe County.

Known Site A location where Miami blues have been verified within the last generation (i.e., one month to one year).

Long-term An extended period of time relative to the life span of individuals in a population. Length is based on commonly used viability procedures and practicality, but is typically at least 100 years.

Metapopulation A collection of local populations connected by occasional dispersal in which there are local extinctions and colonizations. For the purpose of this management plan, a metapopulation is defined as an aggregate of populations separated by barriers such as water, highways, or urban areas with little to no host plants or nectar sources.

Pollard Transect Common method for surveying butterfly species and abundance in which an observer walks an established route (transect) and records all butterflies seen within five meters on each side and in front.

Population Individuals of the same species that occur in a defined area at the same time and regularly interact or interbreed.

Reintroduction	Moving Miami blues to re-establish populations in formerly occupied habitat. This could include both captive-bred stock or those translocated from wild populations.
Translocation	The intentional human-assisted movement of Miami blues from one location to another.
Viable Population	A stable, self-sustaining population with a high probability (e.g., more than 95%) of surviving for a long-term period (e.g., 100 years).

CHAPTER 1: INTRODUCTION

Overview

The Miami blue (*Cyclargus thomasi bethunebakeri*) is a Florida endemic butterfly and one of six subspecies of *Cyclargus thomasi*. These subspecies range from Florida to the Lesser Antilles. The Miami blue was severely reduced in range across the southern mainland of Florida during the 1980s and was restricted to the Keys by the early 1990s. There were no confirmed or published reports of Miami blues after Hurricane Andrew in 1992 (USFWS 2009). Subsequently, a single colony was discovered in 1999 at Bahia Honda State Park (BHSP) and a second colony was found in 2006 at Key West National Wildlife Refuge (KWNWR) (Cannon et al. 2007). A variety of anthropogenic and biological factors have been implicated as potential causes of the butterfly's decline. These include urban development, mosquito control pesticides, high mortality and physical disturbance of host plants, nonnative species, disruption of existing ant-larval associations, along with an assortment of demographic, genetic and environmental influences on the persistence of small, widely separated populations (FWC 2003b, Carroll & Loye 2006, Saarinen & Daniels 2006, Daniels 2009a, USFWS 2009).

A single colony of Miami blue butterflies was discovered in 1999 at Bahia Honda State Park.

In 2006, a second colony was found at Key West National Wildlife Refuge.

On November 15, 2002, Florida Fish and Wildlife Conservation Commission (FWC) staff received an emergency petition (Glassberg 2002) to classify the Miami blue as an Endangered species. On December 10, 2002 the Executive Director issued an Executive Order that listed the Miami blue as an Endangered species in Florida under Rule 68A-27.003 (1) F.A.C. to prevent imminent extinction. The agency's Commissioners approved the emergency listing action and directed staff to undertake a comprehensive assessment of the Miami blue's biological status and to summarize the results in a final biological status report (FWC 2003a). The biological assessment indicated that the Miami blue meets the criteria for listing as an Endangered species (Rule 68A-1.004, F.A.C.). On May 11, 2005, the U.S Fish and Wildlife Service (USFWS) added the Miami blue butterfly to the list of federal candidate species. As of November 9, 2009, the Miami blue had a USFWS Listing Priority Number of 3 due to the overall magnitude of threats (high) and immediacy of threats (imminent) (USFWS 2009).

A variety of anthropogenic and biological factors have been implicated as potential causes of the butterfly's decline, including development, pesticides, and nonnative species.

This management plan is a revision of the 2003 Miami blue butterfly management plan (FWC 2003b) which was a culmination of the species listing process (Rule 68A-27.0012, F.A.C.). It is a comprehensive guide for the management and conservation of the Miami blue.

The management plan includes: 1) a summary of available biological information on the Miami blue, 2) an assessment of the threats responsible for the species' status as an Endangered species, 3) a conservation goal and quantitative objectives, 4) conservation strategies and actions to achieve the goal and objectives, 5) an implementation and monitoring strategy, and 6) anticipated economic, social, and ecological impacts.

Taxonomic Classification

The scientific names applied to the Miami blue have changed over time. The Miami blue in Florida had previously been mistaken for *Hemiargus catalina* (Clench 1941, Calhoun et al. 2002). Comstock and Huntington (1943) described the Florida population of the Miami Blue as *Hemiargus ammon bethunebakeri*. The FWC and the USFWS both were petitioned by the North American Butterfly Association (NABA) to list the Miami blue subspecies as Endangered under the scientific name *Hemiargus thomasi bethunebakeri* (Glassberg 2002). However, subsequent to its emergency listing in December 2002 by the FWC, three independent taxonomists contracted by the USFWS have verified the species at BHSP as belonging to the genus *Cyclargus* (Calhoun 2003, FWC 2003b, Miller 2003, Opler 2003). Current literature as well as recent genetic studies all now confirm that the Miami blue butterflies found at both BHSP and KWNWR are *Cyclargus thomasi bethunebakeri* (Pelham 2008, Saarinen and Daniels 2006, Saarinen 2009, Saarinen et al. 2009).

Life History and Habitat

The Miami blue is a small blue butterfly with a forewing length of 10-13 mm. Males and females are both bright blue dorsally, but females have an orange eyespot near the hindwing outer angle. Saarinen (2009) found a significant difference in wing chord length between males and females. Adult males are smaller than females and their coloration is also different. Males are bright blue dorsally with a narrow black margin. Females have reduced blue scaling with broader dark margins and an orange-capped black eyespot near the hindwing outer angle. Both sexes have a tawny gray underside with four black spots on the basal and postbasal areas and a bright orange spot on the hindwing (Gerberg and Arnett 1989; Minno and Emmel 1993, 1994; Glassberg et al. 2000; see Figure 1). The Miami blue is easily confused with other small blue butterflies that are more common—the ceraunus blue *Hemiargus ceraunus*; cassius blue *Leptotes cassius*; and nickerbean blue *Cyclargus ammon ammon* (Glassberg et al. 2000).

The Miami blue is easily confused with other small blue butterflies that are more common.

a.  b.  c. 

Figure 1. Photos of Miami blue butterfly, *Cyclargus thomasi bethunebakeri*. a. male; b female; c underside. Photo credits: a and b: Michelle Wisnieski; c: Jaret C. Daniels, Ph.D., University of Florida.

The blue-white eggs are laid on flowers, flower buds, and terminal growth of the host plants. The larvae have a sluglike shape and are primarily green with a black head capsule, a red-brown mid-dorsal line and white lateral lines. However, multiple color forms exist (Daniels, unpublished). The larvae have a facultative symbiotic relationship with a number of ant taxa (Saarinen & Daniels 2006). Specifically, seventeen ant species have been recorded tending Miami blue larvae either in wild populations, in reintroduction sites following releases of captive raised larvae, or in the laboratory. Furthermore, no ant species has been observed to regularly attack Miami blue larvae or to ignore their presence. These results are notable for the large number of potential ant partners, the consistency of behaviors toward larvae among distantly related ant taxa, and the nearly complete lack of obviously antagonistic interactions (Trager and Daniels 2009). Despite the high diversity of potential ant partners, regular field observations suggest that only a small subset of ant species accounts for the vast majority of interactions with Miami blue butterfly larvae, specifically *Camponotus floridanus* and *Camponotus planatus* (Trager and Daniels 2009). Although protection from predators and parasitoids is thought to be the primary benefit of ant tending, ants may also influence larval growth in the absence of these natural enemies.

The pupae are dark brown to black and attached to a substrate with a silken button and silken girdle. The mean development time from egg to adult is approximately 30 days under laboratory conditions (J. Daniels unpublished). The average survival rate of adult Miami blues is less than 5 days in the wild (Emmel and Daniels 2006). Captive adults, particularly females, can survive longer (J. Daniels pers. comm.). Individuals appear to be very sedentary within the colony sites. The longest recorded movement was approximately 25 feet by one individual (Emmel and Daniels 2003b). The Miami blue occurs at the edges of tropical hardwood hammocks, beachside scrub, and occasionally on pine rocklands (Minno and Emmel 1993, Smith et al. 1994, Glassberg et al. 2000).

Individuals appear to be very sedentary. The longest recorded movement was approximately 25 feet.

The primary larval host plants include the nonnative balloonvine (*Cardiospermum halicacabum*), gray nickerbean (*Caesalpinia bonduc*), a nonnative nickerbean (*C. pulcherrima*), and blackbeads (*Pithecellobium* spp.) (Smith et al. 1994, Calhoun et al. 2002). Other tropical trees and shrubs also are occasionally used as host plants (Klots 1964, Howe 1975). Rutkowski (1971) observed egg-laying on snowberry (*Chiococca alba*). The Bahia Honda population currently utilizes gray nickerbean while the populations located in KWNWR feed on Florida Keys blackbead (*Pithecellobium keyense*) (Ruffin and Glassberg 2000; Emmel and Daniels 2002a, b; Cannon et al. 2007; Daniels 2008).

