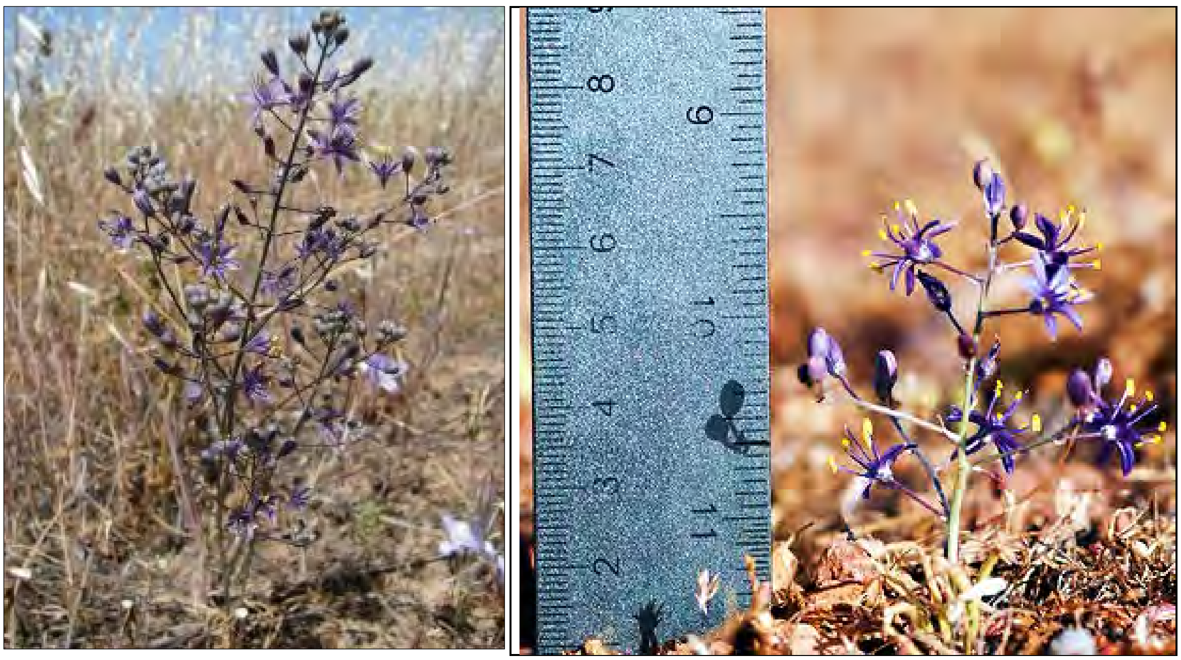
Species Status Assessment for Purple Amole (*Hooveria purpurea* [*Chlorogalum purpureum*])

Santa Lucia Purple Amole
(*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*])
and
Camatta Canyon Amole
(*Hooveria purpurea* var. *reducta* [*Chlorogalum purpureum* var. *reductum*])

Version 1.0



Left: Santa Lucia purple amole blooming at Camp Roberts, San Luis Obispo County, California, Spring 2008 (Occurrence 16). Photo credit Camp Roberts Environmental Staff
Right: Camatta Canyon amole on Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California, April 14, 2013. Photo credit Christopher J. Winchell

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
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EXECUTIVE SUMMARY

Purple amole (*Hooveria purpurea* [*Chlorogalum purpureum*]) was listed as a threatened species in 2000 (65 FR 14878–14888). The purple amole is composed of two varieties, Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*]) and Camatta canyon amole (*Hooveria purpurea* var. *reducta* [*Chlorogalum purpureum* var. *reductum*] separated from one another by approximately 61 km (38 miles).

Purple amole is endemic to Monterey and San Luis Obispo Counties in central California. Santa Lucia purple amole is known from 17 occurrences in four populations in the Santa Lucia Range in southwestern Monterey County (Fort Hunter Liggett) and north central San Luis Obispo County (Camp Roberts) (CNDDB 2020, website). Camatta Canyon amole is known from four occurrences in the La Panza Range and adjacent hills in central San Luis Obispo County (Kofron et al. 2013a, entire). The Santa Lucia purple amole currently occupied area consists of less than 500 hectares (1,230 acres). The Camatta Canyon amole currently occupied area consists of greater than 36 hectares (90 acres). The species needs appropriate soil types, including well-drained with gravel components in the top and subsoil strata; suitable habitats, including openings within blue oak woodland and California buckwheat and/or chamise shrubland, blue oak savanna and valley and California prairie; sparsely vegetated areas with some open, bare ground; adequate annual precipitation; suitable temperatures; insect pollinators; and biological soil crusts.

When the species was listed in 2000, the primary threats to the Santa Lucia purple amole were identified as loss and alteration of habitat, direct loss of plants from construction and use of military training facilities and from military field training activities, displacement by nonnative annual grasses, and potentially by alteration of fire cycles due to military training. Livestock grazing was identified as a potential threat, as it was thought that grazing could be reinstated in occupied habitat in the future. In the 5-year review in 2008, habitat loss and alteration resulting from military activities was thought to have been considerably lessened with implementation of completed or draft Integrated Natural Resources Management Plans and monitoring programs at Fort Hunter Liggett and Camp Roberts. The threat posed by nonnative, annual grasses was identified as recurring. Fires had removed the nonnative annual grasses in some areas during some years. However, because of the clumped and limited distribution of the purple amole in a semiarid environment, wildfire could destroy a substantial portion of the population. Grazing was no longer considered a threat because all sheep and cattle grazing was terminated at both installations. New threats to the taxon identified in 2008 included: herbivory, soil displacement and bulb disturbance resulting from Botta's pocket gophers (*Thomomys bottae*) and feral pigs (*Sus scrofa*). Currently, we consider the primary threats to the Santa Lucia purple amole to be displacement from nonnative, invasive species, anthropogenic disruptions from ongoing military activities and/or disturbance from wildlife species, fire (although it may have some species benefits), and climate change, including extended drought and increasing temperatures.

When the species was listed in 2000, the primary threats to the Camatta Canyon amole were identified as illegal vehicle trespass into the population on Forest Service land, road maintenance, displacement by nonnative annual grasses and by livestock grazing, depending upon the intensity of grazing use within the population area (65 FR 14879). In the 5-year review in 2008, we identified the primary threats to Camatta Canyon amole to be cattle grazing, illegal motorcycle trespass, displacement by nonnative annual grasses, and wildfire (Service 2008, p. 19). More recently, Kofron et al. (2013a, p. 45–46) identified the primary threat to be invasive plants, and other threats were Botta's pocket gopher, uncontrolled cattle grazing, road maintenance, and possibly lack of fire. Currently, we consider the primary threats to the taxon to be the displacement from nonnative, invasive species, and climate change, including severe drought and increasing temperatures. Secondary threats are ground disturbance from gophers and off-highway vehicle recreation. Minor threats include road vehicles and road maintenance along Red Hill Road. Potential threats include heavy cattle grazing — strategic cattle grazing, and if not practicable then light cattle grazing, may be beneficial; farming; and road maintenance on the private property north of State Highway 58, in the right-of-way of State Highway 58, and on the private property south of it.

We evaluated the resiliency of Santa Lucia purple amole populations and Camatta Canyon amole occurrences under current conditions and under two future scenarios. High resiliency populations/occurrences have a high probability of persistence. Moderate resiliency populations/occurrences have a moderate probability of persistence. Low resiliency populations/occurrences have a low probability of persistence and a high risk of extirpation due to stochastic events.

We evaluated the resiliency of the Santa Lucia purple amole populations using information on density, level of disturbance, productivity, and occupied area. We evaluated resiliency of Camatta Canyon amole occurrences using information on occupied area, protected status, land use, and number of primary threats. Future scenario 1 includes the effects of RCP 8.5 for climate change for 50 years with no additional management actions and future scenario 2 includes the effects of RCP 4.5 for climate change for 50 years with implementation of plausible management actions. For Santa Lucia purple amole, the resiliency analysis under current conditions shows that three of the four populations have moderate resiliency and one is low. Under Future Scenario 1, resiliency does not change. Under Future scenario 2, with increased management, resiliency increases from low to moderate in one population, Nacimiento River North - Fort Hunter Liggett. For Camatta Canyon amole, the resiliency analysis under current conditions shows that one occurrence has moderate resiliency and two occurrences have low resiliency; there is insufficient information to calculate a resiliency score for occurrence 4. Under Future Scenario 1, one occurrence remains in moderate condition and the two in low current condition become extirpated. Under Future scenario 2, with increased management, one occurrence remains in moderate condition, the two in low current condition become extirpated, and occurrence 4 moves from unknown to moderate condition.

Given morphological and ecological differences between Santa Lucia purple amole and Camatta Canyon amole, representation across both varieties contributes to the purple amole's ability to adapt to changing environmental conditions over time. Both varieties have relatively small geographic ranges with mostly similar landscape features throughout. Although information is lacking regarding genetics of either variety, we consider each to comprise one genetic unit due to geography. The productivity data for Santa Lucia purple amole suggest three of the four populations may currently be declining. The combined data from several studies suggest that the number of Camatta Canyon amole, where monitored, has declined. Thus, declining numbers of individuals may affect genetic diversity, and the spatial extent and associated ecological representation of both Santa Lucia purple amole and Camatta Canyon amole are inherently low. Under future scenario 1, populations/occurrences are expected to decline further. Under future scenario 2 with increased management, resiliency of Santa Lucia purple amole populations improves; but, two of the four occurrences of Camatta Canyon amole are forecast to become extirpated. Therefore, purple amole currently and into the future has low adaptive capacity across its two varieties, given declining numbers, the small spatial extent, and habitat and environmental uniformity.

Because all four populations of Santa Lucia purple amole are situated relatively close together and all four occurrences of Camatta Canyon amole are situated very close together, each could be simultaneously affected by a catastrophic event. Given that the two varieties are separated by approximately 61 km (38 miles), a prolonged, catastrophic drought could affect both varieties simultaneously. However, the two varieties are far enough apart such that a large, intense wildfire is unlikely to deleteriously affect both varieties at once. Redundancy will always be limited for local, endemic taxa with naturally limited geographic ranges; however, having two spatially separated varieties provides some level of redundancy for the species as a whole. With increased management under future scenario 2, improved resiliency of Santa Lucia purple amole and increased distribution of Camatta Canyon amole may increase the protection for the species from extinction due to catastrophic events in the future as compared to current conditions.

Table of Contents

1 INTRODUCTION

This document presents the Species Status Assessment (SSA) for purple amole (*Hooveria purpurea* [*Chlorogalum purpureum*]). This species comprises two varieties, Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*]) and Camatta Canyon amole (*Hooveria purpurea* var. *reducta* [*Chlorogalum purpureum* var. *reductum*]. We, the U.S. Fish and Wildlife Service (Service), developed this SSA for purple amole to compile and evaluate the best available scientific information on the species' biology and factors that influence its viability.

1.1 LISTING HISTORY

Original Listing
Notice: 65 FR 14878–14888
Date of Final Listing Rule: March 20, 2000
Entity Listed: *Chlorogalum purpureum*
(includes both varieties [var.] *Chlorogalum purpureum* var. *purpureum* and *Chlorogalum purpureum* var. *reductum*)
Classification: Threatened

1.2 STATE LISTING

Purple amole is not listed by the state of California under the California Endangered Species Act (CESA). Santa Lucia purple amole is recognized as a California Rare Plant Rank List (CRPR) 1B.1 taxon by the California Native Plant Society ([CNPS] 2020, website), which indicates that it is considered rare or endangered in California (1B). The State of California listed Camatta Canyon amole as rare under the California Endangered Species Act in 1978 (California Department of Fish and Game 2020) and Camatta Canyon amole is recognized as a CRPR 1B.1 taxon by the California Native Plant Society.

1.3 APPROACH OF THE SPECIES STATUS ASSESSMENT

Following the SSA Framework (Service 2016, entire), an SSA begins with a compilation of the best available information about the species (such as taxonomy, life history, and habitat requirements) and its ecological needs at the individual, population, and species levels. Next, an SSA describes the current condition of the species' habitat and demographics, and the probable explanations for past and ongoing changes in abundance and distribution. Lastly, an SSA forecasts the species response to plausible future scenarios with differing environmental conditions and conservation efforts.

The SSA is based on the conservation biology principles of resiliency, representation, and redundancy to evaluate the current and future condition of the species (Smith et al. 2018, entire). Ultimately, an SSA characterizes a species' ability to sustain populations in the wild over time, using the best scientific understanding of the current and future abundance and distribution of the species within its ecological settings.

Resiliency describes the ability of populations to withstand environmental stochasticity. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance.

Representation describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Measures may include the number of varied niches occupied, gene diversity, heterozygosity, or alleles per locus.

Redundancy describes the ability of a species to withstand catastrophic events. Redundancy is characterized by having multiple, resilient populations distributed within the ecological settings of the species and across its range. Redundancy can be measured by the number of populations and their spatial distribution and degree of connectivity.

The scientific information used for this SSA is from a variety of resources such as primary peer-reviewed literature, reports submitted to the Service and other public agencies, species location information in Geographic Information Systems (GIS) databases, and expert experience and observations. Previous analyses presented in other Service documents including the original listing (65 FR 14878–14888), critical habitat (67 FR 65414–65445), and a 5-year review (Service 2008, entire) were also utilized.

