

Saint Francis' Satyr
(Neonympha mitchellii francisci)

**5-Year Review:
Summary and Evaluation**



**U.S. Fish and Wildlife Service
Southeast Region
Raleigh Ecological Services Field Office
Raleigh, North Carolina**

5-YEAR REVIEW
St. Francis' satyr (*Neonympha mitchellii francisci*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: This review was conducted by Heather Lessig and Nick Haddad of North Carolina State University (NCSU) in cooperation with the U.S. Fish and Wildlife Service's Raleigh Field Office. The Service conducted the final assessment of the butterfly's listing status. All literature and documents used for this review are on file at the Raleigh Field Office and available to the public. Information used in the review is based on published literature, technical reports, unpublished data and surveys, and personal communications with knowledgeable researchers familiar with the species. The draft of this document was distributed for peer review (see Appendix A) and comments received were addressed, as appropriate.

B. Reviewers

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C. Background

1. **Federal Register Notice citation announcing initiation of this review:** 74 FR 31972, July 6, 2009
2. **Species status:** Declining (2013) Monitoring by Ft. Bragg and NC State University biologists indicate that numbers are lower than previous years. Surveyors believe that it could be attributed to hotter than normal temperatures during the two flight periods as well as hardwood and cane succession. It is highly unlikely that this species is still threatened with collection.
3. **Recovery achieved:** 2 (26-50% recovery objectives achieved)

4. Listing history:

Original Listing

FR notice: 60 FR 5263

Date listed: January 26, 1995

Entity listed: species

Classification: endangered

5. Associated rulemakings: None.

6. Review History:

Final Recovery Plan – 1996

Recovery Data Call – 2012, 2011, 2010, 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, and 1998.

7. Species' Recovery Priority Number at start of review (48 FR 43098): The recovery priority number assigned to St. Francis Satyr butterfly (SFS) is a 3, indicating a high degree of threat and a high recovery potential for this subspecies.

8. Recovery Plan:

Name of plan: Saint Francis' Satyr Butterfly Recovery Plan

Date issued: April 23, 1996

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. Is the species under review listed as a DPS? No. The Endangered Species Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population of a species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is an invertebrate, and the DPS policy is not applicable, the application of the DPS policy to the species' listing is not addressed further in this review.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes.

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? No. The SFS was first described in 1989 (Parshall and Kral 1989), and at

the time the recovery plan was outlined in 1996, little information on the species was formally known and published. Due to the investment in time and resources by Ft. Bragg Army Installation as well as researchers at the NC Natural Heritage Program and NC State University, knowledge on species' biology and habitat has increased greatly in the intervening 17 years, including new information on population size, population structure, species-habitat relationships, and captive-rearing techniques. Genetic analysis has confirmed that SFS is in a separate lineage from all other populations of *Neonmypha mitchellii* (Stephen Hall, NC Natural Heritage Program, June 28, 2010, pers. comm.).

- b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?** Yes, however, we have learned a lot on this butterfly recently and anticipate continuing to work to adapt that into our recovery program.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

The recovery plan for the SFS states that the species will be considered for downlisting when the existing metapopulation has been stable or increasing in numbers for at least 10 to 15 years and when a long-term protection and management plan is in place to ensure its continued survival. Delisting will be considered when the existing metapopulation has been protected and stabilized and when at least three other populations have been discovered or established in the sandhills region and they have been stable or increasing for 10 to 15 years. Population fluctuations are believed to be substantial; a period of 10 to 15 years is believed to be essential to define "naturally occurring" fluctuations. Protection and management plans must be implemented for all populations before reclassification can be considered.

The recovery plan does not specify where those additional populations should occur, due to uncertainty about the species' historic range. One likely location is in the Sandhills Gamelands, east of Ft. Bragg and adjacent to Camp McCall.

We need to clarify two points before addressing downlisting criteria. First, the population at Ft. Bragg consists of a number of small inactive (i.e., formerly occupied) and active sites (subpopulations), ranging in size from 0.2-2.0 ha in size. Without further information, it must be assumed that these sites, or subpopulations (active or inactive), are part of one population found in a range that is approximately 10 x10 km at Ft. Bragg. Second, most active sites are found in artillery impact areas that are restricted in access, which complicates the protection, management, monitoring and research activities aimed at furthering our understanding of this species. In most years, since the recovery plan was written, these sites have not been visited during adult flight periods. There are

currently three active subpopulations outside artillery impact areas that are monitored annually, and at least seven active subpopulations within artillery impact areas that have been visited 1-3 times during adult flight periods since 1994. There may be more active sites within artillery impact areas, some of which are accessible and have yet to be discovered, and others in places that can likely never be accessed.