Primary host plants for larvae include gray nickerbean, a nonnative nickerbean, nonnative balloonvine, and blackbeads.

Adults are reported to feed on a variety of flowering plants including Spanish needles (*Bidens pilosa = alba* var. *radiata*), cat tongue (*Melanthera nive*a), scorpiontail (*Heliotropium angiospermum*), and gray nickerbean. Other flowering plants that are used include coastal searocket (*Cakile lanceolata*), blacktorch (*Erithalis fructicosa*), wild sage (*Lantana involucrata*), and fogfruit (*Phyla nodiflora*) (Gerberg and Arnett 1989, Minno and Emmel 1994, Cannon et al. 2007, Daniels 2008).

Since the Miami blue has poor dispersal capabilities (Emmel and Daniels 2003b), it is important that nectar sources occur near host plants. Adult Miami blues are found in all months of the year. Peak abundance is between June and September on Bahia Honda and generally between November and March in KWNWR (Emmel and Daniels 2002a, b; Cannon et al. 2007; Daniels 2008).

Distribution and Population Status

Five subspecies of *Cyclargus thomasi* are found in the Bahamas and the Greater and Lesser Antilles (Smith et al. 1994). The sixth subspecies, the Miami blue, *C. t. bethunebakeri*, has been recorded in the Bimini Islands, Bahamas (Smith et al. 1994) but is generally reported to be endemic to Florida (Calhoun et al. 2002). The historical range of the Miami blue is not completely known. Klots (1964), Kimball (1965), and Howe (1975) generally agree that the historic range of the Miami blue occurred in the southern half of Florida. However, the range map in Opler's (1992) account has the species' distribution into north Florida. With the exception of the latter account, most of the literature describes the Miami blue as a coastal species whose historical distribution ranged as far north as Hillsborough County on the Gulf Coast and Volusia County on the Atlantic Coast and extended south to the Florida Keys and the Dry Tortugas (Klots 1964, Howe 1975, Calhoun et al. 2002) (Figure 2). Collection records indicate the butterfly was most abundant on the extreme southeastern mainland and Upper Florida Keys (primarily Key Largo), becoming increasingly rare at the periphery of its range (Carroll and Loye 2006); however, preference for certain south Florida sites among collectors has likely biased this trend. Small colonies also reportedly occurred on Marco Island, Sanibel Island, and Chokoloskee on the southwest coast (Minno and Emmel 1993, Glassberg et al. 2000, Calhoun et al. 2002).

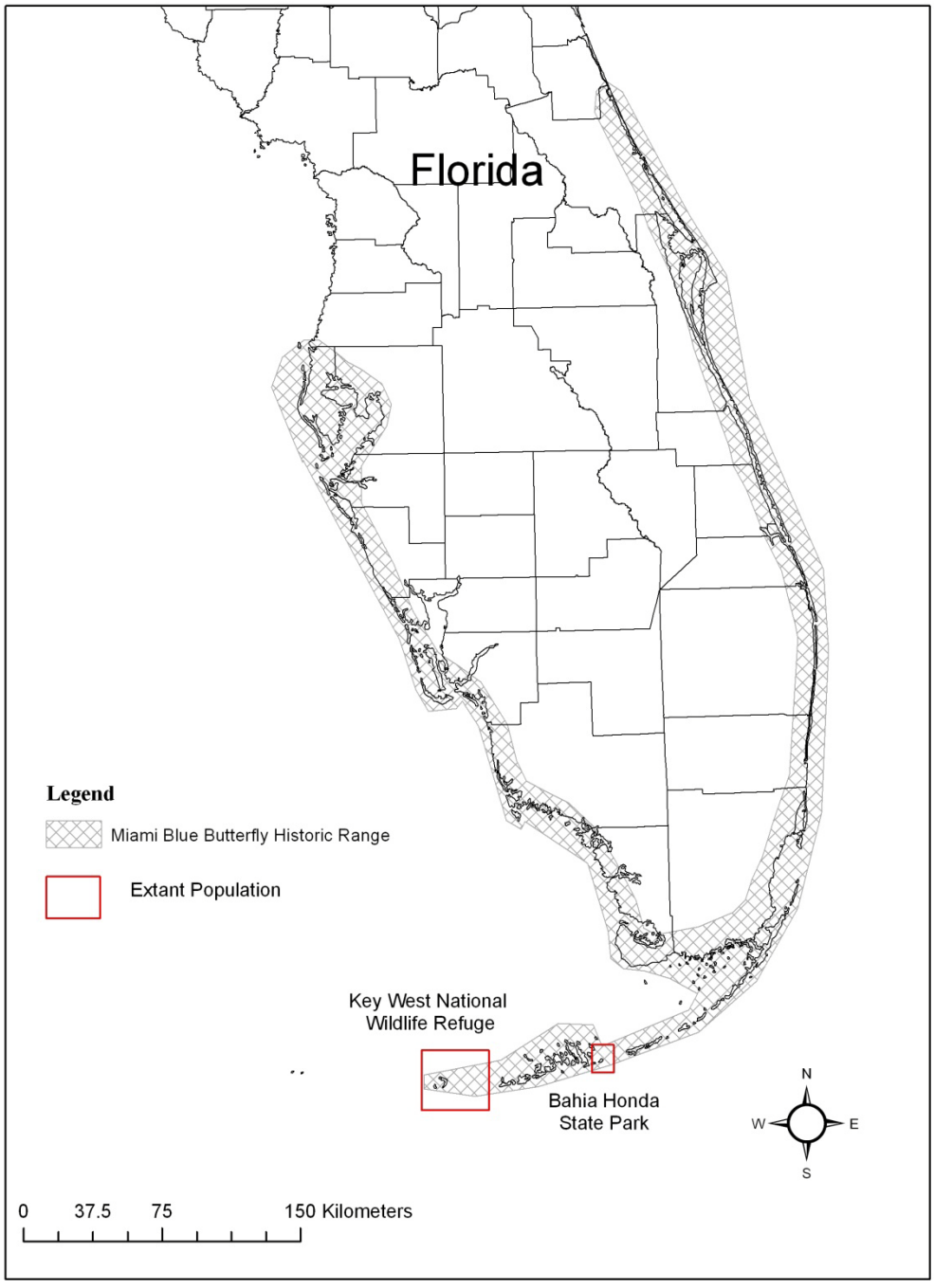

Figure 2. Historic Range and Extant Population of the Miami blue butterfly in Florida

Distribution and abundance have been significantly reduced over the last three decades. By the early 1990s, the Miami blue was presumed extirpated.

The overall distribution and numerical abundance of the butterfly have been significantly reduced over the last three decades, and by the early 1990s the Miami blue was presumed extirpated. The last confirmed report was on Big Pine Key on March 1992 (Glassberg et al. 2000, Calhoun et al. 2002). From 1992-1999, numerous surveys for the Miami blue at historical locations as well as within other suitable habitat were conducted by qualified individuals and biologists, but no Miami blues were sighted (Calhoun et al. 2002, Edwards and Glassberg 2002, Glassberg 2002). The butterfly was finally observed on November 1999 at Bahia Honda State Park in the Florida Keys (Ruffin and Glassberg 2000). Subsequent visits after 2000 have found the Bahia Honda State Park metapopulation to generally range between 50 and 150 individuals (Calhoun et al. 2002, Emmel and Daniels 2007). The numbers were severely impacted by the hurricanes of the 2005-2006 seasons (Emmel and Daniels 2007; Salvato and Salvato 2007; Daniels 2009a, b). In 2007, numbers rebounded in late June but peak numbers remained below those found prior to the 2005 hurricane season. Similar depressed numbers were found in 2008. Such low numbers were likely the result of both a severe drought and recent impacts to the nickerbean host plant from green iguanas (*Iguana iguana*) feeding on the terminal nickerbean growth. Survey results for the south-end colony site of Bahia Honda from 2002-2009 are presented in Figure 3.