2 SPECIES INFORMATION

2.1 NOMENCLATURE

Chlorogalum purpureum was first described by Townshend Brandegee in 1893 from specimens collected in the Santa Lucia Mountains of Monterey County, near the unincorporated area of Jolon, by William Vortriede and Alice Eastwood (Brandegee 1893, p. 159). Hoover (1964, p. 123) recognized two varieties, *C. purpureum* var. *purpureum* and *C. purpureum* var. *reductum*. He diagnosed *C. purpureum* var. *reductum* from the nominate variety by its smaller size, and referred to it as the "dwarf variety:" *C. purpureum* var. *reductum*, 10 to 20 centimeters/4 to 8 inches tall; and *C. purpureum* var. *purpureum*, 25 to 40 centimeters/10 to 16 inches tall (Jernstedt 2012, p. 1285).

Hoover’s treatment of the two varieties persisted until 2018, when Taylor and Keil proposed a new genus, *Hooveria* for *C. purpureum* (both varieties, *C. p.* var. *purpureum* and *C. p.* var. *reductum*) and *C. parviflorum*. Their distinction as a new genus is based primarily on flowering times; these two species flower during the day (diurnal) and the rest of the species remaining in *Chlorogalum* flower during the evening (vespertine). Additional evidence to support this new treatment includes: small flowers with the style longer than the perianth (outer parts of the flower, sepals and petals collectively), chromosome number 2n = 60, and other molecular phylogenetic evidence suggesting that *Chlorogalum* is not monophyletic. The authors chose the name *Hooveria* in honor of Dr. Robert Hoover, to commemorate his contributions to the record of the California flora and his substantial collections (Taylor and Keil 2018, entire).

2.2 DESCRIPTION

This description of the diagnostic characters for purple amole is based on Taylor and Keil (2018, p. 2) and the *Chlorogalum purpureum* treatments in the Jepson eFlora (Jernstedt 2012, website). Purple amole is an herbaceous perennial with a tunicate (concentric layers of membranous sheathing) bulb. The bulbs are 2.5 to 3 centimeters (cm, 0.98 to 1.2 inches) long with white to brown bulb scales. The species has basal (develops from the base of the rootstalk, as opposed to the stem) linear leaves with undulate (or wavy) margins that are between 2 to 5 millimeters (mm, 0.1 to 0.2 inch) wide. The midrib of the leaves is thickened. Purple amole inflorescences are panicles, which are multi-branched, compound racemes where each flower occurs on a pedicel (or stalk). In this arrangement the lower flowers mature first. The flowers are diurnal, with one to many per node. The perianth parts are deep blue to purple and recurved. There are six undifferentiated tepals (perianth parts not clearly separated into petals and sepals) with nectaries at the base and they are 5 to 8 mm (0.2 to 0.3 inch) long. These persist in fruit and twist together above the ovary. The flowers have six stamens that attach at the base of the tepals and the style (five to six mm long or 0.2 inch) is exserted beyond the length of the perianth. The species has a superior ovary and stigma has three minute lobes. Purple amole has three-valved, capsule fruits. There are two black seeds per locule; although one may abort and the seeds are about three mm (0.1 inch) long.

Santa Lucia purple amole is distinguished from Camatta Canyon amole by inflorescence length. Inflorescences in Santa Lucia purple amole are 25 to 40 cm (10 to 16 inches) long and 10 to 20 cm (4 to 8 inches) long in Camatta Canyon amole (Jernstedt 2012, website). Santa Lucia purple amole occurs in the northeastern portion of the Outer South Coast Ranges, on the east side of the Santa Lucia Range in Monterey and San Luis Obispo counties. Camatta Canyon amole occurs in the southeastern portion of the Outer South Coast Ranges, on the northeast side of the La Panza Range (and adjacent hills) and is only found in San Luis Obispo County (Jernstedt 2012, website; California Natural Diversity Database [CNDDB] 2020, website; Consortium of California Herbaria Portal [CCH2] 2020, website). Representative photographs of the taxa are provided in Figures 1 and 2.

Figure 1a. Santa Lucia purple amole blooming in May at Fort Hunter Liggett, Monterey County, California (Occurrence 9). Photo credit Darlene Woodbury, Fort Hunter Liggett.

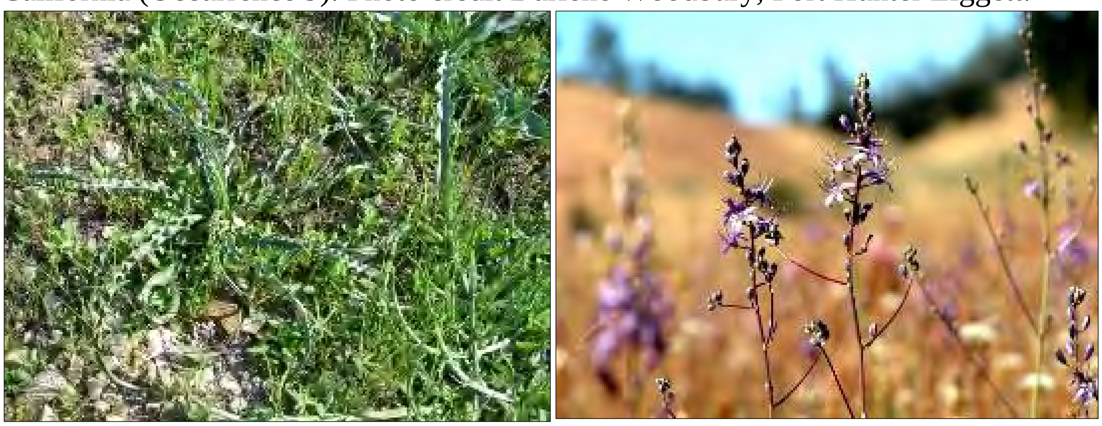

Figure 1b. Santa Lucia purple amole vegetative growth and in bloom at Fort Hunter Liggett, Monterey County, California (Occurrence 9). Photo credit Darlene Woodbury, Fort Hunter Liggett.

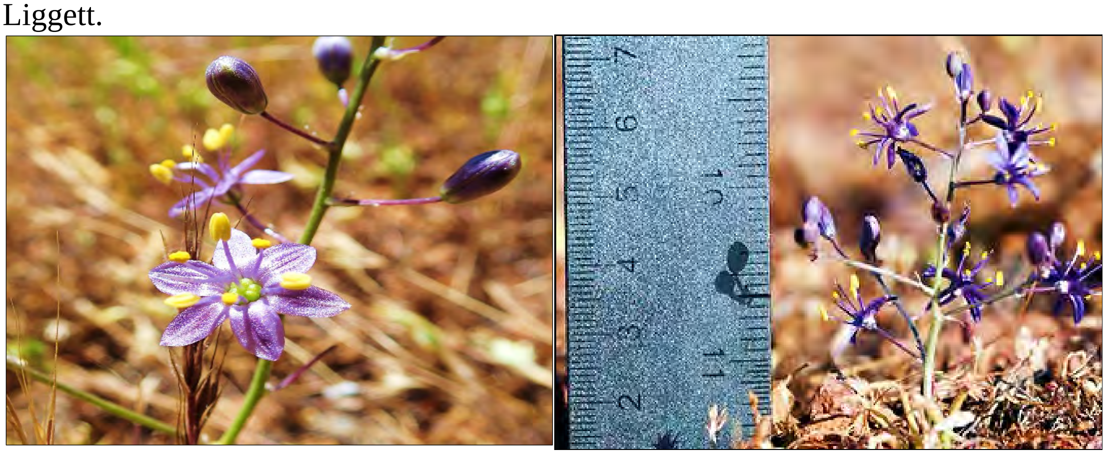

Figure 2. Left: Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) on Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California, 23 April 2019. Photo credit Connie Rutherford. Right: Camatta Canyon amole on Red Hill Ridge, 14 April 2013. Photo credit Christopher J. Winchell.

2.3 DISTRIBUTION

Purple amole is endemic to Monterey and San Luis Obispo Counties in central California (Figure 3). Santa Lucia purple amole is known from 17 occurrences in the Santa Lucia Range in southwestern Monterey County (Fort Hurter Liggett) and north central San Luis Obispo County (Camp Roberts) (CNDDB 2020, website). Camatta Canyon amole is known from four occurrences in La Panza Range and adjacent hills in central San Luis Obispo County (Kofron et al. 2013a, entire).

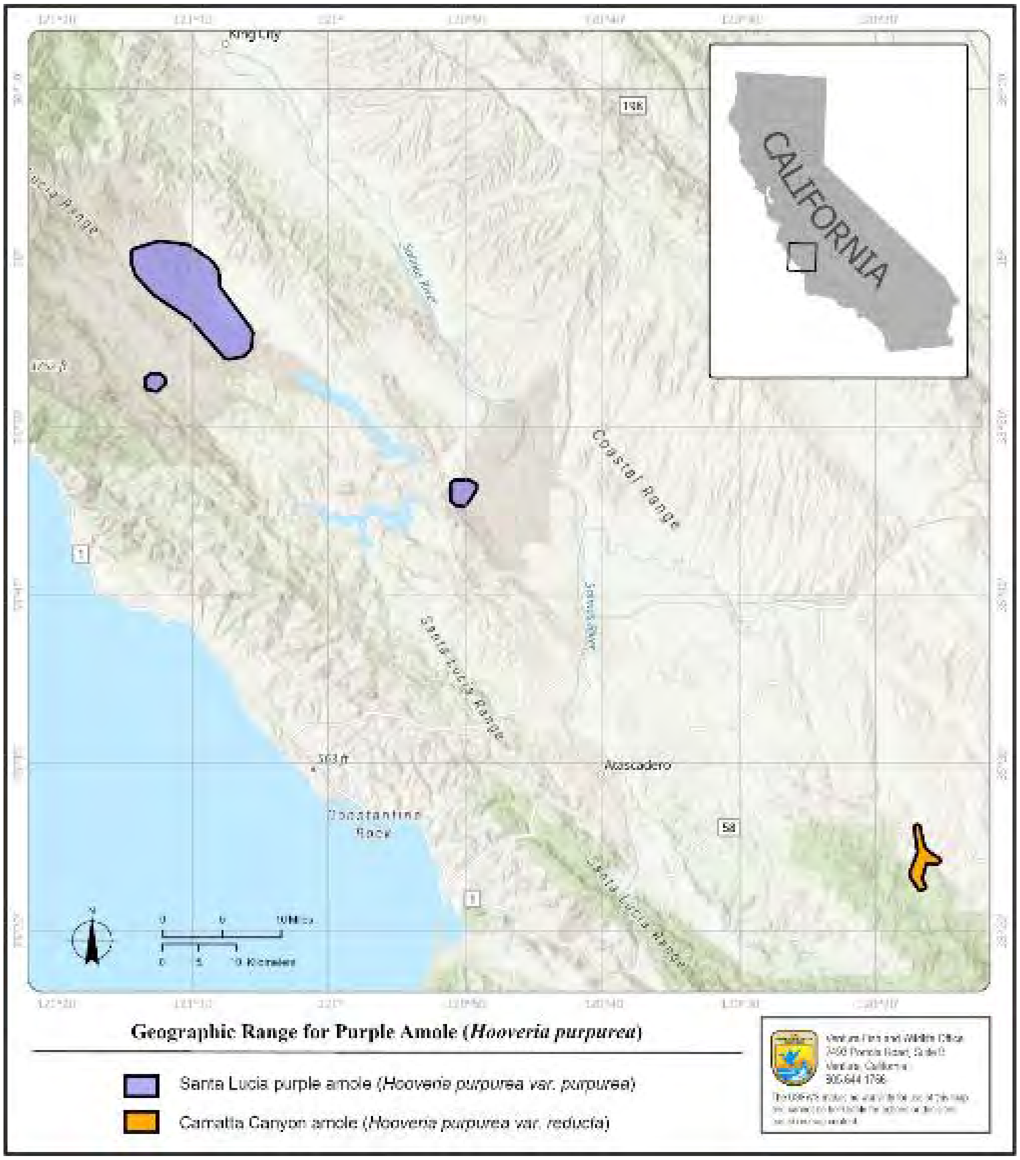

Figure 3. Known distribution of purple amole (*Hooveria purpurea*), throughout Monterey and San Luis Obispo counties, California, which includes two varieties, Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea*) and Camatta Canyon amole (*Hooveria purpurea* var. *reducta*).

2.3.1 Santa Lucia purple amole

Herbarium records indicate that the historical distribution of Santa Lucia purple amole was a small area centered on the unincorporated community of Jolon in southern Monterey County. Jolon is a historic town located in the San Antonio River Valley, west of the Salinas River and approximately 27 kilometers (km; 17 miles [mi]) south of King City. All 26 known specimens from the period of 1895 through 1969 were collected in localities that reference Jolon, except for two that mention Milpitas Ranch (CCH2 2020, website). The Milpitas Ranch was one of the original ranchos formed when the Mission San Antonio de Padua lands were divided and secularized into Mexican land grants. William Hearst acquired the approximately 63,940-hectare (158,000-acre) rancho in 1925, then sold it to the U.S. Army in 1940, when it became Fort Hunter Liggett (FHL; U.S. Army) (Milpitas Historical Society 2020, website). Based on the available information, the likely historic range of the taxon includes the entire lowland valley between Mission San Antonio de Padua, southeast to regions around the historic town center of Jolon.

No new collections of the variety were made until 1975 with no change to the known historic range. In 1979, Lawrence Heckard and Rimo Bacigalupi collected Santa Lucia purple amole approximately 11 km (6.8 mi) north of Jolon. The exact location is unknown, but this extended the taxon's range into uplands beyond the San Antonio and Jolon valley floors. Later in 1983 David Keil collected the taxon approximately 11 km (6.8 mi) to the south, near the end of Sam Jones Road. This further expanded the known distribution over the Santa Lucia Mountain Range. In the late 1990's several more collections were made in lowland areas east of Jolon. These collections nearly doubled the variety's known geographic extent in Monterey County.