There are currently insufficient data to assess downlisting criteria. Although some monitoring of SFS at Ft. Bragg began in the early 1990's, it was irregular in years and sites visited (Hall 1993, Hall and Hoffman 1994). Monitoring of SFS subpopulations in impact areas is very difficult due to safety and access issues; therefore, systematic sampling has not been feasible since 1994. Regular monitoring of some sites has been conducted annually since 2002 (Haddad et al. 2009). Without comprehensive population estimates prior to 2002, not enough time has passed to accurately track trends of populations that naturally fluctuate due to environmental variation. The information available from 2002 onward shows the overall population to be stable, although subpopulation levels fluctuate annually. The stable level for the overall population is lower than that seen in one year of high abundance in 2004. No populations have yet been detected outside of Department of Defense (DoD) lands on Ft. Bragg, NC (Hall 2003, Haddad et al. 2009).

The ongoing investment of time and resources, and cooperation in management and access of the Ft. Bragg military installation, have been critical in accumulating knowledge of SFS biology and management, in maintaining population stability of the species, and ensuring continued access for researchers. Beginning in the early 1990's, Ft. Bragg Endangered Species Branch received funding and military support that led to collaborations with the NC Natural Heritage Program (primarily Steve Hall) and NCSU researchers, contributing to describing life history traits of the species and the establishment of the long-term monitoring program that began in 2002. The Ft. Bragg Endangered Species Branch has provided significant support in maintaining communication between military personnel and researchers and in obtaining access to restricted areas on base that are critical for researchers, in addition to lending aid for captive-rearing efforts. In coordination with the Service, Ft. Bragg has developed a SFS research and monitoring program with specific goals and objectives in their Integrated Natural Resource Management Program (INRMP) to facilitate recovery efforts of the species. The Service is coordinating permitting for a whole-genome sequencing project to ascertain the taxonomy of the Mitchell's Satyr complex; the project will verify whether St. Francis' Satyr is distinct. Ongoing cooperation with these partners continues to be vital for species persistence.

The following progress has been made toward achieving several goals outlined in the recovery plan:

1. Protect and manage existing populations and essential habitat.

A long-term monitoring system has been in place since 2002 to estimate population size at all major butterfly sites occurring outside artillery impact areas. Adults are counted during each of two flight periods using transect counts and/or mark-recapture methods (Haddad et al. 2008). In addition, sites that have historically supported SFS subpopulations but are not currently occupied (also known as “inactive” subpopulations) are regularly monitored to check for re-colonization by individuals from nearby subpopulations.

Several steps have been taken to protect existing populations. All SFS sites are buffered, with clear markings that sites are off limits to military training activities. In one subpopulation that is in a heavily trafficked navigation training area, military training activities have been greatly reduced and training routes re-drawn. Most sites are inaccessible and see virtually no military traffic. Some attempt is made by Environmental Compliance Specialists at Ft. Bragg to regularly patrol sites during adult flight periods and law enforcement officials on Ft. Bragg are briefed annually on the need to deter collection at SFS sites. Locations are kept confidential among researchers and some military personnel, thereby minimizing opportunities for collection of the species for unlawful commercial gain. The DoD has provided extensive support to maintain habitat and continue research on the SFS.

A long-term management plan to address the habitat requirements and threats at occupied sites remains incomplete, primarily because we do not have a complete understanding of disturbance factors, particularly beaver inundation and fire, operating at the landscape scale to maintain high quality habitat (described below; Kuefler et al. 2008). In addition, because of where the subpopulations are located, planning habitat management must minimize interference with military training activity. Until we can clearly articulate the optimal disturbance management for the butterfly, it will be difficult to specify a management plan. Researchers and the military are currently working closely to retain beaver activity in focal areas and to allow fires through wetlands. Although most wetlands occupied by SFS are not used by military personnel, there may be other landscape-level factors, like the density of roads, which affect beaver activity or wetland suitability.

2. Continue research into the species’ life history, ecology, and reasons for decline.

Extensive research into life history and ecology of SFS has been conducted since the recovery plan was written. From 1994 to 2004, research into the life history of SFS was conducted by Steve Hall of the North Carolina Natural Heritage Program and Erich Hoffman of the Endangered Species Branch at Ft. Bragg (Hall 1993, Hall and Hoffman 1994, Hall et al. 2001, Hall 2003). Since 2002, Fort Bragg managers have collaborated with Nick Haddad and his lab at North Carolina State University to develop a partnership aimed at supporting a long-

term monitoring and management plan. These combined efforts have led to increased knowledge of population trends, species-habitat interactions, and species' dependence on disturbance regimes (e.g. Hall et al. 2001, Hall and Haddad 2005, Kuefler et al. 2008, Haddad et al. 2009, Bartel et al. 2010). Much of this information is reported below in section 2.3.1 Biology and Habitat.