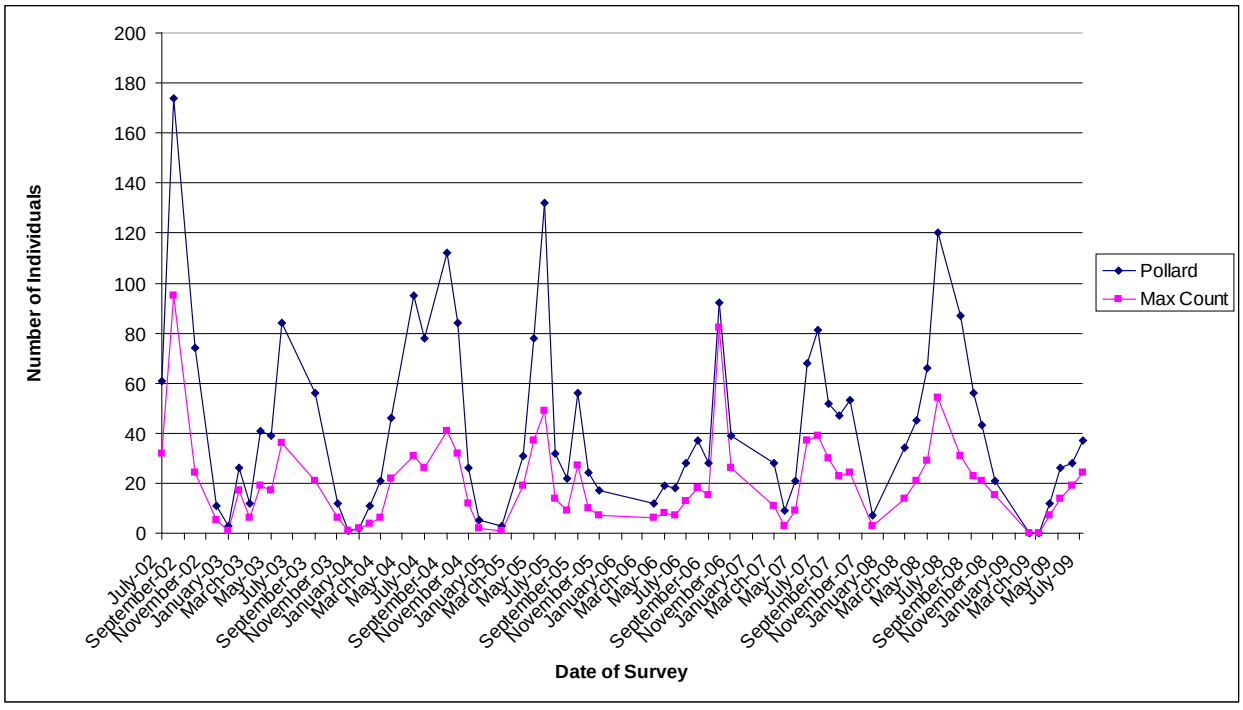

Figure 3. Total number of adult Miami blue butterflies observed using pooled Pollard transect and max counts in the south-end colony site of Bahia Honda State Park, Monroe County, Florida from July 2002 to July 2009 (J. Daniels unpublished). The pooled Pollard counts represent the sum of counts from three consecutive days; the max counts are the highest daily count for a given set of surveys.

Extensive surveys for the Miami blue have been conducted between 1990 and 2007 at no fewer than 40 locations in mainland Florida and the Keys. These surveys, conducted by multiple qualified individuals, failed to detect other metapopulations of this butterfly (Daniels 2009b; Edwards and Glassberg 2002; Emmel and Daniels 2002a, b; Minno and Minno 2009). An unconfirmed report of ten adult individuals on Sugarloaf Key in the Florida Keys in 2002 was investigated but yielded no butterflies during five separate surveys later that year (Emmel and Daniels 2002b). In 2006, additional populations were discovered within the Key West National Wildlife Refuge by refuge staff and volunteers (Cannon et al. 2007). These populations occurred on Boca Grande and the islands of the Marquesas. Follow-up surveys in 2007 recorded Miami blues occurring on multiple islands in KWNWR. Recent surveys by the University of Florida (UF) and the FWC have found a maximum of 25 individuals on any one visit. No adults have been recorded on Boca Grande since 2008 (Daniels 2008, T. Wilmers pers. comm.). The current distribution of known metapopulations is shown in Figure 2.

Historic and Ongoing Conservation Efforts

Several conservation efforts were initiated by the FWC, the USFWS, and other entities prior to the Miami blue butterfly being listed as an Endangered species in Florida. The 2003 Miami blue butterfly management plan (FWC 2003b) outlined conservation strategies necessary to meet the conservation goal and objectives. Several of these strategies have been met, with others still ongoing. The FWC, USFWS, UF, Florida Department of Agriculture and Consumer Services (FDACS), Department of Environmental Protection (DEP), the North American Butterfly Association (NABA), the National Park Service (NPS), Florida Keys Mosquito Control District (FKMCD), and Florida A&M University (FAMU) have all contributed funds, staff, and/or resources towards the conservation of the Miami blue.

Survey and Monitoring

In June 2002, UF conducted a one-year status monitoring study of the Miami blue throughout its historic range and conducted a mark-recapture study on the Bahia Honda population. The University of Florida continued to monitor the BHSP metapopulation regularly from 2002 through the 2009 field season. Surveys at KWNWR were initially conducted by refuge staff and volunteers during 2006-2007 (Cannon et al. 2007). Subsequently, UF researchers with assistance from FWC and refuge staff continued regular surveys through April 2010 (Daniels 2008, J. Daniels pers. comm.). In addition, NABA members have conducted numerous counts throughout the Keys to determine butterfly status and distribution (M. Salvato pers. comm.). Likewise, Minno and Minno (2009) conducted butterfly surveys in the Florida Keys and southern Florida from August 2006 through June 2009 but did not find any other metapopulations of Miami blues besides those at BHSP and KWNWR.

In 2003, the FWC authorized University of Florida to initiate a Miami blue captive breeding program and to draft a reintroduction plan.

Captive Propagation and Reintroduction

In 2003, the FWC authorized UF to initiate a Miami blue captive breeding program in Gainesville, Florida and to draft a reintroduction plan (Emmel and Daniels 2003a). A total of 100 eggs was collected from ten randomly captured female Miami blues originating at a combination of seven colony sites within Bahia Honda State Park over a four-month period from February to May 2003. The resulting 100 eggs were used as the foundation for building the captive colony at the University of Florida. To avoid inbreeding, a rigorous breeding protocol was established along with the regular addition of butterflies from BHSP. The captive population has been extremely successful since its inception, yielding over 23,000 captive bred organisms for research, colony maintenance, and reintroduction (J. Daniels pers. comm.). Butterfly reintroductions were initiated in April 2004 and continued through the 2009 field season. Reintroductions have taken place at Everglades National Park, Biscayne National Park, and Dagney Johnson Key Largo Hammocks State Park. Since 2004, approximately 7,140 organisms have been released (J. Daniels pers. comm.). Unfortunately, work still needs to continue to determine why the reintroductions have not taken hold. Miami blue larvae and adults released at these sites have failed to reproduce and persist over time.

Research

Multiple research projects have been conducted by several agencies and universities in Florida. The University of Florida conducted research on the genetic diversity of wild and captive populations in order to maximize the genetic diversity of the species and for directing pairings of butterflies in captivity. Genetic microsatellite markers were developed, and are used in combination with non-invasive wing fragment sampling to monitor the diversity of the captive and wild populations over time (Saarinen and Daniels 2006, Saarinen 2009).

Florida A&M University conducted research to examine the effects of aerially applied mosquito control pesticides on the Miami blue (Zhong et al. 2009). Mortality of Miami blues was significantly different between treated areas and drift zones. Currently, Mote Marine Laboratory and Florida International University are looking at the effects of ground-based applications of pesticides on non-target species and imperiled species of butterflies at Big Pine Key, Florida. The United States Geological Survey is also currently researching cholinesterase inhibition in butterflies following aerial applications of mosquito control pesticides.

Research has also been conducted by the University of Florida to identify the different taxa of ants that tend Miami blue larvae at BHSP and KWNWR, as well as to examine the mutualistic interactions between them (Saarinen and Daniels 2006, Trager and Daniels 2009). The University of Florida, through mark-recapture studies in the field and captive rearing in the lab, has found the Miami blue to have a very short life-span and to have very poor dispersal abilities (Emmel and Daniels 2003b, Emmel and Daniels 2006).

Public Awareness and Outreach

The Miami Blue Butterfly Work Group was formed in 2004 to coordinate conservation efforts, exchange information, and address concerns that arose during the recovery of the Miami blue. The Work Group was composed of federal, state, and local governments, nongovernmental organizations (such as NABA) and multiple mosquito control organizations from south Florida. The Work Group later morphed and expanded into two separate entities, the Imperiled Butterflies of Florida Workgroup (IBWG) and the Florida Coordinating Council for Mosquito Control's (FCCMC) Imperiled Species Subcommittee. The IBWG was formed after the recognition that several other species of butterflies were in decline, primarily in south Florida. Lessons learned in conserving the Miami blue could be applied proactively to other declining species, thus preventing the need for future listing by state or federal government. The IBWG, with cooperation from the FWC and other agencies, is also working with land management agencies to train staff, volunteers, and contractors on the life history of the Miami blue and the proper management of Miami blue host plants and nectar sources. The Imperiled Species Subcommittee was initially formed to resolve the conflict between mosquito control spraying and the recovery and reintroduction of Miami blues to their historic range. The Imperiled Species Subcommittee has now expanded to include any imperiled species in Florida that are potentially impacted by mosquito spraying operations.

