Species Status Assessment Report
for
Speyeria nokomis nokomis

Prepared by the Western Colorado Field Office
U.S. Fish and Wildlife Service Ecological Services, Grand Junction, Colorado

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Contributors and Acknowledgements

This document was produced by Terry Ireland – Western Colorado Field Office (FO), with assistance of the Speyeria nokomis nokomis Core Team including Tracey Switek – Utah FO, Eliza Gilbert – New Mexico FO, John Nystedt – Arizona FO, Creed Clayton – Western Colorado FO, and Justin Shoemaker – DOI Regions 5&7. Aimee Crittendon – Western Colorado FO produced the range map. Kurt Broderdorp – Western Colorado FO reviewed the document for consistency with SSA guidance and format. John Guinotte - DOI Regions 5&7 facilitated climate model selection and coordinated with climate modeler Imtiaz Rangwala – North Central Climate Adaptation Science Center & CIRES, University of Colorado, Boulder, who quickly provided climate information for the S. n. nokomis range.

Significant and invaluable input to nearly all aspects of this SSA as well as contribution of literature was provided by the Technical Team members including Scott Ellis, Mike Fisher, Steve Cary, Alan Myrup, and Chad Smith. A special thank you goes out to Scott for coordinating with land owners and leading field trips in 2018 and 2019 to determine current status of colonies and collect a few specimens for genetic analysis.

Dr. Paul Opler – Colorado State University (CSU) provided biological information early on as well as facilitated information on species locations and allowed Scott Ellis to obtain numerous S. nokomis specimens from the Gillette Museum at CSU for genetic analysis. This SSA was also substantially helped by technical input and quick processing of a whole genome analysis from Dr. Nick Grishin (Howard Hughes Medical Institute and Departments of Biophysics and Biochemistry, University of Texas Southwestern Medical Center) in addition to primary authors Qian Cong (Institute for Protein Design and Department of Biochemistry, University of Washington), and Jing Zhang and Jinhui Shen both from the Departments of Biophysics and Biochemistry, University of Texas Southwestern Medical Center. Without the genomic analysis, range delineation of S. n. nokomis would have remained uncertain as it had been for over a century. The population and viability analysis for this SSA would have thus been skewed with likely inclusion of two major populations (Chuska Mountains and Uinta Mountains) and at least part of another major population (Great Basin and Southwest Utah Mountains) that are now known to be hybridized with other S. nokomis subspecies and are now considered outside the range of S. n. nokomis proper.

Authors Note: *Due to disruption by COVID-19 a final genetic report was not written in time for this version of the SSA. Therefore, names of a couple populations and some other minor details differ between the draft genetic report (Cong et al. 2019) and this SSA.*

Suggested reference: U.S. Fish and Wildlife Service. 2021. Species status assessment report for *Speyeria nokomis nokomis*. Grand Junction, Colorado.

EXECUTIVE SUMMARY

This species status assessment (SSA) report communicates the results of the comprehensive biological status review by the U.S. Fish and Wildlife Service (Service) for a subspecies of silverspot butterfly (*Speyeria nokomis nokomis*), and provides a thorough account of the subspecies' overall viability and, therefore, extinction risk. This SSA report provides the best available biological information to advise a 12-month Finding listing decision, as required by the Endangered Species Act (ESA).

To evaluate the biological status of *S. n. nokomis,* both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation (together, the 3R's).

Chapter 2 describes what the different life stages of *S. n. nokomis* look like, the taxonomy and genetics of the species, the distribution, habitat requirements, life cycle, and ecological needs of individuals, populations, and the species. The butterfly is relatively large with up to a 3-inch wingspan. The males are typically bright orange on the upper side and females are typically cream to light yellow with brown or black. The underside wings of both sexes have silvery-white spots giving them their generic common name of silverspot butterfly. The butterfly completes its entire life cycle in one year.

Based on recent genetic analysis, there are 5 silverspot subspecies in the United States and Mexico with 10 major populations of *S. nokomis* within the United States. A new range for *S. n. nokomis* is established in this SSA based on the genetic analysis and limits the distribution to east-central Utah through western and south-central Colorado and into north-central New Mexico. The genetic work revealed eight populations of *S. n. nokomis* plus there are two other populations that are derived from observation-only for a total of 10 currently known populations. Due to the new range delineation the former common name, Great Basin silverspot butterfly, is no longer valid as it is not found within the Great Basin; therefore, the subspecies is only currently known by its scientific name.

Populations of *S. n. nokomis* are known to occur between 5,200 and 8,300 feet. The butterfly requires moist habitats in mostly open meadows with a variety of herbaceous and woody vegetation. *S. n. nokomis* eggs are laid on or near the bog violet (*Viola nephrophylla*/*V. sororia* var. *affinis*), which the larvae feed on exclusively. A variety of flowering plants provide adult nectar sources.

Chapter 3 assesses the current condition of *S. n. nokomis*. Habitat loss and fragmentation; incompatible livestock grazing; human-caused hydrologic alteration; and genetic isolation are considered major factors influencing the species and can affect the 3 R's and species viability. However, if implemented properly, mowing for native hay, grazing, and burning can be compatible and beneficial for *S. n. nokomis*. Populations of *S. n. nokomis* are genetically isolated due to intermittent occurrence of suitable habitats throughout their range.

There are currently 19 colonies representing the 10 populations that are considered extant and were analyzed for current (and future) condition. Current resiliency for each population ranges from very low (five populations) to high (two populations) with one population having low resiliency and another two populations having moderate resiliency. Current redundancy is determined to be moderate and representation is thought to be low – moderate.

Chapter 4 assesses future condition for *S. n. nokomis*. We consider four plausible future scenarios that include climate model predictions out to 2050 as well as conservation measures in two scenarios. Scenario 1 has relatively mild predicted climate change and with conservation measures population resiliency is predicted to increase with eight populations in moderate condition and two in high condition. Representation and redundancy are predicted to increase to moderate in Scenario 1. In Scenario 2, population resiliency is again predicted to increase from the current condition with six populations in moderate condition, two high, and two low. Representation and redundancy are again predicted to be moderate under Scenario 2. Climate is predicted to change rather significantly in scenarios 3 and 4, negating any conservation measures even if implemented, and the species overall future condition (in term of the 3R's) is predicted to decrease from current condition under both scenarios. In scenarios 3 and 4, we predict one population to be in moderate condition, three to be low, one very low, and five to be extirpated. Under both scenarios 3 and 4, representation is predicted to decrease to low and redundancy decreases to very low. Based on the best available information, the subspecies is projected to be in better overall future condition (in terms of the 3R's) in scenarios in which climate change is mild and conservation measures are implemented. Although *S. n. nokomis* has survived through severe and sustained drought over past millennia, future habitat conditions may preclude its survival especially if the climate changes as predicted in scenarios 3 and 4.

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CHAPTER 1: INTRODUCTION

1.1 Background

The Service published a proposed rule in 1978 to designate *Speyeria nokomis nokomis* as either threatened or endangered under the Endangered Species Act of 1973, as amended (Act). In 1984 it was placed on the category 2 candidate list in a notice of review. Category 2 candidate species comprised taxa for which information was in possession of the Service indicating that a proposal to list the species as endangered or threatened was possibly appropriate, but for which conclusive data on biological vulnerability and threat(s) was not currently available to support proposed rules at the time. Subsequent notices of review in 1989, 1991, and 1994 also included it as a category 2 candidate species. In February 1996, the Service proposed removing all category 2 species in a candidate species notice of review and finalized this action in a December 1996 notice of final decision. This resulted in the removal of *S. n. nokomis* from the candidate list. In 2013, the Service was petitioned to list *S. n. nokomis* by WildEarth Guardians. In 2016, the Service issued a 90-day finding stating that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted and announcing our intent to proceed with a status review.

We conducted this Species Status Assessment (SSA) to compile the best scientific and commercial data available regarding the species' biology and factors that influence the species' viability. This SSA report will be the biological underpinning of the Service's forthcoming listing decision for the species. Should this species become listed under the ESA, we intend this report to support all functions of our Endangered Species Program and we will update it as new information becomes available. The SSA process and this SSA report do not represent a regulatory decision by the Service under the ESA. Instead, this report provides a review of the best available information strictly related to the biological status of *S. n. nokomis* and our scientific evaluation of its current and future condition.

1.2 Analytical Framework

This report summarizes our SSA analysis for *S. n. nokomis* using the SSA framework (Smith *et al.* 2018). The SSA framework is an analytical framework with three assessment stages:

1. **Species Needs.** An SSA begins with a compilation of the best available biological information on the species (taxonomy, life history, and habitat) and its ecological needs at the individual, population, and species levels, based on how environmental factors act on the species and its habitat.

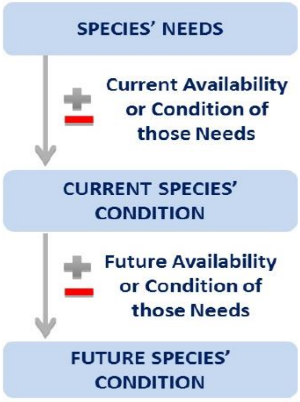

Figure 1. Species status assessment stages. Source: USFWS (2016).

2. **Current Species Condition.** Next, an SSA describes the current condition of the species' habitat and demographics, identified in step one, Species Ecology, and the probable explanations for past and ongoing changes in those needs, such as abundance and distribution within the species' ecological settings (i.e. areas representative of the geographic, genetic, or life history variation across the species range).

3. **Future Species Condition.** Lastly, an SSA forecasts the species' response to probable future scenarios. The SSA characterizes a species' ability to sustain populations in the wild over time (viability) based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings.

To assess viability, we use the conservation biology principles of resiliency, redundancy, and representation, also referred to as the 3R's (Shaffer and Stein 2000; Wolf *et al*. 2015).

- **Resiliency** is the ability of a species' population to respond to and recover from disturbances and perturbations. These include the normal year-to-year variation in rainfall and temperature, as well as stochastic events such as fire, flooding, and storms. Generally speaking, resilient populations have abundant individuals within habitat patches of adequate size and quality to maintain survival and reproduction in spite of disturbance. Simply stated, resiliency is having the means to recover from "bad years." Connectivity between populations may add to a given population's resiliency through the exchange of individuals or genetic material from neighboring populations.

- **Redundancy** is the ability of a species to withstand catastrophic events. Redundancy protects species against the unpredictable and highly consequential events for which adaptation is unlikely. In short, it is about spreading the risk. Redundancy is best achieved by having multiple populations widely distributed across the species' range. Having multiple populations reduces the likelihood that all populations would be impacted simultaneously, while having widely distributed populations reduces the likelihood of populations possessing similar vulnerabilities to a catastrophic event. Given sufficient redundancy, no single or multiple catastrophic events are likely to completely wipe-out a species. Thus, the greater redundancy a species has, the more viable it will be.

- **Representation** describes the ability of a species to adapt to long-term changes in the environment; it is the evolutionary potential or flexibility of a species. Representation is the range of variation found in a species, and this variation (called adaptive diversity) is the source of species' adaptive capabilities. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (environmental variation) of populations across the species' range. The greater the adaptive diversity, the more responsive the species will be over time and thus, the more viable the species will be. Maintaining adaptive diversity includes conserving both the ecological diversity and genetic diversity of a species. Ecological diversity is described by the physiological, ecological, and behavioral variation exhibited by a species across its range. Genetic diversity is defined by the number and frequency of unique alleles within and among populations.

> In addition to preserving the breadth of adaptive diversity, maintaining evolutionary potential requires maintaining the evolutionary processes that drive evolution; namely, gene flow, genetic drift, and natural selection. Gene flow is expressed through the physical transfer of genes or alleles from one population to another through immigration and breeding. The presence or absence of gene flow can directly affect the size of the gene pool available. Genetic drift is the change in the frequency of alleles in a population due to random, stochastic events. Genetic drift always occurs, but is more likely to negatively affect populations that have a smaller effective population size and populations that are geographically spread and isolated from one another. Natural selection is the process by which heritable traits can become more (selected for) or less (not selected for) common in a population based on the reproductive success of an individual with those traits. Natural selection influences the gene pool by determining which alleles are perpetuated in particular environments. This selection process generates the unique alleles and allelic frequencies, which reflect specific ecological, physiological, and behavioral adaptations that are optimized for survival in different environments.

Together, the 3R's—and their core parameters of abundance, distribution, and diversity—comprise the key characteristics that contribute to a species ability to sustain populations in the wild over time. When combined across populations, they measure the health and viability of the species as a whole.

1.3 Materials and Methods

Species experts on (and off) the Technical Team contributed much *S. n. nokomis*-specific information and provided review of this document. Literature was also reviewed and original sources were obtained when possible.

CHAPTER 2 – SPECIES ECOLOGY

2.1 Key Findings

Chapter 2 describes what the different life stages of *S. n. nokomis* look like, the taxonomy and genetics of the species, the distribution, habitat requirements, life cycle, and ecological needs of individuals, populations, and the species. *S. n. nokomis* adults are large and showy with the males being a bright orange on the upper side with black markings and the females generally being yellow and brown (Figures 2, 5, and 6). The underside of both sexes are slightly different from each other but both have silvery-white spots, particularly on their hindwings (Figures 3, 4, 7, and 8). The butterfly completes its entire life cycle in one year but there are five stages in the butterfly life cycle: the egg; pre-winter 1st instar larva; post-winter 1st – 6th instar larva; pupa; and adult. Description of the eggs, larvae, and pupae are in section 2.2.

Silverspot butterflies are in the Order Lepidoptera (butterflies and moths), are in the Family Nymphalidae (brush-footed butterflies), and in the subfamily Heliconiinae. Based on recent genetic analysis a new range for *S. n. nokomis* has been established. The genetic work reveals 5 subspecies including 10 distinct major populations of *S. nokomis* throughout the U.S. and limits the distribution of *S. n. nokomis* specifically to Colorado, New Mexico, and east-central Utah.

Populations of the butterfly are known to occur between 5,200 and 8,300 feet in mountain valleys or near the base of mountains in floodplains. The butterfly requires moist habitats with a variety of herbaceous and woody vegetation, which provide breeding, feeding, and sheltering sites. Eggs are laid haphazardly on a variety of vegetation including on and near the bog violet (*Viola nephrophylla*/*V. sororia* var. *affinis*), which the larvae of *S. n. nokomis* feeds on exclusively. The bog violet only grows in wet meadows supported by springs, streams, and near-surface groundwater, which are, in turn, supported by meltwater from valuable mountain snowpack. Light interspersion of willow (*Salix* spp.), other shrubs, or trees in the meadows or somewhat thicker woody vegetation at the margins of meadows appears beneficial for egg laying, as well as providing protection of the violet and larval butterflies. Occasional natural or human-induced disturbance is likely beneficial to set back succession of both woody and herbaceous vegetation in order to enhance growth of violets. A variety of flowering plants are adult nectar sources, providing energy for mate finding, mating, and egg laying.

For populations to be moderately or highly resilient at least 3 colonies with a minimum total of at least 12 acres of habitat may be needed. More colonies and larger habitat acreages undoubtedly provide more resiliency. Populations with sufficient amount of suitable habitat and multi-colony metapopulations are likely more resilient than single-colony populations, unless perhaps the single colonies are very large. The number of individual butterflies needed in each colony or metapopulation to be resilient is not known but the more butterflies the more likely genetic diversity will be maintained in a population and throughout the subspecies. Populations of *S. n. nokomis* are isolated due to intermittent occurrence of suitable habitats throughout their range. Some of this isolation is likely natural but some is likely due to human fragmentation of habitat. Redundant and resilient populations no more than 10 miles apart and covering different ecological settings (representation) would provide a greater chance of naturally maintaining genetic diversity and viability of the subspecies. Representation appears evident through differing elevations of colonies and populations and differing genetic representation in populations. Distribution of the butterfly was originally obtained using a public database but was refined by species experts on the SSA's Technical Team.

Figure 2. Male S. n. nokomis upper side. Photo by Terry Ireland, USFWS, Unaweep Canyon, Aug. 2018.

2.2 Species Description

Adults

S. n. nokomis are the largest *Speyeria* and adults have wingspans from 6.3 to 7.9 cm (2.5 to 3.1 inches) (Selby 2007, p. 14). The adults are dimorphic (Figures 2-8). The upper side of the male's forewings and hindwings are orange-brown basally and bright orange distally. The upper side of the female's forewings and hindwings are brown to black and cream to yellow. The underside forewing of both sexes is similar, being primarily light brown to orange with the most distal part shifting to cream, yellow, or light orange with a few silvery-white spots. The underside hindwing of both sexes has numerous silvery-white spots and is where the common name, silverspot butterfly, is derived. The wings of both sexes also have dark vermiculate markings, chevrons, and spots. In addition, the primary features of the male's underside hindwing are light brown to burnt-orange basal

Figure 3. Male S. n. nokomis underside. Photo by Terry Ireland, USFWS, Unaweep Canyon, Aug. 2018

Figure 4. Male S. n. nokomis underside. Photo by Mike Fisher, Unaweep Canyon, Aug. 1998.

Figure 5. S. n. nokomis female upper side. Photo by Robb Hannawacker, Aug. 2020.

Figure 3. Female S. n. nokomis upper side. Photo by Mike Fisher, Unaweep Canyon, Aug. 1998.

Figure 2. S. n. nokomis female underside. Photo by Robb Hannawacker, Aug. 2020.

discs with a light orange to yellow crescent. The female's underside hindwing basal discs are deep olive or brown with a yellow or cream crescent. The males have orange bodies, the females have dark brown or black bodies. Both sexes have brownish-orange antennae and the black clubs are tipped with orange.

Subspecies of *S. nokomis* have historically been morphologically differentiated by the underside hindwing disc, though variation in the discs and rest of the wings and bodies can occur even within a subspecies due to environmental or genetic influences. Compare the male underside hindwing discs in figures 3 and 4 and the female underside hindwing discs in figures 7 and 8 for indication of color variation. Also the upper side can vary especially in females; see figures 5 and 6. Future surveyors can attempt to use morphological characteristics to determine subspecies if genetic analysis is not immediately available. However caution should be used due to variability. General descriptions of hindwing disc coloration between *S. nokomis* subspecies are described in Appendix A.

Figure 6. Female S. n. nokomis underside. Photo by Mike Fisher, Unaweep Canyon, Aug. 1998.

Larva

There are six larval stages. Each stage grows by an average of 60 percent and head capsule size increases from 0.35 to 3.5 millimeters (mm) from the first to last stage (Scott and Mattoon 1981, p. 12). Specific lengths of *S. n. nokomis* larva have not been measured (Mike Fisher, pers. comm., 2020a). However, 1st instar larvae of different species of *Speyeria* are described as being 1-2.5mm (Sims 2017, p. 1) and eastern *S. cybele* which may be as large as *S. n. nokomis* (Mike Fisher, pers. comm., 2020a) may grow to 55mm in their 6th instar stage (Dunford 2007, p. 31). Larvae are "orangish-ochre, dark beneath, with six rows of long orangish-ochre spines, black patches around dorsal and subdorsal spines, two black transverse stripes on the rear of each segment, and orangish-ochre lateral and dorsal stripes; head black, orangish on top rear" (Scott 1986, p. 326; Selby 2007; pp. 14,17). Figure 9 shows a 6th instar larva.

Figure 7. Mature S. n. nokomis larva from Mesa County, Colorado. Photo by Steve Spomer.

Pupae

The pupae of *S. n. nokomis* are “orangish-ochre, with a black transverse serrate band on the front of each abdomen segment (Figure 10). The thorax and most of the wing are primarily black. The top of the thorax has an orangish triangular spot” (Scott 1986, p. 326; Selby 2007, p. 17).

Figure 8. Pupae of S. nokomis from Chuska Mountains, New Mexico. Photo by James Scott (Scott 1986, Color Plate 5; copied from Selby 2007, p. 16).

2.3 Species Taxonomy

The following table represents a simple arrangement of the taxonomy of *S. n. nokomis*.

Table 1. Taxonomic classification of S. n. nokomis.