Of particular importance is the recognition of the dependence of SFS on disturbance, particularly by beaver. These relationships were discovered during initial surveys and have been verified with continued observation and habitat restoration research. Most SFS subpopulations are found in abandoned beaver dams or along streams with active beaver complexes. SFS cannot survive in sites that are either inundated by flooding or succeed to riparian forest. Thus, SFS often requires disturbance by beaver to maintain its habitat. However, anecdotal evidence of several sites inside the impact areas showed that they remained occupied by SFS with little if any influence of beaver activity (E. Hoffman, Ft. Bragg, June 17, 2010, pers. comm.). The challenge for future management is to understand the ideal activity level of beaver to maintain SFS.

One conundrum in understanding SFS dependence on disturbance is one site in the artillery impact area, an extensive canebreak that is apparently maintained by frequent fire, but with little evidence of beaver. Outside artillery impact areas, controlled and wild fires have been observed to severely reduce SFS population size without later recovery. Yet, SFS is maintained by fire in at least one site. Therefore, more research is needed to understand why and how fire maintains this subpopulation, especially if fire is to be used as a management tool elsewhere. Fire has failed to maintain SFS populations in two sites outside artillery impact areas. Understanding the importance of fire, beaver activity, and the interplay between the two is critical to successfully manage suitable SFS habitat.

3. Conduct searches for additional populations.

Currently all known subpopulations are restricted to Ft. Bragg and populations have not been located on private land or elsewhere (Hall, 1993, Haddad et al. 2009). Initial baseline surveys were conducted by Ft. Bragg from 1994 to 1996, with 21 SFS sites with at least one butterfly present discovered across the installation, including 14 sites within the impact areas (E. Hoffmann, Ft. Bragg, June 17, 2010, pers. comm.). Since the recovery plan was written, a number of additional sub-populations have been discovered, including two active subpopulations and one currently inactive subpopulation, all located outside artillery impact areas. The number and size of SFS subpopulations within artillery impact areas are still largely unknown. Although impact areas have potential as high quality habitat due to frequent artillery and flares that cause annual fires, access to these areas is restricted and only granted on an extremely limited basis (Hall et al. 2001). In 2009, four of the originally detected 14 subpopulations, plus two new subpopulations, were confirmed to be active with

large populations (hundreds of individuals, and at two sites, possibly thousands of individuals). Of the original 14 sites, four have been observed to have low population numbers (with two having substantially reduced numbers), and three are now thought to be inactive. Three sites discovered in 1994 cannot be checked because they are in highly restricted areas. Because sites have been accessed so infrequently, it is difficult to estimate population sizes. There are likely other sites within impact areas that support subpopulations but cannot be accessed.

4. Establish additional wild populations within historic range.

The historic range for SFS consists solely of the area currently known to be occupied by the species within Ft. Bragg (Stephen Hall, NC Natural Heritage Program, June 28, 2010, pers. comm.). No new populations have been established. Efforts are currently underway to augment existing populations at Ft. Bragg with releases of captive-reared adults. A limited number of adults were released in July and August 2009 at an unoccupied site in the northwest sector of Ft. Bragg in a pilot attempt to establish a new breeding population. In 2011, an experimental habitat restoration project created four additional sites to establish new subpopulations. Over the past two years, adults have been successfully released to these sites.

5. Develop education and information programs.

Most efforts to increase public awareness about SFS have been through publication in scientific journals of relevant species' ecology and life history traits, although some popular press articles have been released. Ft. Bragg's Endangered Species Branch has collaborated with scientists to develop partnerships with the scientific community. Some educational programs targeted to school-age children, as suggested in the recovery plan, have been developed by Ft. Bragg since 1996. During special events, such as Earth Day celebrations and Career Day, school children from Ft. Bragg and the surrounding community schools have been targeted through educational presentations. In addition, educational booths have been set up at local community events, including BugFest at the NC Museum of Natural Sciences, to educate the general public. Several Boy Scout troops and Eagle Scout projects have targeted educating school children about the SFS. In 2011, the SFS was highlighted in the Service's Endangered Species Bulletin as well as in the Wildlife in North Carolina magazine.

C. Updated Information and Current Species Status

Biology and Habitat

A great deal of new information about the SFS biology and life history has been discovered in the past 18 years (summarized by Kuefler et al. 2008, this report) including: 1) the ability to predict adult emergence in the first flight period based on growing degree days; 2) known predators, including dragonflies (eastern

pondhawks) and spiders (black and yellow argiope, fishing spiders); 3) adult lifespan, average 3-4 days; 4) dispersal ability, which is extremely limited; 5) knowledge of captive rearing; and 6) identification of the larval host plant as *Carex mitchelliana* (Haddad, July 19, 2012, pers. comm).