Other public awareness and outreach efforts include a natural history and identification brochure produced by UF, entitled, "The Miami Blue Butterfly of Bahia Honda State Park." Bahia Honda State Park also created an educational kiosk describing butterflies found at the park. Several articles regarding Miami blue conservation efforts have been written in popular magazines such as *Florida Wildlife* and *National Wildlife.*

Stakeholder Input

FWC staff solicited input from the general public and from key stakeholders at several stages while drafting the current document. There were two advertised public comment periods (December 18, 2009 to February 2, 2010 and March 12 to April 26, 2010) when interested parties were invited to submit comments to a project-specific e-mail address. The FWC hosted a key stakeholder meeting on January 21, 2010, at its South Regional Office in West Palm Beach. In addition to FWC staff, participants at the meeting included representatives of the Florida Department of Environmental Protection, the Florida Keys Mosquito Control District, the University of Florida, the U.S. Fish and Wildlife Service, the National Park Service, and the North American Butterfly Association.

Stakeholders provided comments and valuable information both at the January 2010 meeting and later, throughout the finalization of the revised management plan. In addition to stakeholder input, general comments submitted by the public covered the following issues:

- General support for Miami blue butterfly conservation
- Support for reintroduction, including a pledge for partnership

- Support for Miami blue habitat protection, restoration, and the use of habitat corridors
- Support for iguana eradication
- An offer to sell land for conservation
- Concern about restrictions to collecting non-imperiled insects
- Opposition to funding captive propagation
- Opposition to using Miami blues for pesticide experiments

All comments received were reviewed by staff and considered for addressing in the revised plan, and all those who submitted comments were thanked for their interest.

CHAPTER 2: THREAT ASSESSMENT

Reasons for Listing (2003)

In 2003, the Miami blue met three of the five criteria for listing as an Endangered species under Rule 68A-1.004, F.A.C. (FWC 2003a, b). As stated in the final biological status report (FWC 2003a), the primary reasons for listing this species as Endangered were:

Population Reduction

A range-wide population reduction of > 80% during the previous ten years was suspected based on a > 99% decline in area of occupancy from 1992 to 2002.

Extent of Occurrence, Area of Occupancy

The Miami blue's extent of occurrence was not completely known. It potentially occurred throughout the Florida Keys over an area of approximately 158 square miles. However, the documented extent of occurrence equaled the area of occupancy, which was less than one square mile. Thus the Miami blue's documented extent of occurrence was less than 40 square miles and its area of occupancy was less than 4 square miles. Additionally, the species was found in only one location and had undergone a suspected 99% decline in area occupied.

Population Size and Trend

The number of mature individuals was far less than 250 individuals and all individuals were contained within a single subpopulation.

Reasons for Maintaining Listing (2010)

In 2010, data available on the range-wide Miami blue population since the initial status review were evaluated relative to each of the five criteria for state listing under Rule 68A-1.004 F.A.C. In order to qualify for state listing as either Endangered, Threatened, or Species of Special Concern, the Miami blue must meet at least one of the five criteria for one of the categories. The Miami blue butterfly population at Bahia Honda State Park fluctuated seasonally but overall remained small but stable during the period between 2002 and 2009 (Fig. 2), and a new metapopulation was discovered in the Key West National Wildlife Refuge (Cannon et al. 2007). While a formal status review was not conducted, the total number of adults at both metapopulations combined is still below the threshold of 250 individuals, so the Miami blue still qualifies as an Endangered species.

Present Threats

Four threats are suspected in the range-wide population decline of the Miami blue. Although specific data demonstrating cause and effect of these threats upon Miami blue populations are limited, they have been proposed by one or more researchers or have been suspected in the decline of species living in similar habitats:

1. Habitat Loss and Degradation

Much of the remaining Miami blue habitat along Florida's coastlines is subject to intense development pressure and urbanization or has already been developed. The resident Florida human population in 1980 was estimated at 9.9 million and grew to 15.2 million by 2000 (U.S. Census Bureau 2003). By 2060, Florida's population is projected to more than double in size (Zwick and Carr 2006).

Climate change is also a major threat to south Florida, resulting in sea level rise and possible destruction of Miami blue habitat. Webster et al. (2005) found the number of Category 4 and 5 hurricanes to have doubled in the last 30 years, possibly due to global climate change.

2. Habitat Fragmentation and Group Isolation

Imperiled species are faced with an assortment of demographic, genetic, and environmental influences that challenge the persistence of small, widely separated populations. Remaining Miami blue habitat is extremely fragmented by highways, cities, and unsuitable habitat. Isolation as a result of habitat fragmentation lowers the probability of recolonization in species with limited dispersal abilities (Cushman and Murphy 1993). Isolation may severely limit gene flow and increase the probability of inbreeding, leading to decreased genetic diversity over time. Genetic diversity is essential to species conservation (Frankham 1996). As habitat fragmentation expands and populations become smaller and more isolated, genetic diversity tends to erode. The corresponding loss of genetic diversity reduces future evolutionary potential and brings about a decline in individual fitness, both of which can increase the risk of extinction among populations and species (Saccheri et al. 1998, Reed and Frankham 2003).

The small size of remaining populations of Miami blues makes them highly susceptible to demographic and environmental impacts.

The small size of remaining populations of Miami blues makes them susceptible to demographic and environmental impacts, long before genetic influences are felt. Extinction risks include natural occurrences such as drought and large-scale disasters such as tropical cyclones and catastrophic wildfires. These incidents may completely eliminate small or isolated Miami blue populations, their host plants, and their nectar sources (Calhoun et al. 2002; Emmel and Daniels 2002a, b).

3. Mortality

Spraying of insecticides to control adult mosquito populations may be a mortality factor for Miami blue larvae and adults (Eliazar and Emmel 1991, Hennessey et al. 1992, Salvato 1999). Experimental exposure of Miami blue larvae to aerial spray of mosquito control pesticides resulted in reduced survival (Zhong et al. 2009). Improper application of herbicides may cause direct harm to butterflies or reduce their host plants and nectar sources (Russell and Schultz 2010).

However, it should be noted that Miami blues have disappeared from large conservation lands that are not subject to pesticide application, including Everglades and Biscayne national parks, so some other mortality factor or factors seem to be indicated. Moths and butterflies may be subject to a variety of mortality factors, including pathogens, parasites, parasitoids, and predators; perhaps the latter may be implicated in the Miami blue's decline (Minno and Minno 2009).

Butterfly collecting, though generally not detrimental to butterfly populations, may stress small local populations and lead to the loss of individuals and genetic variability (Pyle 1976; Emmel 1995a, b; USFWS 1998; Alexander 2003). There is no evidence or information on current or past collection pressure on Miami blues, and such may be unlikely (J. Daniels pers. comm.).

4. Invasives

Invasive exotic species can alter the population dynamics of native species in a number of ways, most notably through competitive exclusion, niche displacement, or predation (Keeler et al. 2006, Mooney and Cleland 2001). Additionally, habitat disturbance and herbicide application for control and management of invasives may negatively impact butterfly populations (Russell and Schultz 2010). Similarly, exotic insect predators or parasitoids can dramatically impact native insect populations causing severe declines (Boettner et al. 2000, Benson et al. 2003). Red imported fire ants and Mexican twig ants may negatively impact the *Camponotus* ants that occasionally tend Miami blue larvae and offer them some degree of protection from predators and parasitoids. Fire ants and other nonnative predatory ants also may feed upon Miami blue eggs and larvae (Emmel and Daniels 2003b, Saarinen and Daniels 2006). Nonnative green iguanas (*Iguana iguana*) pose a threat because they feed on the Miami blue's host plants (and inadvertently on Miami blue eggs and larvae), most notably in Bahia Honda State Park. The nickerbean stands have received significant damage which has prompted the park to move forward with eradication efforts to remove the iguanas. Additional surveys and research are needed to better determine potential impact of invasive species on existing populations of the Miami blue butterfly.

Nonnative green iguanas pose a threat because they feed on the Miami blue's host plants (and inadvertently on Miami blue eggs and larvae).

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CHAPTER 3: CONSERVATION GOAL AND OBJECTIVES

The intent of this plan is to set a scientifically defensible, reasonable, and explicit conservation goal and objectives for the Miami blue. The conservation goal provides broad direction for management of the species, while the conservation objectives establish numerical benchmarks by which success in achieving that goal can be measured. The goal and objectives have been developed based on the species' current population status, reasons for listing, and underlying threats to the species' continued survival.