Kingdom	Phylum	Class	Order	Family	Genus	Species	Subspecies
Animalia	Arthropoda	Insecta	Lepidoptera	Nymphalidae	Speyeria	nokomis	nokomis

The genus of the species has shifted over time. Edwards (1862) originally assigned the species’ genus as *Argynnis* (Fabricius 1807) but a subsequent classification named it *Speyeria* (Scudder 1872), for which it remained for 148 years. However, based on genomic analysis Zhang et al. (2020, pp.1, 17) switched the genus back to Edwards’ original name of *Argynnis* and the name change was recently and officially recorded in the nationally recognized list of Butterflies of America (Pelham 2021). Except for a few minor details this SSA was written prior to the official name change. As such, we are leaving the genus as *Speyeria* in this version of the SSA but will change it to *Argynnis* during the first update to the SSA whenever that occurs.

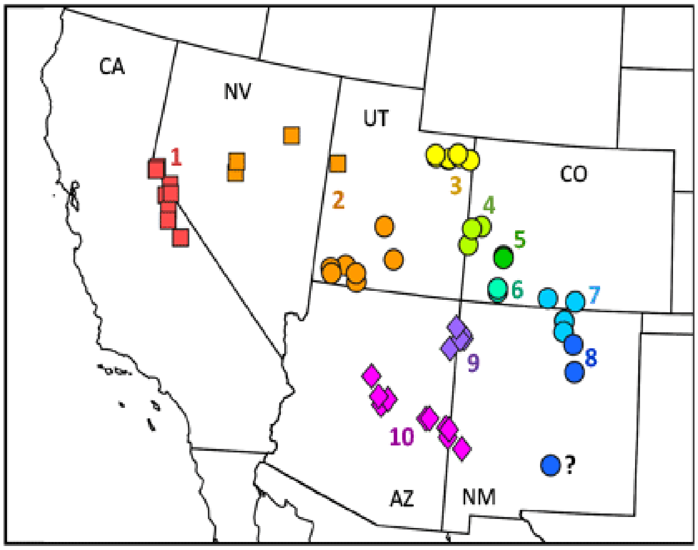

Figure 11. S. nokomis populations based on PCA analysis (Cong et al. 2019, Figure 6, p. 7)

A recent whole genome analysis conducted by Cong *et al.* (2019) has reduced the number of subspecies from six (as described in Selby 2007, p.13) to five. Additionally, the genetic evidence by Cong *et al.* (2019) supports information in Selby (2007, p. 11), which suggested (through morphology) that there is a greater degree of genetic mixing with

S. n. apacheana as one heads further west from western Colorado or with *S. n. nitocris* as one heads further south and southwest from the Four Corners area. Cong *et al*.'s (2019) analysis consequently, suggests that the range of the nominal *S. n. nokomis* does not enter the Great Basin and thus the common name Great Basin silverspot butterfly is a misnomer. Therefore, we are using only the scientific name *S. n. nokomis* when referring to the subspecies of focus addressed in this SSA report and use *S. nokomis* to refer to the species in general.

Cong *et al*. (2019) also suggests that there are three "segregates" with varying levels of genetic mixing causing them to be intermediate hybrids between the nominal subspecies of *S. n. nokomis*, *S. n. apacheana*, and *S. n. nitocris*. Figures 11 and 12 describe the unaffiliated segregates and names of major populations that make up identified subspecies (Cong *et al*. Figure 6, p.7; Figure 9, p. 10). The segregate identified as Population 2 (or Great Basin and Southwest Utah Mountains) is a mix between all three subspecies, though primarily between *S. n. nokomis* and *S. n. apacheana* with minimal transgression of *S. n. nitocris* genes (Cong *et al*. 2019, Figure 14, p. 17). In fact, the gradation (or cline) is most apparent in Population 2 where the eastern half is more similar to *S. n. nokomis* (orange circles) and the western half is more similar to *S. n. apacheana* (orange squares) (Cong *et al*. 2019, Figure 6, p. 7). Population 3 (or Uinta Mountains) is a mix between *S. n. nokomis* and *S. n. apacheana*. Population 9 (or Chuska Mountains) is a mix between *S. n. nokomis* and *S. n. nitocris*. These hybrid segregates are not included within the range of *S. n. nokomis* due to the degree of genetic mixing with the other respective subspecies and are unaffiliated with any one subspecies (though they are still *S. nokomis*). Population 1 is subspecies *S. n. apacheana*, Populations 4-8 constitute subspecies *S. n. nokomis*, and Population 10 is *S. n. nitocris*. The other two subspecies *S. n. coerulescens* and *S. n. wenona* are primarily or fully in Mexico and are not shown in Figures 11 or 12. As the climate has warmed and dried since at least the last ice-age over the last several thousand years, it is likely that sub-speciation has occurred since habitat has become fragmented. Consequently, it is likely that introgression of genes into *S. n. nokomis* from the other subspecies or segregate populations no longer occurs or occurs infrequently enough to not swamp the genetic makeup of *S. n. nokomis* thus retaining the subspecies. In fact, as presented in figures 11 and 12 here and Figure 14 in Cong *et al.* (2019, p. 17) the genetic analysis has been able to detect isolation of populations 4-8 from each other with little sign of interbreeding. Consequently, based on evidence it is likely that sub-speciation due to fragmentation of habitat and genetic isolation has been occurring for centuries and there's little chance that introgression of genes will occur from outside of the *S. n. nokomis* range or if introgression does occur that it occurs infrequently enough to not substantially alter the genetic makeup of *S. n. nokomis*.

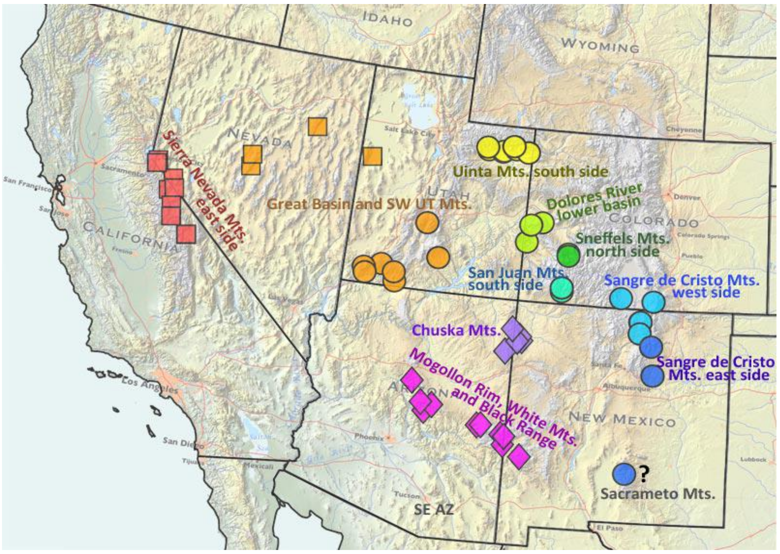

Figure 12 provides names for each of the numbered populations as identified in Cong *et al*. (2019, Figure 10, p.9). Population names are consistent in this SSA when referring to the unaffiliated segregates (2 – Great Basin and Southwest Utah Mountains; 3 – Uinta Mountains; and 9 – Chuska Mountains) but we use subspecies names for the other populations (1 – *S. n. apacheana*; 4-8 – *S. n. nokomis*; and 10 – *S. n. nitocris*). Due to some genetic differentiation between geographic areas the subspecies *S. n. nokomis* is divided in Figures 11 and 12 into the five different populations (4-8) but the various analytic tools used in the analysis reveal that the populations are genetically similar enough to constitute the subspecies *S. n. nokomis* (Cong *et al*. 2019). Cong *et al*.'s (2019) findings of genetic clines are similar to previously published articles based on morphology (Swisher and Morrison 1969, p. 4; Ferris and Fisher 1971, p. 49). Selby (2007, pp. 11, 18) based his range maps on those two articles. Cong *et al*. (2019, p.22) point out in their conclusions that the Uinta Mountains Population "could be" included within the range of *S. n. nokomis*. Figure 13 below is a TreeMix analysis which illustrates that, though close to the nominal *S. n. nokomis* range (populations 4-8), the Uinta Mountains Population does branch off from the other populations (Cong *et al*., Figure 10, p.11). The genetic proximity is also consistent with the Principal Component Analysis (PCA) in Cong *et al*. (2019, pp. 4-11). However, one of the lead authors of Cong *et al*. (2019) stated that his opinion is that the Uinta Mountains Population should not be included in the range of the nominal *S. n. nokomis* (Dr. Nick Grishin, U. Texas – Southwestern, pers. comm., 2020a). Consequently, based on this opinion and the genetic evidence, the Service will not include the Uinta Mountains Population within the range of *S. n. nokomis*. The green line in Figure 13 below indicates that the Sneffels Mts. north side (aka San Juan Mts. North Side) is the suspected type locality for *S. n. nokomis*. Further information on the genetics can be found in Cong *et al*. (2019) and Appendix B. Additionally, discussion of existing and proposed common names can be found in Appendix C.

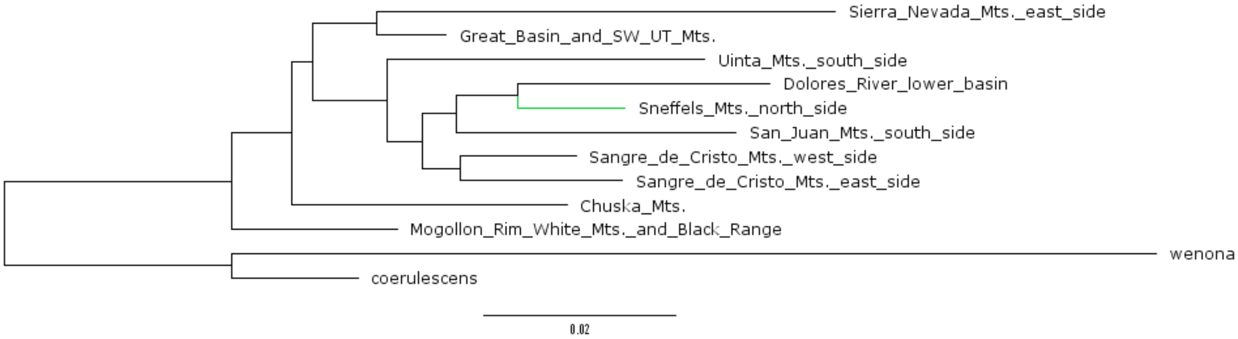

Figure 13. TreeMix analysis showing genetic branching-off of the Uinta Mountains Population (3) from nominal S. n. nokomis populations (4-8)(Cong et al. 2019, Figure 10, p.11).

Figure 12. S. nokomis population names (Cong et al. 2019, Figure 9, p. 10)

2.4 Current and Historic Distribution

Establishment and mapping of the Current Range

Based on the best available scientific information per recent genetic work, the range of *S. n. nokomis* is now better understood than it has been in over a century (Cong *et al.* 2019). As stated in section 2.3, the range now excludes the Great Basin and Southwest Utah Mountains area (Population 2), the Uinta Mountains area (Population 3), and the Chuska Mountains area (Population 9) for which inclusion in the *S. n. nokomis* range was previously uncertain (Selby 2007, Figure 3, p.11 and p.14). Genetic mixing between the subspecies appears to occur not far from the known locations of identified subspecies (Cong *et al*., 2019, p. 21).

Consequently, only a 30-mile buffer was established around *S. n. nokomis* sites in this SSA to establish the furthest extent of the range (Figure 14). This buffer distance was established with Cong *et al*.'s (2019, p.21) cautionary statement in mind but is also based on a rough upper average distance between known colonies or distances stray butterflies have been found from known colonies (Scott Ellis, pers. comm., 2020a; Mike Fisher, pers. comm., 2020b).

The buffer is established to include an area on the margins of the known range where *S. n. nokomis* could possibly be found in the future. However, this buffer estimate should be recognized as rough and it may be adjusted in the future if genetic analysis determines it should be adjusted. Based on Cong *et al*. (2019) and the small buffer around known locations of the butterfly a "new" broad-brush range based on a minimum convex polygon is thus illustrated in Figure 14.

It needs to be recognized, however, that no *S. n. nokomis* have ever been found east of the Sangre de Cristo Mountains in Colorado or the northern half of the range in New Mexico so the minimum convex polygon, especially with 30-mile buffer, is overly broad in this area and perhaps most of the eastern side of the range as drawn. Also, *S. n. nokomis* has never been known to occur ubiquitously across the range but rather occurs in small, isolated, patches of specific habitat within specific elevations as described further in section 2.5.

Populations 4-8 in Cong *et al*. (2019, Figure 6, p.7; Figure 11 above) cumulatively represent the range of *S. n. nokomis*. However, within these five major populations genetic analysis reveals that there is finer subdivision (Cong *et al*. 2019, Figure 8, p. 9; Figure 15 below). This finer subdivision identifies eight populations of *S. n. nokomis* that appear to be genetically isolated from one another. These eight populations are named in Cong *et al.* (2019, Figure 8, p. 9; Figure 15 below) after their counties of occupation as: Conejos, Costilla, La Plata, Mesa, Montrose, Ouray, San Miguel/Mora, and Taos.

Subsequent to Cong *et al*. (2019), and subsequent to Peer, Partner, and Technical Team review of the draft SSA, a colony in Grand County, Utah, was found to be genetically connected to the Mesa Population colonies (Nick Grishin, pers. comm., 2020b). Furthermore, a colony in San Juan County, Utah, was confirmed extant in August 2020 (Robb Hannawacker, pers. comm., 2020) and, due to its proximity (9 air miles) and geographic connection we are considering it part of the Montrose Population.

The approximate location of the Grand County colony is shown in Figure 14 but the location of the San Juan County colony is not. Due to these two pieces of last-minute information, we are changing the name of the Mesa Population to Mesa/Grand and are changing the name of the Montrose Population to Montrose/San Juan. There are two other locations that are observation-only (Archuleta and Garfield populations) that have not yet been genetically analyzed which are designated as their own populations in this SSA due to large geographic distance from neighboring populations. Consequently, there are 10 single-colony or multi-colony populations (containing 19 colonies) for which we will analyze current and future conditions.

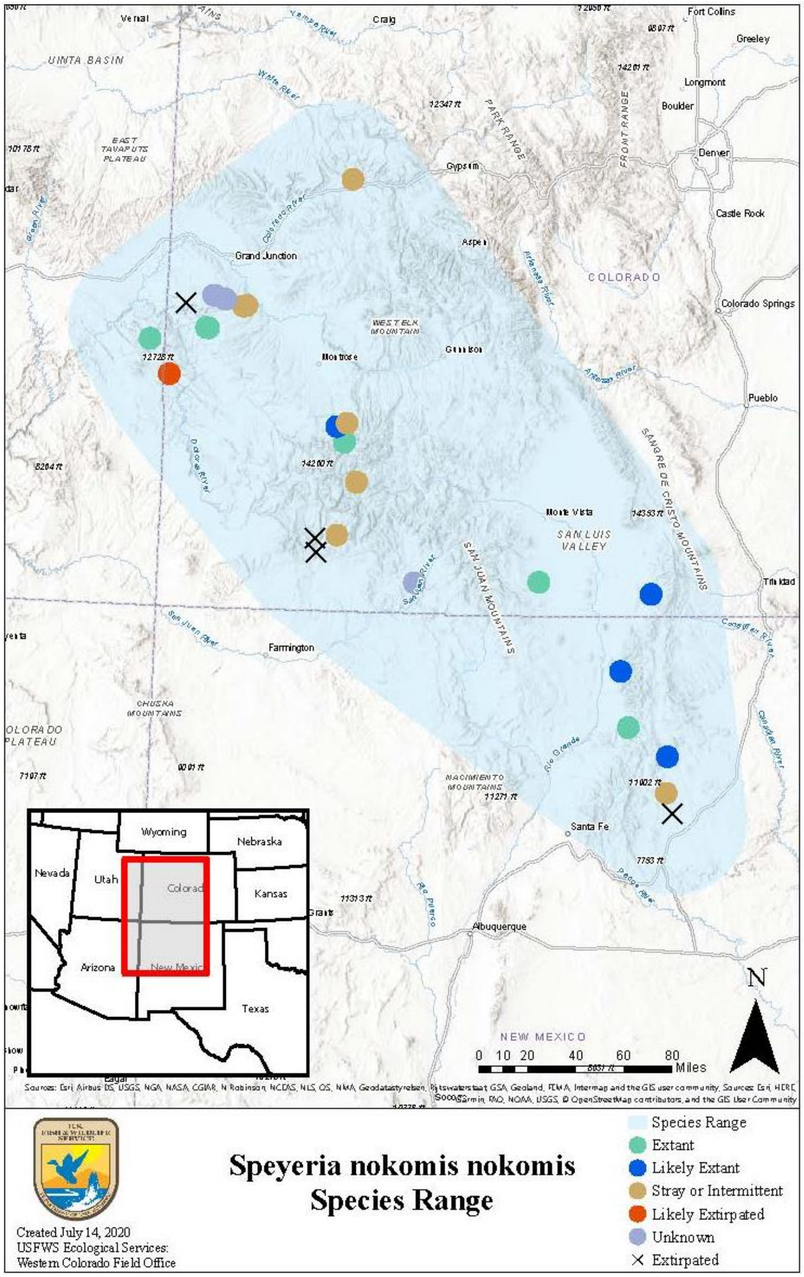

Figure 14. Speyeria nokomis nokomis range.

For, the rest of this report "population" refers to one of the 10 single-colony or multi-colony populations within the range of *S. n. nokomis*. We currently know of or consider there to be six single-colony and four multi-colony populations with 2-6 colonies each. If a population consists of more than one colony it is considered a metapopulation since butterflies from the colonies likely interbreed and may frequently or occasionally augment neighboring colonies (or likely did so within the last several decades). Three of the four metapopulations were determined genetically through Cong et al. (2019) to be connected.

However, the fourth metapopulation (Montrose/San Juan) is a presumed metapopulation based on proximity and geographic connection of the two colonies in the metapopulation since the recently confirmed colony has not been genetically analyzed. Due to the preponderance of single-colony populations the term population will be used most frequently even if referring to a metapopulation but the term metapopulation may also be used. A colony is defined in this report as an area known to be occupied at some point in time with sufficient bog violets to serve as a production area for *S. n. nokomis* and is largely separated from other habitat areas that produce *S. n. nokomis*. The colony areas also include surrounding nectar sources, so colony habitat areas may be larger than just the area where bog violets occur.

The Paradox colony in the Montrose/San Juan Population is likely extirpated, but because we could not confirm its extirpation as of writing this SSA, we will include it in the analysis of current and future conditions. Similarly, even though we couldn't confirm existence of the unknown, intermittent, and even likely extant colonies/populations in 2018 or 2019 we will consider them to be existing based on discussion with Scott Ellis and Mike Fisher (pers. comm., 2020) or Mike Fisher himself (pers. comm., 2020c) and will analyze them in the current and future conditions in this SSA. We are not including analysis of habitat for stray observations or for extirpated colonies and will only mention them as necessary.

Distribution records were initially retrieved from the Symbiota Collections of Arthropods Network (SCAN 2020) but were subsequently placed more precisely, and duplicate locations removed, based on expert input from Scott Ellis and Mike Fisher (pers. comm., 2020) and for the New Mexico populations with agreement by Steve Cary (pers. comm., 2020a). Status of individual colonies were also confirmed with Scott Ellis and Mike Fisher (pers. comm., 2020) or Mike Fisher himself (pers. comm., 2020c) (Figure 14). Colony locations in Figure 14 are broadly accurate but have been obscured/off-set to protect specific locations.

A colony first discovered in San Juan County, Utah, in 1978 by lepidopterist Dr. James Scott, but not known to us until shortly before publication of this report, was in fact confirmed to be extant in 2020. This population is within the range shown in Figure 14 and further discussion of it can be found in section 3.5. The FWS was also recently made aware of other potential colonies but those colonies' validity and current status need to be explored. Additional habitat areas and colonies could occur as well or be formed if flooding, for example, creates habitat suitable for the bog violet and butterfly. Should the potential colonies be found to be extant in the next few years (or other new colonies found) their status and current condition ranks will be included in an updated version of the SSA if and when an update occurs.