In March 2011 NC State University (NCSU) began work on a large scale project funded through the Department of Defense's Strategic Environmental Research and Development Program (SERDP) to restore wetland habitat for St. Francis' satyr populations. Sixteen 30 x 30 m plots were created along riparian creek drainages in close proximity to active butterfly colonies and used either inundation, hardwood removal, or both, to create what we believe is high quality habitat for St. Francis' satyr. Initial analysis of differences in sedge density and herbaceous cover from implementation to one year later (Spring 2012) suggests that sites with hardwood removal are most likely to result in an increase of these beneficial categories. NCSU will continue with this five-year project to experimentally determine which treatment is most effective in supporting St. Francis' satyr populations, and whether these sites act as sources or sinks for the overall metapopulation.

a. Abundance, population trends, demographic features, or demographic trends:

The onset of each of two flight periods can vary; the first flight period is highly predictable based on climate patterns classified into growing degree days, which accounts for heat input into ecosystems. The peak activity of the second flight period is approximately 62 days after the peak of the first flight period. Males are more easily detected and more active than females, although they tend to have lower survivorship, and, in general, both sexes are highly sedentary. Individual butterflies are most active in the afternoon on sunny days but more likely to be observed on overcast or partly cloudy days (Kuefler et al. 2008). Adult lifespan is only a few days and adults generally do not feed on nectar. However between 1994 and 2001, SFS was observed nectaring on fetterbush (*Clethra alnifolia*) which flowers on two occasions late in the flight period (E. Hoffman, Ft. Bragg, June 17, 2010, pers. comm.).

The ability to determine accurate population counts of the total population has consistently been affected by limited access to impact areas on base. Changes in regulations prior to 2001 have been discussed by Hall et al. (2001) and access to impact areas is still highly restricted. While subpopulations outside impact areas can be regularly monitored, those within impact areas are rarely monitored. As a result, a discussion of population trends must consider separately populations inside versus outside of impact areas. This complication makes it difficult to understand population dynamics and trends.

After the original subpopulation of SFS was first detected outside impact areas, broad, base-wide surveys were conducted irregularly for several years to determine general population size and distribution (Hall 1993, Hall and Hoffman 1994, Hall et al. 2001, Hall 2003). Starting in 2002, several large colonies were monitored annually during each flight period to obtain systematic population counts. Monitoring was performed using both transect counts (a modified Pollard-Yates method; Pollard 1977) and mark-release-recapture techniques (Kuefler et al. 2008), both of which can provide robust estimates of population size (Gross et al. 2007, Haddad et al. 2008). Population counts from 2002-2009 show fairly stable sizes, with a strong peak in butterfly abundance in 2004 (Figure 1).

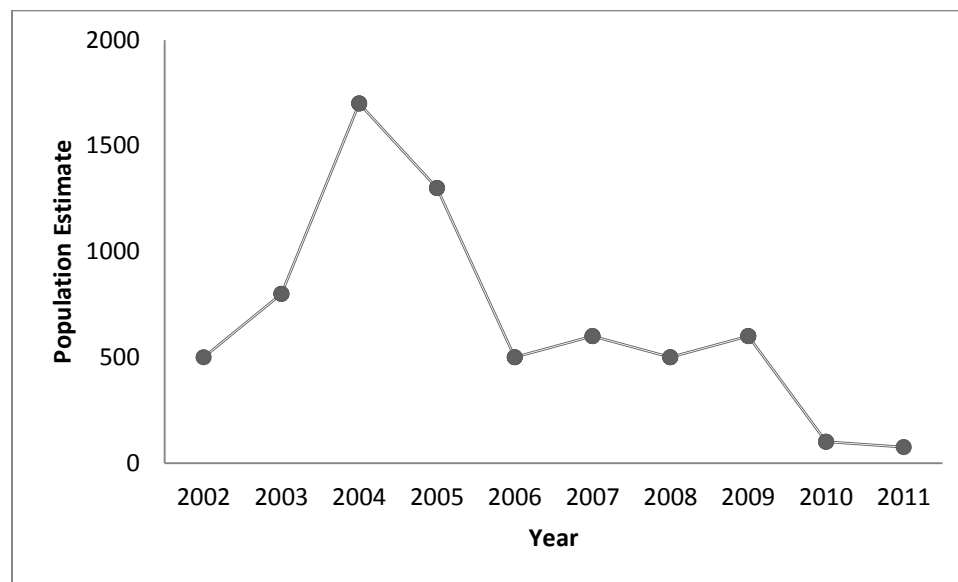


Figure 1. Annual population estimates of the Saint Francis' satyr from 2002-2011. Figure taken from N. Haddad, unpublished data.

Regular monitoring of populations outside of the impact show dramatic declines in 2010 and 2011. In fact, population counts have decreased dramatically - representing the lowest count of individuals in populations outside impact areas since monitoring began regularly in 2002. This decline is most likely due to several factors that have continued to impact populations in the past several years, most notable dry environmental conditions and hardwood and cane succession. The rate of decline in St. Francis' satyr population sizes outside artillery impact areas is alarming. Natural habitat regeneration through typical dynamics caused by beaver and fire are not keeping up. Additional active restoration will be critical. NCSU is currently experimenting with some restoration techniques, but fire and fire break closure should also be considered.