At time of listing in 2000, Keil collected Santa Lucia purple amole approximately 31 km (19.3 mi) southeast of the community of Lockwood. This collection extended the known range into north-central San Luis Obispo County (CCH2 2020, website). Its range has not changed since the year 2000. The current distribution of Santa Lucia purple amole is illustrated in Figure 3, which includes data from the CNDDB (2020, website) and the CCH2 (2020, website) herbaria collections. The variety's geographic range is restricted and it only occurs in a small portion of south-central Monterey and north-central San Luis Obispo counties. There are presently 17 element occurrence records for purple amole in CNDDB (2020, website). All the known occurrences, except for CNDDB Occurrence No. 19 (collected by Heckard and Bacigalupi in 1979) are located within active military installations. The Monterey County populations (excluding CNDDB Occurrence No. 19) occur on FHL and the San Luis Obispo County population is on Camp Roberts (California Army National Guard). The taxon distribution has not changed since the last 5-year review completed by the Service in 2008. Santa Lucia purple amole occupies a total area of approximately 500 hectares (1,235 acres; according to spatial data provided to the Service from each of the installations). We consider there to be four main, extant populations of the variety throughout the range, based on geography, topographical and land use barriers, and monitoring strategies (Figure 4). Three are located within FHL in Monterey County: 1) those occurrences distributed around the historic town center of Jolon, 2) those located generally south of the unincorporated community of Lockwood, 3) the northern Nacimiento River population. The fourth is in San Luis Obispo County within Camp Roberts. Additional information about the four populations of purple amole according to the respective CNDDB occurrences that comprise them is provided in Appendix A.

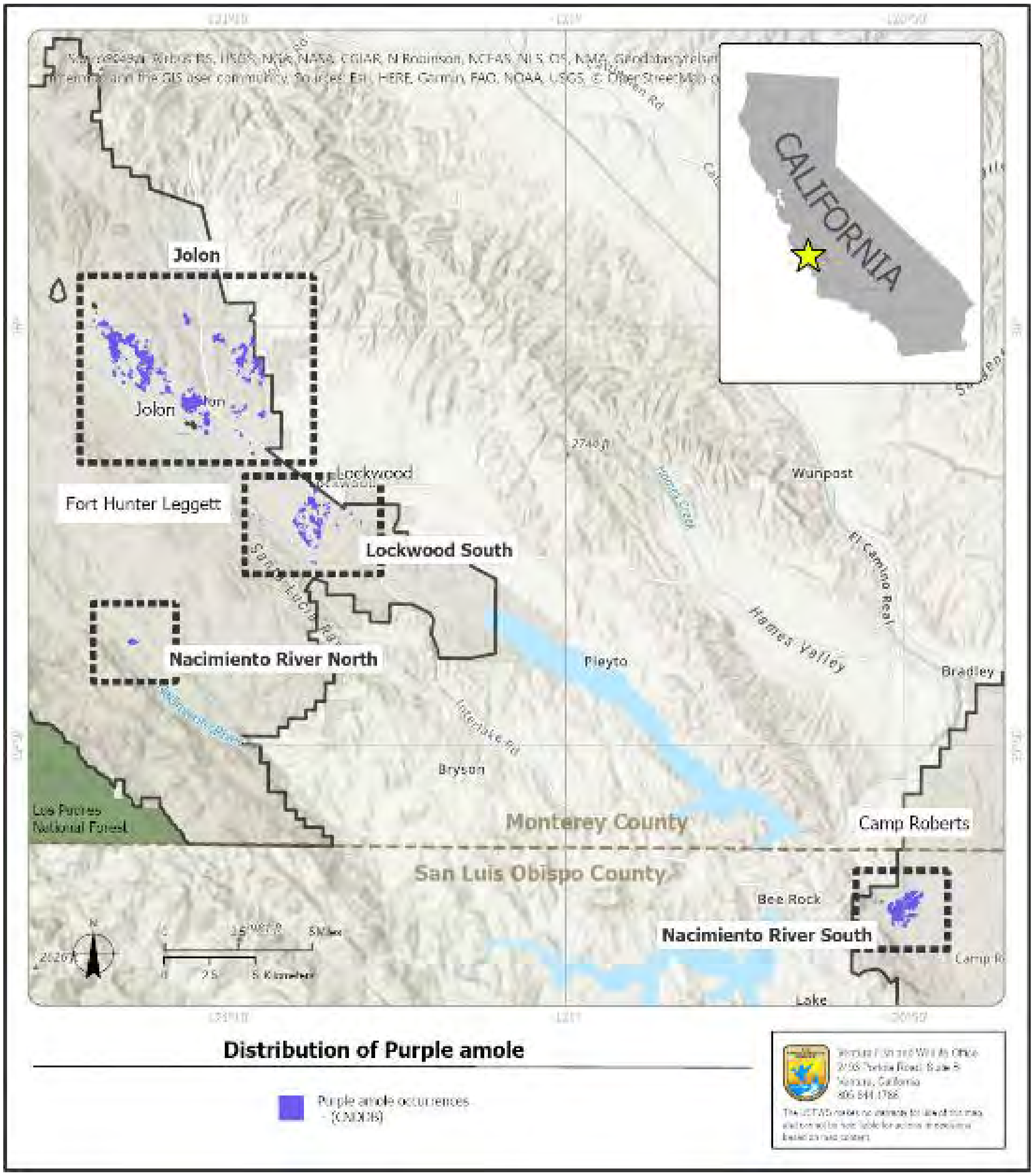

Figure 4. Known distribution of Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*]), throughout Monterey and San Luis Obispo counties, California. Regional inset is placed over the historic town of Jolon as the primary geographic reference for the taxon (CNDDB 2020, website; CCH2 2020, website).

2.3.2 Camatta Canyon amole

At time of listing in 2000, Camatta Canyon amole was known from two occurrences: Red Hill Ridge (including Red Hill Mesa) in Los Padres National Forest, and 7 kilometers/4 miles to the south on one private property. Population estimates ranged from 1,000 to 300,000 plants on less than 4 hectares/10 acres (Service 2000 entire). In the previous 2008 5-year review (Service 2008 entire), three occurrences were known with population estimates ranging from 100,000 to 500,000 plants on up to 52 hectares/128 acres (California Department of Fish and Game 2007, p. 1; Center for Plant Conservation 2007, p. 1). In 2013, Kofron et al. (2013a, p. 42) reported four occurrences in a slightly increased geographic area, with population estimates ranging from 20,000 to 500,000 plants on at least 12 hectares/30 acres. In 2020, Camatta Canyon amole is known from four occurrences on four properties (Table 1), 61 kilometers/38 miles southeast of the nearest occurrence of Santa Lucia purple amole on Camp Roberts.

As currently known, Camatta Canyon amole is endemic to La Panza Range and vicinity in central San Luis Obispo County, occurring in the rain shadow at intermediate elevations (488 to 633 meters/1,601 to 2,077 feet) on the northeast side and adjacent hills (Figure 5). Camatta Canyon amole is narrowly distributed; however, it likely has greater distribution than is currently known. Learning the distribution is hindered by its short time above ground with flowers, and lack of access to private properties for searching. At time of listing, Service (2000, p. 14897; 2002, p. 65416) estimated the known occupied area to be 5.1 hectares/12.6 acres, composed of national forest, 3 hectares/7.4 acres; private land north of State Highway 58, 2 hectares/4.9 acres; and private land south of State Highway 58, 0.1 hectare/0.2 acre. The California Department of Fish and Game (2007 entire) estimated the occupied area (known and unknown) as 52 hectares/128.2 acres. Kofron et al. (2013a, entire) reported the known occupied area as 12 hectares/29.7 acres, and with potential for a greater occupied area on private land north of State Highway 58, especially in critical habitat (Service 2002, p. 65444). Additional information about the four CNDDB occurrences of Camatta Canyon amole is provided in Appendix B.

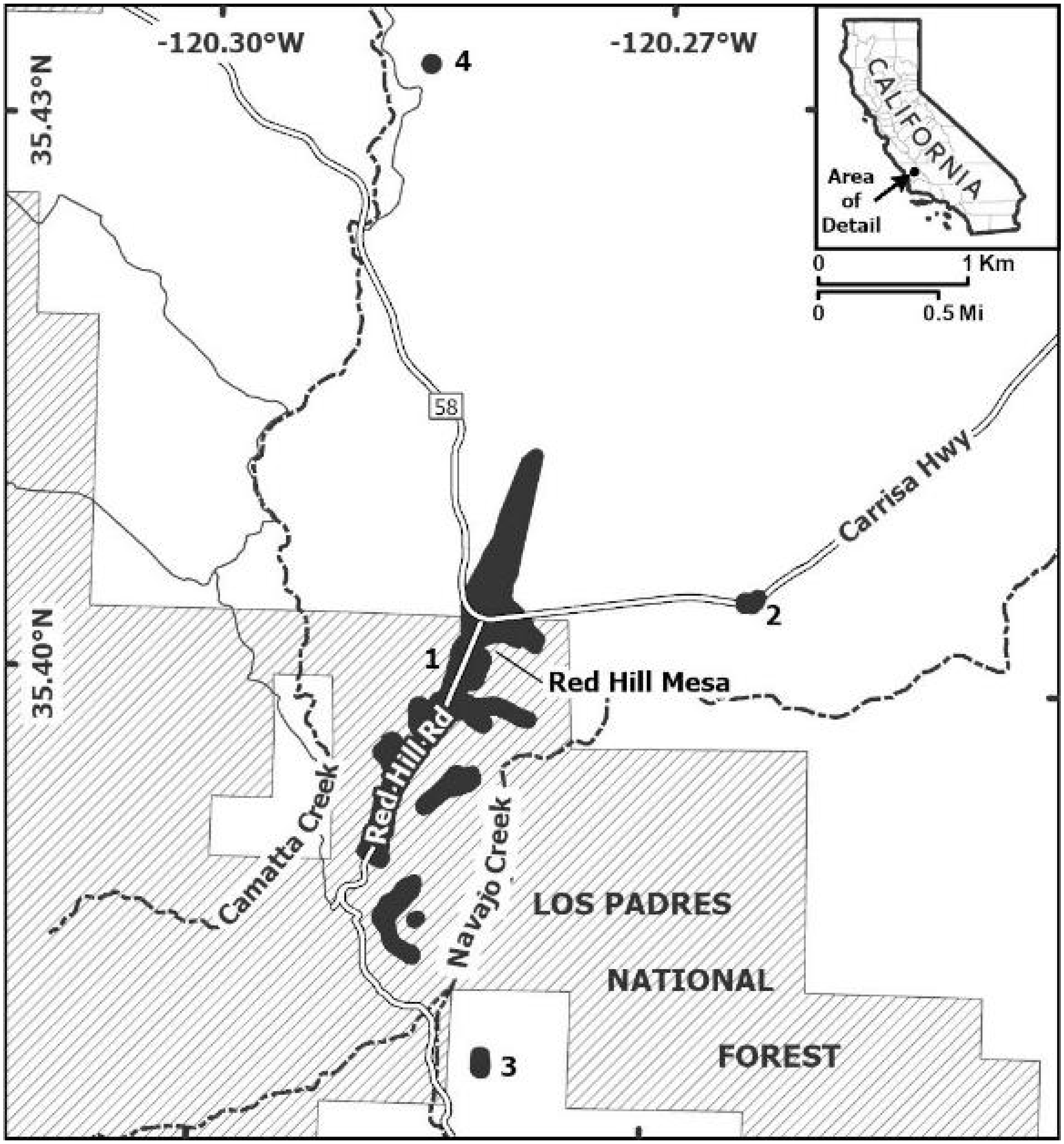

Figure 5. Geographic distribution of the four known occurrences of Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) in San Luis Obispo County, California. Each occurrence is indicated by its respective number in the California Natural Diversity Database (CNDDB).

2.4 LIFE HISTORY

Purple amole is a geophyte, where the perennating bud (and leaves) is born from within the underground bulb during seasonally favorable conditions. The bulb is essentially an underground bud and technically a modified and highly compressed stem. The bulb scales are modified, fleshy leaves that surround the central-most axillary bud (Jepson Flora Project 2020, website). It functions as a storage organ to supply reserved nutrients to the plant for survival during unfavorable conditions when it is dormant for extended time periods and also for the onset of rapid growth at the start of the growing season (Dafni et al. 1981, p. 652; Rundel 1996, p. 355 and 359). Like many geophytes, purple amole is adapted to a Mediterranean climate regime characterized by winter rainfall and dry summers. Root and leaf growth take place during the wet season and flowering and fruiting is completed before the start of the dry summer months (Holland 2004, p. 8; Service 2008, p. 3; Hoover 1940, p. 138; Rundel 1996, p. 355).

2.4.1 Vegetative Growth

Vegetative growth and development (whether from seed or bulb) are stimulated by adequate temperatures and rainfall after dormancy is broken (Woodbury 2020, p. 1). The first Santa Lucia purple amole leaf shoots typically appear above the ground surface in December or January (Holland 2004, p. 11; Niceswanger 2001a, p. 1); the vegetative growth stage of the life cycle is short, typically from December through March (Woodbury 2006, p. 1). Above average rainfall can prolong vegetative growth and delay flowering (Holland 2009, p. 10).

2.4.2 Flowering

Purple amole inflorescences start to develop in early spring. Individuals usually produce a single inflorescence (Wilken 2003, p. 5). The typical flowering period extends from April through June (Jernstedt 2012, website; CNPS 2020, website; Calflora 2020, website). Peak floral expression normally occurs during mid-April through mid-May (Niceswanger 2001a, p. 6; Niceswanger 2001b, p. 3; Wilken 2000, p. 14). The panicles emerge from the basal rosette on a single flower stalk that extends vertically. The lowest flowers open first, with one or more per node; while the top flowers remain closed tightly in bud. Plants continue to flower and terminal buds at the center of the floral axis will continue to develop as long as conditions are favorable. At some point in the flowering season, the terminal buds will cease to develop and wither, which signals the end of the flowering phase. The lower flowers of the panicle continue to develop and progress to fruit when the tips have begun withering. However, no new flowers are formed at this stage (Niceswanger 2001b, p. 7; Hoover 1940, p. 138).