Conservation Goal:
To secure multiple viable self-sustaining wild metapopulations of Miami blues throughout its historic range so that it no longer requires listing.

Miami Blue Conservation Goal

The conservation goal is to secure multiple viable self-sustaining wild metapopulations of Miami blues throughout all or parts of its historic range so that it no longer requires listing.

Attainment of this goal would result in removing the Miami blue from Florida's list of Threatened and Endangered species.

Miami Blue Conservation Objectives

1) Maintain the two known existing metapopulations at Bahia Honda State Park and Key West National Wildlife Refuge

2) Establish a network of at least three additional viable self-sustaining metapopulations, with at least 50 adults each, in Monroe and Miami-Dade counties, allowing adequate connectivity for natural gene exchange, within 10 years

3) Establish at least 10 additional viable self-sustaining metapopulations, with at least 50 adults each, in the remainder of the historic range within 15 years, for a total of at least 15 metapopulations.

Attainment of these objectives would constitute a seven-fold increase in the current number of metapopulations (from 2 to at least 15), increasing connectivity and ultimately their long-term resilience and viability. Establishment of additional metapopulations will increase the Miami blue's range, extent of occurrence, and area of occupancy.

The proposed minimum size of "at least 50 adults" to define a viable, self-sustaining population is based partly on the work of Shaffer (1981), who "obtained number in the range of 50" as a minimum viable population or, in other words, the number needed to prevent population collapse. It is also based partly on the observed seasonal fluctuations for part of the Bahia Honda metapopulation (J. Daniels unpublished, Figure 3), although more data from additional

metapopulations are needed. It should be emphasized that although Figure 3 seems to indicate a metapopulation that periodically approaches zero, Bahia Honda nevertheless has thus far remained a self-sustaining population.

CHAPTER 4: RECOMMENDED CONSERVATION ACTIONS

Conservation Strategies and Actions to Achieve the Conservation Objectives

Strategy: Implement actions to maintain, protect, and monitor known metapopulations

Conservation Action 1. Maintain and Protect the Known Metapopulations of Miami Blues

a. Protect, restore, and enhance suitable habitat

Invasive vegetation should be removed and the natural establishment of host plants and nectar sources encouraged. The growth of host plants in close proximity to nectar sources should be encouraged wherever possible. Ongoing efforts to eradicate or reduce green iguanas should be continued at sites supporting Miami blues to limit the impact of these nonnative herbivores on Miami blue host plants and nectar plants.

b. Eliminate or minimize pesticide spraying at or around Miami blue populations

No-spray zones for all pesticides should be established around populations of Miami blues. Particularly, the use of mosquito adulticides should be eliminated or conducted in such a manner that it does not negatively impact Miami blue populations. It has been recommended that aerial no-spray buffer zones at least 750 m in width should be established where possible around Miami blue populations to minimize the probability of accidental pesticide drift into the path of Miami blues and other non-target species (Hennessey et al. 1992). Similarly, buffer zones should be established for truck-based applications of adulticides, given the propensity for drift and the persistence of adulticides on foliage for more than 2 weeks (Pierce 2008). Following a review of Zhong et al. (2009), the FCCMC (2010) recommended that the appropriate width of mosquito spray buffer zones for Miami blue populations be determined by further research. Proactive and lower-impact methods of mosquito control should continue to be employed, including source reduction, biological control agents, and suspending or reducing spraying during the breeding seasons of non-target species (Emmel 1991).

Conservation Action 2. Monitor Known Populations

a. Implement appropriate monitoring protocol and survey methods

Two variables should be monitored and assessed to detect change in range-wide Miami blue population status. The primary variable for assessing population status is the number of individuals at all existing populations. The secondary variable for assessing population status is the number of known sites.

Standardized, repeatable survey methods are important for allowing comparisons of population estimation through time for the same site, and for comparisons of survey data for different sites. Three different types of surveys are used with butterflies to determine

presence and assess changes in abundance, evaluate effectiveness of management actions, and determine distribution and dispersal patterns. Meandering surveys or timed area searches involve observers walking in a meandering pattern looking forward, to the sides, and behind them and recording all butterflies of the species of interest (Hyde et al. 2001). Pollard transects require observers to walk established transects and record all butterflies within five meters of the transect on each side and in front of the observer (Pollard 1977). Mark-recapture surveys require the observer to capture the butterfly with a net and mark the butterfly on the outer hind wing with a fine non-toxic permanent marker to allow identification if recaptured (J. Daniels pers. comm.).

It should be emphasized that the less invasive transect and meandering surveys are recommended for endangered species or species in decline (Opler 1995). However, dispersal and mobility studies require mark-recapture surveys (Knutson et al. 1999). It is recommended that only highly experienced researchers use the mark-recapture technique on Miami blues.

The most commonly used survey method for Miami blues is the Pollard method (Pollard 1977). This method of transect monitoring uses a fixed-rate walk which is uniform with respect to area covered and time spent. The fixed nature of the transects allows for concurrent monitoring of other natural resources such as the plant communities or other species occurrence. Typically, all butterfly species seen within an estimated five meters on either side of the transect, within five meters above the ground and within five meters in front are recorded. The observer records what they see while walking and does not attempt to follow or track down unidentified species. The Pollard method allows the recorder to make field observations that will also provide valuable information on the life history of these species such as host plant use, adult nectar source use, natural mortality factors, territoriality, courtship, mating and oviposition behavior, specific habitat requirements, and specific threats to the species' survival.

Ideally, transects are visited once a month during hours when there is the most sunlight and less than 50% cloud cover (conditions most suitable for butterfly activity). This is typically between the hours of 10 am and 4 pm, although the butterflies may avoid the heat of the day (between noon to 2 pm). Annual Miami blue activity peaks in the summer at Bahia Honda (J. Daniels unpubl. data, Figure 3), but may peak during the winter months at KWNWR (Cannon et al. 2007). The goal of monthly monitoring is quite feasible at BHSP, which is accessible by car from US 1. Regular monthly monitoring at KWNWR is more problematic and uncertain because access is by boat and thereby dependent on the vagaries of weather, tides, and scheduling issues.

b. Develop a comprehensive database to accommodate all monitoring data and to track the status and trends of individual metapopulations

A comprehensive database is necessary to provide a centralized, accessible means for documenting population changes in extant sites, reintroduction sites, and in the species' range-wide status. Additionally, the database will help track conservation actions and facilitate implementation of the management plan. The database should include basic

information on population size, sampling history, voucher specimens, location, ownership, habitat type and condition, and management.

Conservation Action 3. Maintain Legal Protections for Miami Blues

a. Maintain current regulations

In 2003, FWC adopted two rules protecting Miami blues. One listed the Miami blue as an Endangered species. The other rule prohibited the take, harassment, possession, sale, or transport of Miami blues except under permit.

Two rules that directly protect Miami blues were adopted by the FWC in December 2003. The first rule listed the Miami blue as an Endangered species. The second rule prohibited the take, harassment, possession, sale, or transport of Miami blues, or parts thereof, or their eggs, larvae, or pupae except as authorized by permit from the Executive Director, with such permits only being issued for activities that further the goals and objectives of the species' management plan. These rules continue to provide important legal protection to the Miami blue. It is recommended that they be maintained in effect. No other regulations are proposed at this time.

In addition to FWC rules, the Miami blue is protected from unauthorized collection at Bahia Honda State Park by DEP. A permit from the National Park Service (NPS) or USFWS is required for scientific research and/or collection in national parks or national wildlife refuges (USFWS 2009). However, there is potential for unauthorized or illegal collection and take of Miami blues on BHSP and KWNWR. The U.S. Fish and Wildlife Service (2009) continues to consider the Miami blue a candidate species for federal listing, but emphasizes that "…the protection currently afforded the Miami blue butterfly is limited. Although take of individuals is prohibited, there is no substantive protection of Miami blue habitat or protection of potentially suitable habitat."

b. Maintain FWC permitting framework

A permit is required by the FWC for any activity that is expected to result in the take of Miami blues on private or public property. A Scientific Collecting Permit is issued by the FWC for research purposes where the proposed activity will result in a net benefit to the Miami blue butterfly. An Incidental Take Permit is required for activities that cause the take of Miami blues or its habitat. These permits are only issued if the take is compensated with action that clearly enhances the survival of the species. In practice, because Miami blues are currently known to exist only on public lands (Bahia Honda State Park and Key West National Wildlife Refuge), the ongoing habitat management activities on those lands are recognized as generally compatible with Miami blue conservation.