Since surveys in the impact areas are opportunistic, relatively little is known about population abundance within impact areas. In 1994, six populations within impact areas were observed with high abundances in the hundreds of adult individuals. Hall et al. (2001) were able to survey two subpopulations within impact areas in 2001, but limited access and poor weather conditions resulted in little information on the SFS population other than that observed abundances were low. Still, both sites likely supported hundreds of adult individuals. More recently, access to restricted areas was granted during the adult flight period in 2009. Four subpopulations originally observed in 1994 still support large populations (of six that were thought to have supported large subpopulations in 1994). One subpopulation each was flooded and burned and neither currently supports large subpopulations. Two new, large subpopulations were discovered. One of the large subpopulations from the 1994 survey is not currently accessible.

To summarize, in 1994 there were thought to be six large subpopulations, and now there are thought to be seven known, large subpopulations located within impact areas. There may be others that cannot be surveyed because they are in highly restricted areas. It is highly likely, based on anecdotal observations within the impact areas and the potential for suitable habitat to occur there, that additional subpopulations exist within them and could be detected with additional survey work. Additionally, based on 2009 observations, it appears that a large portion of the entire population occurs within the impact areas.

b. Genetics, genetic variation, or trends in genetic variation:

Chris Hamm (Michigan State University) and Richard Brown (Mississippi State University) are investigating relationships among this *Neonympha mitchelliana* complex using morphometric and advanced genetic techniques. In addition to this molecular work, analysis is underway at NC State University to look at genetic variation between subpopulations of SFS. This is being done using microsatellite DNA markers to determine the amount of genetic diversity and gene flow between subpopulations, which can provide evidence of population bottlenecks or extinction and re-colonization rates.

c. Taxonomic classification or changes in nomenclature:

Following its discovery, the SFS was listed as a subspecies of the Mitchell's satyr (*Neonympha mitchelliana*) complex. The nominate species is *N. m. mitchellii*, which is distributed sparsely in the mid- and eastern US, including in Michigan, Alabama, Mississippi, and Virginia, and formerly in New Jersey. Although the Alabama, Mississippi, and Virginia populations were discovered after the recovery plan for SFS was written and are morphometrically similar to SFS, current molecular genetic evidence supports that they are distinct from SFS, and that SFS should remain as a separate subspecies from all other populations in the *Neonympha* complex (Goldstein et al. 2004).

d. Spatial distribution, trends in spatial distribution, or historic range:

Despite extensive survey efforts, the SFS has never been detected outside of Ft. Bragg. The current distribution is much reduced from the proposed historic range. At Ft. Bragg, there have been observations of both extinctions and new subpopulations. Outside artillery impact areas, the type location discovered in 1983 now supports only occasional, apparently transient individuals. Of the two sites known in 1994, one currently supports a large subpopulation, and the other is inundated by beaver and unoccupied by butterflies. Since 2000, four additional subpopulations have been discovered, of which one is large, one is declining, and two have occasional transient individuals. Within artillery impact areas, the distribution of sites has changed as described above, and there are now thought to be seven large subpopulations. Thus, there are now known to be nine large and one declining subpopulations at Ft. Bragg (Kuefler et al. 2008).

Dispersal of marked individuals between subpopulations has been infrequently observed (Kuefler et al. 2008). Out of more than 1000 marked individuals over five years, only five individuals were observed to move between sites: three between the closest sites (approximately 400 m apart), and two between the next closest sites (approximately 1 km apart). Observations of transient individuals found kilometers from large subpopulations imply that longer distance dispersal, up to 2 km, is possible, but rare. Regardless, individuals have not been detected regularly moving along wetland or forest corridors to colonize new sites. This dispersal limitation makes further fragmentation of the population highly problematic. SFS dispersal mechanisms and behavior need additional study. Understanding their dispersal dynamics will have important management implications.

e. Habitat or ecosystem conditions:

The distribution of SFS at the local subpopulation level is most closely tied to grassy wetlands with numerous sedges that are created and maintained through a regular disturbance regime (Hall 1993, Hall 2003, Kuefler 2008). Dominant sedges in subpopulations occupied by SFS include *Carex mitchelliana*, *C. atlantica*, *C. lurida*, *C. lonchocarpa*, and *C. glaucescens*.

The most influential disturbances for these sites are beaver impoundments, which create inundated regions highly favorable to sedge growth (Hall 2003, Bartel et al. 2010). Beavers, eliminated from North Carolina in the late 1800s, are now common on the landscape. Since beavers are also abundant outside of Ft. Bragg, there is potential for SFS habitat creation or maintenance. Although there is a general policy of leaving beavers on Ft. Bragg, they are eradicated when they flood roads and become pests. Until the early 2000s, this was true even near SFS habitat. Now, Ft. Bragg is working to maintain beavers in watersheds where SFS is found as well as throughout the training lands.