Historic Colonies

In exception to the range as shown, there is an additional location of *S. n. nokomis* not included in Figure 14 as explained further. This is for the formerly named "*S. n. tularosa*" specimens that supposedly came from south-central New Mexico near the town of Mescalero, Otero County (see further discussion in Appendix B). The specimens are now known through the Cong *et al.* (2019) genetic analysis to be S. *n. nokomis* and based on the genetics are likely south of the most southern (extirpated) site of the historic town of Beulah, New Mexico, shown on Figure 14 as an "X". This led Cong *et al*. (2019, p. 22) to state that Mescalero could be the specimens' location but their actual place of collection is unknown as the analysis simply proves that the specimens are likely south of Beulah (somewhere around the Sangre de Cristo Mountains). The town of Beulah was about 83 air miles to the north of Mescalero. The location of "Mescalero" on the label is suspicious because, besides the two Mescalero specimens, no *S. n. nokomis* or even other subspecies of *S. nokomis* have been found around the Sacramento Mountains in which the town of Mescalero is situated. Although Scott (1986, range map, p. 326), shows *S. nokomis* range going south to include the Mescalero area, Scott and Fisher (2014, p. 22) subsequently dismiss the location. However, another expert on the SSA's Technical Team stated that it is not a surprise that genetic similarity was found between the "*tularosa"* (Mescalero) specimens and the Beulah specimens since the paleoecological split between the Southern Rockies (Sange De Cristo Mountains) and the Sacramento Mountains was likely only 5-10,000 years ago versus the split from the Sacramento Mountains and Gila Mountains (in *S. n. nitocris* range) which happened at the onset of the Rio Grande rifting about 25 million years ago (Steve Cary, pers. comm., 2020b). Thus he agrees with Cong *et al.*'s (2019, p. 22) conclusion that the provenance (location) of the specimens may still need to be investigated and that the purported location of "Mescalero" on the labels could be correct, but "speculation abounds".

Therefore, based on the recent genetic analysis, the historic range almost certainly extended further south than what is shown on Figure 14, but whether that is, for example, 8 miles or 83 miles to the Sacramento Mountains is unknown. Wherever the "Mescalero" colony was located, it is likely extirpated or lepidopterists would have rediscovered it in the last 89 years (through 2020) since the 1931 collections. Consequently, for now we are only considering the "historic range" as including those areas of extirpated colonies as shown in Figure 14. In the future, should someone find *S. n. nokomis* in the Sacramento Mountains or between there and known locations to the north we will update the range map. Further, discussion of the known historic sites follows.

The exact location of the historic Beulah town site colony is not quite known and the town was subsequently named Buelacita, but also no longer exists. However, based on a "Buelacita" sign and finding of a sawmill foundation, large sawmill table, and sawmill blade in the 1970s the general location is thought to be known and, based on evidence, it appears the colony became extirpated after a number of homes were constructed and logging ceased. The cessation of logging may have also allowed encroachment of trees into the colony, further making it unsuitable for *S. n. nokomis* (Scott and Fisher 2014, p. 3).

Two of the other extirpated sites are in the La Plata Population north of Durango. One of these sites was quite large and well known but unfortunately became extirpated sometime shortly after 1987 when the Dalton golf course and surrounding subdivisions were built (Scott Ellis and Mike Fisher, pers. comm., 2020). The other colony was discovered by Scott Ellis but was smaller and was extirpated from a couple homes being built on the site shortly after 1990 (Scott Ellis and Mike Fisher, pers. comm., 2020).

The other known extirpated site is the Unaweep Seep colony which is part of the Mesa/Grand Population in Unaweep Canyon. A shift in vegetation to willow, grass, sedge (*Carex* spp.), and spike rush (*Eleocharis* sp.) was noted and may have caused elimination of the bog violet and thus extirpation of the colony (Arnold 1989, pp. 9, 14; Ellis 1999, pp. 3, 5, 6). Livestock grazing incompatible with the needs of the bog violet and butterfly may have caused the vegetation to shift, but this is only suspected based on it being the only major human management action on the area and no in-depth study to confirm this suspicion. The State of Colorado designated the area as a State Natural Area in 1983 in part because of *S. n. nokomis* (Ellis 1999, p. 2). The colony site is on Bureau of Land Management (BLM) land and a 2015 Resource Management Plan finalized an 85-acre Area of Critical Environmental Concern, again in part because of the butterfly, but also because of the site's unique geologic and hydrologic qualities that support a wide variety of species. Unfortunately, the colony likely became extirpated after Arnold's 1989 study or shortly after 1999 when Ellis (1999, p. 2, 7) noted very few bog violets remaining (no sightings of *S. n. nokomis* were mentioned). No monitoring we are aware of occurred from 2000 until 2017 when Terry Ireland and Heidi Plank (formerly BLM) surveyed it and no bog violets or *S. n. nokomis* were spotted (Terry Ireland and Heidi Plank, pers. observation, 2017).

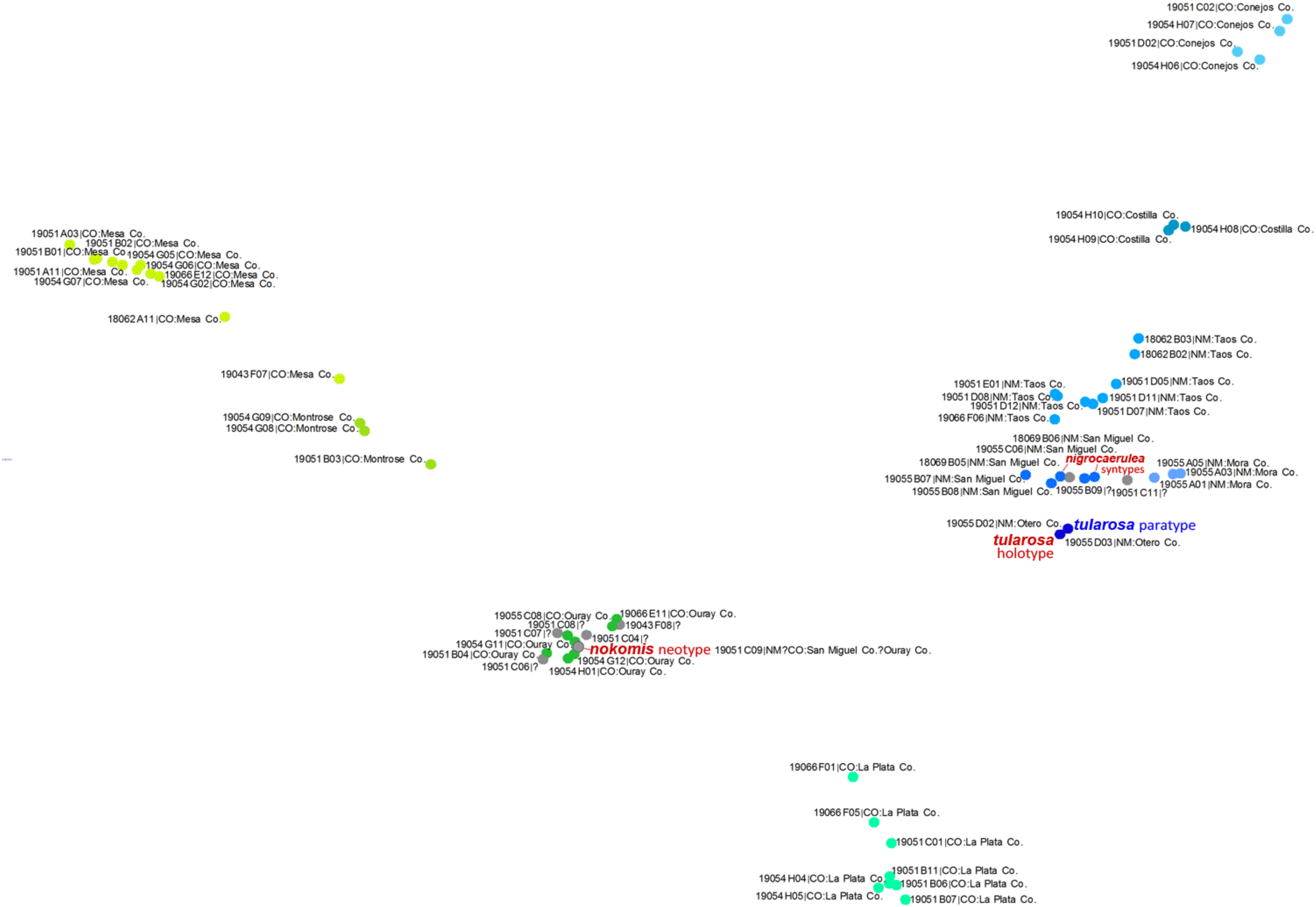

Figure 15. Genetically analyzed populations of S. n. nokomis used for analysis in this SSA (Cong et al. 2019, Figure 8, p. 9).

2.5 Habitat

Figure 16. Viola nephrophylla/V. sororia var. affinis (bog violet). Photo by Terry Ireland, USFWS, Aug. 2018

S. n. nokomis occurs in permanent spring-fed meadows, seeps, marshes, and boggy streamside meadows (Scott 1986, p. 326, Selby 2007 and references therein, p. 22). The only known larval host plant is *Viola nephrophylla/V. sororia* var. *affinis* (bog violet, Figure 16) (Scott 1986, p. 326; Tracey Switek, USFWS, pers. comm., 2020). Other *V. sororia* varieties or subspecies are not synonymous with *V. nephrophylla* (Tracey Switek, USFWS, pers. comm., 2020). Microhabitat for the bog violet is soggy soil and shade often under willows (*Salix* spp.) or other shrubs that are typically at the margins of the habitat or sparsely mixed in with herbaceous habitat (Figure 17) (Selby 2007 and references therein, p. 22). Associated herbaceous vegetation typically includes sedges, grasses, and forbs (Scott 1986, p. 326; Selby 2007, p. 22). The violet is widely distributed in the western U.S. but occurs in naturally scarce habitats subjecting it to threats from development or excessive grazing or hydrological alteration (Hovanitz 1969, p. 20; Hammond and McCorkle 1983, p.219; Selby 2007, p. 22). Forbs, which serve as nectar sources for adult *S. n. nokomis*, include native and introduced thistles (*Cirsium*, *Carduus*, etc.), horsemint (*Agastache*), joe pye weed (*Eupatorium maculatum*), and other native or introduced forbs; typically blue and yellow composites (Scott 1986, p. 327; Ellis 1989, p. 18; Selby 2007; p. 23).

Figure 17. Wet meadow habitat with Lepidopterist Scott Ellis looking at S. n. nokomis in Unaweep Canyon. Photo by Terry Ireland – USFWS, Aug. 2018.

S. n. nokomis is known to occur from roughly 5,200 feet to just over 8,300 feet in elevation (Scott Ellis and Mike Fisher, pers. comm., 2020). However, one observation is from 9,250 feet near Silverton, Colorado (SCAN 2020). Although the source is reliable in regards to the Silverton specimen's identification as *S. n. nokomis*, due to the elevation it is suspected that it was blown up the Animas River from an existing or now extirpated colony several miles downstream (Scott Ellis and Mike Fisher, pers. comm., 2020). Based on the currently known upper and lower colony elevations the butterfly's elevational range is expected to occur between 5,000 and 8,500 feet.

2.6 Life Cycle and Individual Needs

Figure 18 depicts the life cycle of *S. n. nokomis* (Scott and Mattoon 1981, pp. 12, 14; Selby 2007, p. 21). Eggs are typically laid in mid-September and take 10-18 days to hatch. Female *Speyeria* can lay many hundreds of eggs and even more than 600 eggs may be laid by a single female (Mattoon et al. 1971, p. 248; Paul Opler, Colorado State University, pers. comm., 2018). Eggs are laid singly and are typically not clustered though there have been as many as 8 eggs observed (laid singly) on a violet leaf (Arnold 1989, p. 12). In the only known study in nature of *S. n. nokomis* oviposition sites, and in order of frequency, eggs were observed being placed on bog violets, miscellaneous vegetation, grasses/sedges, and bark, typically within about three feet of violets (Arnold 1989, pp. 13, 23). Willow stems, trunks, logs, twigs, and debris are also often used (Selby 2007, p. 24; Scott Ellis, pers. comm., 2018a; Mike Fisher, pers. comm., 2020d). Three feet has been noted for other *Speyeria* taxa to be well within the 1st instar larvae's ability to reach (Arnold 1989, pp. 13). However, based on other's observations it is likely that most ovipositions are within 1 foot of violets (Scott Ellis, pers. comm., 2020b).

The substrate on which eggs are laid can be variable as long as the eggs are laid relatively close to the violet because 1st instar larvae hatch then soon seek shelter for winter diapause (Mike Fisher, pers. comm., 2020d). Just before seeking winter shelter the larvae hydrate by drinking and absorbing water (Alan Myrup, pers. comm., 2020a; Stout 2020). Successful diapause sites occur where the moisture level is not too wet and not too dry (Selby 2007, p. 24; Mike Fisher, pers. comm., 2020d). The 1st instar larvae are in diapause for approximately 225 days. Mortality of *Speyeria* species appears to be very high during diapause (Mattoon et al. 1971, p. 248). Although no observation of wintering sites is actually known in nature it is logical that they seek shelter under leaves and debris at the base of violet plants or willows or other woody vegetation, which may prevent them from being trampled (Scott Ellis, pers. comm., 2020b; Mike Fisher, pers. comm., 2020d). They are known to seek shelter under leaves in artificial conditions (Mike Fisher, pers. comm., 2020d). They have also been observed communally in diapause in artificial conditions but due to nature of eggs being laid singly and haphazardly it is suspected that communal diapause is rare in nature and potentially only occurs in optimum locations (Mike Fisher, pers. comm., 2020d).

It is thought that microclimate and moisture levels provided by flowing water of springs or streams is sufficient to keep larvae alive during the winter such that insulation from snowpack is not necessary to prevent freezing (Scott Ellis, pers. comm., 2020b). Often within the range of *S. n. nokomis* very cold weather is preceded by snow which may insulate larvae before the coldest temperatures hit the days after the storm. Most of the *S. n. nokomis* are at an elevation that has some snow cover for most of the winter that may help larval survival, but the snow cover is variable enough that the butterfly may have adapted to variable conditions and it may not necessarily be a large factor in larval survival (Scott Ellis, pers. comm., 2020b; Mike Fisher, pers. comm., 2020d). However, especially higher elevation snow pack is crucial to supply water for springs and streams that *S. n. nokomis* relies on to support its habitat.

In approximately mid-May when fresh violet leaves are present larvae emerge from diapause and start feeding on the violets until about mid-July. After feeding on violets, and sheltering on them and adjacent debris for approximately two and a half months, the larvae form a chrysalis and enter pupation where they metamorphose into adults. Pupation takes approximately 17 days (Selby 2007, p. 21).

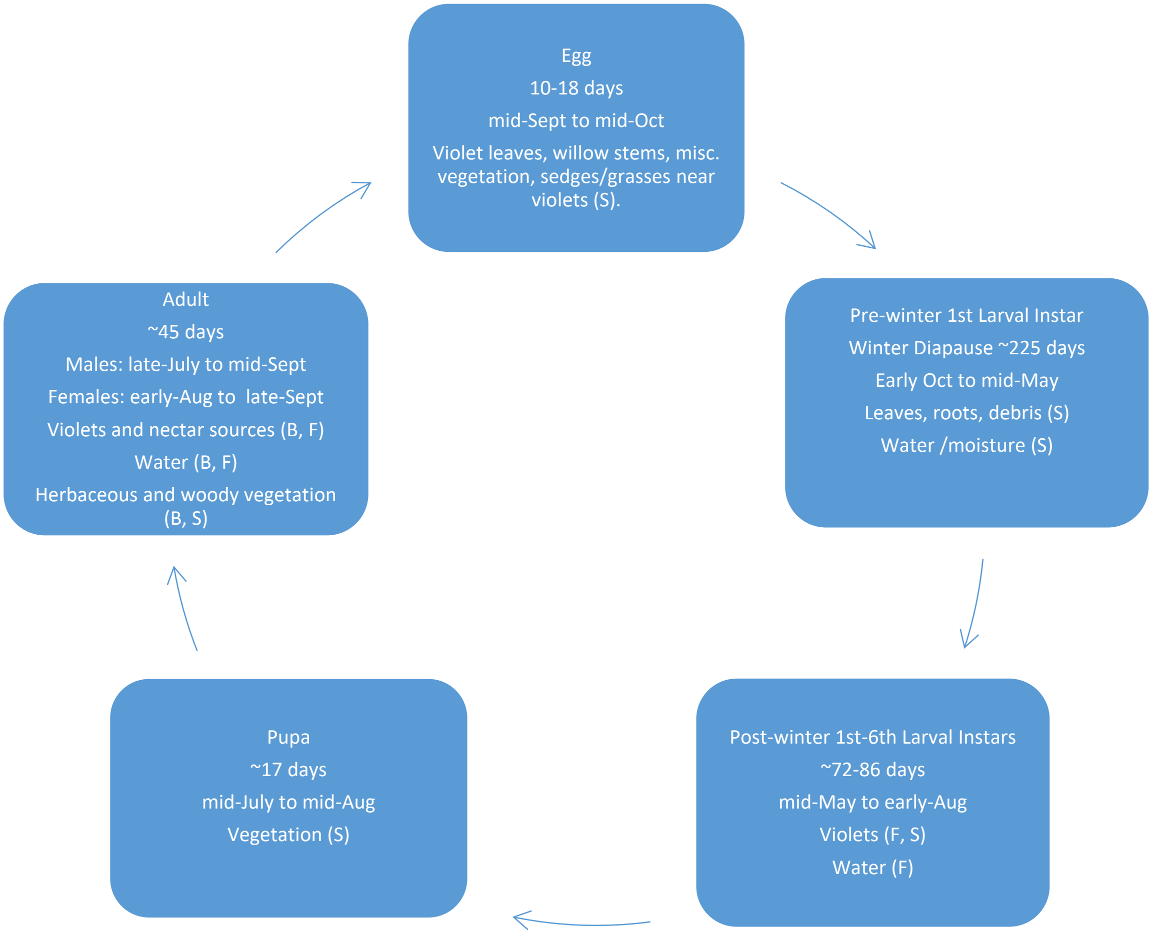

Figure *18*. Life cycle diagram including resource needs; B: breeding; F: feeding; S: sheltering (Scott and Mattoon, 1981, pp. 12, 14; Scott 1986, p. 326; Selby 2007, p. 21).

At the end of July to mid-August adult butterflies emerge from the pupal case and live approximately 45 days (Selby 2007, p. 21). Males emerge at the end of July or beginning of

August and last until about mid-September. Females emerge the first to second week of August and last until about the end of the third week of September (Selby 2007, p.21). The later emergence of females likely maximizes the number of matings for males and reduces the amount of time and energy for females to mate (Scott 1977, pp. 917-921; Scott and Mattoon 1981, p. 15; Selby 2007, p. 21). During this time the adults will nectar on a variety of plants (mostly composites) for energy in mate finding and egg laying.

A survey of this SSA's Technical Team provides a range of temperatures that adult butterflies will fly in to seek mates and nectar. The lower temperature range reported was 50-70°F and the upper range was 85-100°F (Steve Cary, pers. comm., 2020c; Scott Ellis, pers. comm., 2020c; and Mike Fisher, pers. comm., 2020e). The preferred temperature range according to Scott Ellis (pers. comm., 2018b) appears to be 65-85°F and is supported by the additional ranges given by himself and the other Technical Team members. If the temperature is down around 50°F the butterflies will need sun to warm up enough to fly and if it's between 90-100°F they can only fly for short intervals and then seek shade (Scott Ellis, pers. comm., 2020c; Mike Fisher, pers. comm., 2020e).

Nokomis males will fly all day but the best time appears to be approximately late morning from 11:00 AM to 1:00 PM (10:00 AM to 12:00 PM without daylight savings) (Mike Fisher, pers. comm., 2018). During that time frame, males will most actively be searching for newly emerged females for which to mate. Females do not fly around much unless disturbed and tend to be crepuscular, nectaring on sunny days especially in late afternoon. When laying eggs they stay in the grass and bushes near violets. If it begins to cloud up in early afternoon females get active before it gets too dark and can be seen on the wing more frequently. A thin cloud layer that allows the site to remain bright but cuts the sun intensity is amazing for female activity but rarely occurs on any given day. If the weather is cloudy/rainy little to no activity occurs but both males and females will heavily nectar the first sunny day (Mike Fisher, pers. comm., 2018).