Conservation Action 4. Foster Public Support for Miami Blue Conservation

a. Educate the public, land managers, and others about Miami blues

Unless this would increase the risk of illegal collection or intrusion, placing informational signs near accessible Miami blue populations provides the public with the special opportunity to see and learn about an imperiled species in close quarters. An example is the educational kiosk on the Miami blue at BHSP. Interpretive tours could also be conducted at such sites, as long as they don't disturb the normal behavior of the butterflies. As with the BHSP brochure on Miami blues, printed information on the natural history, status, and conservation needs of the butterfly could be developed and disseminated to landowners and visitors on-site, to conservation organizations, and to the media. In all such materials, key messages should include information on the Miami blue's specific host plants and habitat needs, the importance of conservation refuges and corridors, and actions that can be taken to help ensure the survival of imperiled species.

b. Continue using the Imperiled Butterflies of Florida Workgroup to exchange information between and among agencies, managers, biologists, mosquito control districts, and private landowners

The IBWG is an important medium for exchange of ideas related to Miami blues and other imperiled butterflies. This group should continue to meet at least once a year to discuss management achievements and failures, new techniques, translocation progress, regulatory issues, and other topics as deemed necessary. This stakeholder meeting approach has proven to be successful with other endangered members of the butterfly family that includes the Miami blue (Sferra and Ewert 1994).

c. Continue to discuss mosquito-control related issues through the Imperiled Species Subcommittee of the Florida Coordinating Council on Mosquito Control

This subcommittee, composed of several governmental and nongovernmental organizations, is the appropriate forum to discuss completed, ongoing, and proposed research involving Miami blues (and other imperiled wildlife) and mosquito control pesticides. It is critical to involve this group in consideration of non-target spray drift and appropriate buffer zones for aerial and ground pesticide application.

As a tangible example of the results of this collaboration, the Florida Coordinating Council on Mosquito Control (FCCMC) adopted three recommendations from its Imperiled Species Subcommittee regarding the Miami blue, mosquito spraying, and permitting issues (FCCMC 2010). The FWC and others participated in the development and adoption of the recommendations. These recommendations are as follows:

1. Require buffers (to be determined by research) for known natural populations and allow for incidental take for those populations that are reintroduced into areas that normally receive mosquito control.

2. Recommend incidental take permits (from the FWC or relevant agencies) to Mosquito Control Districts for Miami blue populations in areas that normally receive mosquito control.
3. Recommend that additional research be conducted to determine impacts to non-target species and to address mitigation options that reduce risk to sensitive non-target species from mosquito control.

d. Identify and engage partners with the funding needed to achieve objectives

Establishing partnerships among public agencies, non-profit organizations, private foundations, and other entities interested in financially supporting the conservation of imperiled species is a pivotal action that will help determine the timeliness and effectiveness of Miami blue conservation efforts.

Strategy: Implement actions to establish new metapopulations

Conservation Action 5. Determine How to Successfully Reintroduce Miami Blues

a. Maintain the Miami blue captive propagation program

Captive or controlled propagation of a species is usually the last option when attempting to conserve a species in danger of extinction. With only two known metapopulations in existence, the Miami blue qualifies for such an effort. However, controlled propagation is not a substitute for addressing factors responsible for decline of a threatened species (USFWS 2000). The conditions at recipient sites that led to the demise of the previous population must be eliminated or substantially improved prior to release of captive reared individuals (Gore 2000). Additionally, rigorous protocols must be developed to guard against unintended consequences such as genetic drift from small founder populations, possible human health impacts from reduction or elimination of mosquito control, and decreased personal property rights associated with regulations.

Emmel and Daniels (2003a) and the previous FWC Miami blue butterfly management plan (FWC 2003b) proposed the establishment of a captive propagation program and a program to release captive-bred Miami blues into existing populations or unoccupied suitable habitat. A captive breeding program was initiated at the University of Florida in February 2003. Rigorous breeding protocols were established and have resulted in the production of over 23,000 captive-bred organisms since the program's inception (J. Daniels pers. comm.). This program should be maintained in order to continue active scientific research and to produce organisms for reintroduction. Current efforts should refine the reintroduction methodology and assessment of organisms following release (see b and c immediately following).

b. Conduct field experiments using captive-bred stock

Despite many releases of captive-bred Miami blues in protected areas within the taxon's historic range, none of these attempts has led to successful reintroduction. A series of experimental field releases combined with immediate follow-up monitoring is needed to determine the factors that have led to the failure of previous reintroduction attempts. Such controlled field experiments have already been proposed (Daniels 2009c) and will be initiated once target study sites, adequate funding, volunteers, and captive-bred Miami blue stock are in place. One such study site, Bill Baggs Cape Florida State Park on Key Biscayne, is the subject of a recently approved memorandum of understanding between the FWC and the DEP.

c. Attempt translocations for reintroduction

Reintroduction attempts have used captive-bred Miami blues several generations removed from the wild stock originally collected in Bahia Honda State Park. To examine whether there are any inherent differences between wild and captive bred material, some reintroduction attempts should be made using Miami blues translocated directly from wild populations from either BHSP or KWNWR. Before proceeding, caution would be exercised to ensure that translocations had minimal effect on the source populations. As with releases using captive-bred stock, translocation protocol would include rigorous follow-up monitoring of Miami blue status at the recipient site.

Conservation Action 6. Identify and Establish Sites for Reintroductions or Use as Corridors

a. Identify suitable habitat from previous research and mapping

Of the 15 coastal Florida counties that make up the Miami blue's historic range (Figure 2), this butterfly is currently found only in Monroe County. Achievement of the Miami blue conservation goal depends on implementing a comprehensive program to identify public and private lands throughout the historic range with suitable habitat, appropriate management, and landowners willing to contribute to the long-term survival and conservation of the Miami blue. A number of public conservation lands were identified in the original reintroduction plan by Emmel and Daniels (2003a), but reintroduction attempts have been unsuccessful to date. Therefore, recommended work should be done to determine successful reintroduction techniques (Conservation Action 5) and to identify factors that led to the decline and disappearance of Miami blues across most of its historic range.

In addition to identifying suitable sites for proposed reintroductions, it will be important to consider the lands between those sites as conservation corridors for Miami blues migrating between metapopulations. Given the limited dispersal abilities of the butterfly (Emmel and Daniels 2003b), such corridors will be critical. Movement of individuals within a metapopulation is also crucial to maintaining genetic diversity and for recolonizing areas following local extinctions (Knutson et al. 1999). The probability of

recolonization is a function of patch size and distance to the nearest occupied patch (Thomas et al. 1992). Private lands are located between most of the proposed reintroduction sites on public lands. These private lands might not meet all the criteria for selection as a reintroduction site, but could serve as conservation corridors or "stepping stones" to larger optimal sites (Shreeve 1995). Safeguarding conservation corridor lands could be accomplished through conservation easement or acquisition.

These efforts must be supported through access to, and interpretation of, aerials and GIS landcover maps that indicate potentially suitable habitat for the Miami blue. Such habitat maps are currently available for the Keys (Dean Jue, Florida Natural Areas Inventory, pers. comm.) and will need to be obtained for comparable areas of mainland Florida. An interactive database of potential sites, landowner contact information, floral and faunal site surveys, and status of reintroduction efforts should be established.

b. Identify and engage public and private landowners using incentive programs and cooperative agreements

The first major hurdle to achieving the conservation goal and objectives is the development of successful reintroduction techniques (Conservation Action 5 above). The next step is to foster extraordinary coordination and cooperation among landowners, land managers, volunteers, and other stakeholders across several counties to establish reintroduced populations of Miami blues. The identification and implementation of incentives may be critical to ensure the long-term viability of these newly established metapopulations.

Incentives may be provided to private and public agencies that conduct activities that reduce or remove threats to, or otherwise improve conditions for, the Miami blue. One such incentive program is a Candidate Conservation Agreement with Assurances (CCAA). CCAAs are formal agreements between the USFWS and one or more parties to address the conservation needs of federally proposed or candidate species, or species likely to become federal candidates, before they become listed as endangered or threatened under the federal Endangered Species Act. The participants voluntarily commit to implementing specific actions that will remove or reduce the threats to these species, thereby contributing to stabilizing or restoring the species so that federal listing may be no longer necessary. CCAAs provide assurances to nonfederal property owners who voluntarily agree to manage their lands to remove threats to imperiled species. These are assurances that future regulatory obligations by the USFWS, in excess of those the parties agree to at the time they enter into the CCAA, will not be required.

In addition to CCAAs, other potential federal programs to be investigated include U.S. Fish and Wildlife Service's Coastal Program and Partners for Fish and Wildlife Program, Candidate Conservation Agreements (without assurances), and Habitat Conservation Plans (HCPs).