Disturbance from periodic fires also contributes to shaping SFS habitat. Fire resets succession, where grassy wetlands naturally succeed to shrub lands and then hardwood forest, although at the local level it can reduce SFS populations.

The relative importance of beaver activity versus fire as disturbance regimes is still uncertain. There is one large site within the artillery impact area of Ft. Bragg, a large canebrake, that is clearly maintained by fire and not beaver; however, very few such habitats exist inside or outside artillery impact areas. Fires have been observed to severely reduce SFS population sizes in two sites. While fire may be responsible for maintaining this site in an early successional, herb-dominated state, it is likely that the site was originally created by beaver activity (Hall 2005). Regardless, disturbances in general reset succession and lower canopy layers (Hall 1993) and when either or both disturbance regimes are suppressed, suitable habitat for SFS diminishes and population persistence is more tenuous.

The presence of roads may interact with beavers to affect habitat quality. Outside artillery impact areas on Ft. Bragg, a series of roads intersect streams at regular intervals. Beavers often dam these streams where culverts cross under roads. Inside artillery impact areas, there are few roads, and beaver dams occur in complexes, with a mixture of inundated, abandoned, and successional sites in close proximity and in long stream networks. Sandy roads also may disrupt sedge populations through increased siltation into streams (Hall 2005).

Some progress has been made in the development of predictive species distribution models to determine sites on Ft. Bragg that might provide suitable habitat for the SFS (Bartel and Sexton 2009, Haddad et al. 2009). These models include geographical information about sites, such as elevation, attributes of vegetation, and density of vegetation by canopy layer. Model development includes comparing sites where butterflies are present with those where they are absent. These models have proven extremely predictive on Ft. Bragg, and have been used to find two new sites within artillery impact areas (J. Wilson, undated, pers. comm.). The models are being extended off Ft. Bragg in an attempt to identify potential SFS habitat. One limitation to using the models is that the resolution of available remotely sensed data off base does not match the high quality data available on Ft. Bragg.

f. Other:

Captive-rearing of SFS larvae began with efforts to raise larvae of a surrogate species, the Georgia satyr (*Neonympha areolata*) (Hall and Haddad 2005, Haddad et al. 2007). Initial attempts were conducted in controlled environmental chambers at NC State University. Larvae were reared on plant cuttings, which resulted in problems with larvae not pupating at times consistent with individuals in the wild. Cuttings of *Carex* dry quickly, inhibiting larval growth rates. In recent years, larvae reared on potted plants in the field have produced positive results. In the summer of 2009, 67 eggs were collected from captured females, of which 38 hatched and 22 (58%) survived to adulthood. Larvae were raised successfully on three different host plants (*C. mitchelliana*, *C. lurida*, and *C. atlantica*). There is no clear preference for one host species. J. Abbott found that Georgia satyrs selected *C. mitchelliana*, but performed best on *C. lurida* (Haddad et al. 2008). SFS larvae fed on all three species but developed more slowly on *C.*

atlantica than *C. lurida* or *C. mitchelliana*. From individuals that have been successfully reared to adulthood, 2-3 per female are released back into the female's subpopulation, 1-2 per female have been sacrificed for genetic studies, and the rest have been introduced into a site for population augmentation. Captive-rearing efforts will be expanded as additional resources become available.

2. Five-Factor Analysis

- a. **Present or threatened destruction, modification or curtailment of its habitat or range:** The primary threat to the SFS is loss of habitat due to both natural and human-caused changes. Habitat modification has occurred due to beaver eradication and suppression of periodic fires, both of which are restored to the landscape around known SFS populations. Future efforts will need to precisely define the frequency and severity of disturbance needed to maintain suitable habitat. For now, beavers in the vicinity of SFS subpopulations should not be eliminated without consultation with biologists with knowledge of SFS.

Suitable habitat is highly susceptible to variation in rainfall and subpopulations can be reduced with too much or too little stream flow. Although it is impossible to completely manage natural fluctuations in environmental conditions, the highly fragmented nature of the population means that uncontrollable factors can cause extinctions of small populations.

Most populations are not susceptible to disturbance from military training activities. While some believe that known subpopulations should remain buffered, others believe this is unnecessary in areas there is no high military traffic.

An important unknown factor affecting SFS populations may be the presence of roads, and their impact on beaver populations and wetland formation should be evaluated. There are strong differences in the extent of populations inside and outside artillery impact areas, and one major difference is the degree to which roads divide riparian habitats. As many large subpopulations occur within artillery impact areas, access to these areas during adult flight periods would allow more accurate determination of requirements for suitable habitat for SFS, and would facilitate restoration for butterfly populations.