To summarize, individual needs of *S. n. nokomis* include wet meadows, supported by springs, seeps, streams, or irrigated areas that contain the bog violet and other herbaceous vegetation. The butterflies may benefit from a light interspersion of willow or other shrubs for shade and for larval shelter. More dense willow and shrubs often surround open meadows where *S. n. nokomis* occurs and, as long as the woody vegetation does not take over the meadows, the margins of denser stands can be beneficial for shade and shelter as well.

2.7 Population Needs

Populations need abundant individuals within habitat patches of adequate size and quality to maintain survival and reproduction. In general, the greater the suitable habitat acreage, and the greater the number of individuals within a population, the greater the resilience. Furthermore, colonies and populations need to be close enough to each other for individuals to breed with each other in order to maintain genetic diversity. A professional estimate is that *S. n. nokomis* likely do not fly more than 5-10 miles and if they fly further from their colony than that they will likely not find another colony (Scott Ellis, pers. comm., 2020a; 2020d; 2020e). Additionally, *S. n. nokomis* needs the bog violet to be of sufficient extent and density to support colonies and populations. We are defining colonies in this SSA to mean areas of abundant violets that produce butterflies as well as surrounding habitat with nectar sources. If there is narrow but contiguous nectaring habitat up or down a drainage but without violets (or with only sparse violets) we consider those areas transitional corridors and, though likely valuable for dispersal and genetic connectivity, we do not include those corridors in acreage calculations of a colony.

S. n. nokomis has some populations that have single colonies and some have more than one colony creating a metapopulation. A metapopulation structure is where individuals in colonies are close enough to interbreed and can recolonize temporarily extirpated colonies. Colonies in a functioning metapopulation can be recolonized if local naturally occurring (stochastic) events cause extirpation of a colony. For instance, a flood may extirpate a colony but if there's a nearby source for the bog violet and associated plant species, the area may return to suitable habitat condition and be recolonized by the butterfly.

Unfortunately, for *S. n. nokomis* there is very little information on what an adequate-sized habitat patch is, especially if there is only a single colony in a population. A professional estimate for minimum patch size of colonies is 2 acres if the habitat has as reliable groundwater source and has high violet density; 5 acres if violets are less dense due to natural or human-caused variability within a patch (Scott Ellis, pers. comm., 2020e). Although it's possible a single 2-acre or 5-acre patch of habitat could support the butterfly for a period of time, a more resilient population will likely contain at least three colonies of those sizes or greater. A three-colony metapopulation will have a better chance of survival by simply spreading the risk of extirpation if a natural event occurs at one or two of the colonies. Thus, the remaining one or two colonies can recolonize the extirpated sites assuming suitable habitat remains or reestablishes. Due to natural variability in soil and topographic conditions, it is assumed that it is more likely that an area will have less dense violets than dense violets. Consequently, under this assumption, a minimum amount of habitat for a resilient population may be 12 acres; two colonies 5 acres in size and one colony 2 acres in size. Due to its isolation, a single-colony population likely needs to have hundreds of acres of habitat in order to assure there are enough butterflies to maintain genetic diversity and be viable over the long-term. What the specific minimum threshold is for single colonies to remain viable is unknown but the larger the acreage is the greater the resiliency and higher likelihood of viability.

There is also little information on the minimum number of *S. n. nokomis* individuals needed to sustain a colony. There have only been two demographic studies for *S. n. nokomis.* Both occurred at the same locations 10 years apart; 1979 and 1989 (Arnold 1989). The 1989 study found a daily estimate of between 48 and 260 butterflies with two different models at the Unaweep Seep colony (Arnold 1989, p.6, 14). A combined population estimate at the Unaweep Seep colony and another upstream colony in Unaweep Canyon (which is considered two colonies in this SSA due to intervening transitional habitat) resulted in a range of daily abundance from 594 to 2,689 butterflies.

The Unaweep Seep colony population estimate increased from 1979 but detrimental habitat changes were also noted and only 1 of 5 springs at the Unaweep Seep colony were occupied in 1989 (Arnold 1989, pp. 6, 7, 14). Despite a number of individual butterflies and relatively large size (approximately 31 acres) the Unaweep Seep colony subsequently became extirpated sometime after 1989, likely due to encroachment of willow, grass, and sedge (Arnold 1989, pp.

9, 14). However, the upstream colonies in the1989 study had a much higher number of butterflies despite having a smaller combined acreage of about 12.5 acres. Consequently, quality of habitat may have as much weight in determining resiliency of a colony or population as does overall size of a habitat patch or number of individuals. Habitat quality could potentially be measured by density of violets. Indeed, Arnold (1989, p. 20) reveals that the upstream colonies in his study had a much higher abundance of violets. Consequently, populations appear to have greater chance for survival when containing more violets.

Based on observation of grazed and burned properties in Unaweep Canyon, it was determined that occasional or well-managed grazing and burning likely benefit the violet by reducing willows as well as thatch buildup from grasses and sedges (Arnold 1989, p.14; Ellis 1989, pp. 18, 19). Consequently, natural factors or management that leads to early seral stages or at least more open conditions where willow, grass, sedge or other vegetation does not outcompete violets is important to colonies and populations.

S. n. nokomis and other *S. nokomis* subspecies have the ability to move between colonies within a continuous or nearly continuous riparian zone (Arnold 1989, pp. 10, 14; Fleishman et al. 2002, p.708). For example, there used to be six colonies (now five) along a 5-mile stretch in Unaweep Canyon that had likely genetic interchange (Ellis 1989, p. 3). However, these are considered separate colonies due to the natural or human-caused patchiness of bog violets up and down the canyon. In the mark-recapture study by Arnold (1989, pp. 10, 14, 21) in Unaweep Canyon, about 50 percent of the recaptured butterflies had moved between two colonies separated by about 0.75 miles. Based on Arnold's 1989 work, it was speculated that *S. n. nokomis* could easily move at least one mile and, based on this, Ellis (1989, p. 19) further speculated that there was exchange of individuals among all the Unaweep Canyon colonies every one to five years. This also provided the basis for Ellis' professional judgement that colonies or populations further than 5-10 miles from each other are likely isolated (Scott Ellis, pers. comm., 2020a; 2020d; 2020e).

In summary, to be resilient populations need water to sustain violets for the larvae, occasional or seasonal disturbance by grazing from native ungulates or domestic livestock, or burning, mowing, or non-catastrophic flooding to occasionally remove vegetation that might otherwise crowd out the violets and other nectar plants for the adults. Furthermore, based on expert opinion and evidence from Arnold (1989) and Ellis (1989), the most resilient populations need to be at least 2 acres in size with dense violets or at least 5 acres in size with less dense violets, have a few to several colonies within 0.75 to 5 miles of each other but likely not exceed 10 miles from each other (Scott Ellis, pers. comm., 2020e).

Single-colony populations likely need to have a very large habitat area, in the hundreds of acres, but might still need occasional immigration from other populations to maintain genetic diversity and resiliency for long-term persistence. Based on the scant evidence, it is unknown what the minimum number of individuals are that are needed to sustain a *S. n. nokomis* colony or population, and even apparent natural but detrimental habitat factors can cause extirpation of seemingly large colonies. Without additional study it is not truly known what the minimum viable habitat size is, nor density or abundance of bog violets or nectar sources is to sustain a colony or population, nor the maximum distance between colonies or populations that can be reached for genetic interchange on a regular basis. Furthermore, it is not truly known if very large single-colony populations can be resilient without occasional genetic interchange from other populations.

2.8 Species Needs

To be viable, *S. n. nokomis* needs to have sufficient quality and quantity of habitat for resilient populations, numerous populations to create redundancy in the event of catastrophic events, and broad enough genetic diversity to adapt to changing environmental conditions (representation). The subspecies will have a better chance of long term viability if the single-colony populations and even the metapopulations occasionally receive individuals from other populations such that genetic interchange occurs and they are able to adapt more readily to environmental changes. Table 2 provides a summary of ecological needs for the subspecies.

Table 2. Ecological requirements for S. n. nokomis viability.

The three R's	Requisites of Viability	Description
Resiliency (ability to withstand stochastic (non-catastrophic natural) events	Consistent water supply to support violets, nectar sources, some shrubs, and microclimate for larval survival.	Water supply is driven by higher elevation snowpack. Springs or near-surface ground water can elevate temperatures and provide appropriate humidity. On-site snow cover can also insulate larvae from freezing and desiccation and might boost larval survival but may not be as important as spring or groundwater presence.
	At least 2 acres of habitat with dense violets or at least 5 acres with less dense violets to support each colony. At least 3 colonies if habitat is small.	Minimum sizes are requirements to maintain viable colony per professional opinion. An assumption is that a metapopulation needs 3 colonies to be resilient and minimum of 12 acres total (one 2-acre patch and two 5-acre patches). Distance between the two most-distal colonies in a metapopulation to maintain genetic interchange should be no more than 20 miles (per genetic evidence) but more likely no more than 5 or 10 miles (per professional opinion).
	Single-colony; very large (likely hundreds of acres)	Minimum size for single colony unknown; likely hundreds of acres to have enough individuals to sustain genetic diversity.
	Native or non-native nectar sources	Provide energy for mating, egg-laying, and possible flight to neighboring colony. Density of nectar sources unknown.
Redundancy	Numerous metapopulations or single-colony populations spread out to prevent loss by catastrophic events.	More is better.
Representation (ability to maintain adaptive capacity)	Genetically diverse populations	Genetic diversity can provide adaptation advantages. Genetic connection of populations likely provides greater diversity of genes.
	Distribution of populations throughout their range to capture ecological diversity	Populations in different ecological settings likely provide for adaptation and contribute to viability.

CHAPTER 3 – CURRENT CONDITION

3.1 Key Findings

Habitat loss and fragmentation; incompatible livestock grazing; human-caused hydrologic alteration; genetic isolation; climate change; climate events; invasion by non-native plants, larval desiccation; disease; predation; fire, and pesticides are all factors that influence or could influence species viability. Factors have been divided into minor and major categories. One or more major factors are given a single negative rank. Although current climate conditions have changed in the last 36 years (Lukas et al. 2014, entire) they are not thought to be severe enough to have influenced current species resiliency or viability and are consequently included as a minor factor in this Current Condition chapter.

Little demographic and habitat information is available so the number of metrics ranked for current condition is limited and cause and effect linkages for minor and even major factors is also limited. Consequently, current condition is assessed based on what little published information is available for *S. n. nokomis* and relies on species expert input to a large extent as well as information on other species or concepts in scientific literature. Major factors influencing species viability include habitat loss and fragmentation from development or agricultural conversion, incompatible grazing, hydrologic alteration, and genetic isolation of colonies and populations. If implemented properly, mowing for native hay, grazing, and burning can be compatible and beneficial for *S. n. nokomis*. Little conservation effort has been directed towards *S. n. nokomis* and the two efforts that occurred were both in Mesa County in the Mesa/Grand Population.

There are currently 19 colonies representing 10 populations that are considered extant. There are five populations that have very low resiliency. One population has low resiliency, two populations have moderate resiliency, and two others have high resiliency. With 10 populations widely distributed redundancy is determined to be moderate and representation is thought to be low – moderate. Seven of the 19 colonies representing five populations were confirmed to be extant in 2018-2020 surveys.

3.2 Materials and Methods

Current conditions are assessed in relation to what *S. n. nokomis* ecological requirements were determined to be in Chapter 2. However, the only measurements available that are consistent across populations are habitat patch size, number of colonies, and approximate distance between colonies within a population from which genetic connectivity can be estimated. Additionally, the presence and potential influence of the three major habitat factors effecting the species (habitat loss and fragmentation, grazing, and hydrologic alteration), were derived from aerial imagery and/or on-the-ground knowledge. Therefore, these metrics are used to characterize the current resiliency condition of populations in this SSA (see section 3.5 "Current Condition by Population" on how metric ranks were derived). If in-depth study of habitat parameters, demographic parameters, and other human or natural factors are conducted in the future the SSA can be updated to reflect that new information.

Resiliency rankings and categories are established based on best available information and professional opinion. Habitat patch sizes are estimates but SSA Technical Team experts Scott Ellis, Mike Fisher, and Steve Cary drew habitat polygons themselves or were coordinated with to draw patches between 2018 and 2020 using aerial imagery based on their best estimates of individual colony bog violet areas and primary nectar source areas. Determination of the number of colonies within a population was primarily based on expert input from Scott Ellis and Mike Fisher (pers. comm., 2020) and for the New Mexico populations with agreement by Steve Cary (pers. comm., 2020a). Status of individual colonies was also confirmed with Scott Ellis and Mike Fisher (pers. comm., 2020) or Fisher himself (pers. comm., 2020c) (Figure 14).

The recent whole genome analysis determined that, within *S. n. nokomis* range, there are eight populations (Cong *et al*. 2019, Figure 8, p. 9; Figure 15 above). However, we are currently considering there to be an additional two populations for a total of 10 populations. Two of the populations were not included in the analysis by Cong *et al.* (2019) due to lack of samples (Archuleta and Garfield). Based on distance from other populations (40-80 miles) these two will likely remain their own populations even if future specimens are found and analyzed.

Within the range shown in Figure 14 and amongst all 10 populations, there are four known colonies that have been extirpated, three of these relatively recently in about the last 30 years and one, Beulah, perhaps as long ago as 117 years (Scott and Fisher 2014, p. 3). Beyond briefly mentioning the extirpated colonies we are not analyzing them in the current or future condition analysis for this SSA. Also, stray sightings will not be considered in the current and future condition analysis for this SSA. Not including the extirpated colonies or stray sightings, there are 19 colonies that make up the 10 single-colony or multi-colony populations we are analyzing.

3.3 Factors Influencing Species Viability

Habitat loss and fragmentation; incompatible livestock grazing; human-caused hydrologic alteration; genetic isolation; climate change; climate events; invasion by non-native plants, larval desiccation; disease; predation; fire, and pesticides are all factors that influence or could influence species viability. Factors have been divided into minor and major categories. For this SSA, factors considered minor are those that are ongoing and routine, such as larval mortality due to natural predation, or where current observation or evidence does not indicate they have a meaningful impact on species viability and does not support them being placed in major factors. It is possible, however, that with research some minor factors, such as exotic plant invasion or pesticides, could be realized as major factors in the future.

3.3.1. Minor Factors

Exotic Plant Invasion

The Taos Population of *S. n. nokomis* has experienced some invasion by Siberian elm (*Ulmus pumila*) and it would not be unexpected for them to increase especially if changes in climate reduce snowpack and water levels in the wet meadows of the Taos Population (Steve Cary, pers. comm., 2020d) or other populations since Siberian elm is widespread in the butterfly's range. Similarly the extirpated Unaweep Seep colony location has had invasion by Himalayan blackberry (*Rubus armeniacus*) and tree-of-heaven (*Ailanthus altissima*) and, though not known to occupy other colonies at present, these plant species could invade other colonies (Heidi Plank, pers. comm., 2020). Other exotic woody or herbaceous species can rapidly take over habitat (such as Russian olive (*Eleagnus angustifolia*), tamarisk (*Tamarix* spp.), or leafy spurge (*Euphorbia esula*)) and could be an issue, or could become an issue, but there is currently little to no plant data at colonies (Ellis 1989, pp. 14-15).

Some non-native thistles such as Canada thistles (*Cirsium arvense*) occur in or around colonies and can create monocultures (Ellis 1989, p. 14; Selby 2007, p. 30). Efforts have occurred in the west to control exotic thistles but Canada thistles (as well as native thistle) provide a nectar source for *S. n. nokomis*. Additionally, the adventive (exotic but not well-established) bull thistle (*C. vulgare*) and burdock (*Arctium minus*) can provide nectar sources (Ellis 1989, p. 14). Since *S. n. nokomis* use exotic thistles, aggressive control of them has been lamented (Mike Fisher, pers. comm., 2020f). It does not appear monocultures of Canada thistle or other exotic vegetation have replaced native vegetation beneficial for the butterfly at observed colonies (Scott Ellis and Terry Ireland, pers. observation, 2018) but study of plant composition at all the colonies is needed to determine levels of exotic plant presence. Exotic plant invasion is currently placed under the minor category because exotic species are not currently known to be a major factor influencing the species viability.

Climate Events

Climate events are defined in this SSA as events that would happen within the range of normal variability. However, they may still cause reduction of habitat and number of butterflies. A record of other *Speyeria* in Utah indicate that too much rain can reduce numbers of butterflies but on the other hand may be beneficial to violets which can support greater numbers of butterflies the following year(s) (Alan Myrup, pers. comm., 2020b). Similarly floods may at least temporarily reduce habitat and vegetation as well as butterfly numbers. For instance, the Lake Fork River in northeast Utah (outside of range of *S. n. nokomis*) flooded in spring 2019 limiting or causing extirpation of butterflies at a known colony in the Uinta Mountains Population (Scott Ellis, Lydia Thompson, and Terry Ireland, pers. observation, 2019) that had been there the year before (Alan Myrup, pers. comm., 2019). However, the flood event was not outside the norm for past observed flood events in that drainage. This event provides an example of when normal climate events can cause reduction in individual butterflies or temporary extirpation of a colony but are not expected to cause permanent reduction or extirpation. Thus climate events are not expected to reduce species viability in the long-term and are considered as a minor factor influencing the species viability.

Climate Change

The climate already appears to be changing from human impacts with earlier springs and warmer temperatures. Temperature in Colorado increased in the 30 years prior to 2014 by 2°F and by 2.5°F in the last 50 years (Lukas et al. 2014, p.2). Snowpack, as measured by snow water equivalent, has mostly been below average in Colorado since 2000. The timing of snowmelt and peak runoff has also shifted 1-4 weeks earlier in the last 30 years in Colorado. Furthermore, the Palmer Drought Severity Index has shown an increasing trend in soil-moisture drought conditions due to below average precipitation since 2000 and the warming trend (Lukas et al. 2014, p. 2). More recent analysis in a newspaper article using National Oceanic and Atmospheric Administration (NOAA) temperature data shows that much of the northern half of the *S. n. nokomis* range has reached or is above 3.6°F over the long term average since 1895 and it's reported that average annual flows in the Colorado River Basin have declined by 20 percent over the past century (Eilperin 2020, entire). However, tree ring and other paleoclimate data indicate that there were more severe and sustained droughts prior to recent climate data (since 1900) (Lukas et al. 2014, pp. 2, 3). The butterfly has survived through the more severe past droughts and, despite noted changes in climate over the last 36 years, climate has thus far not been a detectable factor in reduction of species viability. Consequently, at the present and for the current condition analysis, climate change is considered a minor factor. However, climate appears to be at the verge of becoming a major factor and additional discussion of climate change is in Chapter 4 – Future Condition.

Desiccation of larvae

Desiccation of overwintering larvae may be a stressor if soil moisture and air humidity is too low or if larvae cannot remain hydrated. It is suspected that soil moisture and dead vegetation, along with some air flow, provide suitable conditions that prevent desiccation (Mike Fisher, pers. comm., 2020g). Hydration also appears to be needed prior to 1st instar larvae overwintering and is achievable if free water for drinking is available and if soil or air moisture is sufficient for absorption (Alan Myrup, pers. comm., 2020a, Stout 2020). Snow cover may also provide some desiccation prevention and thermal cover although Scott Ellis (pers. comm., 2020b) did not think it was a significant factor. Mike Fisher (pers. comm., 2020d) agreed with Ellis but added that snow cover may be of benefit during extreme cold; however, in general extreme cold in *S. n. nokomis* range is preceded by snow, thus extreme cold may kill some larvae but is likely not a major factor that reduces species viability.

Disease

There are no diseases known that have caused significant declines or extirpation of colonies/populations that we are aware of. However, viruses, bacteria, fungi, etc. have been stated as causing mortality in butterflies (Scott 1986, p. 70). Artificial rearing has revealed that if there is no air flow in overwintering sites high humidity can also cause mold and mildews that can kill larvae (Mike Fisher, pers. comm., 2020g). In contrast to potential desiccation problems (see below) from a warmer/drier climate, or potentially one with less snow and colder temperatures, it is possible heavy rains or climate-change induced rains at abnormal times of year or heavier than normal rains could cause an increase in mortality from mold or mildews. However, we currently have no data to suggest disease is a factor influencing species viability.