Santa Lucia purple amole flowering is closely related to plant size or maturity; we assume this to be true for Camatta Canyon amole as well. Demographic research has shown that Santa Lucia purple amole is most likely to flower when plants attain approximately eight leaves or when the widths of the widest leaf reach seven to eight mm (0.3 inch). In an ex situ setting individual Santa Lucia purple amole plants required three to five years before flowering (Holland 2004, p. 11). At FHL in situ, it took more than one year for a plant to reach reproductive maturity (Niceswanger 2001, p.11). Camatta Canyon amole planted as seed on Red Hill Ridge required 12 years or more to flower and produce seeds (Koch and Hillyard 2009).

Flowering is generally dependent on precipitation events between the months of January through May, which naturally varies as well as other factors such as the amounts of rainfall, timing of events, number of rain-days, and frequency (Woodbury 2014, p. 13). Flowering and total precipitation during the months of December through March had a positive correlation, as did total rainfall during the month of February. Therefore, plant development, including flowering, is dependent on rainfall, and the timing of that rainfall may also be important (Guretzky et al. 2005, p. 9, 14 and 15).

2.4.3 Fruiting

Little is known about the pollination system of the species. Purple amole is reported to be self-compatible, but showed reduced production of viable seed in comparison to individuals where access to pollinators was unrestricted in an ex situ setting (Service 2008, p. 8; Holland 2004, p. 11). To date, no pollination studies on the species have been conducted. The species is generally assumed to be pollinated by insects; although no specific pollinators have been identified.

The first flowers of Santa Lucia purple amole start to fruit about one month after opening and the majority of flowers have developed fully formed fruits within another three consecutive weeks. The typical fruiting window of Santa Lucia purple amole is May through June (Woodbury 2014, p. 5; Wilken 2003, p. 7). The leaves of the plant begin to wither and both the leaves and the peduncle (main stem of the inflorescence) turn tan (or light brown) as the fruits are maturing (Wilken 2000, p. 10; Hoover 1940, p. 138).

2.4.4 Seed

Seed production is closely tied to the fruiting processes described above. Seed production in the Santa Lucia purple amole typically peaks in late June through early July (Woodbury 2005, p. 1; Woodbury 2006, p. 1). However, scattered individuals may continue seeding through August (Holland 2004, p. 11). The black, ripened seeds typically sit within the opened capsules after the fruits have dehisced and are dispersed by wind, or some other mechanical disturbance that would knock them out and onto the immediately adjacent ground beneath the parent plant (Niceswanger 2001, p. 7; Taylor and Keil 2018, p. 2). Santa Lucia purple amole seeds are relatively large (approximately 3 mm [0.12 inch]), so they are not expected to disperse very far from the parent plant. Granivorous animals may inadvertently disperse the seeds, but seed predation and dispersal in this taxon and other members of the genus have not been studied. Seed dispersal mechanism is unknown for Camatta Canyon amole. Dispersed seed presumably remains in place throughout the winter months until germination is stimulated by adequate temperatures and rainfall (Woodbury 2020, p. 1).

For Santa Lucia purple amole, approximately 17 percent of the total number of sampled individuals produced seed in a study conducted at FHL from 2005 through 2011, with an average of 35 seeds per plant. The average number of seeds produced per plant annually ranged from 19 to 49 over the course of the study. The greatest overall productivity (25 percent of the sampled individuals producing seed with an average of 49 seeds per plant) occurred in 2008 when the annual precipitation was close to normal and 85 percent of the rain fell in January and February (Woodbury 2014, p. 9 and 13). Prior to this, the number of seeds produced per plant at FHL between 2002 and 2004 ranged from six to 17 (Guretzky et al. 2005, p. 11). Even earlier between 1998 and 2000, a range of one to 386 seeds per plant was found at FHL (Niceswanger 2001, p. 12). The average number of seeds per plant observed at Camp Roberts between 2006 and 2011 was 65 (Holland 2012, p. 16). Productive individuals are likely to remain vegetative, meaning that they will not form an inflorescence and/or flower the following year, or will enter dormancy (Holland 2004, p. 11).

A few efforts to quantify Santa Lucia purple amole recruitment have been conducted. At FHL transect sampling throughout the population was completed between 1999 and 2000 and only 68 seedlings were found within that time period (Niceswanger 2001, p. 11). Another effort occurred in 2009 and approximately 80 seedlings were observed (Woodbury 2014, p. 10).

Seed bank longevity and/or persistence has not been studied in purple amole and little information on the subject is available for the genus.

2.4.5 Dormancy

Dormancy is an integral part of the life cycle in most geophytes (Reintal et al 2010, p. 111; Dafni et al. 1981, p. 652). However life span in purple amole individuals remains unknown. Wilken has suggested that Santa Lucia amole individuals may persist for 15 years or longer (Holland 2004, p. 11).

3 BIOLOGICAL NEEDS

This section describes the biological needs of purple amole, which are essentially what the species requires to maintain itself in the wild over time (Service 2016, p. 10). Our understanding of purple amole's biological needs is primarily based on the physical characteristics of occupied habitat and the distinct stages of its life cycle.

3.1 CRITICAL HABITAT (2002)

We designated critical habitat in 2002 (Service 2002, entire). Primary constituent elements are the physical and biological features that are deemed essential to the conservation of the species at the time of designation, and may require special management considerations or protections.

The primary constituent elements of critical habitat for Santa Lucia purple amole include:

1. Soils that are sandy clay to loamy clay, well-drained on the surface, and are often overlain with fine gravel; and
2. Plant communities in functioning ecosystems that support associated plant and animal species (e.g., pollinators, predator-prey species, etc.), including valley and foothill grassland (most similar to the needlegrass series and California annual grassland series in Sawyer and Keeler-Wolf (1995)), blue oak woodland or oak savannahs (Holland 1986), and open areas within shrubland communities (most similar to the Chamise series in Sawyer and Keeler-Wolf (1995), although percent cover of chamise at known Chlorogalum purpureum var. purpureum areas is unknown). Within these vegetation community types, Santa Lucia purple amole typically appears where there is little cover from other species which compete for resources available for growth and reproduction (67 FR 65425).

The primary constituent elements of critical habitat for Camatta Canyon amole include:

1. Well-drained soils with a large component of gravel and pebbles on the upper soil surface; and

2. Plant communities in functioning ecosystems that support associated plant and animal species (e.g., pollinators, predator-prey species, etc.), including grassland (most similar to the California annual grassland series in Sawyer and Keeler-Wolf (1995) or the pine bluegrass grassland, nonnative grassland and wildflower field descriptions in Holland (1986)), blue oak woodland or oak savannahs (Holland 1986), oak woodland, and open areas within shrubland communities (most similar to the Chamise series in Sawyer and Keeler-Wolf (1995), although percent cover of chamise at known Camatta Canyon amole areas is unknown). Within these vegetation communities Camatta Canyon amole appears where there is little cover of other species which potentially compete for resources available for growth and reproduction (67 FR 65425).

3.2 ADDITIONAL HABITAT REQUIREMENTS

More recent observations, reports, and data have increased our understanding of purple amole's habitat requirements and what is vital to support the species throughout its various life cycle stages. In addition to the Service critical habitat primary constituent elements described above, purple amole, both varieties, also needs the following:

1. Sparsely vegetated areas with some open, bare ground;
2. Adequate annual precipitation to support vegetative growth, avoid desiccation and stimulate seed germination;
3. Suitable temperature regimes to facilitate dormancy, avoid desiccation, support vegetative growth and stimulate seed germination;
4. Insect pollinators to enable sexual reproduction, maintain genetic diversity, and ensure seed production, and
5. Biological soil crusts, which enhance many aspects of the habitat conditions to benefit the taxon.

3.3 INDIVIDUAL NEEDS

Biological needs at this scale equate to the basic habitat requirements and ideal ecological setting for individual purple amole plants throughout all stages of the life cycle. Habitat quality and quantity are also incorporated into individual needs and these parameters ultimately determine how well individuals are able to survive and whether or not they reproduce (Smith et al. 2018, p. 306). Additional information about each of the species' biological needs is provided below. After this discussion, this information and how each need relates to the taxon's life cycle is summarized in Table 1.

Appropriate Soil Types

Purple amole individuals have specific soil and edaphic requirements. Santa Lucia purple amole grows in sandy and/or clay loams that have gravel components in the top and subsoil strata. Camatta Canyon amole grows specifically in hard, rocky red soil (mapped mostly as Arbuckle sandy loam; Natural Resources Conservation Service 2003, p. 115; 2018, p. 1) (see Appendix C for photos). In addition, Camatta Canyon amole appears to inhabit soil that has never been turned for agriculture.

Appropriate soils are required to sustain and break dormancy and for the seed germination phase of the life cycle.

Suitable Habitats

Purple amole occurs in a semiarid environment with a Mediterranean climate (hot, dry summers, and cool, wet winters).

Santa Lucia purple amole occurs in cismontane (predominantly oak [*Quercus* spp.]) woodland and savanna, chaparral and valley and foothill grassland plant communities (CNDDB 2020, website; USFWS 2000 – 65 FR 14878–14888, p. 14878; Woodbury 2019, p. 1; Terra Verde Environmental Consulting 2018, p. 2; Kofron et al. 2013a, p. 39). Oak woodland communities that support Santa Lucia purple amole typically have blue oak (*Quercus douglasii*) as the dominant (with greater than 50 percent relative cover) or co-dominant tree in the canopy. Other hardwoods or conifers may be less than 30 percent relative cover in the tree canopy and gray pine (*Pinus sabiniana*) is the most common associate in blue oak woodland habitats that support purple amole. Santa Lucia purple amole grows in association with a variety of other low-growing grasses and native, annual forbs. Native plant species associated with the taxon include: rusty popcornflower (*Plagiobothrys nothofulvus*), miniature lupine (*Lupinus bicolor*), goldfields (*Lasthenia californica*), common soap plant (*Chlorogalum pomeridianum* var. *pomeridianum*), mesa brodiaea (*Brodiaea jolonensis*), wild oat (*Avena fatua* and *A. barbata*), storksbill (*Erodium* spp.), soft chess (*Bromus hordeaceus*), narrow tarplant (*Holocarpha virgata*), clarkia (*Clarkia affinis* and *C. purpurea*), and agoseris (*Agoseris grandiflora* and *A. heterophylla*, Woodbury 2009, p. 1; Holland 2009, p. 4; Holland 2012, p. 4; Woodbury 2019, p. 9).

Camatta Canyon amole generally needs open areas with a light cover of native plants in blue oak (*Quercus douglasii*) savanna, blue oak woodland and California prairie. Native plant species associated with Camatta Canyon amole include blue oak, chamise (*Adenostoma fasciculatum)*, crown brodiaea (*Brodiaea coronaria*), winecup clarkia (*Clarkia purpurea*), sand pygmyweed (*Crassula erecta*), bluedicks (*Dichelostemma capitatum*), sanicle (*Sanicula* sp.), California goldfields, sky lupine (*Lupinus nanus*) and gilia (*Gilia* sp.) (Magney 1988 entire; Service 2002, p. 65416; Kofron et al. 2013a, p. 45).

Suitable habitat types are required for the vegetative growth, flowering and dormant stages of the life cycle. Dormant individuals, whether in the bulb state or ungerminated seed, are unlikely to break dormancy unless habitats are suitable.

Sparsely Vegetated Areas with Some Open, Bare Ground

Individuals tend to occur in more sparsely vegetated areas, with at least some bare ground and less nonnative herbaceous cover (Guretzky et al. 2005, p. 12; Holland 2004, p. 10; Holland 2005; p. 3). Sparsely vegetated areas and open, bare ground components are important biological needs required by the taxon and without these, habitats are less suitable. This need is a requirement for the vegetative growth and flowering stages of the species' life cycle.

Adequate Annual Precipitation

Ultimately vegetative growth is dependent on annual bulb recharge that is mediated by adequate winter precipitation. Vegetative growth and development (whether from seed or bulb) are stimulated by adequate moisture after dormancy is broken (Woodbury 2020, p. 1). Newly sprouted seedlings cannot support both leaf development and bulb establishment in the absence of adequate winter rainfall either. Adequate annual precipitation is required for the vegetative growth and flowering stages of the life cycle.

Suitable Temperature Regimes

Early leaf tissues are vulnerable to temperature extremes and cannot tolerate persistent hot conditions. Above average temperatures increase evaporative loss and can lead to desiccation. Extensive withering from heat can result in leaf death and eventually kill individuals. Vegetative growth and floral development are also dependent on suitable temperatures.

Insect Pollinators

Insect pollinators are essential for individuals to reproduce in the wild. Un-pollinated flowers typically senesce and will not produce fully formed fruits, and viable seed will not form. Although purple amole is thought to be self-compatible, a pollination mechanism is required to produce viable seed (65 FR 14878p.p.). Specific insect pollinators for purple amole have not been identified. Native bees are likely responsible for pollination of individuals, based on common soap plant as a functional analogue (Stockhouse II and Wells 1978, p. 125–128). Insect pollinators are required for fruit and seed development.