State programs that may benefit private landowners and the Miami blue include the Florida Forestry Stewardship Program, the Wildlife Habitat Incentives Program (WHIP),

the Environmental Quality Incentives Program (EQIP), the Landowner Incentive Program (LIP), and the Private Stewardship Grants Program. The Florida Fish and Wildlife Conservation Commission could also pursue initiatives modeled after the federal Safe Harbor program.

c. Implement reintroductions on approved, suitable sites

Once landowner approval and agreements are in place, reintroductions can commence—using captive-bred or translocated Miami blue stock as deemed appropriate. These new populations will then be subject to the same rigorous monitoring conducted at the wild metapopulations (Conservation Action 2), and their status updated in the monitoring database.

Achievement of the Miami blue conservation goal depends on implementing a comprehensive program to identify public and private lands throughout the historic range with suitable habitat, appropriate management, and landowners willing to contribute to the long-term survival and conservation of the Miami blue.

Strategy: Conduct Additional Research to Support Miami Blue Conservation

In addition to the priority research needed to determine how to successfully reintroduce Miami blues (Conservation Action 5 above), there are many facets of Miami blue life history and ecology that remain poorly understood or unknown. Active pursuit of research on the following topics will be critical to improve our understanding of this species, and the results will help guide and refine recommended conservation actions and the management plan as a whole.

Identify factors that caused Miami blue decline and disappearance

The cause of the decline of the Miami blue is not known. Habitat loss, degradation, and fragmentation would seem to be obvious factors, but large areas of seemingly suitable habitat are not occupied. Although mosquito spraying has been blamed for butterfly declines in the Florida Keys, the Miami blue has disappeared from vast conservation lands that are not sprayed, such as Everglades National Park and Biscayne National Park. This would seem to indicate that some other factors, as yet unknown, are responsible for the decline and disappearance of Miami blues. One suggested explanation is that exotic predatory ants or perhaps parasitoids are the main cause of decline (Minno and Minno 2009). Research is needed to determine the factors negatively impacting the Miami blue in Florida.

Determine suitable habitat characteristics

Little is known about the habitat characteristics required to maintain a Miami blue population. More information on native nectar sources is needed. In concert with research on reintroduction and the factors that led to the Miami blue's decline and disappearance across its range (above),

additional studies are required to define optimal habitat which will facilitate release of captive bred Miami blues.

Determine role of fire in Miami blue habitat

Minno and Emmel (1993) reported that Miami blues once inhabitated the pine rocklands of Big Pine Key in the Florida Keys. Fire suppression has led to the overgrowth of woody plants and the suppression of shade-intolerant native forbs (Bergh and Wisby 1996). Studies are needed to examine the role that fire has on the host plants and nectar sources for Miami blues, the potential impact of prescribed burning on Miami blues and their habitat, and how to integrate Miami blue reintroduction with the goals of prescribed fire programs.

Study population ecology

Additional research on the population dynamics, ecological requirements, and Miami blue behavior is needed for all extant populations as well as any new populations established via reintroduction.

Conduct additional studies on impacts of pesticides and buffer zones

To follow up on the results of previous studies (e.g., Eliazar and Emmel 1991, Salvato 1999, Pierce 2008, Zhong et al. 2009), ongoing and additional studies on the effects of pesticides on Miami blues are needed. More information on adequate buffer zones for aerial and ground application is needed to resolve both conservation and public health concerns.

Study larval host plant preferences

Recent research trials have indicated that captive-bred larvae of the Miami blue are capable of utilizing all three major known or historic host plant species: gray nickerbean, balloonvine, and blackbead (J. Daniels pers. comm.). It is not known, however, if larval developmental time, survival, or fitness varies with a particular host or if adult females show particular preference for individual host species. Additional research is needed to better understand this dynamic.

Determine impacts of anticipated climate change

The FWC has launched an agency-wide initiative to confront the growing evidence of ongoing climate change and to position itself as a lead player to forecast, plan for, and ameliorate the impacts of climate change on Florida wildlife. According to the U.S. Climate Change Science Program (USCCSP), sea-level rise is the largest climate-driven challenge to low-lying coastal areas and refuges in the sub-tropical ecoregion of southern Florida, and much of low-lying coastal south Florida "will be underwater or inundated with salt water in the coming century" (USCCSP 2008, p. 5-31, as cited in USFWS 2009; Intergovernmental Panel on Climate Change 2007, 2008). Faced with this prognosis, research directed toward ensuring the survival of Miami blues and other imperiled fauna of the Keys and coastal South Florida will be critical.

Investigate the usefulness of a population viability analysis (PVA)

Population viability analysis is a set of tools developed to estimate a species' risk of extinction. The methods rely on mathematical theory in conjunction with information about the population makeup and life history attributes (Schultz and Hammond 2003). The data needed to construct a PVA depends on the questions being asked about the population in question. Example questions to pose about the Miami blue include: 1) what is the risk of extinction of different metapopulations; 2) what is the optimum number of Miami blues to reintroduce to a site of a given area; and 3) what is the relative value of one large site as compared to several small sites. As few as six population surveys may be sufficient to estimate extinction rate (Morris et al. 1999 cited in Schultz and Hammond 2003).

CHAPTER 5: IMPLEMENTATION STRATEGY

Priority Actions

There has been considerable work on the Miami blue since the first management plan (FWC 2003b) was drafted. Protective regulations have been established, a successful captive breeding program developed, reintroduction attempts made, various research projects completed, surveys and searches of suitable habitat conducted, and an additional wild metapopulation discovered. These efforts have increased our information on the Miami blue and shifted the priority actions required for its short-term and long-term survival and conservation.

A prioritized approach to this management plan will help achieve the conservation objectives and will facilitate the coordination necessary to successfully implement the plan. The actions in the summary list below are derived from Chapter 4.

Priority actions to be undertaken by the FWC

- Maintain legal protections for the Miami blue

Priority actions to be undertaken by other agencies and the FWC

- Maintain and protect known metapopulations of Miami blues on Bahia Honda State Park and Key West National Wildlife Refuge
- Conduct periodic surveys of known Miami blue populations, including an assessment of the health of host and nectar plants
- Reduce threats to known populations as needed (e.g., continue iguana eradication program)
- Conduct controlled field experiments with extensive monitoring to establish methods for reintroduction
- Attempt translocations from wild populations in reintroduction attempts
- Identify and engage partners to secure multi-year funding and logistical support to maintain the captive propagation program
- Identify and engage partners to secure funding to support research on reintroduction techniques
- Identify and secure suitable sites for reintroductions or for use as corridors
    - Compile a database of historic and potential sites from previous efforts and habitat mapping
    - Identify and engage public and private landowners of suitable reintroduction sites
    - Use incentive programs and cooperative agreements to foster partnerships
- Implement a reintroduction program
    - Reintroduce Miami blues
    - Regularly monitor reintroduced populations
    - Manage habitat as appropriate to maintain reintroduced populations

Priority actions for private citizens

- Report new or previously undiscovered Miami blue populations to the FWC and USFWS
- Report disturbances or violations to Miami blues to the Wildlife Alert number (1-888-404-3922)
- Manage habitats on private lands to benefit Miami blues and other species of conservation concern
- Support Miami blue conservation actions

Proposed Implementation Schedule

Highest priority strategies should be initiated as soon as possible and should be the first consideration of those undertaking Miami blue conservation.

Prioritization of strategies and actions will facilitate the extensive coordination and cooperation necessary to successfully implement the plan. The highest priority strategies should be initiated as soon as possible and should be the first consideration of agencies and groups undertaking Miami blue conservation. The following implementation schedule includes the highest priority actions for achieving the conservation goal and objectives over a five-year period.