Predation

Specific predators of *S. n. nokomis* have not been observed; however, birds, rodents, reptiles, amphibians, and other insects undoubtedly prey on them or parasitize them resulting in mortality or injury (Scott 1986, pp. 70, 71). The longer growing season already observed due to climate change (Lukas et al. 2014, p. 2) is not thought to be of benefit to the butterfly due to a longer period of exposure to negative survival factors such as predators (and parasitoids) (Mike Fisher, pers. comm., 2020g). It is suspected that more predation or parasitism could already be occurring due to longer growing seasons but we have no evidence that it is currently at a level that is causing reduction of viability of the species and is therefore currently considered a minor factor.

Collecting

Collecting has occurred in *S. n. nokomis* colonies and it is possible collecting in small colonies could affect them (Ellis 1989, p. 15; Selby 2007, p. 31). However, collecting is not currently thought to be a significant stressor for *S. n. nokomis* since most colonies occur on private land and current collecting pressure is not thought to be extensive (Scott Ellis, pers. comm., 2020f). Habitat impacts are more significant than collecting pressure (Scott Ellis, pers. comm., 2020f) and, thus, collecting is currently considered a minor factor. There is concern with collecting if public land, or even private land, colony locations are revealed in the future but currently this factor does not appear to be reducing species viability.

Prescribed Burning or Wildfire

Direct mortality of butterfly larvae in the litter layer during dormant season burns has been observed in skippers (*Hesperia* spp.) and indirect mortality of larvae resulting from increased exposure to extreme winter conditions after fall burns remove the insulating litter layer has also been observed (Dana 1991, pp. 1, 55). Improperly timed burns can temporarily limit the availability of resources (such as bog violets and nectar sources) or cause delayed blooming or other phenology changes (Selby 2007, pp. 30, 31). Therefore, extensive and/or too frequent of burns (every one to two years), especially in the summer, is likely to negatively influence *S. n. nokomis*. However, there is no evidence that burns have currently impacted *S. n. nokomis* and burns are therefore currently not considered to have influenced species viability. Burns can be beneficial for *S. n. nokomis* as described in section 3.3.3.

Pesticides

Pesticides (insecticides, herbicides, fungicides) have been widely used in the U.S. and could be influencing *S. n. nokomis* populations to some degree. Insecticides such as neonicotinoids and pyrethroids are known to cause impacts to monarch butterflies and their caterpillars (*Danaus plexippus*) and herbicides such as glyphospates affect their host plant milkweeds (*Asclepias* *syrica*) and could impact the butterfly themselves (Malcolm 2018, p. 281-284; Olaya-Arenas and Kaplan 2019; p. 10-14). In *S. n. nokomis* range there is more haying and grazing than cropland, and as a consequence there may be less application of pesticides on or near colonies than in many parts of the U.S. but the amount and type of pesticide use near *S. n. nokomis* colonies needs to be studied. We currently have no evidence that mortality of the butterfly, bog violet, or native nectar sources have occurred from pesticide use and are not aware that it has currently reduced the viability of the species.

3.3.2 Major Factors

Habitat Loss and Fragmentation

Habitat loss from golf course and housing development is known to have caused extirpation of two historic colonies north of Durango, Colorado, (Scott Ellis and Mike Fisher, pers. comm., 2020). The remaining known site in the La Plata Population has residential and commercial development across the street from it and one of two drainages supplying it water has relatively new housing and golf courses all around within 1.5 air miles potentially degrading downstream *S. n. nokomis* habitat through hydrologic alteration. Housing development also appears to have been a contributing factor in extirpation of the Beulah, New Mexico, colony (Scott and Fisher 2014, p. 3). It's possible that Rifle Gap Reservoir and Dam degraded and fragmented habitat since one butterfly was sighted at a small wetland downstream of the dam and the reservoir flooded and fragmented habitat upstream. Additional habitat alteration upstream and downstream from a variety of factors also has likely fragmented habitat. Many other colonies/populations have development around them that also either directly encroach on the habitat or likely have caused degradation and fragmentation from homes, roads, hydrologic alteration and habitat conversion.

Agricultural habitat conversion can cause loss or fragmentation of habitat and typically involves mowing native meadows or growing exotic grasses for hay, though a variety of orchards also occur near riparian areas within *S. n. nokomis* range. Although it's unknown if all agricultural conversion has caused habitat to become unsuitable, a look at aerial imagery reveals that agricultural conversion has been extensive within *S. n. nokomis* range. It has likely caused loss of unknown colonies over the last 150 years and has fragmented native habitat causing less connectivity between colonies and populations. Annual mowing may be less detrimental than mowing two or three times a summer. One site in the Chuska Mountains Population (now out of *S. n. nokomis* range) (Cong *et al*. 2019) has had *S. nokomis* for many years even though mowing occurs there once a year typically in late August or September (Chad Smith, pers. comm., 2019). Adults are flying then and most females have likely laid eggs by then. There is a fence in the middle of the mowed field that has lots of violets and may serve to protect the eggs from mowing but there are also a good number of violets in the middle of the field (Chad Smith, pers. comm., 2019). Consequently, the violets appear to largely not be affected by the mowing. Additionally, either the only eggs that survive are along the fence line, or the violets and bases of other vegetation in the mowed part of the field protect the eggs from crushing, or spaces between the tractor tires allow for some of the eggs to not be crushed.

Despite potential compatibility with annually mowing native hay fields, agricultural conversion to unsuitable crops or fragmentation of habitat has been extensive. Additionally, direct or indirect effects of development of water diversion structures and removal of water from the natural system for agricultural has undoubtedly reduced habitat available for *S. n. nokomis* and therefore reduced viability of the species. Furthermore, residential and commercial development and other development like roads continues to limit and/or degrade habitat in or adjacent to existing colonies/populations. Habitat loss and fragmentation, therefore, reduces viability of the species.

Grazing

Livestock grazing may cause habitat loss and degradation if excessive, especially in the naturally scarce habitats of *S. n. nokomis* (Hammond and McCorkle 1983, p. 219). Grazing that is incompatible with *S. n. nokomis* can result from excessive grazing and/or timing of the grazing. Year-round grazing or summer grazing is typically incompatible because livestock graze on the violet leaves, nectar sources, and other vegetation necessary for the butterfly when the larvae and adults need them (Ellis 1999, p. 5). For example, an area explored in 2018 just south of a known site in the Ouray Population, has underlying hydrology and soils beneficial for *S. n. nokomis* but the habitat is unsuitable due primarily to grazing and perhaps to a lesser extent occasional mowing for hay (Figure 19). Bog violet, other forbs, and small willows beneficial for *S. n. nokomis* are evident immediately on the other side of the fence in Figure 19. Light or moderate

Figure 19. Incompatible grazing in Ouray Population causing habitat unsuitability. Notice bog violet leaves on the fence line. Photo by Terry Ireland, USFWS, 2018.

grazing in the summer may not cause significant impacts to colonies, however (Arnold 1989, p. 14).

If one or more kinds of vegetation is too dense it can prevent the bog violet from persisting and thus cause extirpation of the butterfly. This occurred in the Unaweep Seep colony in the Mesa/Grand Population perhaps primarily as result of spike rush invasion of meadows but also seemingly because of grass, sedge and willow invasion (Arnold 1989, pp. 9, 14; Ellis 1999, pp. 3, 5, 6). It is unknown if this would have occurred without grazing or, as the primary human use of the land, if long-term grazing was the factor that shifted vegetation. Without occasional setback of vegetation it would not be unexpected for other herbaceous or woody vegetation to crowd out violets.

Grazing is ongoing in suitable habitat for the species and can limit availability of habitat throughout the range. Though it can be compatible, it is expected to continue to be a major factor influencing species viability.

Hydrologic Alteration

Hydrologic alteration is also a factor influencing species viability. Hydrologic alteration can result from a variety of sources including diversions for agricultural and domestic use, erosion and stream channel incision caused by livestock grazing, mining, roads, dredging and filling of wetlands, removal of beaver dams, creation and operation of large human-made dams, etc. For example, the only known colony in the Costilla Population has a diversion ditch delimiting its south side that may have reduced the size of colony and that ditch and other diversions have allowed for extensive agricultural development in the drainage that has altered native habitat and likely dropped the water table in much of the area. The Paradox colony in the Montrose/San Juan Population also has had livestock grazing and water diversions occur over the last 30 years, which has degraded the quality of the wet meadow areas and lowered the water table (Scott Ellis and Terry Ireland, pers. observation, 2018).

Many drainages in the Sacramento Mountains, where the Mescalero *S. n. nokomis* colony may have occurred, succumbed to incision of streams around 1900, in turn lowering water tables and eliminating wet meadow habitat (Steve Cary, pers. comm., 2020e). Incision of stream channels occurred due to erosion from deforestation, conversion to agricultural and grazing lands, mining, etc. (Steve Cary, pers. comm., 2020e, 2020f). Beaver were also eliminated around 1900 in the Sacramento Mountains (and other parts of the west), which also undoubtedly caused reduction of water tables and elimination of wet meadow habitat suitable for *S. n. nokomis* or other wetland dependent species (Steve Cary, pers. comm., 2020e, 2020f). Hydrologic alteration that degrades riparian areas and lowers water tables from natural systems has occurred not only in the Costilla Population, Montrose/San Juan populations, and Sacramento Mountains but extensively in the western U.S including much of the *S. n. nokomis* range. Hydrologic alteration continues to limit suitable habitat and is a major factor influencing the viability of the species.

Genetic Isolation

Isolation can cause detrimental genetic and demographic effects and is a concern for *S. n. nokomis* population resiliency as well as redundancy and representation. Genetic isolation within the analyzed populations of *S. n. nokomis* does not currently appear to be an issue but may be in the future, especially if some populations become extirpated, leaving remaining populations even more isolated than in the current condition (Nick Grishin, pers. comm., 2020c). Lower levels of genetic diversity can reduce the capacity of a population to respond to environmental change and may lead to reduced population fitness, such as longevity and fecundity (Darvill *et al.* 2006, p. 608). Britten et al. (1994) found low genetic diversity, likely from genetic drift (disappearance of genes as individuals die), in *S. n. apacheana* as a result of genetic isolation and small population sizes. Genetic exchange between and within populations can alleviate problems with genetic drift and also augment populations demographically. In *S. n. apacheana*, Fleischman et al. (2002, p. 708) documented routine dispersal distances up to 4 km (2.5 miles), and 26 percent of the recaptured butterflies had emigrated from the initial patch of capture. Britten *et al.* (2003, p. 232) stated that this migration appears to play an important role for *S. n. apacheana* populations both demographically and genetically. Consequently, the ability or inability of *S. n. nokomis* individuals to migrate between colonies and populations is expected to also be of benefit or detriment, respectively, for *S. n. nokomis*.

Cong *et al.*'s (2019) finding of genetic isolation amongst populations of *S. n. nokomis* suggests reduced population fitness from genetic drift or other reasons could be of concern in the future. All known *S. n. nokomis* populations are at least 24.5 miles from each other and analysis indicates that they are genetically isolated from each other (Cong *et al.* 2019). Genetic analysis recently revealed that the Grand County colony is genetically similar to the Mesa County colonies and, hence, are part of the same population. Until recently (20-30 years ago) when Unaweep Seep was extant, the Grand County colony and Unaweep Seep colony in Mesa County were just under 20 miles apart. Since alleles within genes can remain in the genome for hundreds or thousands of years, 20-30 years is a short time frame for separation of genetically similar colonies. Therefore, based on the latest scientific evidence (Cong *et al.* 2019), populations that are at least 20 miles apart are assumed to be separate populations. Currently, the distance between the two closest populations, which we know are genetically different and represent separate populations, is 24.5 air miles (between the Taos and San Miguel/Mora populations in NM). Consequently, and more specifically, the distance where populations of *S. n. nokomis* may not interbreed and thus may not support each other genetically or demographically appears to be somewhere between 20 and 24.5 air miles. The minimum distance of 20 miles, based on findings of Cong *et al.* (2019), will be used in our analysis of genetic connectivity. The genetic analysis increases the distance from Ellis' professional opinion that colonies/populations further than 10 miles are likely isolated from each other (Scott Ellis, pers. comm., 2020e); however, the shorter the distance the better the chance of genetic and demographic exchange as indicated in section 2.7 through Arnold (1989), Ellis (1989) and Scott Ellis, pers. comm., (2020a; 2020d; 2020e). Genetic connectivity rankings for the current condition (and future condition scenarios) are explained further below in section 3.5.

Reasons for isolation, specifically whether from natural fragmentation or human habitat alteration, is not currently known for all colonies. It is also not known how long single colonies may have been isolated from each other. If an isolated colony has enough area of habitat to support a large population it may be resilient enough to survive without nearby colonies (such as the large Taos colony) and thus remain a viable population for a long time. However, many of the *S. n. nokomis* populations, whether single-colony or multi-colony metapopulations have limited amount of habitat. It is unknown specifically how long it will take for low genetic diversity to become a threat to *S. n. nokomis* but isolation of populations suggests loss of genetic diversity could be a threat at some point, if loss of populations through lack of demographic support does not occur first, and both are cause of concern for species viability.

Cumulative effects

By using the SSA framework to guide our analysis of the scientific information documented in the SSA report, we have not only analyzed individual effects on the species, but we have also analyzed their potential cumulative effects. We incorporate the cumulative effects into our SSA analysis when we characterize the current and future condition of the species. Our assessment of the current and future conditions encompasses and incorporates the factors individually and cumulatively. Because the SSA framework considers not just the presence of the factors, but to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of factors.

Table 3. Major factors likely to be negatively influencing current populations.

Population	**Habitat Loss and Fragmentation**	**Grazing**	**Hydrologic Alteration**	**Genetic Isolation WITHIN Population**
Archuleta		X		X
Conejos				X
Costilla	X		X	X
Garfield	X		X	X
La Plata	X		X	X
Mesa(CO)/Grand(UT)	X	X	X	
Montrose(CO)/San Juan(UT)	X	X	X	
Ouray	X	X	X	
San Miguel/Mora	X		X	X
Taos	X	X	X	

3.3.3 Beneficial Factors

Mowing

Mowing once per summer or early fall could be beneficial to open the canopy for violets, reduce a buildup of thatch from rank vegetation, and keep woody vegetation from encroaching beyond what is suitable for the butterfly. This would most likely only be beneficial if adequate nectar sources remain in the field or if there are enough within a short distance around the field to supply nectar to the adult butterflies.

Grazing

Winter and spring grazing (October to mid-April), if not too intense, can be compatible (Arnold 1989, pp. 14-15). This is because removal of thatch from the dead vegetation limits competition in the spring for the violets and can reduce woody vegetation so it does not encroach beyond what is suitable for the butterfly. It also may approximate historic grazing patterns by native ungulates (deer and elk), which come down to lower valleys in the winter where there is less snow. Arnold (1989, p.14) noted that horses grazed an apparently healthy colony in the spring and summer, so some light to moderate grazing that time of year maybe acceptable, though it's unknown if late spring and summer grazing can be beneficial. In contrast, grazing when violets have emerged and are actively growing may be detrimental if livestock readily consume or trample the violets.

Burning

Burning of meadows to reduce dead vegetation and knock back woody vegetation to suitable levels for the butterfly can also be beneficial and can possibly increase violet density (Arnold 1989, p. 14; Ellis 1989, p. 14).

Exotic Plant Invasion

Some exotic plants considered invasive or adventive may provide nectar sources that benefit *S. n. nokomis* (Ellis 1989, p. 14; Mike Fisher, pers. comm., 2020f). However, especially with invasive plants, this may only be the case where native nectar sources have been substantially reduced or eliminated.

3.4 Conservation Efforts

The historic Unaweep Seep colony in the Mesa/Grand Population received conservation efforts through designation of land around the colony as a State Natural Area in 1983 (Ellis 1999, p. 2). The BLM also established a Research Natural Area around it in 1983 (Ellis 1989, p. 1) and designated it as an Area of Critical Environmental Concern through their 2015 Resource Management Plan (Heidi Plank, BLM, pers. comm., 2017). Some monitoring, at least for the bog violet, occurred through 1999 (Ellis 1999, entire) but sometime after 1989 or possibly 1999 the colony became extirpated (Ellis 1999, pp. 2, 7). Habitat monitoring actions were recommended but it is unclear whether any of them were ever implemented (Ellis 1999, pp. 8-9).

The only other conservation effort that was contemplated was also in the Mesa/Grand Population. An assessment of the butterfly and it's habitat for The Nature Conservancy was conducted to determine conservation efforts that could be taken to preserve the butterfly in Unaweep Canyon (Ellis 1989, entire). Management actions including conservation agreements, easements, and fee title acquisitions were recommended but lack of landowner enthusiasm precluded further pursuit of the actions in 1990 (Scott Ellis, pers. comm., 2020g). No other populations or colonies have had conservation efforts directed at them that we are aware of.

3.5 Current Condition by Population

As described in section 3.2 - Materials and Methods, there are 10 populations we are examining for current condition. The only resiliency metrics available across all populations are the cumulative size of the population, number of colonies, genetic connection within the populations, and best estimate of occurrence of the three major habitat-related factors. The patch size and number of colony metrics were ranked relative to each other with the assumption that more habitat and more colonies per population will provide more resiliency. Section 2.7 - Population Needs, describes the number of acres needed for population resiliency. For habitat size rankings, based on best available information, and an assumption that not all habitat is high quality, to be more resilient populations need to have at least 12 acres of habitat (in either single-colony populations or cumulatively in metapopulations). Populations with less than 12 acres are considered less resilient and received a ranking of 1. Middle sized colonies (12-66.4 acres for the known populations) received a ranking of 2 since they are more than 12 acres. Only one population (Taos) has a very large number of acres and, based on expert opinion from a Technical Team member, consequently received a ranking of 6 since it is significantly larger than the next largest population. Due to the large habitat size the colony has high potential for abundant nectar sources and abundant butterflies, thus giving it a higher likelihood of resiliency.

The more colonies in a population the greater resiliency because if one or even two of the colonies becomes extirpated then the remaining colony or colonies have an opportunity to recolonize the habitat (assuming habitat remains or returns to suitability). Multiple colony metapopulations are also more likely to have a better chance at maintaining genetic diversity, so a corresponding rank was given to each colony in a population for both the number of colonies and for genetic connection within a population. Consequently, the "Number of Colonies" ranking illustrates a metapopulation's higher resiliency but the metapopulations also get a higher ranking by the "Genetic Connection Within a Population" ranking. Conversely, the populations with isolated colonies do not get bumped up in rank because they are less likely to maintain genetic diversity. Due to the fact that the formerly named "Grand Population" has recently been found to be genetically connected to the Mesa Population (Nick Grishin, pers. comm., 2020b) the way genetic connection is ranked has been changed from the peer review draft to the current finalized version 1 draft of the SSA. Habitat patches in the formerly named "Grand Population" and "Mesa Population" (from the historic Unaweep Seep colony) are just under 20 air miles apart.

Consequently, the new genetic information suggests that colonies within 20 miles can be genetically connected and thus colonies between 20 and 10 air miles apart will now receive a rank of 1. However, based on observation and professional judgement by Ellis (pers. comm., 2020e) it is likely that colonies within 10 miles (and especially within 5 miles) have a better chance to maintain genetic connectivity. Therefore, populations where the two most distal colonies are within 10 miles will receive a "genetic connection within a population" rank of 2. This change in ranking modifies the overall resiliency rank for the Taos Population, which has two colonies 16 air miles apart and now receives a genetic connection ranking of "1" where it received a "0" in the peer review draft. Also, the Montrose/San Juan Population receives a "2" ranking for genetic connectivity because we now know there are two colonies within 9 air miles of each other. The new genetic connectivity ranking for the Montrose/San Juan Population coupled with a bump up in ranking for an additional colony (the newly confirmed San Juan County colony) changes the ranking from a very low resiliency ranking of 1 to a moderate resiliency ranking of 4 (even without the habitat size ranking being changed as a result of no available data). The Montrose/San Juan Population consequently has a footnote related to the population's habitat size ranking.