Biological Soil Crusts

Purple amole is often associated with biological soil crusts (cyanobacteria, lichen and moss on the soil surface; Kofron et al. 2013a, entire), which are important elements of arid and semiarid ecosystems (Beymer and Klopatek 1992, p. 139). Biological soil crusts stabilize soil against erosion, fix atmospheric nitrogen, form organic matter (Eldridge and Greene 1994 entire), retain soil moisture, discourage weed growth (Belnap et al. 2001, p. 2), and provide favorable sites for growth of native plants (Lesica and Shelly 1992, p. 53). Sustaining and breaking dormancy and seed germination phases of the life cycle are likely dependent on the presence of biological soil crusts.

Table 1. Purple amole individual needs by life stage

Individual Need	Vegetative Growth	Flowering	Fruiting and Seed Production	Dormancy and Seed Germination
Appropriate soil types				X
Suitable habitats	X	X		X
Sparsely vegetated areas with some open, bare ground	X	X		
Adequate annual precipitation	X	X		
Suitable temperatures	X	X		X
Insect pollinators			X	
Biological soil crusts				X

3.4 POPULATION/OCCURENCE SCALE

At this scale, a population (Santa Lucia purple amole) or occurrence (Camatta Canyon amole) is defined as a group, or groups, of individuals that have the capability to interbreed though exchange of pollen and are geographically similar; meaning that the physical and environmental effects that may influence the group, or groups, of individuals are similar within a population, but different between populations. Generally speaking, populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction regardless of disturbance and other environmental variation (Service 2016, p. 12). We consider there to be four main, extant populations of Santa Lucia purple amole based on geography, topographical and land use barriers, and monitoring strategies (Figure 4). Camatta Canyon amole is known from four occurrences on four properties (Figure 5), 61 kilometers/38 miles southeast of the nearest occurrence of Santa Lucia purple amole. In the absence of information on probability of persistence, we evaluate the resiliency of Santa Lucia purple amole based on density, disturbance, productivity, and occupied area for each population. We evaluate the resiliency of Camatta Canyon amole based on occupied area, protected status, land use, and threats present for each occurrence.

Resilient populations/occurrences are able to tolerate environmental stochasticity and remain stable through periods of both favorable and unfavorable conditions. Purple amole populations/occurrences must be able to survive dormancy, reproduce and maintain adequate abundance within a sufficient area to be viable. Resilient populations/occurrences of purple amole must be comprised of various age classes to survive dormancy during unfavorable conditions. Seed bank longevity and/or persistence has not been studied in purple amole and little information on the subject is available for the genus.

3.5 SPECIES SCALE

The species needs redundancy to be able to withstand catastrophic events, such as large-scale wildfire or catastrophic drought, such that single or multiple catastrophic events are less likely to cause the species to go extinct and the populations can more easily re-establish if affected. The species also needs representation within and among varieties to be able to adapt to novel changes in its environment. Adequate representation includes the breadth of genetic and ecological diversity within the species so that it can adapt to both near-term and future changes in its environment.

4 POPULATION DISTRIBUTION AND ABUNDANCE

4.1 Santa Lucia purple amole

Santa Lucia purple amole occupies a total area of approximately 500 hectares (1,235 acres; according to spatial data provided to the Service from each of the installations). We currently consider there to be four main populations throughout the range (See Section 2.3, Figure 2 and Table 1): (1) Jolon on FHL 248 hectares (612.8 acres), (2) Lockwood South on FHL 31.6 hectares (78.1 acres), (3) Nacimiento River North on FHL 2.3 hectares (5.7 acres), and (4) Nacimiento River South on Camp Roberts 216.2 hectares (534.2 acres). Only those populations that have suitable habitat and support extant occurrences are considered. CNDDB Occurrence No. 19 was excluded from our analysis of the species current condition because it was mapped on private property within an unknown location based on a collection from 1979 (CNDDB 2020, website; CCH2 2020, website). The status of this occurrence is unknown and the record needs to be updated with supporting fieldwork.

Three populations occur on FHL and two of them (Jolon and Lockwood South) are a geographically close pair that are situated longitudinally along the northeast side of the San Antonio River. The two populations are generally separated topographically and most of the colonies occur at higher elevations on opposite sides of a large, flat section of the San Antonio River Valley (refer to Figure 4). The occurrences were likely contiguous prior to historical farming practices. FHL Training Area 22 is currently located within this section of valley (between the two populations), which further justifies the consideration of Jolon and Lockwood South as separate populations because the training area is disturbed and supports military land uses. The two populations are not totally isolated from one another and some small patches with robust plants do still occur in this area. Therefore, the two populations share some degree of connectivity facilitated by the Jolon Road/FHL Military Reserve boundary, wildlife, and pollinators. The other two smaller populations of purple amole, Nacimiento River North (FHL) and Nacimiento River South (on Camp Roberts), are much more geographically isolated and discrete.

In this section, we discuss the geographic distribution of each Santa Lucia purple amole population based on spatial data maintained and periodically updated in Geographic Information Systems (GIS) from each of the installations. While the actual extent of the populations may be slightly larger or smaller than depicted in CNDDB, these datasets are likely the most accurate representation of the variety’s distribution. The Santa Lucia purple amole distribution layers from FHL were last updated in 2017 and the layers from Camp Roberts were collected in 2001.

Both FHL and Camp Roberts have large transect monitoring datasets for the populations on the two installations. However, the data collection methods are not uniform across each installation and methods used and attributes collected have changed many times over the course of these endeavors. The numbers of individuals presented below for each population are an approximation of abundance based on the best available information.

Fort Hunter Liggett

FHL established fourteen 50-m (164-ft) long-term monitoring transects on the installation, scattered throughout the three populations that occur there. Then FHL established twenty-one 1 m^2 (10.76 ft^2) monitoring quadrats across each of the sampling transects (Woodbury 2019, p. 5). We used the FHL dataset from 2008 through 2020 to evaluate new information since the 2008 5-year review (Service 2008). Annual monitoring data for 2012, 2015, and 2017 could not be included in the abundance analysis because either a different subset of transects was monitored that year or the data were not collected for a particular year. FHL collected density monitoring data between the months of January and March of each sampling year (Woodbury 2019, p. 18).

Jolon

The Jolon population on FHL is by far the largest of the four Santa Lucia purple amole populations. It covers approximately 248 hectares (612.8 acres) and includes 11 of the 17 CNDDB element occurrences of the taxon (CNDDB 2020, website; see Table 1). FHL monitors 10 transects within the Jolon population (Woodbury 2019, p. 5). The total area sampled within this population was 210 m^2 (2,260 ft^2). The average density of individuals per m^2 is 13 individuals. The data for density per m^2 at this population are summarized in Figure 6 below.

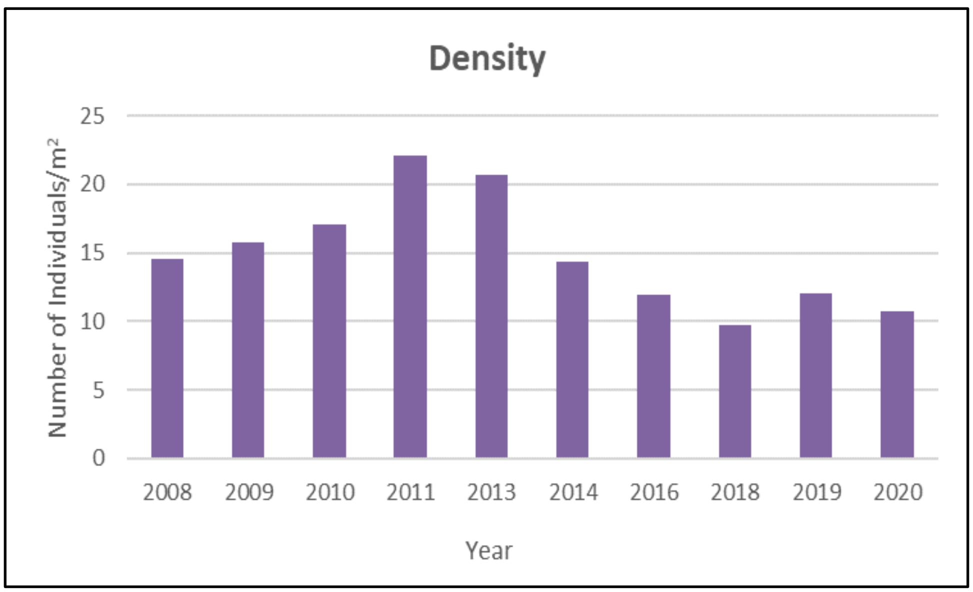

Figure 6. Density of Santa Lucia purple amole per m^2 within the total 210 m^2 (2,260 ft^2) sampling area at the Jolon population on Fort Hunter Liggett, Monterey County, California. Ten transects were monitored within this population.

Lockwood South

This population is the second largest Santa Lucia purple amole population on FHL and it extends over approximately 31.6 hectares (78.1 acres). Three of the 17 CNDDB element occurrences of the variety are located within the Lockwood South population (CNDDB 2020, website; see Table 1). FHL monitors two transects within this population totaling 42 m^2 (452 ft^2; Woodbury 2019, p. 5).

The average density of individuals per m^2 is 18 individuals. The data for density per m^2 at this population are summarized in Figure 7 below.

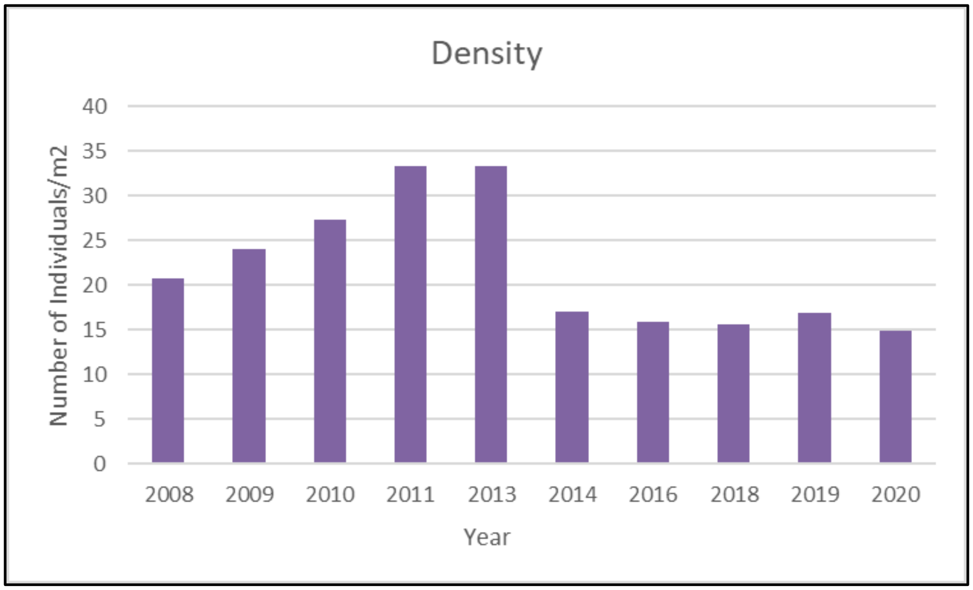

Figure 7. Density of Santa Lucia purple amole per m^2 within the total 42 m^2 (452 ft^2) sampling area at the Lockwood South population on Fort Hunter Liggett, Monterey County, California. Two transects were monitored within this population.

Nacimiento River North

The smallest population of the four is the Nacimiento River North population on FHL. It occupies a total area of approximately 2.3 hectares (5.7 acres) and includes only one CNDDB element occurrence (CNDDB 2020, website; see Table 1). There are two monitoring transects established within this population and the sampling area is 42 m^2 (2452 ft^2; Woodbury 2019, p. 5). The average density of individuals per m^2 is 25 individuals. The data for this population are summarized in Figure 8 below.

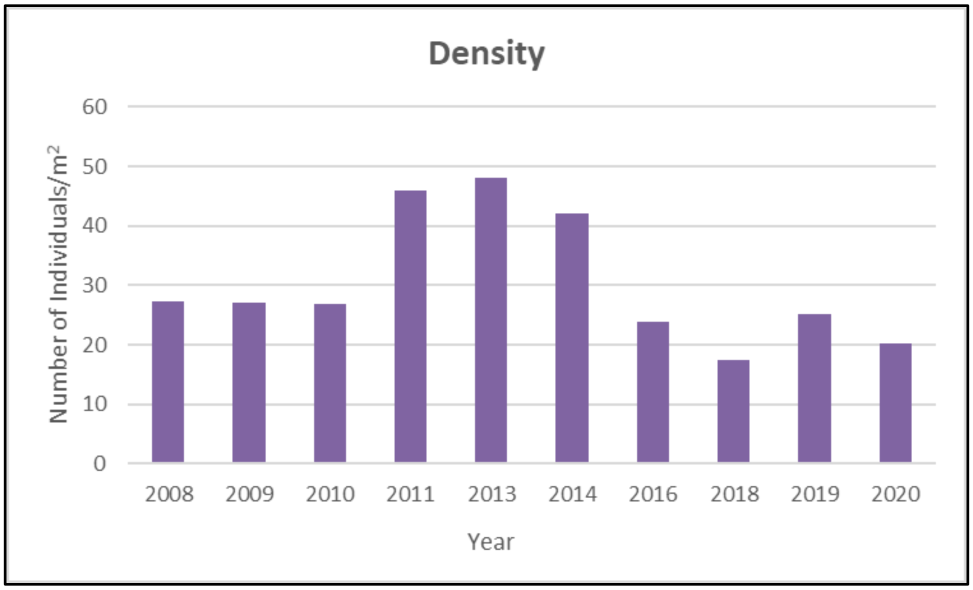

Figure 8. Density of Santa Lucia purple amole per m^2 within the 42 m^2 (452 ft^2) sampling area at the Nacimiento River North population on Fort Hunter Liggett, Monterey County, California. Two transects were monitored within this population.