Actions that the FWC and partners including local governments, other state agencies, federal agencies, universities, and non-governmental organizations should continue

- Maintain, protect, and monitor known metapopulations of Miami blues on Bahia Honda State Park and Key West National Wildlife Refuge
- Maintain legal protections for Miami blues
- Continue surveys for Miami blues at historic locations
- Identify and coordinate funding sources to maintain captive propagation program (to reduce risk from environmental catastrophe, for reintroduction, and for other research)
- Develop and implement education and outreach messages and materials to further public support for Miami blue conservation
- Continue using the Imperiled Butterflies of Florida Workgroup to exchange information between and among agencies, managers, biologists, mosquito control districts, and private landowners
- Continue to discuss mosquito-control related issues through the Imperiled Species Subcommittee of the Florida Coordinating Council on Mosquito Control

Actions that the FWC and partners should begin or implement within the next 12 months

- Begin research on reintroduction techniques to be conducted on Bill Baggs Cape Florida State Park
- Identify and coordinate funding sources to support research on reintroduction techniques

- Develop a database to track status and trends of wild and reintroduced populations

Actions that the FWC and partners should begin or implement within the next five years

- Draft and finalize agreements and incentive programs to facilitate reintroduction attempts at different sites
- Identify and secure suitable sites for reintroductions or for use as corridors
  - Use maps and field visits to identify suitable habitats within historic range and rate sites for potential to support Miami blues
  - Identify and engage public and private landowners
  - Implement necessary incentives (e.g., LIP, WHIP, HCPs)
  - Draft agreements (e.g., memoranda of understanding) with partners to secure approval for reintroduction
- Implement a reintroduction program
  - Reintroduce Miami blues
  - Regularly monitor reintroduced populations
  - Manage habitat as appropriate to maintain reintroduced populations
- Encourage the initiation and conduct of additional research projects to support Miami blue conservation, including:
  - Mosquito pesticide buffer zones
  - Ant interactions
  - Parasitoid interactions
  - Impacts from invasives (e.g., iguanas)
  - Role of fire and prescribed burning on Miami blues and their habitat
  - Identification of contributing factors of decline and disappearance of Miami blues from most of historic range
- Investigate the usefulness of a PVA to address specific questions about Miami blues
- Manage habitats on county and city lands to benefit Miami blues and other species of conservation concern
- Support Miami blue conservation actions

Required Resources and Other Costs Associated with Implementation

The South Regional Species Conservation Biologist and Invertebrate Taxa Coordinator, both staff in the Division of Habitat and Species Conservation's Species Conservation Planning Section, will together serve to coordinate implementation of the Miami blue management plan. These positions will be responsible for coordinating and tracking implementation of the plan and for providing an annual report on progress towards plan activities to be included in the FWC's annual legislative report on threatened and endangered species.

The FWC

Several FWC staff will assist with the implementation of the plan. The projected annual costs of their salary and other expenditures are presented below.

$ 5,000 – 10% time Regional Species Conservation Biologist
$ 1,750 – 5% time Assistant Regional Species Conservation Biologist
$ 5,000 – 10% time Invertebrate Taxa Coordinator
$ 2,800 – 8% time Florida Wildlife Legacy Initiative Biologist
$ 400 – 1% time Public Outreach Staff
$ 400 – 1% time Permitting Staff
$ 1,000 – Field and office equipment and supplies
$ 2,225 – Transportation costs (estimated 5,000 miles/year @ $0.445/mile)
$ 1,600 – Per diem costs (estimated 20 days @ $80/day)
$ 300 – Vehicle maintenance
$20,475 – Total annual cost

The FWC and Partners

Funds from grants and other sources will be needed to support captive propagation facility maintenance (estimated at around $36,000/year) and to support field research, surveys, reintroduction activities, and preparation of public outreach materials.

Management Plan Review and Revision

The status of the range-wide Miami blue population should be periodically assessed to ensure progress toward the conservation goal and objectives. Revision of the plan may be warranted if monitoring reveals a declining trend despite management efforts or successful establishment of reintroduced populations. Future research on reintroduction techniques, pesticide effects, habitat requirements, genetic variability, and/or management techniques also could necessitate a revision of the plan. Any decrease in the area of occupancy or number of mature individuals from the 2009 level will require accelerated action from the FWC. At a minimum, the management plan should be revisited for potential revision within 5 years of this revision approval.

CHAPTER 6: ANTICIPATED IMPACTS

The parties potentially affected by the Miami blue management plan include private landowners, public land managers, scientific researchers, and citizens of the State of Florida. An assessment of the anticipated economic, social, and ecological impacts of implementing the plan was based on the management actions proposed herein and on issues raised through the public comment process. No comments specifically related to the social or ecological impacts of the plan were received. In the absence of additional public input, social and ecological impacts related to the plan's implementation are difficult to assess.

Economic Impacts

A preliminary assessment of economic impacts was based on the management actions proposed in this management plan.

Estimated cost to the FWC of implementing the proposed management plan

Addressing the approved Miami blue rules necessitates a commitment of staff time and resources: to review permit applications for direct and indirect take; to develop, implement, and oversee landowner incentive programs; to coordinate with the USFWS on development and implementation of Candidate Conservation Agreements with Assurances or other Federal programs; and to develop and implement appropriate outreach programs.

Implementation of the management plan will require recurring funds for mapping, surveys, travel, meetings, coordination with landowners, and support for captive propagation, reintroduction, and other research projects. For example, FWC staff are needed to continue participating in the IBWG and the FCCMC. The full scope of the FWC's commitment will depend, in part, on participation and cooperation with the USFWS and other partners, and the success of the captive propagation, translocation, and reintroduction plan. The FWC budget for Miami blues will be addressed on an annual basis as part of the FWC's operational planning process. Management actions proposed in this plan must be considered and prioritized along with other agency programs, species' needs, and available resources.

One comment received from the public suggested that it is a waste of funds to maintain a captive propagation facility and program, and that those funds would be better spent on habitat restoration for wild populations. At present, we consider captive propagation critical: (1) to provide insurance against the danger of an environmental catastrophe extirpating the wild populations; and (2) to provide stock for reintroduction and other research projects to improve our ability to conserve Miami blues. Should such research result in the successful reintroduction and self-sustaining of Miami blues within the historic range, and we are able to achieve the management plan's conservation objectives, then the captive propagation program would have fulfilled its purpose and could be terminated.

Estimated cost to potentially affected parties of implementing the rules

The permits required under the rules are no-cost permits. However, mitigation and minimization activities required under these permits might increase costs incurred by permit applicants. There is also a potential for lost uses on private lands colonized by Miami blues, but also potential for a gain by landowners being able to showcase their role in Miami blue conservation.

Estimated cost to other agencies and land managers of implementing management plan

Implementation of the plan will have financial impact on other public agencies. The USFWS has funded the survey and monitoring of the existing Miami blue population, as well as surveys on potential habitat, and mosquito control studies. The Florida Keys Mosquito Control District has also funded research on effects of pesticides on non-target insects. The National Park Service, the USFWS, the Florida Park Service, counties and municipalities, and private property owners may incur costs to manage for Miami blues if they become established naturally or are reintroduced to their lands. In general, however, it is expected that DEP, USFWS, and other land managers with existing or reintroduced Miami blue populations can maintain them through normal ongoing habitat management activities. Targets for other potential expenditures could include: control of invasive plants and animals; signage, fencing, or other tools to prevent or limit human disturbance to the Miami blues, their host plants, and nectar plants; and general outreach programs and materials to educate the public about the butterfly.

Estimated impact on the tourism and health care industries

Implementation of the plan has potential economic cost to local tourism and health care industries if mosquito-borne diseases became epidemic as a result of decreased mosquito control and no-spray zones in areas where the Miami blue is present or reintroduced. In 1989, Florida was visited by over 65 million people who spent over 30 billion dollars (Mulrennan 1991). A St. Louis encephalitis epidemic in Florida in 1990 is thought to have been responsible for a 15% decrease in tourist-related business in the last quarter of that year (Mulrennan 1991). Subsequent outbreaks of West Nile virus throughout the state of Florida and dengue fever in the Florida Keys have increased the demand for mosquito control (L. Hribar pers. comm.). However, if such outbreaks were ever detected at sites where Miami blues occur, the sites could be treated with larvicides or adulticides applied by truck, ideally in a manner that would avoid negatively impacting Miami blue concentrations. If such actions necessitated closing the sites (especially state parks) to the public, that would pose another economic impact.

Implementation of this management plan may have positive economic impacts because the presence of so rare a species could raise public interest and increase income from local tourism. Butterfly viewing is rapidly becoming as popular as bird watching (J. Daniels pers. comm.). Overall, 4.2 million people participated in some form of residential or nonresidential wildlife-viewing recreation in Florida in 2006, resulting in a total economic benefit of $5.248 billion (Zwick and Carr 2006).

Social Impacts

Potentially positive social effects on the management plan include: increased public awareness of the Miami blue and habitats as well as other butterfly species which are in decline in Florida; public recognition and support of the FWC and partners for taking a comprehensive approach to Miami blue management; and the development of integrated working relationships among the various public agencies and private landowners involved with the species' management. Conversely, if the plan is not implemented there could be negative social impacts. Continued loss of the species and its habitat could erode public confidence in the FWC's ability to manage and conserve the wildlife resources of the state. Furthermore, with any reduction to the Miami blue population, society runs the risk of irreplaceably losing biodiversity, with all of its potential unknown consequences and benefits to nature and humans.

Ecological Impacts

We currently do not foresee any negative ecological impacts due to implementation of the management plan. Implementation of the plan should have positive ecological impacts, through maintenance and enhancement of habitat, for the Miami blue and other butterflies that share its habitat, and host plant and nectar plant needs.

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