Lastly, a ranking of -1 is given if a population has one or more major threats identified in the population. Ranking for this category is either 0 (no major threats) or -1 because we do not know enough about the immediacy or extent of threats to each population nor the effects of the threats to each specific population sufficiently enough to definitively state that the threats should be additive (and thus receive a -2, -3, or -4 ranking for example). For example, if housing development occurs around a colony, and/or if agricultural activity or grazing occurs, and/or if human-caused alteration of hydrology exists (usually in concert with one of the other major threats) then a -1 habitat rank is applied. The negative habitat rank is only applied to more directly obvious anthropogenic activities in the Current Condition (and future scenarios 1 and 2), not climate change-induced hydrologic changes (i.e. snow pack reduction in predicted future scenarios) even though climate change can be attributed to human activity. Further discussion of how climate change-induced hydrologic change is addressed is stated under the Chapter 4 - Future Condition section.

Some colonies within the multi-colony populations may or may not have the same factors present as their sister colonies but a negative factor in one colony will nonetheless reduce resiliency in the whole population because the colony presumably contributes less to the population's overall resiliency. Discussion of the current condition of each population follows with individual metric ranks and total rank for each population provided in Table 4. Definitions of current status used for the populations in this SSA are:

Extant: Adult *S. n. nokomis* observed in one or more of last four years (2017-2020).

Likely Extant: *S. n. nokomis* observed during surveys in the last 5-9 years and habitat is still present as far as can be determined.

Unknown: Not surveyed within the last10 years but adults were present when last surveyed and habitat is still present as far as can be determined.

Intermittent: Adults seen periodically or only once with no additional survey effort but habitat is or appears to still be present.

Likely Extirpated: Adults not seen in recent survey, though survey of area not complete, and habitat is degraded.

Extirpated: Adults not present for numerous years; bog violet may or may not be present. Or, a formerly occupied colony has been destroyed by habitat alteration from human actions.

It is presumed that populations and colonies whose status is likely extant, unknown, or intermittent still have a chance of being extant and are included along with extant populations in our resiliency analysis. However, some of these areas have not been surveyed recently and because of the annual life cycle of the butterfly it is possible that these populations are no longer occupied.

Archuleta Population

The Archuleta Population is a single isolated colony first known in the late 1970's or early 1980's. Mike Fisher (pers. comm., 2020c) visited it in 2019 but was not able to adequately survey it. Its status is, therefore, prescribed as "unknown" for the purposes of this SSA. Obvious signs of grazing include a nearby cattle exclosure. Based on habitat within the exclosure it appears the habitat outside, including the S. *n. nokomis* habitat, is grazed incompatibly and thus receives a negative habitat factor rank. A survey in 2020 revealed no butterflies or violets and land outside the grazing exclosure appeared to be overgrazed (Aran Johnson, pers. comm., 2020). However, additional surveys in 2021 are needed to determine status of the population. The colony is on private land.

Conejos Population

The Conejos Population is a single colony on a State Wildlife Area. It is of moderate size relative to other populations. Mike Fisher (pers. comm., 2020c) stated that a lepidopterist with knowledge of the species identification visited there in 2019 and found the butterfly so we consider this population "extant." This is the only population we know of that does not have signs of moderate or extensive human activity near it. Looking at aerial imagery, there is virtually no development and little agriculture upstream of the colony site. A potentially suitable habitat area below the colony was surveyed for a few hours by Scott Ellis and Lydia Thompson in 2019. Grazing appeared minimal and they found extensive sedges but no bog violet suggesting there's some underlying hydrologic effects not readily apparent (Scott Ellis, pers. comm., 2020h). However, due to suitable presence of water at the colony site there is no negative habitat factor rank applied to this population.

Costilla Population

The Costilla Population is a single colony originally found by lepidopterist James Scott (Mike Fisher, pers. comm., 2020c) and then reconfirmed in 2010 by Mike Fisher (Scott Ellis and Mike Fisher, pers. comm., 2020). Agricultural activity, perhaps for hay production but maybe other crops, occurs extensively both upstream and downstream and a water diversion ditch forms the southern boundary of the colony. However, looking at aerial imagery, habitat in the colony itself still appears undisturbed so we prescribe a status of "likely extant". The colony is on private land.

Garfield Population

The Garfield Population is a single colony represented by an observation of an adult(s) in 2006 by a knowledgeable lepidopterist (SCAN 2020). There is no data on bog violet occurrence and suitable habitat appears no more than an acre. Habitat may have been larger at one time but was likely impacted directly and hydrologically by Rifle Reservoir and Dam. Due to its unique and precarious location, and lack of survey since 2006, it is unknown if this is still a colony or ever was. We assigned its status as “intermittent” to capture what may be the northernmost extent of *S. n. nokomis’* range. It’s possible the sighting was a stray but it would have had to come at least 80 air miles from its nearest neighbor, the Mesa/Grand Population, or farther from other populations. Consequently, it is likely the location is an annually occupied colony or intermittently occupied with adults occasionally coming from a nearby colony of unknown location. There is potentially suitable habitat upstream of the reservoir and maybe downstream, though there are a lot of factors affecting the habitat. Nonetheless, due to the 2006 sighting, further survey of the colony location and the Rifle Creek drainage is warranted. Land ownership between private and public is not known but is likely private.

La Plata Population

The La Plata Population is currently only represented by a single colony; two other colonies formerly occurring there have been extirpated. The extant colony was first found in 1996 by observation-only, from knowledgeable lepidopterists (SCAN 2020). According to Mike Fisher (Scott Ellis and Mike Fisher, pers. comm., 2020) the remaining colony is intermittently occupied. However, if that is the case it means there is another colony of unknown location nearby providing occasional adults. Bog violets have been confirmed here in the past but Scott Ellis (Scott Ellis and Mike Fisher, pers. comm., 2020) did not see any violet-feeding butterflies there in 2019 and did not have access to confirm violet presence. The remaining colony has nearby housing and commercial development and may be impacted by hydrologic alteration upstream. This colony occurs on private land.

Mesa (CO)/Grand (UT) Population

The Mesa/Grand Population is a multi-colony metapopulation that is thought to consist of six colonies. A seventh colony (Unaweep Seep) used to exist downstream, and at the lowest elevation of the Mesa County colonies, but it became extirpated likely between 1990 and 2000. The colony was on land which is still managed by the BLM. All the other colonies in Colorado are on private land. Mike Fisher observed a butterfly at the most-upstream Mesa County colony in 1998 but the colony has not been surveyed since then. The habitat still appears suitable so the colony status is considered “unknown”. Scott Ellis and Terry Ireland surveyed the next colony downstream in 2018 (Scott Ellis and Terry Ireland, pers. observation, 2018) and found *S. n. nokomis* and bog violets so the colony status is “extant”. The next colony downstream was observed from the road and a few *S. n. nokomis* were observed so the colony is “extant”. The next colony down was not surveyed in 2018 and Scott Ellis is the last known person to observe butterflies there in 1989 but habitat does not appear to have been altered so the status is “unknown”. Scott Ellis and Terry Ireland (pers. observation, 2018) were not able to survey the fifth and last possibly remaining colony from the road in 2018 due to trees and shrubs blocking the view, so the status is “unknown”. This colony too was last surveyed in 1989 by Scott Ellis. Nonetheless, the two colonies in Colorado with butterflies give the Mesa/Grand Population an “extant” status.

In addition, a moderate-sized colony in Grand County, Utah, was confirmed extant in 2019 (Scott Ellis and Lydia Thompson, pers. observation, 2019). Butterflies in this colony were also recently genetically identified as being part of the Mesa Population (Nick Grishin, pers. comm., 2020b). Besides a dirt road used for recreational purposes the colony in Grand County does not have much development around it and is on public land. It does appear to have some grazing but it is suspected that it is winter-grazed so the grazing might be compatible (Scott Ellis and Lydia Thompson, pers. observation, 2019). A property above the colony has center pivot irrigation and may draw some water away from the colony, but water supply still appears to be year-round. However, without further information it is uncertain whether the irrigation is actually affecting the colony because the center pivots are at the apex of a very gentle divide between two drainages and, if surface water is used for the irrigation, most if not all of the surface water flows appear to come from and potentially return into the other drainage.

However, there appears to be a minor drainage or two that flows into the drainage with the colony and it is unknown if subsurface flows are affected by the irrigation. Consequently, this adds to the negative habitat factor rank applied to the Mesa/Grand Population. There is also extensive agriculture, grazing, and some hydrologic alteration in this population within Colorado. Some areas that at least held nectar sources and formed contiguous habitat between colonies have been altered enough by mowing or grazing that habitat has been lost. However, some colonies or areas in between may benefit from occasional mowing. Spring grazing and burning also likely still occur in the colonies and timing of both those activities may be beneficial or at least compatible (Arnold 1989, Ellis 1989); however, current management is not truly known.

Montrose (CO)/San Juan (UT) Population

Just south of the town of Paradox a road cuts through *S. n. nokomis* habitat creating two patches on either side. No butterflies were seen here in 2018 by Scott Ellis and Terry Ireland (pers. observation, 2018). Potentially suitable habitat upstream and downstream was surveyed but most looked like it had been negatively affected by grazing, agricultural conversion, and hydrologic alteration. Scott Ellis had not been to the area for 30 years and said Paradox Creek has become incised since then and center pivot irrigation systems have been installed to irrigate hay or other crops. The habitat upstream of the road seemed reduced from Ellis’s memory and certainly may be if the creek has become incised. The habitat immediately downstream had obvious signs of grazing but most of the patch could not be surveyed due to brush blocking the view and private land access. Further attempt to survey the habitat patch downstream of the road should be made.

A colony, previously unknown to FWS, was recently confirmed in August 2020 in San Juan County, Utah, by Robb Hannawacker (pers. comm., 2020). This colony is likely genetically connected to the Paradox colony in Montrose County since it is only approximately 9 air miles west and is up a drainage that flows eastward into Colorado a few miles south of Paradox. Habitat size of this colony is unknown but rankings for the “Number of Colonies” and “Genetic Connectivity Within a Population” were adjusted due to its confirmed existence and likely genetic connection to the Paradox-area colonies. Since it will be considered part of the Montrose Population the population status changes from “likely extirpated” (in the peer reviewed draft) to “extant” and, again, the name of the population is changed to the Montrose/San Juan Population.

Ouray Population

The Ouray Population is a multi-colony population consisting of three colonies in the Uncompaghre River drainage. The most upstream colony had butterflies in it in 2018 as confirmed by Mike Fisher (Mike Fisher, pers. observation, 2018). Most of the colony is on the west side of the river where the butterflies were observed, but a smaller patch of habitat with a few bog violets exists on the east side. The colony is grazed and, as indicated by aerial imagery, perhaps occasionally mowed. The next colony downstream last had *S. n. nokomis* observed in it in 2017 (Mike Fisher, pers. comm., 2020c). Mr. Fisher briefly surveyed the area in 2018 and 2019 and did not see butterflies there but still thinks the colony is likely extant. The colony has a paved road running through it, has housing development immediately to the north, and has upstream hydrologic alteration on a tributary to the Uncompahgre River that feeds or used to feed water to the colony. It also has as an irrigation ditch along the road but the ditch happens to be where the most violets are, so the ditch appears beneficial to this colony. The last colony is intermittently occupied according to Mike Fisher (pers. comm., 2020c). He has not seen *S. n. nokomis* there in about 4 years but the bog violets were still there in 2019. In 2020 Mr. Fisher surveyed all three colonies in the Ouray Population and found no butterflies (Mike Fisher, pers. comm., 2020h). However, additional surveys in 2021 are needed to determine status of the population. The colonies are on private land.

San Miguel/Mora Population

The San Miguel/Mora Population currently consists of a small single colony. The historic Beulah site used to occur in this population. The population is now represented by the Coyote Creek colony first discovered in 2003 by Mike Fisher (pers. comm., 2020c). Mr. Fisher saw butterflies there in 2006 and 2010 but did not see any in 2019; however, it was later in the season when he went by so they could still be there and the status is, therefore, prescribed as likely extant. Mr. Fisher saw a stray butterfly south of there around Mora so it’s possible more butterflies exist around there. The Coyote Creek colony has some development immediately near it on the west side and low density development in the higher hillsides to the east and west. There has also been hydrologic alteration in the drainage upstream but there is generally not too much development upstream. This is the only population on the east side of the Sangre de Cristo’s in Colorado and New Mexico. The Coyote Creek colony is either on private land or State Park land.

Taos Population

The Taos Population has two known colonies in it. One colony appears very large (approximately 519 acres) and the other to the north quite small (about 2 acres). The large colony was confirmed extant by Steve Cary (pers. comm., 2019). The smaller colony was surveyed by Mike Fisher in 2019 when he did not find the butterfly but he did find it in 2010 and considers it “likely extant” (Mike Fisher, pers. comm., 2020c). There is some development on all but the north side of the Taos colony including housing, roads, water ditches, etc. The smaller colony is narrow and sandwiched between a small highway to the south and a straightened creek channel and agricultural field to the north. It also has quite a few trees and shrubs in it. The colonies are on private land.

The two Taos County colonies are 16 air miles apart. However, based on recent knowledge of the 20-mile genetic connection between the Grand County and Mesa County colonies, we have also made a last-minute change to the “Genetic Connectivity Within a Population” ranking for the Taos Population. Rather than a “0” we give the Taos Population a genetic connectivity ranking of “1” because the two colonies are 10-20 miles away from each other.

Resiliency Ranking and Color Codes

Resiliency is ranked by individual population. Redundancy and representation is ranked for the species as a whole (see Current Condition summary below and Table 13). To illustrate higher or lower resiliency, number ranks and corresponding colors for resiliency categories have been established in Table 4 (and Future Condition tables (9-12)) as follows:

Black category – 0’s; predicted extirpation (future scenarios only);
Red category – 1’s; very low resiliency;
Orange category – 2 and 3’s; low resiliency;
Yellow category – 4’s to 6’s; moderate resiliency;
Green category – 7’s and above; high resiliency.

Table 4. Current condition resiliency rankings for S. n. nokomis populations based on habitat size, number of colonies, genetic isolation, and negative habitat factors in each population.

Population	**Current Status**	**Size in Acres**	**Rank**	**Number of Colonies and Rank**	**Genetic Connectivity Within a Population**	**Negative Habitat Factor Rank**	**Population Resiliency**
COLORADO/ UTAH							
Archuleta	Unknown	11.9	**1**	**1**	**0**	**-1**	**1**
Conejos	Extant	39.2	**2**	**1**	**0**	**0**	**3**
Costilla	Likely Extant	4.3	**1**	**1**	**0**	**-1**	**1**
Garfield	Intermittent	1.0	**1**	**1**	**0**	**-1**	**1**
La Plata	Intermittent	5.2	**1**	**1**	**0**	**-1**	**1**
Mesa (CO)/Grand (UT)	Extant	66.4	**2**	**6**	**2**	**-1**	**9**
Montrose (CO) /San Juan (UT)*	Extant	1.0	**1**	**2**	**2**	**-1**	**4**
Ouray	Extant	59.3	**2**	**3**	**2**	**-1**	**6**
NEW MEXICO							
San Miguel/Mora	Likely Extant	1.0	**1**	**1**	**0**	**-1**	**1**
Taos	Extant	521.2	**6**	**2**	**1**	**-1**	**8**

*The recently confirmed colony in San Juan County, Utah, was added to the “Number of Colonies” ranking for the Montrose Population but habitat size is not available so the acreage and rank for that category was not adjusted. Due to the confirmed existence of the colony the status of the Montrose Population was also changed from “likely extirpated” to “extant” and “San Juan” was added to the name of the Population. The “Genetic Connectivity Within a Population” rank was also increased because of proximity to the colony in Montrose County. If new information on habitat size and (lack of) genetic relatedness are found in the future this SSA can be updated accordingly.

3.6 Summary of Current Condition

Resiliency

Of the 10 populations, five have a very low resiliency. One, single-colony, population (Conejos) has a slightly higher relative resiliency due to no apparent negative habitat factors, so is considered low resiliency. With addition of the San Juan County colony the Montrose/San Juan Population is considered to have moderate resiliency (even without knowledge of acreage size) and another population (Ouray) also ranks as moderate resiliency primarily due to a combination of habitat size and number of colonies. One colony in the Taos Population is very large and, due primarily to this, but also the addition of a "1" rank for genetic connectivity the Population's resiliency score is considered high based on the best available information (Scott Ellis, pers. comm., 2020e; Nick Grishin, pers. comm., 2020b). The last population (Mesa/Grand) has a relatively moderate amount of habitat and, even though its rank was reduced due to some negative habitat factors, it has the most colonies with good genetic connection (all less than 10 miles except the Grand County colony), thus it also has a high resiliency ranking.

Redundancy

With 10 populations spread across 284 air miles north to south and 237 air miles east to west there appears to be adequate redundancy should catastrophic events occur that cause extirpation of one or a few populations. However, if catastrophic events cause extirpation of the Mesa/Grand Population, Taos Population, or even the Ouray Population it could be quite detrimental to the viability of the species because 6 of the populations have very low or low resiliency. Due to the fact that we are not entirely positive that all populations are truly extant, and due to low resiliency of many populations, more resilient populations would contribute to species' viability. However, assuming all populations are still extant, we consider the current condition of species redundancy to be moderate.

Representation

Eight butterfly populations were identified based on genetic differentiation (Cong *et al.* 2019). The other two populations were designated as such because they are more than 20 air miles away from other populations (41 and 80 miles) and it is likely populations more than 20 miles apart are not genetically connected (Scott Ellis, pers. comm., 2020e; Nick Grishin, pers. comm., 2020b). It is likely there is representation of adaptability due to the genetic differences. However, since many of the populations are single colony and all populations appear isolated from one another genetic drift could be causing limited genetic diversity which is a concern for the species. In general, the bog violet and butterfly occur in the same habitat across the range but ecological representation adding to adaptive capacity through occurrence at different elevations gives a low-moderate species representation. Future analysis of ecological settings at all colonies/populations is needed and will better reveal representation across the range.

Current Species Viability

There are currently 19 colonies representing the 10 populations that are considered extant. Current resiliency for each population ranges from very low (five populations) to high (two populations) with one population having low resiliency and another two populations having moderate resiliency. Current redundancy is determined to be moderate and representation is thought to be low – moderate.

CHAPTER 4 – FUTURE CONDITION

4.1 Key Findings

With conservation measures implemented in Scenario 1 and relatively mild predicted changes in climate by 2050 species viability is predicted to improve (by way of the 3R's) from the current condition. Conservation efforts under Scenario 2, also help increase species viability from the current condition, but not as much as Scenario 1 due to a predicted moderate change in climate. Climate is predicted to change rather significantly in scenarios 3 and 4 and, thus, species viability is predicted to decrease from the current condition under both scenarios.

4.2 Development of Future Scenarios

In this chapter, we forecast the resiliency of *S. n. nokomis* populations and the redundancy and representation of the species over the next 30 years (to the year 2050) using a range of possible future scenarios. We selected 30 years because climate models are thought to be relatively accurate up to this point and, besides human habitat impacts, are likely to be the biggest driver of changes to resiliency, redundancy, and representation. We use future climate predictions developed for southern Colorado and northern New Mexico (Rangwala 2020a, 2020b). Four climate models captured the range of model predictions, thus we evaluate four future scenarios, though there could be numerous scenarios. Three of the four models captured have Representative Concentration Pathway (RCP) 4.5 and the other one captured an RCP 8.5 model. An RCP 4.5 is considered a medium emissions scenario. An 8.5 is considered a high emissions scenario. The higher the emissions the greater chance the climate will change further from the 1971-2000 baseline. Current policies are projected to take us slightly above the RCP 4.5 emission trends by mid-century (Hausfather and Peters 2020, p. 260).

The climate models are presented below in tables 5 and 6. In layman's terms the climate model scenarios for both Colorado (including the Grand Population in Utah) and New Mexico are as follows:

Scenario 1: Warm
Scenario 2: Hot/Dry Summers/Very Wet Winters
Scenario 3: Very Hot/Very Dry Summers/Wet Winters
Scenario 4: Hot/Very Dry Summers/Dry Winters

There is little change in most precipitation metrics compared to the temporal baseline (1971-2000) in Scenario 1, thus there is no precipitation identifier for Scenario 1.
Most of the currently extant colonies are in rural to semi-rural areas without a high likelihood of dense development so county population growth projections likely will not apply to most populations since most of the growth in a county typically occurs around larger towns or cities. However in Scenario 3 and 4 we assume development will occur around the colonies/population areas. The four scenarios represent future conditions; Scenario 1 and 2 have conservation efforts applied but Scenario 3 and 4 do not. Our evaluation of future condition presents a plausible

range of expected species responses, using the results of our Current Conditions (Chapter 3) as the baseline.