Camp Roberts

Nacimiento River South

The Nacimiento River South population is the only one located on Camp Roberts. It extends over approximately 216.2 hectares (534.2 acres) and includes one CNDDB element occurrence (CNDDB 2020, website; see Table 1). Camp Roberts established nine 100-m (328 feet) long monitoring transects. However, several of them were shortened because these transects did not extend into areas that contained Santa Lucia purple amole plants (Holland 2008, p. 4; Terra Verde Environmental Consulting 2019, p. 4 and 25). Camp Roberts used 20 randomly selected 1-m^2 (10.76 ft^2) quadrats along each transect for sampling. Therefore, the total area sampled on Camp Roberts is 180 m^2 (1,937 ft^2). We used this dataset from 2008 through 2019 (the same as for FHL) to evaluate new information since the 2008 5-year review (Service 2008). Annual monitoring data for 2010 and 2012 could not be included in the abundance analysis because data were not collected during these particular years. Camp Roberts collected the early season density monitoring data between the months of February through March of each sampling year (Terra Verde Environmental Consulting 2019, p. 7; Terra Verde Environmental Consulting 2015, p. 4). The average density of Santa Lucia purple amole plants within the sampled area for this population over the established time period is unknown because the raw data are not available. The average density of individuals per m^2 is 6 individuals. The data for this population are summarized in Figure 9 below.

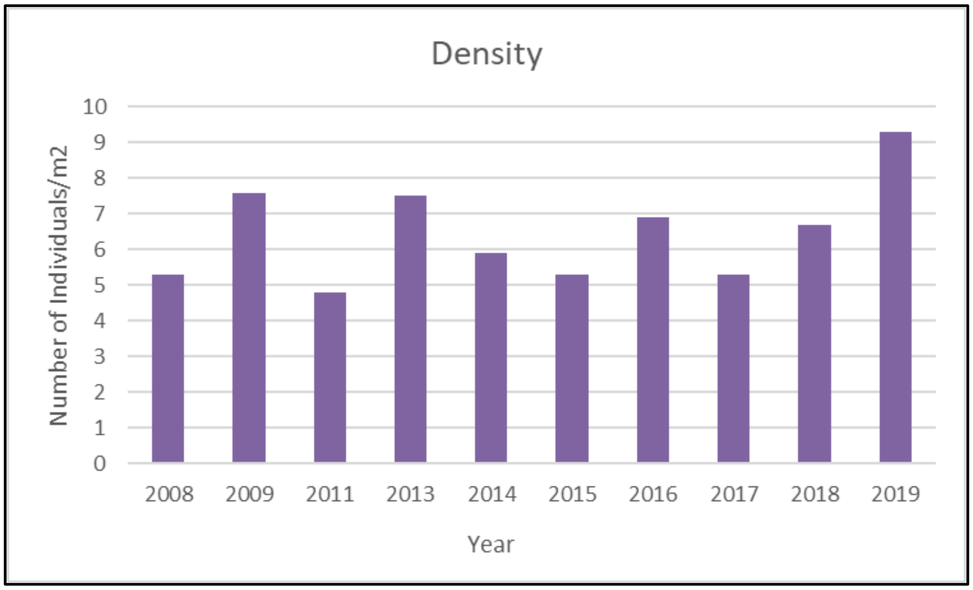

Figure 9. Density of Santa Lucia purple amole per m^2 within the 180 m^2 (452 ft^2) sampling area at the Nacimiento River South population on Camp Roberts, San Luis Obispo County, California. Nine transects were monitored within this population.

4.2 Camatta Canyon amole

The distribution of Camatta Canyon amole as currently known is greater than 36 hectares/89 acres across four CNDDB occurrences (Table 2). The taxon occurs mostly on Los Padres National Forest (21.15 hectares/52.26 acres), extending also onto both sides of State Highway 58 in the right-of-way (1.2 meters/3.9 feet beyond each shoulder; 0.12 hectare/0.30 acre), north onto one private property (>14.84 hectares/36.67 acres) and also likely east, and 3 kilometers/1.9 miles south of State Highway 58 on one private property (0.36 hectare/0.90 acre). The right-of-way of State Highway 58 is managed by California Department of Transportation, which designated the relevant area as a Botanical Management Area. The private property with Camatta Canyon amole immediately north of State Highway 58 is primarily a cattle ranch (129.5 $kilometers^2$/50 $miles^2$; Lazy Arrow Adventures 2019 entire). The private property with Camatta Canyon amole south of State Highway 58 is rural residential (4.19 hectares/10.36 acres). The extent of Camatta Canyon amole across national forest and private properties is not fully known.

Table 2. The four known occurrences of Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) in San Luis Obispo County, California. The measurements of known area exclude Red Hill Road and State Highway 58.

Occurrence		Known area	Protected	Land use	Year last observed
1	private property N St Hwy 58	>14.84 hectares/36.67 acres	no	primarily cattle ranching[A] potentially farming[B]	2019
	right-of-way St Hwy 58	313 $meters^2$/374 $yards^2$	no	roadside	2020
	Los Padres National Forest	21.15 hectares/52.26 acres	yes	multipurpose	2020
2	right-of-way St Hwy 58	882 $meters^2$/1,055 $yards^2$	no	roadside	2020
3	private property S St Hwy 58	0.36 hectare/0.90 acre	no	rural residential	2015
4	private property N St Hwy 58	unknown	no	rural residential cattle ranching[A] potentially farming[B]	1988

[A] including non-strategic cattle grazing and exotic wildlife.
[B] dry farming for barley and wheat previously occurred over a large area of the property.

The primary occupied area is occurrence 1 (greater than 36 hectares/89 acres; 584 to 632 meters/1,916 to 2,073 feet elevation) near Red Hill Road at State Highway 58. Red Hill Road is a graded dirt road south of and intersecting State Highway 58, which is a two-lane paved road. Red Hill Road bisects Red Hill Ridge and Red Hill Mesa for 1.8 kilometers/1.1 miles through occurrence 1. The occurrence comprises predominantly Red Hill Ridge (including Red Hill Mesa), which is the primary ridge extending south and north (2.9 kilometers/1.8 miles), along with four spur ridges and a nearby ridge to the south. All of these ridges have hard, rocky red soil. Camatta Canyon amole grows in the relatively flat and level open areas on ridge tops, and in particular on Red Hill Mesa. The southernmost one-fifth of Red Hill Ridge overlooks upper Camatta Canyon with Camatta Creek.

On Los Padres National Forest, Camatta Canyon amole grows in relatively flat and level open areas on ridge tops, including Red Hill Mesa, in blue oak savanna, blue oak woodland and California prairie, and often with biological soil crusts. Along State Highway 58, Camatta Canyon amole typically grows away from dense grasses, either among low-growing plants or in open areas around chamise (Edell 2007, p. 1). Information is limited regarding Camatta Canyon amole on the private property north of State Highway 58. However, Gaskin (1990 entire) mapped the taxon on the flat top of Red Hill Ridge extending north of the highway (>14.8 hectares/36.7 acres), along with a comment that it was growing also in the dirt road where disturbed by scraping, which is contrary to our understanding. In May 2011, Kofron et al. (2013a, p. 44) observed Camatta Canyon amole on this private property from across the boundary fence near Red Hill Road, counting approximately 60 plants from one vantage point and also observing predominantly tall grasses with an absence of grazing. According to Yost (2019a, p. 1), who visited the private property and observed Camatta Canyon amole, the plant likely has greater abundance and distribution here than on national forest. On the private property south of State Highway 58, Camatta Canyon amole grows in and along a dirt road on a hilltop (Kofron and Rutherford 2015c, p. 1).

Monitoring. Several biologists monitored Camatta Canyon amole on Red Hill Ridge irregularly from 1987 to 2020, counting the numbers of emergent plants in plots during April and May, which are the typical months of flowering. The data and rainfall are shown in Table 3. Magney (1987 entire, 1988 entire, 2018 entire) established 10 random circular plots (each 1.13 meter/44 inch diameter = 1 meter^2/1.2 yards^2) on Red Hill Ridge, which comprised the known extent of the taxon in 1987. He observed 6.5 plants/meter^2 (mean of 10 plots) in 1987, and 10.7 plants/meter^2 (mean of 10 plots) in 1988. Borchert (2018 entire) established 11 new circular plots (each 0.5 meter^2/0.6 yard^2) at random along a transect in "typical habitat" on Red Hill Ridge, and he reported the following numbers (each is a mean of the number of plants in 11 plots x 2): 1991, 18.0 plants/meter^2; 1992, 17.8 plants/meter^2; 1993, 16.9 plants/meter^2; 1995, 23.5 plants/meter^2; 1996, 22.9 plants/meter^2; and 1997, 19.6 plants/meter^2. Cattle grazing occurred on Red Hill Ridge during 1987 to 1997 (excluding 1990; U.S. Forest Service 2007, p. 5), although we have no precise details. Simpson (2012) sampled 18 random rectangular plots (each 50 meters x 0.5 meters/164 feet x 1.6 feet) in what appeared to be the densest areas on Red Hill Ridge in 2012, and he observed 5.3 plants/meter^2. In 2013, our biologists (Kofron et al. 2013b, entire) assisted David Magney in attempting to find his 10 circular plots from 1987 and 1988 by searching for the center pins with a metal detector. They found only the center pin for plot 5, which was reestablished in 1988 due to vandalism of the pin placed in 1987. Therefore, they reestablished the 10 plots using the stated descriptions comprising distances from landmarks along with compass bearings (Magney 1987 entire, 1988 entire; Table 4). In effect, the 10 reestablished plots are in approximate locations in the same immediate vicinities of 1987 rather than precise original locations, including two plots that were shifted slightly due to treefall or road widening/fence placement. Kofron and Rutherford (2014 entire; 2015b entire; 2016 entire; 2017 entire; 2018 entire; 2019 entire; 2020 entire) subsequently counted the numbers of emergent Camatta Canyon amole from 2014 to 2020, using the mean number of plants in three adjacent circular plots (OOO; each 1.13 meter diameter = 1 meter^2 x 3) at each approximate location. They recorded the following numbers of Camatta Canyon amole: 2014, 2.4 plants/meter^2 (mean of 10 plots); 2015, 0.3 plants/meter^2; 2016, 6.5 plants/meter^2; 2017, 6.7 plants/meter^2; 2018, 3.4 plants/meter^2; 2019, 4.0 plants/meter^2; and 2020, 6.9 plants/m^2 (Table 5). Cattle grazing did not occur on Red Hill Ridge during 2012 to 2020.

Table 3. Monitoring of Camatta Canyon amole on Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California (part of occurrence 1). Plants/m^2 = mean of number of plants in plots sampled by biologists. Rainfall data (December 1 to April 15) are for Salinas Dam (west of La Panza Range), 21 kilometers/13 miles southwest of Red Hill Ridge. Biologists were the following: Mark Borchert and Lloyd Simpson, U.S. Forest Service; Christopher P. Kofron and Connie Rutherford, U.S. Fish and Wildlife Service; and David L. Magney, California Native Plant Society.

Year	Plants/m^2	Rainfall mm	Monitoring date	Plots	Biologist
2020	6.9	406	Apr 29	10 in approximate locations of 1987	Kofron + Rutherford 2020
2019	4.0	756	Apr 23	10 in approximate locations of 1987	Kofron + Rutherford 2019
2018	3.4	336	Apr 25	10 in approximate locations of 1987	Kofron + Rutherford 2018
2017	6.7	749	Apr 18	10 in approximate locations of 1987	Kofron + Rutherford 2017
2016	6.5	373	Apr 26	10 in approximate locations of 1987	Kofron + Rutherford 2016
2015	0.3	228	Apr 27	10 in approximate locations of 1987	Kofron + Rutherford 2015
2014	2.4	229	Apr 30	10 in approximate locations of 1987	Kofron + Rutherford 2014 w/Magney
2012	5.3	249	May 2-3	18 random in densest areas, 50 m x 0.5 m each	Simpson 2012 w/ Rutherford + Kofron
1997	19.6	561	Apr 18	same 11 of 1991	Borchert 2018
1996	22.9	496	Apr 24	same 11 of 1991	Borchert 2018
1995	23.5	877	May	same 11 of 1991	Borchert 2018
1993	16.9	782	May 25	same 11 of 1991	Borchert 2018
1992	17.8	547	May 7	same 11 of 1991	Borchert 2018
1991	18.0	451	May 24	11 random, 0.5 m^2 each	Borchert 2018
1988	10.7	288	May 8	9 in same locations of 1987, 1 approximate	Magney 1988
1987	6.5	232	May 9	10 random, 1 m^2 each	Magney 1988

Table 4. Center coordinates and descriptions of 10 circular plots (each = 1 meter^2/1.2 yards^2) for Camatta Canyon amole used in 1987 and 1988 (Magney 1987, 1988), and also in 2014, 2015, 2016, 2017, 2018, 2019 and 2020 (Kofron et al. 2013b, p. 1; Kofron and Rutherford 2014, 2015a, 2016, 2017, 2018, 2019, 2020 entire). The plots are on Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California.