A key for future success of SFS is restoration. Restoration involves several stages, including the ability to predict accurately high quality habitat, to rear SFS to adulthood in large quantities, to create new habitat via hardwood removal to retard succession, or temporary inundation to create wetlands, and to introduce SFS into augmentation or experimental populations. Currently, Ft. Bragg is experimenting with different methods to restore these sensitive habitats. The most important next steps to develop these efforts are to

continue to monitor the restored wetland habitat experiment to determine which treatment is most effective in supporting St. Francis' satyr populations, and whether these sites act as sources or sinks for the overall metapopulation and to identify suitable habitat off of Ft. Bragg.

2. Overutilization for commercial, recreational, scientific, or educational purposes: Since the emergency listing of the species in 1994 and simultaneous federal prosecution of illegal butterfly collectors (Williams 1996), there has been no evidence of collection of SFS other than minimal permitted collection for scientific purposes. However, poaching remains a significant threat to the SFS based on its extreme rarity and has required that all locations of all colony sites be kept strictly confidential among researchers. If these sites were made known to the general public, it is likely that individuals would be threatened by collection again and could face extinction.

3. Disease or predation: There has been no research into the presence of disease in the SFS population and minimal research into levels of predation. These were not indicated as problems in the recovery plan or any subsequent publication, since most of the focus on threats to the population lies with maintaining suitable habitat and protection of adult butterflies. The short lifespan of adults most likely limits the ability of any disease to establish, although larvae may be susceptible. *Wolbachia*, a bacterial parasite, has been detected in Mitchell's satyr, and there is preliminary evidence that it also infects SFS (C. Hamm, Michigan State University, undated, pers. comm.). Predation has been observed directly by other invertebrates (most notably dragonflies and spiders), and indirectly by birds (beak marks on wings have been observed in around 5% of adults [Hall et al. 2001, Haddad et al. 2003, Haddad et al. 2004, Haddad et al. 2005]). There is no clear evidence that these predators are a threat to adult population sizes (Haddad et al. 2006).

4. Inadequacy of existing regulatory mechanisms: The SFS is protected by the Endangered Species Act of 1973 but has no additional protection in the state of North Carolina. Permits are required for all research conducted on the species and are currently held by researchers at North Carolina State University and Mississippi State University. Since the entire species range is restricted to military lands, current regulatory mechanisms provide adequate protection to prevent human-induced habitat destruction. However, the inability to access and evaluate subpopulations within impact areas limits the ability to accurately assess subpopulation sizes and to estimate how many individuals are left in the wild. Without systematic monitoring, the fate of these subpopulations will remain uncertain relative to their viability and potential as source populations for other sites.

5. Other natural or manmade factors affecting its continued existence: None

2.4 Synthesis

The primary threats to the SFS at the time it was listed as Endangered were over-collection and habitat loss. These threats remain relevant today, and without federal protection the likelihood of extinction of SFS would increase. In addition, small population size, limited dispersal ability and highly restricted distribution range make the SFS highly vulnerable. Environmental stochasticity has always influenced population structure, although current habitat conditions persist under limited disturbance regimes, which greatly affect population fluctuations. With the elimination of natural controls to create wetlands and then prevent succession, suitable habitat has become much less prevalent and can be easily eliminated by small-scale, short-term environmental events. The few remaining subpopulations that constitute the metapopulation are under high pressure to act as source populations for new colonization. Knowledge about total population size, species-habitat interactions, and what constitutes suitable habitat has greatly improved since the time of the recovery plan but is still lacking in important details. As a result, SFS populations remain at a critically low level and require continued management intervention to persist in the wild. We conclude that the SFS continues to meet the definition of an Endangered species and should remain listed as such.