With snowpack and snow water equivalent, in particular, likely providing the majority of the water supply to the populations, droughts or warming and drying of habitat are likely the biggest climate factors driving *S. n. nokomis* resiliency. As stated in Lukas et al. (2014, pp. 2-3) past climate records from tree rings and paleoclimate indicators suggest droughts were more severe and sustained than anything since modern records began around 1900. The butterfly has therefore, survived these more severe and prolonged droughts in the past and survived more recent (but short-term) droughts of 2002 and 2018.

Nonetheless, there was likely more opportunity for butterflies to survive the droughts of centuries ago because human influence on the landscape was minimal. With human habitat alteration occurring in most populations and the likely resultant isolation of populations there are undoubtedly fewer and more isolated colonies and populations of the butterfly now than there once were. Granted, drying and warming of the climate and changing of topography over millennia or at least since the last ice age may have naturally isolated some of the populations. If drying and warming occurs as predicted in the four climate models it is highly unlikely that the butterfly will be able to move upslope since it would likely only be able to do that if habitat is continuous and the bog violet already occurs there (Scott Ellis, pers. comm., 2020c).

Out of four predicted climate scenarios to 2050 for the *S. n. nokomis* range in Colorado three of the four suggest extreme droughts like 2002 or 2018 will occur three or four years out of five (Rangwala 2020a; Table 5). The best Colorado scenario suggests extreme droughts will occur once every five years. The New Mexico extreme drought predictions for three of the four scenarios suggest extreme droughts will occur two to four years out of five, but, compared to Colorado the best drought scenario increases in New Mexico from once every five years to once every three years (Rangwala 2020b; Table 6).

If it appears hydrology of colonies/populations will be impacted by human activity a negative habitat factor rank is applied (though other factors may have also given a -1 rank). However, for the future scenarios, climate change induced hydrologic changes are expressed through reduction in acreage size of habitat since, if there's less water, extent of the bog violet in a colony will undoubtedly be reduced and extent of nectar sources will also likely be reduced. It is assumed that acreage size will be reduced by the percentage of snow pack reduction in the predicted future scenarios but actual percent reduction of habitat could be more or less than the percent reduction of snowpack. An intensive long-term study of each colony would have to ensue to determine actual amount of habitat versus amount of snow pack. As it turns out habitat size adjustment only effects the habitat size ranking for the Taos Population. We have not attempted to include additional adjustments for evaporative stress but if temperatures are higher that could cause more evaporation and even less available water to the butterfly's habitat.

The summary table below describes changes in the future climate for Colorado by 2050 (2040-2069) relative to the 1971-2000 period under four climate scenarios:

Table 5. Climate Scenarios by 2050 for Silverspot Butterfly (Colorado)

Climate Metric	Scenario 1 (MRI-CGCM3.rcp45)	Scenario 2 (HadGEM2-ES365.rcp45)	Scenario 3 (HadGEM2-ES365.rcp85)	Scenario 4 (IPSL-CM5A-MR.rcp45)	*Historical Value*
Winter Precipitation, inches (% change relative to historical)	1.6 (0)	1.9 (+19)	1.7 (+6)	1.5 (-6)	*1.6 inches*
Summer Precipitation, inches (% change relative to historical)	2.9 (+4)	2.7 (-4)	2.5 (-11)	2.4 (-14)	*2.8 inches*
Coldest Winter Temperature, ºF (increases relative to historical by ºF)	-2 (1)	3 (6)	6 (9)	3 (6)	*-3 ºF*
Hottest Summer Temperature, ºF (warmer relative to historical by ºF)	98 (3)	101 (6)	104 (9)	101 (6)	*95 ºF*
Avg. Winter Minimum Temperature, ºF (warmer relative to historical by ºF)	20 (2)	24 (6)	26 (8)	24 (6)	*18 ºF*
Avg. Summer Maximum Temperature, ºF (warmer relative to historical by ºF)	89 (3)	93 (7)	96 (10)	92 (6)	*86 ºF*
Growing Season Length (#days) (higher relative to historical by #days)	183 (20)	185 (22)	194 (31)	186 (23)	*163 days*
Winter Snowline (ft) (upward shift relative to historical, ft)	6490 (440)	7370 (1320)	7810 (1760)	7370 (1320)	*6050 ft*
Snowpack/Snow Water Equivalent, in (% change relative to historical)	0.09 (-10%)	0.07 (-30%)	0.045 (-55%)	0.05 (-50%)	*0.1 Inches*
Potential Evapotranspiration (Annual), in (% change relative to historical)	47 (+5%)	52 (+15%)	54 (+20%)	52 (+15%)	*45 inches*
Frequency of Extreme Drought Years like 2011/2018	Once in every five years	Three in every five years	Four in every five years	Three in every five years	*Twice between 1980-2018*

Values and projected changes described above are for the location at **38.475ºN; 107.907ºW** and a mean elevation of **5,780 ft**. Winter is Dec, Jan, Feb; Summer is Jun, Jul, Aug. Dataset: MACA metdata v2 (4-km downscaled climate projections) and gridMET (4-km historical).

Table 6. Description of Climate Scenarios by 2050 for Silverspot Butterfly (Colorado).

Future Climate Scenario	Projected Changes in Climate Metrics
Scenario 1	• Moderate increases in temperatures of 2°F in winter nighttime and 3°F in summer daytime temperatures • Very limited changes in precipitation with no change in winter and slight increases in summer precipitation • Hottest summer daytime high increases by 3°F; severe drought conditions occur once every 5 years • Moderate reductions in winter snowpack (10% lower) • Growing season increases by 3 weeks, and evaporative stress increases by 5%
Scenario 2	• Large increases in temperatures of 6°F in winter nighttime and 7°F in summer daytime temperatures • Large increases in winter (20% more) and slight reduction in summer (5% less) precipitation • Hottest summer daytime high increases by 6°F; severe drought conditions occur three in every 5 years • Large decreases in winter snowpack (30% lower) • Growing season increases by 3 weeks, and evaporative stress increases by 15%
Scenario 3	• Very large increases in temperatures of 8°F in winter nighttime and 10°F in summer daytime temperatures • Small increases in winter (5% more) and moderate decreases in summer (10% less) precipitation • Hottest summer daytime high increases by 9°F; severe drought conditions occur four in every 5 years • Substantial decreases in winter snowpack (55% lower) • Growing season increases by 1 month, and evaporative stress increases by 20%
Scenario 4	• Large increases in temperatures of 6°F in winter nighttime and 6°F in summer daytime temperatures • Small decreases in winter (5% less) but larger reductions in summer (15% less) precipitation • Hottest summer daytime high increases by 6°F; severe drought conditions occur three in every 5 years • Substantial decreases in winter snowpack (50% lower) • Growing season increases by more than 3 weeks, and evaporative stress increases by 15%

Information provided by Imtiaz Rangwala (Imtiaz.Rangwala@colorado.edu) North Central Climate Adaptation Science Center & CIRES, University of Colorado, Boulder

The summary table below describes changes in the future climate for New Mexico by 2050 (2040-2069) relative to the 1971-2000 period under four climate scenarios:

Table 7. Climate Scenarios by 2050 for Silverspot Butterfly (New Mexico)

Climate Metric	Scenario 1 (MRI-CGCM3.rcp45)	Scenario 2 (HadGEM2-ES365.rcp45)	Scenario 3 (HadGEM2-ES365.rcp85)	Scenario 4 (IPSL-CM5A-MR.rcp45)	*Historical Value*
Winter Precipitation, inches (% change relative to historical)	2.0 (0)	2.8 (+40)	2.4 (+20)	1.8 (-10)	*2 inches*
Summer Precipitation, inches (% change relative to historical)	5.6 (-5)	4.9 (-20)	4.5 (-25)	4.1 (-30)	*6 inches*
Coldest Winter Temperature, °F (increases relative to historical by °F)	-5 (4)	-1 (8)	1 (10)	-5 (4)	*-9 °F*
Hottest Summer Temperature, °F (warmer relative to historical by °F)	89 (3)	91 (5)	95 (9)	92 (6)	*86 °F*
Avg. Winter Minimum Temperature, °F (warmer relative to historical by °F)	13 (3)	16 (6)	17 (7)	15 (5)	*10 °F*
Avg. Summer Maximum Temperature, °F (warmer relative to historical by °F)	80 (2)	84 (6)	87 (9)	84 (6)	*78 °F*
Growing Season Length (#days) (higher relative to historical by #days)	129 (12)	153 (36)	167 (50)	157 (40)	*117 days*
Winter Snowline (ft) (upward shift relative to historical, ft)	8200 (900)	9100 (1800)	9400 (2100)	8800 (1500)	*7300 ft*
Snowpack/Snow Water Equivalent, in (% change relative to historical)	0.45 (-10%)	0.43 (-15%)	0.25 (-50%)	0.2 (-60%)	*0.5 Inches*
Potential Evapotranspiration (Annual) (% change relative to historical)	51 (+15%)	53 (+20%)	57 (+30%)	51 (+15%)	*44 inches*
Frequency of Extreme Drought Years like 2002/2018	Once in every three years	Two in every five years	Four in every five years	Three in every five years	***Twice between 1980-2018***

Values and projected changes described above are for the location at **36.737ºN; 105.907ºW** and a mean elevation of **8,200 ft**. Winter is Dec, Jan, Feb; Summer is Jun, Jul, Aug. Dataset: MACA metdata v2 (4-km downscaled climate projections) and gridMET (4-km historical).

Table 8. Description of Climate Scenarios by 2050 for Silverspot Butterfly (New Mexico)

Scenario 1	• Moderate increases in temperatures of 3°F in winter nighttime and 2°F in summer daytime temperatures • Very limited changes in precipitation with no change in winter and slight decreases in summer (5% less) precipitation • Hottest summer daytime high increases by 3°F; severe drought conditions occur once every 3 years • Moderate reductions in winter snowpack (10% lower) • Growing season increases by 2 weeks, and evaporative stress increases by 15%
Scenario 2	• Large increases in temperatures of 6°F in winter nighttime and 6°F in summer daytime temperatures • Very large increases in winter (40% more) but large decreases in summer (20% less) precipitation • Hottest summer daytime high increases by 5°F; severe drought conditions occur two in every 5 years • Moderate reductions in winter snowpack (15% lower) • Growing season increases by 5 weeks, and evaporative stress increases by 20%
Scenario 3	• Very large increases in temperatures of 7°F in winter nighttime and 9°F in summer daytime temperatures • Large increases in winter (25% more) but large decreases in summer (25% less) precipitation • Hottest summer daytime high increases by 10°F; severe drought conditions occur four in every 5 years • Substantial decreases in winter snowpack (50% lower) • Growing season increases by 7 weeks, and evaporative stress increases by 30%
Scenario 4	• Large increases in temperatures of 5°F in winter nighttime and 6°F in summer daytime temperatures • Moderate decreases in winter (10% less) but much larger reductions in summer (30% less) precipitation • Hottest summer daytime high increases by 6°F; severe drought conditions occur three in every 5 years • Substantial decreases in winter snowpack (60% higher) • Growing season increases by more than 5 weeks, and evaporative stress increases by 15%

Information provided by Imtiaz Rangwala (Imtiaz.Rangwala@colorado.edu) North Central Climate Adaptation Science Center & CIRES, University of Colorado, Boulder.

In addition to increased drought frequency, too much rain at the wrong time, and/or elevated average temperature, could reduce survival or mating potential. As springs get warmer earlier and fall stays warmer longer the larvae may emerge from diapause earlier or not enter pupation until later than normal. Subsequently, late spring and fall frosts could end up killing active larvae (Scott Ellis, pers. comm., 2020i). Similarly, the larval activity may be asynchronous with the bog violet food source resulting in larval starvation (Scott Ellis, pers. comm., 2020i). Furthermore, a longer activity period could expose the larvae to increased parasitism and predation (Mike Fisher, pers. comm., 2020g). Without data and with variability in microsites, it is extremely difficult to predict how these survival factors could be affected and thus there are no rankings for them, but likely influence of a longer growing season and other climate variables are presented in the text.

4.2 Scenario 1 – Warm climate with Conservation Efforts

This scenario assumes:

- No new increase in direct habitat loss by development.
- Existing habitat loss through development does not change.
- Habitat fragmentation by agricultural conversion is reduced or hay mowing occurs no more than annually and allows for improvement in habitat quality.
- Grazing is only conducted in the winter and early spring and at an intensity that is compatible with the needs of the butterfly.
- Efforts made to maintain current hydrology are successful and no colony size adjustment for slightly smaller reduced snowpack is included due to the lowest extreme drought frequencies.
- The possibility for restoration, and especially creation, of habitat is currently unknown, thus size and number of colonies remains the same with respect to those potential activities. The exception is that for the two intermittent colonies future surveys discover a population that is supporting the intermittent colony, thus increasing colonies to two in each population.
- Translocation of butterflies to existing colonies, likely first through rearing larvae in a lab, are implemented in accordance with recommendations by geneticists to boost genetic diversity and are successful. The heading for the genetic ranking is thus stated as “Genetic Connection or Diversity Within a Population” to account for human translocation efforts boosting diversity.

The Scenario 1 climate model is at an RCP level of 4.5, which is approximately the current RCP level produced by humans. Scenario 1 is the most positive outlook for climate at RCP 4.5. Compared to baseline conditions climate metrics are summarized as follows:

- Winter and summer temperatures will get slightly warmer but highs and averages don’t appear to increase much.
- Winter and summer precipitation will stay about the same as baseline conditions.
- The chance of extreme drought rises significantly from the 1980 to 2018 frequency to one in five years for Colorado (CO) or one in three years for New Mexico (NM).

- Snowpack will decrease moderately (10 percent) in both CO and NM and evaporative stress will increase 5 to 15 percent, respectively.
- Growing season increases 20 days in CO and 12 days in NM.
- Winter snowline goes up in elevation 440 feet in CO but actually drops 810 feet in NM.

Overall, climate changes in this scenario appear tolerable for *S. n. nokomis* and with conservation efforts conditions and resiliency improves to moderate for the six low or very low resiliency populations. This scenario's growing season increases 20 days from the baseline in CO and 12 days in NM and will likely reduce larval survival from disease and predation more so than under baseline conditions. Winter snow cover might help prevent freezing and desiccation but due to its long-term variability it is not certain that it necessarily increases survival. Consequently, winter snowlines are summarized but we do not make predictions on resiliency based on snow line and any water contribution this lower elevation snow offers is likely outweighed by benefits of snowpack.

Resiliency rankings result in eight moderate and two high resiliency populations as presented in Table 9. It is assumed that seven of the 10 populations would have resiliency increase due to increased genetic diversity as a result of translocation of butterflies. It is assumed that six populations would also increase in resiliency from habitat-improving conservation efforts. It is conversely assumed that four of the populations could not be significantly improved through conservation efforts due to existing development near them and retain a -1 habitat factor ranking. Redundancy is expected to remain the same (moderate) compared to the current condition (see Table 13). Representation is expected to improve to moderate through increase in genetic diversity via translocations but variability would likely still exist amongst all the populations. This scenario represents a predicted increase in viability for the species from the current condition due to relatively mild climate change coupled with the addition of conservation efforts improving resiliency, the maintenance of moderate redundancy, and an increase to moderate representation from conservation efforts. Should conservation measures not be successful or not be implemented for Scenario 1 we would expect resiliency, redundancy, and representation to be similar to the current condition.

Table 9. Resiliency rankings for S. n. nokomis populations under Scenario 1.

Population	**Current Status**	**Size in Acres**	**Rank**	**Number of Colonies and Rank**	**Genetic Connection or Diversity Within a Population**	**Negative Habitat Factor Rank**	**Population Resiliency**
COLORADO/ UTAH							
Archuleta	Unknown	11.9	**1**	**1**	**2**	**0**	**4**
Conejos	Extant	39.2	**2**	**1**	**2**	**0**	**5**
Costilla	Likely Extant	4.3	**1**	**1**	**2**	**0**	**4**
Garfield	Intermitt.	1.0	**1**	**2**	**2**	**-1**	**4**
La Plata	Intermitt.	5.2	**1**	**2**	**2**	**-1**	**4**
Mesa/Grand	Extant	66.4	**2**	**6**	**2**	**0**	**10**
Montrose/San Juan	Extant	1.0	**1**	**2**	**2**	**0**	**5**
Ouray	Extant	59.3	**2**	**3**	**2**	**-1**	**6**
NEW MEXICO							
San Miguel/Mora	Likely Extant	1.0	**1**	**1**	**2**	**0**	**4**
Taos	Extant	521.2	**6**	**2**	**2**	**-1**	**9**

4.3 Scenario 2 – Hot/Dry Summers/Very Wet Winters with Conservation Efforts

This scenario assumes:

- No new increase in direct habitat loss by development.
- Existing habitat loss through development does not change.
- Habitat fragmentation by agricultural conversion is reduced or hay mowing occurs no more than annually and allows for improvement in habitat quality.
- Grazing is only conducted in the winter and early spring and at an intensity that is compatible with the needs of the butterfly.
- Efforts are made to maintain current hydrology but, due to drop in snowpack and increase in drought frequency, hydrology is not maintained in areas with extensive agriculture or moderate levels of housing development due to need for water for those two major factors. Predicted reduction of snowpack of 30 percent in CO and 15 percent in NM reduce the size of colonies in proportion to that reduction from current condition.
- The possibility for restoration, and especially creation, of habitat is currently unknown, thus size and number of colonies remains the same with respect to those potential activities. The exception is that for the two intermittent colonies future surveys discover a population that is supporting the intermittent colony, thus increasing colonies to two in each population.
- Translocation of butterflies to existing colonies are implemented in accordance with recommendations by geneticists to boost genetic diversity.

Scenario 2 climate model is at RCP level of 4.5, however, since the model is different it predicts more severe changes in climate than the Scenario 1 model. Compared to baseline conditions climate metrics are summarized as follows:

- Winter and summer temperatures will increase (5-9°F) over the historical values in both CO and NM.
- Winter precipitation (including rain) will go up significantly 19 percent in CO and 40 percent in NM.
- Summer precipitation will remain about the same in CO but drop significantly in NM (20 percent).
- Extreme drought is predicted to increase in frequency to every two years out of five in CO and every three years out of five in NM.
- Large to moderate decrease in snowpack 30 percent CO and 15 percent NM.
- Growing season 3 weeks longer and 15 percent more evaporative stress in CO while NM growing season increases 5 weeks and has 20 percent increase in evaporative stress.
- Winter snowline goes up in elevation by 1320 feet in CO and 70 feet in NM.

Increases and decreases in climate metrics are very mixed within each model so effect to *S. n. nokomis* is difficult to decipher. However, climate changes in this scenario are expected to override conservation efforts in some CO populations due primarily to a large decrease in snowpack but also in NM due primarily to increase in evaporative stress. Both these factors will likely create less water for bog violet survival and/or nutrition, limit bog violet distribution, allow for fewer nectar sources, and possibly increase chance of egg mortality and larval desiccation. Additionally, the higher summer temperatures may reduce the amount of time for mating and nectaring in all populations and perhaps even reduce fecundity. Negative habitat factors are thus applied to all populations. We'll assume genetic diversity efforts will produce the same results as Scenario 1 but this may not be the case if fewer butterflies are available for mating or fewer larvae survive. This scenario's growing season increases from Scenario 1 in both CO and, especially, NM and will likely reduce larval survival from disease and predation more so than Scenario 1.

Resiliency rankings for each population follows in Table 10. Population resiliency is generally improved from the current condition but there are fewer populations in the moderate ranking versus Scenario 1. This is due to negative habitat factors being applied to all but two of the populations from less water availability in CO and NM via decreased snowpack. There are no major habitat factors around the Conejos Population and there is grazing but not development or extensive agriculture around the Archuleta Population thus the assumption is that hydrologic conditions can still be maintained for the most part at Scenario 2's degree of climate change. However, a habitat size reduction is applied to these two populations and it should be stated that increased evaporative stress from higher temperature as well as more frequent severe drought likely pushes even the Archuleta and Conejos Populations to a threshold where their resiliency under Scenario 2 is questionable or at least further diminished.