Plot	Center coordinates	Description
1	35.40290/–120.27943	Red Hill Mesa E of Red Hill Rd, 4.3 m N of blue oak, bearing 355°
2	35.40282/–120.27864	Red Hill Mesa E of Red Hill Rd, 6.3 m NW of two small blue oaks, bearing 335°; one is dead in 2013
3	35.40295/–120.27846	Red Hill Mesa E of Red Hill Rd, 26.6 m N of two small blue oaks in plot 2, bearing 22°
4	35.40193/–120.28060	Red Hill Mesa W of Red Hill Rd, 10 m W of small blue oak, original bearing 265°; shifted slightly in 2017 due to tree fall, new bearing 312°
5	35.40279/–120.28022	Red Hill Mesa W of Red Hill Rd, 69.6 m WSW of blue oak in plot 1
6	35.38929/–120.28736	Red Hill Ridge W of Red Hill Rd, 9 m NW of three–trunk blue oak, bearing 320°
7	35.38927/–120.28740	Red Hill Ridge W of Red Hill Rd, 4.6 m NW of two–trunk blue oak, bearing 300°
8	35.40336/–120.27943	Red Hill Mesa E of Red Hill Rd, 3.75 m E of pipe fence
9	35.40305/–120.27956	Red Hill Mesa E of Red Hill Rd, 12 m SE of U.S. Forest Service sign
10	35.40331/–120.27970	Red Hill Mesa W of Red Hill Rd, 12 m S of another U.S. Forest Service sign, next to road

Although the data cannot be tested statistically because of different methods and small sample sizes, we can make two general observations.

1. Substantially more emergent Camatta Canyon amole were observed from 1987 to 1997 (8 years, range of means 6.5 to 23.5 plants/meter^2, mean 17.0 plants/meter^2), which corresponded in time to cattle grazing, than from 2012 to 2020 (8 years, range of means 0.3 to 6.9 plants/meter^2, mean 4.4 plants/meter^2) (Figure 10), which corresponded in time to no cattle grazing.
2. None of the 20 original plots in 1987 and 1988 had 0 plants/meter^2, whereas 33 of 70 reestablished plots (47%) from 2014 to 2020 had 0 plants/meter^2.

Therefore, the combined data of the four studies suggest the number of Camatta Canyon amole on Red Hill Ridge (part of occurrence 1 on national forest) has declined since the 1980’s and 1990’s.

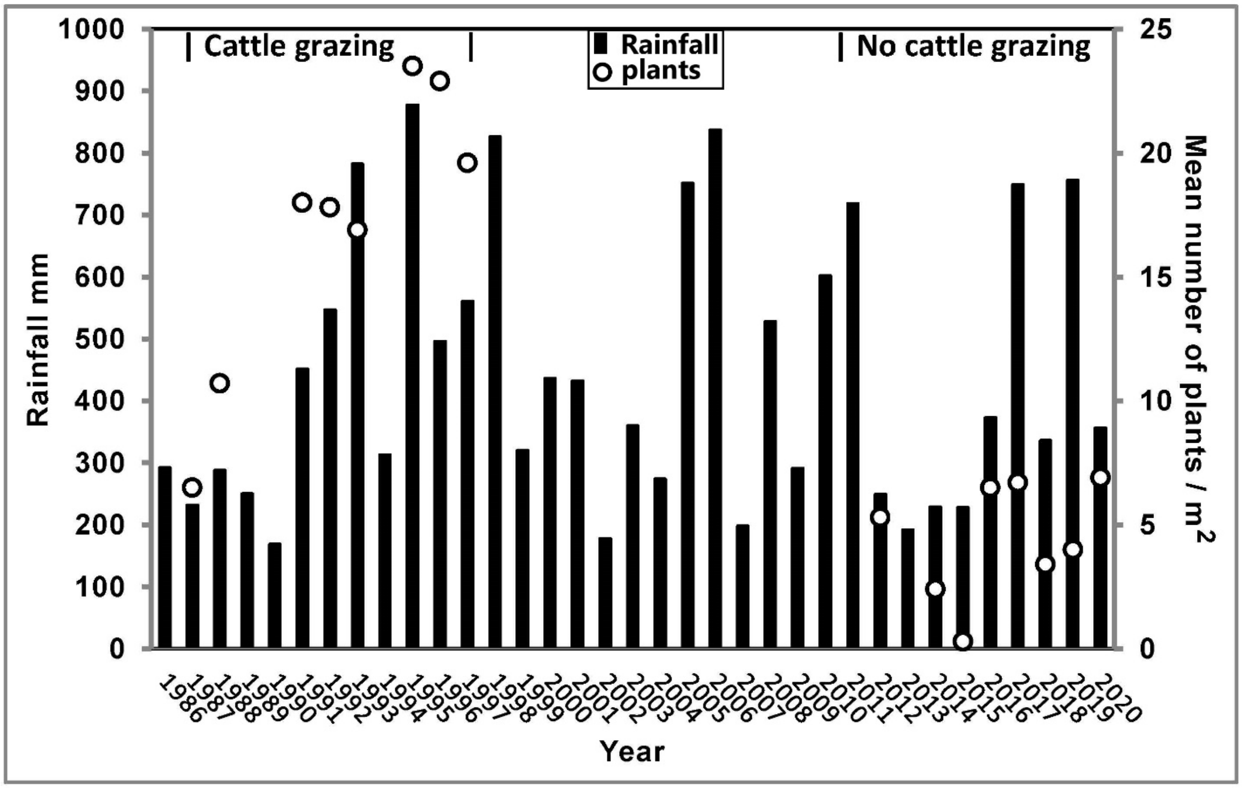

Figure 10. Mean numbers of emergent Camatta Canyon amole in plots on Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California (part of occurrence 1). Monitoring was conducted by biologists identified in Table 3, and it did not occur every year. Rainfall data (December 1 to April 15) are for Salinas Dam (west of La Panza Range), 21 kilometers/13 miles southwest of Red Hill Ridge. The precise details of cattle grazing on Red Hill Ridge from 1987 to 1997 are not known. The data cannot be tested statistically because of different methods and small sample sizes.

Table 5. Numbers of emergent Camatta Canyon amole observed in 10 plots during 9 years from 1987 to 2020 on Red Hill Ridge in Los Padres National Forest (part of occurrence 1), San Luis Obispo County, California. Each plot was in the approximate same location from year to year. The data are from Magney (1988), and Kofron and Rutherford (2014, 2015a, 2016, 2017, 2018, 2019 and 2020). The plots shaded in gray (1, 2, 3, 4, 9 and 10) show an obvious decline in the numbers of plants since 1987 and 1988.

	Plot											
Year	1	2	3	4	5	6	7	8	9	10	Total	Mean
2020	0.0	0.0	0.0	0.0	17.7	13.3	27.7	9.7	0.7	0.3	69.4	6.9
2019	0.0	0.0	0.0	0.0	12.0	2.3	17.7	8.3	0.0	0.0	40.3	4.0
2018	0.0	0.0	0.0	0.0	10.0	8.3	14.3	0.3	0.7	0.0	33.6	3.4
2017	0.0	0.3	0.7	0.0	16.7	11.0	32.3	5.7	0.0	0.0	66.7	6.7
2016	0.0	0.0	3.3	0.0	18.3	13.3	24.0	5.0	0.7	0.0	64.6	6.5
2015	0.0	0.0	0.0	0.0	0.7	1.3	0.7	0.3	0.0	0.0	3.0	0.3
2014	0.0	0.0	1.0	0.0	4.3	2.0	13.3	1.0	1.3	1.0	23.9	2.4
1988	4	7	15	8	16	13	14	6	13	11	107	10.7
1987	4	3	8	4	9	9	7	5	9	7	65	6.5

Conservation measures for Camatta Canyon amole on Los Padres National Forest include signs and a welded pipe fence (with maintenance) along Red Hill Road to prevent off-highway vehicles entering habitat, and ranger patrols. Also, biologists of the U.S. Forest Service irregularly search/survey/monitor/census for Camatta Canyon amole on national forest. The Service with its partners (California Department of Transportation, California Polytechnic State University, Bureau of Land Management, volunteers) has searched/surveyed/monitored/censused for Camatta Canyon amole on national forest annually from 2010 to 2020. The right-of-way of State Highway 58 is managed by California Department of Transportation, which designated the area with Camatta Canyon amole as a Botanical Management Area. This agency gives greater environmental review when planning work here, and their biologists search/survey/monitor/census irregularly: 2001, 2005 and 2006 – efforts led by Thomas Edell; 2017, 2018 and 2019 – efforts lead by Michaela Robbins; and 2020 – efforts led by Barrett Holland. Botanists at California Polytechnic State University plan to search/survey on the private property north of State Highway 58, having conducted a preliminary search in 2019.

5 THREATS

5.1 Santa Lucia purple amole

When the species was listed in 2000, the primary threats to the Santa Lucia purple amole were identified as loss and alteration of habitat, direct loss of plants from construction and use of military training facilities and from military field training activities, displacement by nonnative annual grasses, and potentially by alteration of fire cycles due to military training. Livestock grazing was identified as a potential threat because it was thought that grazing may be reinstated in occupied habitat in the future.

In the 2008 5-year review, the threat of potential habitat loss and alteration resulting from military activities was thought to have been considerably lessened with implementation of a completed or draft Integrated Natural Resources Management Plans (INRMP) and monitoring programs at FHL and Camp Roberts. The threat posed by nonnative, annual grasses was found to be recurring. Fires had removed the nonnative annual grasses in some areas during some years. However, because of the clumped and limited distribution of the purple amole in a semiarid environment, a wildfire could destroy a substantial portion of the population. Grazing was no longer considered a threat because all sheep and cattle grazing was terminated at both installations. New threats to the taxon identified in 2008 included: herbivory, soil displacement and bulb disturbance resulting from gophers and feral pigs.

In the 2020 analysis, we consider the primary threats to Santa Lucia purple amole to be the following: displacement from nonnative, invasive species, anthropogenic disruptions from ongoing military activities and/or disturbance from wildlife species, fire (although it may have some species benefits), and climate change, including extended drought and increasing temperatures (Figure 8). Each of these threats are discussed further below.

5.1.1 INVASIVE SPECIES

Invasive plant species are a primary threat to Santa Lucia purple amole. Nonnative, invasive species displace native plants by reducing their overall fitness and growth, changing the plant community structure, and decreasing native abundance and diversity (Vilà et al. 2011, p. 705). Competition for limited resources (such as light, nutrients, space and water) and changes to the disturbance regime that alter litter quantity are frequently cited as mechanisms for these changes (Gioria and Osborne 2014, p. 3–4; Mack and D'Antonio 1998, p. 195–196). Santa Lucia purple amole requires a low percent cover of other species and is associated with biological soil crusts. Invasive species fill in open spaces within the habitat and occupy areas that support biological soil crusts. Exotic species will also increase the amount of thatch present within the ecosystem, which can competitively exclude Santa Lucia purple amole growth and inhibit seed germination. The dominant nonnative species recently reported in the understory of occupied habitats include: soft chess, wild oat, and storksbill (Woodbury 2019, p. 1; Terra Verde Environmental Consulting 2019, p. 14).

In particular, nonnative European grasses in the understory of occupied habitats increase thatch accumulation, which has a negative effect on Santa Lucia purple amole. Taller, more abundant nonnative grass assemblages in occupied understories may compete with purple amole for open space, negatively affect flowering, decrease productivity, and inhibit seed set and germination. At Camp Roberts, a higher density of purple amole was associated with shorter associated vegetation height in 2017 and 2019 and productivity decreased with greater percent cover (Terra Verde Environmental Consulting 2019, p. 14–15). Equivalent data are not available for FHL.

Increased thatch from nonnative invasive grasses can also increase fuels causing fires to burn hotter, longer and with increased intensity. Increased fuels from accumulated thatch may also increase the frequency and duration of fire events.

5.1.2 ANTRHROPOGENIC AND WILDLIFE DISTURBANCE

Disturbance, whether from human origins (military activities) or resident wildlife species is another primary threat to Santa Lucia purple amole. Anthropogenic disturbance and that resulting from wildlife can cause direct harm to individuals and adversely affect purple amole habitat quality. Military training activities and other ground disturbance resulting from construction, routine maintenance, vegetation and fuels management, and vehicles are considered anthropogenic sources of disturbance to the taxon. Burrowing mammals such as gophers, California ground squirrels (*Otospermophilus beecheyi*), American badgers (*Taxidea taxus*) and other rodents may tunnel through occupied areas and disrupt purple amole bulbs, root systems and biological soil crusts. Small mammals may also eat purple amole leaves and flowering stems. Larger animals, like feral pigs, disrupt Santa Lucia purple amole by overturning soils within occupied habitats and pigs also eat Santa Lucia purple amole plants and bulbs. Hoof punch from tule elk (*Cervus canadensis nannodes*) and mule deer (*Odocoileus hemious*) is another source of animal disturbance that can affect Santa Lucia purple amole and its habitat.

Biologists of FHL and Camp Roberts have been monitoring anthropogenic disturbance and wildlife within their Santa Lucia purple amole populations since the time of listing in 2000. Anthropogenic disturbance at Camp Roberts is broadly classified as military training activities (Terra Verde Environmental Consulting 2019, p. 16 and 20). At FHL it is further characterized to include disturbance from vehicles, mechanical ground disturbance, other ground disturbance, bivouac training, other military training and unauthorized trails/roads (Woodbury 2017, p. 5 and 8; Woodbury 2019, p. 4). At Camp Roberts animal disturbance includes ungulate trampling, as well as herbivory and other ground disturbance from small mammals. Animal disturbance at FHL is classified as any animal activity that caused ground disturbance and includes disturbances from gophers, feral pigs, squirrels and unknown animal (Woodbury 2019, p. 20–21). At FHL anthropogenic disturbance was observed in less than one percent of the plots monitored over the last 10 years; disturbance from wildlife was observed in 62 percent of the plots. Disturbance (whether from wildlife or anthropogenic) outside of the monitoring plots is largely unknown. Quantitative disturbance data are not available for Camp Roberts beyond it being generally observed annually.