3.0 RESULTS

3.1 Recommended Classification

X No change is needed

3.2 New Recovery Priority Number

X No change is needed

Brief Rationale: We propose no change to the listing classification of the SFS. All known populations are restricted to DoD lands at Ft. Bragg and consist of a loosely connected metapopulation both inside and outside impact areas. Two additional subpopulations have not been discovered or established off Ft. Bragg, within the species historic range. Population numbers at Ft. Bragg have remained stable for eight years, with an historic high observed in 2004. The eight years of research collected on SFS population size has not been sufficient to evaluate the stability (or lack thereof) of existing populations for 10-15 years, which was stated as the main criterion for recovery. Further, SFS population dynamics are governed by beaver dynamics and, to a lesser extent fire, which allow the resetting of succession necessary for high quality habitat to persist and slow or prevent the establishment of unsuitable late-successional habitat. Until the effects and interactions between different types of disturbances on SFS abundances and distributions can be better understood, the species will remain critically rare. The current classification of Endangered continues to prevent over-collection of the species, which was one of the main threats originally leading to listing.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Continued long-term monitoring of all sites with known SFS populations and all historically known sites outside artillery impact areas. The recovery plan calls for detailed monitoring for at least 10-15 years that shows populations as stable or increasing, and this trend cannot be shown with current information.
- Increased monitoring of populations within impact areas. It is crucial to obtain accurate estimates of subpopulation sizes within impact areas to determine the total number of SFS remaining in the wild. Even short annual surveys performed during one flight period would provide population information needed to evaluate recovery and understand habitat factors needed for restoration.
- Preservation of existing suitable habitat. Rapid decline in high quality wetland habitat from succession, drought, or other environmental factors could quickly eliminate large established populations that could act as source populations for further colonization. If these potential source populations decline, there will be additional reliance on using captive-raised individuals to establish new sites which could result in reduced genetic variation in the metapopulation overall. More work is needed on how to manage disturbances to optimize habitat suitability.
- Restoration of new suitable habitat for colonization. These sites should closely resemble already established sites and provide high quality habitat for breeding individuals with low potential for human disturbance. Ideally these sites would be established through planned management practices and subsequently maintained through natural periodic disturbance regimes. Determining the effects of fire on SFS habitat and metapopulation dynamics requires more investigation. Efforts to restore habitat through hardwood

removal and temporary inundation could prove important in increasing the area of suitable habitat for the butterfly.

- Continued augmentation of existing populations using captive-reared individuals. The sedentary lifestyle of adults and infrequently observed dispersal events of individuals suggests that colonization of new sites may be difficult to accomplish through regular dispersal among fragmented sites, but could occur with assisted releases. Captive-reared individuals provide an excellent source from which to create new colony sites and could create a link between fragmented populations that would allow population growth.
- Establishment of experimental populations off of Ft. Bragg. To be delisted, SFS will need to occur in two additional populations outside of Ft. Bragg. There are public lands in the vicinity of Ft. Bragg such as the Sandhills Gamelands and the Sandhills National Wildlife Refuge, as well as lands held by non-profit conservation organizations that may be ideal areas to identify or restore habitat suitable for experimental populations. Additional research to determine the exact species historic range would aid and possibly expand choices for population establishment off base.
- Continued habitat surveys to determine key vegetation characteristics of high quality sites. Surveys should be conducted at sites both inside and outside artillery impact areas. These should incorporate possible effects of sedimentation and erosion of roads on vegetation.
- Continued improvement of habitat suitability models through ground-truthing. These can potentially lead the discovery of new SFS populations, which would greatly improve species outlook and may add additional information on habitat requirements.
- Develop a Memorandum of Agreement between Ft. Bragg, USFWS and the NC Natural Heritage Program that sets specific policies that coordinate SFS, beaver and fire management. Further, Ft. Bragg should share (with the above listed parties) their records of where, when and how specific beaver and fire management operations were and will be conducted.
- Additional study for SFS dispersal mechanisms and behavior. Understanding their dispersal dynamics will have important management implications.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of St. Francis Satyr (*Neonympha mitchellii francisci*)

Current Classification:

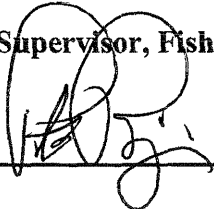
Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Coordinated By: Dale W. Suiter and Sarah McRae, Fish and Wildlife Biologists,
Raleigh Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 11/15/13

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve  Date 12-26-13

APPENDIX A
Summary of peer review for the five-year review of
St. Francis Satyr (*Neonympha mitchellii francisci*)

A. Peer Review Method:

A draft copy of the five-year review was emailed to biologists at the N.C. Natural Heritage Program and Fort Bragg's Endangered Species and Environmental Management Branches. Reviewers provided comments by email, and by modifications to the original document. All of the peer reviewers know the species and are familiar with habitat where it occurs and the threats to its long term survival.

B. Peer Review Charge:

Peer reviewers were asked to provide written comments on the information presented in our analysis of the St. Francis Satyr and to provide comments on the validity of the data. Peer reviewers were asked not to provide recommendations on the legal status of the species.

C. Summary of Peer Review Comments/Report:

In general, the peer reviewers provided positive feedback and some specific comments. One reviewer from the NC Natural Heritage Program provided minor comments throughout the document and was specifically interested in the need to define historic range of the species and determining the level of protection for this species (an invertebrate) on non-federal lands should it be discovered or introduced there. His comments and suggestions were generally accepted.

One reviewer from Ft. Bragg's Endangered Species Branch provided minor edits and suggestions based on their first hand knowledge of the populations and their management at Ft. Bragg. A reviewer from Ft. Bragg's Environmental Management Branch provided extensive comments on the draft document. Many of these comments were redundant or repetitious to the existing text. For the sake of brevity, the additional text was not included in the report. Comments that were substantial or unique were incorporated into the document.

D. Response to Peer Review:

The primary author was in agreement with many of the comments and concerns received from the peer reviewers and tried to address each comment, when appropriate.