Assumption of successful translocation to single-colony populations or the potentially lower diversity Taos Population increases genetic diversity, and the genetic diversity ranking remains high for all populations as in Scenario 1. Under this scenario there are no very low resiliency populations but there are two low, six moderate, and two high resiliency populations. The Mesa/Grand Population resiliency drops a point due to application of the negative factor rank from less available water coupled with human development/agricultural need for the water. The Taos Population also drops a point in rank from size reduction due to less snowpack. We assume in Scenario 2 that the climatic conditions are not so severe as to cause extirpation of colonies/populations and decrease redundancy. Representation might improve slightly through increase in genetic diversity via translocations and variability would likely still exist amongst all the populations but improving diversity could be challenging. Species viability decreases slightly from Scenario 1 due to a slightly worse climate prediction. This scenario represents a predicted increase in viability for the species from the current condition due primarily to conservation efforts. However, climate change is significant enough under Scenario 2 that resiliency and perhaps even redundancy and representation would decline from current condition without conservation measures.

Table 10. Resiliency rankings for S. n. nokomis populations under Scenario 2.

Population	Current Status	Size in Acres	Rank	Number of Colonies and Rank	Genetic Connection or Diversity Within a Population	Negative Habitat Factor Rank	Population Resiliency
COLORADO/ UTAH							
Archuleta	Unknown	8.3	**1**	**1**	**2**	**0**	**4**
Conejos	Extant	27.4	**2**	**1**	**2**	**0**	**5**
Costilla	Likely Extant	3.0	**1**	**1**	**2**	**-1**	**3**
Garfield	Intermitt.	0.7	**1**	**2**	**2**	**-1**	**4**
La Plata	Intermitt.	3.64	**1**	**2**	**2**	**-1**	**4**
Mesa/Grand	Extant	46.5	**2**	**6**	**2**	**-1**	**9**
Montrose/San Juan	Extant	0.7	**1**	**2**	**2**	**-1**	**4**
Ouray	Extant	41.5	**2**	**3**	**2**	**-1**	**6**
NEW MEXICO							
San Miguel/Mora	Likely Extant	0.85	**1**	**1**	**2**	**-1**	**3**
Taos	Extant	443	**5**	**2**	**2**	**-1**	**8**

4.4 Scenario 3 – Very Hot/Very Dry Summers/Wet Winters No Conservation Actions

This scenario is the worst of the four scenarios in regards to negative climate effects and *S. n. nokomis* viability and assumes:

- Some increase in direct habitat loss by development occurs, particularly in colonies close to existing housing development.
- Habitat fragmentation by agricultural conversion is NOT reduced.

- Grazing is not compatible with the needs of the butterfly due to even light summer grazing because of dry summer conditions resulting in little remaining nectar sources, and probable reduced abundance of bog violet.
- No efforts are made to maintain current hydrology (but even if so prove fruitless in the face of extreme drought).
- All populations will have a negative habitat factor rank due to climate-related hydrologic alteration whether there is surrounding development or not. Small single-colony populations will all become extirpated due to lack of water and small colonies within metapopulations will become extirpated reducing resiliency of the population.
- If there are no survey efforts around the two intermittent colonies we will know of no colony supporting them and, based on best available information, will have to assume there are none, thus leaving the colony open to extirpation (as is the current case).
- No translocation of butterflies are implemented and genetic diversity remains in a likely low state.

Scenario 3 climate model emissions are RCP 8.5 and predicts more severe changes in climate than Scenario 1 or 2 climate models. Compared to baseline conditions climate metrics are summarized as follows:

- Winter and summer temperatures will increase (7-10°F) over the historical values in both CO and NM.
- Winter precipitation (including rain) will only go up a small amount (5 percent) in CO but increase 25 percent in NM.
- Summer precipitation will have moderate drop of 10 percent in CO and drop significantly in NM (25 percent).
- Extreme drought is predicted to occur in both States four out of five years.
- A substantial decrease in snowpack will occur in both CO (55 percent) and NM (50 percent).
- The growing season will be 4 weeks longer and 20 percent more evaporative stress in CO while NM growing season increases 7 weeks and has 30 percent increase in evaporative stress.
- Winter snowline goes up in elevation by 1760 feet in CO and 510 feet in NM.

The only increase that’s potentially beneficial in this climate model is an increase in winter precipitation that might modestly ameliorate the hot dry summers, but probably not since snowpack decreases so significantly, droughts occur nearly every year, and evaporative stress increases significantly over baseline conditions. No conservation efforts are included in this scenario but even if they were, climate changes in this scenario are expected to override any conservation efforts. The very hot and dry conditions will likely create less water for bog violet survival and/or nutrition, limit bog violet distribution, allow for few nectar sources, and possibly increase the chance of egg mortality and larval desiccation (though overwinter survival could increase slightly). Due to lack of water under this predicted climate scenario, we assume small single-colonies less than 12 acres have no habitat left in the future and will become extirpated. These are represented in black in Table 11. Additionally, small colonies less than 12 acres in the metapopulations also become extirpated with resultant resiliencies discussed below.

Although the Conejos Population is a single colony, habitat area is large enough we assume it will persist though less water will likely reduce its size and it receives a -1 habitat factor rank under Scenario 3 due to less available water (even though no substantial development or agricultural activities exist around it).

We assume loss of the four colonies under 12 acres in the Mesa/Grand Population and assume the two largest colonies will persist. However, the two largest colonies are more than 20 miles apart and lose their genetic connectivity, thus lowering that rank to 0 and between the two factors result in low resiliency for the Population. In fact, if the predicted climate becomes realized and there are no conservation efforts as stated under this scenario, it would relegate the two remaining large colonies to single-colony populations in the future under this scenario (assuming new colonies are not discovered in between them).

It is likely the Montrose/San Juan Population will lose the Paradox colony (which is already considered “likely extirpated”) due to less water in the already degraded Paradox Creek drainage. However, due to what appears to be a good water supply, we assume the San Juan County colony will persist, albeit likely with reduced habitat size. This is assuming the San Juan County colony is over 12 acres but this assumption appears as though it could be factual based on aerial imagery of moist or wet areas near the confirmed location. Consequently, the 0.45-acre habitat size presented in Table 11 likely underrepresents the actual habitat size but is sufficient for this exercise to illustrate the colony’s persistence.

Breaking slightly from our previous assumptions, we assume a currently “intermittent” colony in the Ouray Population will become extirpated due to less available water even though it is over 12 acres. Surrounding development already appears to diminish habitat quality (as supported by its intermittent occupation) and thus we expect that colony to become permanently extirpated with reduced water. Despite this assumption, because of two relatively large colonies that are within 10 miles of each other the Ouray Population ranks as the most resilient population in Scenario 3.

Lastly, the Taos Population will likely lose its small colony (2.2 acres) due to lack of water which also removes Taos’ genetic connectivity rank. Furthermore, with a predicted 50 percent reduction in snowpack, it is assumed that the Taos colony will decrease by a corresponding 50 percent. Therefore, it would be reduced by 219.5 acres and three points in size rank. The remaining CO/UT populations also are assumed to have a size decrease corresponding to their 55 percent reduction of snowpack and acreages are adjusted accordingly.

Additionally, the higher summer temperatures may reduce the amount of time for mating and nectaring in all populations and perhaps even reduce fecundity. Negative habitat factors due to lack of conservation efforts exist but do not add to the negative habitat factor rank as a result of reduction in hydrology for all populations. Genetic diversity will not increase with no conservation efforts and fewer butterflies will be produced likely creating worse resiliency. However, we kept the genetic diversity rank at “2” for the Ouray Population since, under our assumptions, there are still two or more colonies in each population that are less than 10 miles from each other. This scenario has the longest growing season in both CO and NM and will also likely reduce larval survival due to increased disease and predation more so than in scenarios 1 and 2.

Resiliency rankings for each population follows in Table 11. Five of the previously ranked low or very low resiliency populations under current conditions are expected to become extirpated, one population has a very low resiliency, three are low resiliency, and the Ouray Population retains a moderate resiliency passing the Mesa/Grand and Taos populations as the highest ranking population. Extirpation of colonies will reduce resiliency and redundancy of populations and will also undoubtedly decrease representation from scenarios 1, 2, and the current condition, causing a decline in species viability compared to the current condition and scenarios 1 and 2.

Table 11. Resiliency rankings for S. n. nokomis populations under Scenario 3.

Population	**Current Status**	**Size in Acres**	**Rank**	**Number of Colonies and Rank**	**Genetic Connection or Diversity Within a Population**	**Negative Habitat Factor Rank**	**Population Resiliency**
COLORADO/ UTAH							
Archuleta	Unknown	0	**1**	**0**	**0**	**-1**	**0**
Conejos	Extant	17.6	**2**	**1**	**0**	**-1**	**2**
Costilla	Likely Extant	0	**1**	**0**	**0**	**-1**	**0**
Garfield	Intermitt.	0	**1**	**0**	**0**	**-1**	**0**
La Plata	Intermitt.	0	**1**	**0**	**0**	**-1**	**0**
Mesa/Grand	Extant	19.8	**2**	**2**	**0**	**-1**	**3**
Montrose/San Juan	Extant	0.45	**1**	**1**	**0**	**-1**	**1**
Ouray	Extant	20.5	**2**	**2**	**2**	**-1**	**5**
NEW MEXICO							
San Miguel/Mora	Likely Extant	0	**1**	**0**	**0**	**-1**	**0**
Taos	Extant	259.5	**3**	**1**	**0**	**-1**	**3**

4.5 Scenario 4 – Hot/Very Dry Summers/Dry Winters No Conservation Actions

This scenario is the next to the worst of the four scenarios in regards to negative climate effects and *S. n. nokomis* viability and assumes:

- Some increase in direct habitat loss by development occurs, particularly in colonies close to existing housing development.
- Habitat fragmentation by agricultural conversion is NOT reduced.
- Grazing is not compatible with the needs of the butterfly due to even light summer grazing because of dry summer conditions resulting in little remaining nectar sources, and probable reduced abundance of bog violet.
- No efforts are made to maintain current hydrology (but even if so prove fruitless in the face of extreme drought).
- All populations will have a negative habitat factor rank due to climate-related hydrologic factors regardless of absence of nearby development or agricultural activity or existing development and no conservation efforts. Small single-colony populations will all become extirpated due to lack of water and small colonies within metapopulations will become extirpated reducing resiliency of the population.
- If there are no survey efforts around the two intermittent colonies we will know of no colony supporting them and, based on best available information, will have to assume there are none, thus leaving the colony open to extirpation (as is the current case).
- No translocation of butterflies are implemented and genetic diversity remains in a likely low state.

Scenario 4 climate model emissions are RCP 4.5 but due to less winter and summer precipitation in CO and, especially less snowpack, this scenario is slightly worse for *S. n. nokomis* than Scenario 2 in CO. Interestingly, in NM this model is a fair amount worse than Scenario 2 in regards to less winter and especially summer precipitation but especially due to significantly reduced snowpack even worse than Scenario 3. Overall Scenario 4 is barely better than Scenario 3 but could arguably be worse due to less snowpack and less winter and especially less summer precipitation. Compared to baseline conditions climate metrics are summarized as follows:

- Winter and summer temperatures will increase (4-6°F) over the historical values in both CO and NM.
- Winter precipitation (including rain) will decrease 6 percent in CO but will decrease 10 percent in NM.
- Summer precipitation will have the largest drop of any model of 14 percent in CO and drop significantly in NM (30 percent).
- Extreme drought is predicted to occur in both States three out of five years.
- A substantial decrease in snowpack will occur in both CO (50 percent) and NM (60 percent).
- The growing season will be over 3 weeks longer and 15 percent more evaporative stress in CO while NM growing season increases 6 weeks and also has a 15 percent increase in evaporative stress.
- Winter snowline goes up in elevation by 1320 feet in CO and 70 feet in NM.

With such significant decrease in snowpack, droughts occurring every three out of five years, and the second or third highest evaporative stress increase over baseline conditions the climate is not favorable for *S. n. nokomis* viability. No conservation efforts are included in this scenario but even if they were climate change effects to habitat and the butterfly in this scenario is expected to override any conservation efforts. The very hot and dry conditions will likely create less water for bog violet survival and/or nutrition, limit bog violet distribution, allow for few nectar sources, and possibly increase the chance of egg mortality and larval desiccation. Winter precipitation, if it can even ameliorate summer drought, won't help alleviate the significant reduction in snowpack. Additionally, the higher summer temperatures may reduce the amount of time for mating and nectaring in all populations and perhaps even reduce fecundity. Genetic diversity will not increase with no conservation efforts and fewer butterflies will be produced likely creating worse resiliency. This scenario's second longest growing season in both CO and NM will likely reduce larval survival from disease and predation more so than Scenario 1 and 2 but perhaps not as much as Scenario 3.

Resiliency rankings for each population follows in Table 12. As in Scenario 3, it is expected that climate change will cause extirpation of all small colonies/populations under 12 acres. The size of habitat in remaining populations increases very slightly in CO populations from Scenario 3. Habitat decreases in the Taos Population from Scenario 3 but not enough to change the size ranking. With there being slightly less evaporative stress and slightly less frequency of severe drought remaining populations may, in turn, be slightly more resilient. However, using the rankings in this report, the increase in resiliency from Scenario 3 is immeasurable. Consequently, resiliency rankings are the same with five extirpated populations, one very low and three low resiliency populations, and only one moderately resilient population. Redundancy of populations also remains low and representation is also decreased from scenarios 1, 2, and the current condition.

Table 12. Resiliency rankings for S. n. nokomis populations under Scenario 4.

Population	**Current Status**	**Size in Acres**	**Rank**	**Number of Colonies and Rank**	**Genetic Connection or Diversity Within a Population**	**Negative Habitat Factor Rank**	**Population Resiliency**
COLORADO/ UTAH							
Archuleta	Unknown	0	**1**	**0**	**0**	**-1**	**0**
Conejos	Extant	19.6	**2**	**1**	**0**	**-1**	**2**
Costilla	Likely Extant	0	**1**	**0**	**0**	**-1**	**0**
Garfield	Intermitt.	0	**1**	**0**	**0**	**-1**	**0**
La Plata	Intermitt.	0	**1**	**0**	**0**	**-1**	**0**
Mesa/Grand	Extant	22.1	**2**	**2**	**0**	**-1**	**3**
Montrose/San Juan	Extant	0.5	**1**	**1**	**0**	**-1**	**1**
Ouray	Extant	22.8	**2**	**2**	**2**	**-1**	**5**
NEW MEXICO							
San Miguel/Mora	Likely Extant	0	**1**	**0**	**0**	**-1**	**0**
Taos	Extant	207.6	**3**	**1**	**0**	**-1**	**3**

4.6 Summary of Current and Future Conditions

A comparison of resiliency for each population for the current condition and future scenarios is presented in Table 13 along with summaries of redundancy and representation. With conservation measures implemented in Scenario 1 and relatively mild predicted changes in climate by 2050, species resiliency, redundancy, representation and thus viability improves from the current condition. In Scenario 2, we predict an increase in species viability from current condition, but not as much as Scenario1. Climate is predicted to change rather significantly in scenarios 3 and 4 so resiliency, redundancy, representation and thus species viability is expected to decrease from current condition and scenarios 1 and 2.

Table 13. Summary of resiliency, redundancy, and representation for current condition and four future scenarios.

Population	Current Condition Resiliency	Future Scenario 1 Resiliency	Future Scenario 2 Resiliency	Future Scenario 3 Resiliency	Future Scenario 4 Resiliency
Archuleta	1	4	4	0	0
Conejos	3	5	5	2	2
Costilla	1	4	3	0	0
Garfield	1	4	4	0	0
La Plata	1	4	4	0	0
Mesa/Grand	9	10	9	3	3
Montrose/San Juan	4	5	4	1	1
Ouray	6	6	6	5	5
San Miguel/ Mora	1	4	3	0	0
Taos	8	9	8	3	3
Redundancy	Moderate	Moderate	Moderate	Very Low	Very Low
Representation	Low - Moderate	Moderate	Moderate	Low	Low

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APPENDICES

Appendix A. *S. nokomis* Subspecies Hindwing Disc Colors

Descriptions in the table below for *S. n. apacheana*, *coerulescens*, *nitocris*, and *nokomis* were taken from (Selby 2007, p. 16, and references therein). The *S. n. wenona* hindwing disc description is from dos Passos and Grey (1945, p. 1) where they originally labeled the butterfly as its own species (*S. wenona*). A subsequent article by dos Passos and Grey (1947, pp. 5, 10) placed *S. wenona* as a subspecies, *S. n. wenona*. The table below excludes the junior subjective synonym *S. n. carsonensis*, contained in Selby (2007, p. 16), since it is no longer considered a separate subspecies (Cong *et al*. 2019, pp. 1, 5, 21; also see Appendix B).

Comparison of *S. nokomis* subspecies hindwing disc coloration (Selby 2007 and references therein; dos Passos and Grey 1945).

Subspecies	**Male**	**Female**
S. n. apacheana	Yellowish buff	Light olive-green
S. n. coerulescens	Red-brown	Brown to green
S. n. nitocris	Deep reddish-brown	Black
S. n. nokomis	Light brown	Deep olive
S. n. wenona	Light brown overlaid with light olivaceous green	Green, similar to female *S. n. nokomis*

Appendix B. Additional Genetic Information

Cong *et al*. (2019, pp. 1, 5, 21) determined that *S. n. carsonensis* (California/Nevada) was the same as *S. n. apacheana* and should therefore be regarded as a junior subjective synonym. They also analyzed old specimens labeled as *S. n. nigrocaerulea* (Cockerell 1900, pp. 622) and *S. n. tularosa* (Holland 2010, pp. 78-81) from north-central and supposedly south-central ("Mescalero") New Mexico, respectively. However, Cong *et al*. (2019, p. 12) found these specimens were genetically similar to *S. n. nokomis* and are also both considered junior subjective synonyms. This supports Scott and Fisher (2014, p. 22) who also concluded *S. n. nigrocaerulea* and *S. n. tularosa* were objective synonyms of *S. n. nokomis* for reasons other than genetics. Furthermore, Cong *et al*. (2019) confirmed *S. n. coerulescens* and *S. n. wenona* as distinct subspecies. With *S. n. apacheana*, *nitocris,* and *nokomis* as the other three confirmed subspecies, the most current information available in Cong *et al*. (2019) identify five subspecies of *S. nokomis* rather than six as indicated in Selby (2007, p.13).

Appendix C. Discussion of Existing and Proposed Common Names of *S. n. nokomis*

The common name Nokomis fritillary has generally been used for the full species *S. nokomis* (North American Butterfly Association 2018). It is also often used for the subspecies *S. n. nokomis* (NatureServe 2019) but Great Basin silverspot butterfly has also been a common name attributed to the subspecies (Colorado Natural Heritage Program 2018, NatureServe 2019, Selby 2007 and references therein). Western seep fritillary has also been used for the full species or different subspecies (Scott 1986, p. 326).

Some common names specific to *S. n. nokomis*, whose range is now more restricted based on Cong *et al*. (2019), have been offered up by Cong *et al*. (2019 p. 2), the SSA Technical Team members or the Service's Core Team for this SSA. Cong *et al*. (2019, p. 2) and previous authors or scientists suggest the Nokomis silverspot, Seep silverspot, or Granny silverspot. Additional names suggested by this SSA's Technical Team or Core Team include the Colorado Plateau silverspot, the Sneffel's Silverspot (referring to a mountain near its apparent type locality) the Eastern nokomis fritillary, or the Grand butterfly. The Granny silverspot is derived from Native American languages because Nokomis or Nookomis in Ojibway (Chippewa) Algonquin, Ottowa, Menominee, and Potawatomi Tribes refers to a wise woman or grandmother (Redish and Lewis 2019). The Ojibway (or Ojibwe), extend to Montana (John Nystedt, USFWS, pers. comm., 2020a) so it is possible the etymology of "Granny" or "Grandmother silverspot" made it into native language in the west where *S. nokomis* resides. "Grand silverspot" gives deference to the names Granny or Grandmother silverspot since a "Grand" can refer to a grandparent (John Nystedt, USFWS, pers. comm., 2020b). However, we will leave it up to species experts, taxonomists, and committees of butterfly associations and societies to debate an appropriate common name for *S. n. nokomis* and perhaps the other subspecies and unaffiliated segregates (populations 2, 3, and 9).