5.1.3 FIRE

The overall effects of wildfire on Santa Lucia purple amole are largely unknown. Seeds on the soil surface or within the thatch layer may be destroyed by intense wildfires. Fire events with increased fuel loads also have potential to kill underground bulbs. In addition to these direct impacts, wildfire can kill insect pollinators and reduce their numbers in subsequent years. Wildfires are most likely to occur in the late summer and early fall when much of the vegetation is dry and browned.

Controlled burns are frequently used as a management tool for invasive species that may reduce fuel loads, restore historic disturbance regimes, improve forage and habitat and promote biodiversity. However, many invasive plant species thrive in post-disturbance environments (DiTomaso et al. 2006, p. 535 and 541). In some instances, use of prescribed burns may end up increasing the abundance and cover of the invasive species that they are intended to target, unless the controlled burn efforts are coupled with some type of native plant restoration. Alternatively, prescribed burns can be repeated so that the seed banks of the target species are effectively depleted. Grassland plant communities generally benefit from prescribed burns because of thatch removal, which increases light absorption, raising soil temperatures and nutrient availability and decreases pathogens. Timing of prescribed burns is important to ideally kill targeted species before the seed becomes viable or to destroy it before dispersal. Populations of Santa Lucia purple amole at both military installations have been exposed to several wildfires and prescribed burn events. However, the effects on the taxon are difficult to characterize or quantify and remain largely unknown.

Fort Hunger Liggett

A wildfire burned within FHL Training Area 22 (the area between the Jolon and Lockwood South purple amole populations) in 2008 that contained one of the long-term monitoring transects within the Jolon population. In 2009, FHL reported that this transect was one of four that had the most dense populations of purple amole surveyed. The densities reported were higher than the past two years, but were not statistically significant. Productivity from the surveyed transects was slightly lower that same year (Woodbury 2009, p. 3–5). Prescribed burns occurred at FHL in several areas that contained purple amole monitoring transects within the Jolon and Nacimiento River North populations in 2010. By 2011, increased densities and productivity were observed in burned areas as well as in unburned areas. Density and productivity in transects within burned areas increased 36 percent and 165 percent, respectively from the previous year. While density and productivity in transects within unburned areas increased 24 percent and 55 percent, respectively (Woodbury 2012, p. 7). In 2015, another prescribed burn took place at FHL that included areas within the Jolon amole population. Post-burn reconnaissance surveys were conducted in this area and 12 new patches of Santa Lucia purple amole were discovered totaling 0.3 hectare (0.8 acre; Woodbury 2017, p. 6 and 9).

Camp Roberts

This installation has had three wildfires within the Santa Lucia purple amole population between 2005 and 2016. All the monitoring transects burned in a wildfire during June of 2005. One additional monitoring transect was added just beyond the burn limits in 2006. A prescribed burn occurred in November of 2012 that affected four of the monitoring transects on the eastern side of the population. Then another fire occurred in May of 2016 that affected the same four eastern transects. The burned plots had consistently lower plant densities than the unburned plots and this pattern has persisted from 2013 through 2019. Camp Roberts notes that the burned plots have had consistently lower densities in most years, not solely after the specified burn events (Bales 2020, pers. comm). The unburned plots have had consistently higher productivity than the burned plots from 2014 through 2019. However these differences were not statistically significant in all of the years (Terra Verde Environmental Consulting 2019, p. 3, 9 and 10).

5.1.4 CLIMATE CHANGE

Climate change, including extended drought and increasing temperatures, is a primary threat to Santa Lucia purple amole. Santa Lucia purple amole needs adequate annual precipitation and suitable temperatures to complete its life cycle. The three-year period from 2012 through 2014 was the hottest and driest in California on record over a 100-year time frame (Mann and Gleick 2015, p. 3858). This same three-year period marked the most severe drought conditions the state has experienced in the last 1,200 years (Griffin and Anchukaitis 2014, p. 9017). Climate models show that increasing co-occurrence of dry and warm years raises the risk of unprecedented drought in the western United States because elevated temperatures play a more critical role in water availability than previously thought and this will likely increase overall drought, regardless of simple precipitation trends (Mann and Gleick 2015, p. 3858). The seven consecutive years from 2013 to 2019 are each among the 10 hottest on record, with all 10 of the hottest years having occurred since 2005. The average global land and ocean surface temperature for January through February 2020 was 1.16° Celsius ([C] 2.09° Fahrenheit [F]) above the 20th century average of 12.1°C (53.8°F). This was the second highest January–February period on record, trailing behind the record set in 2016 by only 0.03°C (0.05°F; National Oceanic and Atmospheric Administration [NOAA] 2020, website). The past five years (2015 to 2019) are the five warmest on record and the past decade (2010 to 2019) is also the warmest on record. Since the 1980s, each successive decade has been warmer than any preceding one since 1850 (World Meteorological Organization 2020, p. 5). California is expected to continue to become hotter and drier and climate models of the state show increased temperatures and further drying in the taxon’s current occupied range (Anacker et al. 2013 p. 196).

SANTA LUCIA PURPLE AMOLE CONCEPTUAL MODEL

The influence diagram reflects the interactions between the taxon’s threats and its needs (Figure 11). The influence diagram does not take into account management actions, which may reverse the effects of threats or eliminate them all together. Plausible management activities are addressed in the Future Scenarios Section (Section 7).

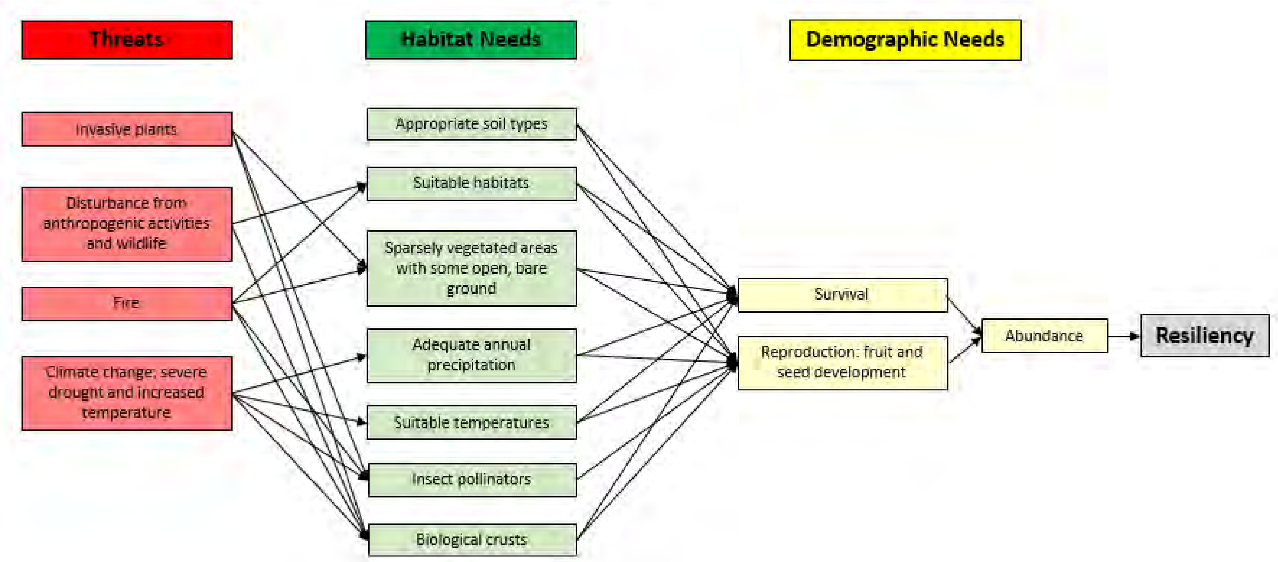

Figure 11. Influence diagram for Santa Lucia purple amole. Red boxes represent the primary threats to the taxon, green boxes are the habitat needs and yellow boxes are the demographic needs. Black arrows are interactions that show how the different factors influence resiliency.

5.2 Camatta Canyon amole

When the species was listed in 2000, the primary threats to Camatta Canyon amole were identified as illegal vehicle trespass into occupied habitat on national forest, road maintenance, displacement by nonnative annual grasses, and cattle grazing (65 FR 14879).

In the 5-year review in 2008, we identified the following primary threats to Camatta Canyon amole: cattle grazing on national forest, illegal motorcycle trespass on national forest, displacement by nonnative annual grasses, and wildfire (Service 2008, p. 19). More recently, Kofron et al. (2013a, p. 45–46) identified the primary threat as invasive plants, and other threats as Botta's pocket gophers, uncontrolled cattle grazing, road maintenance, and possibly lack of fire.

In the 2020 analysis, we consider the primary threats to Camatta Canyon amole to be the following: nonnative, invasive plants, and climate change, including severe drought and increased temperatures. Secondary threats are gophers and off-highway vehicles. Minor threats include road vehicles and road maintenance along Red Hill Road. Potential threats include heavy cattle grazing — strategic cattle grazing, and if not practicable then light cattle grazing, may be beneficial; farming; and road maintenance on the private property north of State Highway 58, in the right-of-way of State Highway 58, and on the private property south of it. We identify wildfire as a possible threat. Each of these threats are discussed further below (Table 6).

Table 6. Identified threats to Camatta Canyon amole in 2020: primary, secondary, minor, and potential.

Occurrence		Invasive plants	Climate change including severe drought and increased temperatures	Gophers	Off-highway vehicles	Road vehicles	Road maintenance	Heavy cattle grazing	Farming
1	private property N St Hwy 58 -	primary	primary				potential	potential	potential[A]
	right-of-way St Hwy 58 -	primary	primary			minor	potential		
	Los Padres National Forest -	primary	primary	secondary	secondary	minor	minor	potential	
2	right-of-way St Hwy 58 -	primary	primary			minor	potential		
3	private property S St Hwy 58 -	primary	primary			minor	potential		
4	private property N St Hwy 58 -	primary	primary					potential	potential[A]

[A] Dry farming for barley and wheat previously occurred over a large area of the property.

5.2.1 INVASIVE SPECIES

Invasive plants are a primary threat to Camatta Canyon amole. The predominant invasive species in the habitat on Red Hill Ridge are slender wild oat (*Avena barbata*), red brome (*Bromus rubens*), soft chess (*B. hordeaceus*) and storksbill (*Erodium* sp.). Invasive species displace native plants by reducing their overall fitness and growth, changing the plant community structure, and decreasing native abundance and diversity (Vilà et al. 2011, p. 705). Competition for limited resources (such as light, nutrients, space and water) and changes to the disturbance regime that alter litter quantity are frequently cited as mechanisms for these changes (Gioria and Osborne 2014, p. 3–4; Mack and D'Antonio 1998, p. 195–196). Invasive species can fill in open spaces within the habitat and occupy areas that support biological soil crusts. In addition, they can cause accumulation of thatch that can result in exclusion of native plants (Molinari and D'Antonio 2020, p. 957). In contrast, Camatta Canyon amole favors a bare soil surface and often with biological crust.

Much of Red Hill Mesa is now covered with invasive grasses (see Appendix C for photos), which in 2017 were up to 76 centimeters/30 inches tall (Kofron and Rutherford 2017). Camatta Canyon amole is usually absent in tall or dense invasive grasses, except at the southern end of Red Hill Ridge where it grows with a dense invasive grass up to 25 centimeters/10 inches tall (Kofron and Rutherford 2017; see plots 6 and 7, Table 5). Kofron et al. (2013a, entire) reported Camatta Canyon amole generally absent in May 2011 due to taller invasive plants (30 to 46 centimeters/12 to 18 inches) that were especially dense around blue oaks. In contrast, a previous staging area for off-highway vehicles with relatively few invasive plants contained 3.2 Camatta Canyon amole per meter^2/1.2 yard^2. Hoover (1970, p. 89) reported that Camatta Canyon amole growing around oak trees on Red Hill Ridge were taller, which he presumed due to looser soil and more humus. However, Borchert (1981, p. 2) observed a general absence of Camatta Canyon amole beneath oak trees. He stated that "individuals often were encountered at the margins of small grass islands, but not where grass height exceeded 4 inches [10 centimeters] and 79% cover, such as beneath the oaks and in the center of the grass patches." Likewise since at least 2011, our biologists usually observed tall and dense invasive grasses in the shaded understory (see Appendix C for photos). It may be that ecological conditions have changed on Red Hill Ridge since Hoover (1970, p. 89) made his observations, with a possible decline in quality of habitat.

Increased thatch from nonnative, invasive grasses can increase the fuel load causing fires to burn hotter and longer, and it can also increase the frequency and duration of fire events.

5.2.2 CLIMATE CHANGE

Climate change including severe drought and increased temperatures is a primary threat to Camatta Canyon amole. Camatta Canyon amole needs adequate annual precipitation and suitable temperatures to complete its life cycle. The 3-year period from 2012 to 2014 was the hottest and driest in California in the 100-year time frame considered by Mann and Gleick (2015, p. 3858), and it included the most severe drought in California in the past 1,200 years (Griffin and Anchukaitis 2014, p. 9017). The six consecutive years from 2013 to 2018 are each among the 10 warmest on record, all 10 having occurred since 2005 (NOAA National Centers for Environmental Information 2019, p. 1). The most recent 5-year (2015 to 2019) and 10-year (2010 to 2019) periods are almost certain to be the warmest on record, and each successive decade since the 1980's has been warmer than any preceding decade since 1850 (World Meteorological Organization 2019, p. 3). San Luis Obispo County ranks 12th in the USA (along with three other counties) for time duration in exceptional drought (the most intense) since 2000 (Bolinger 2019 entire), with most of the exceptional drought having occurred between 2011 and 2015. In brief, California is becoming hotter and drier, and Camatta Canyon amole is in an area that modelling forecasts increased temperatures and increased drying (Anacker et al. 2013, p. 196). The taxon is a habitat specialist with a small geographic range, and its life history traits appear to include low dispersal ability and soil endemism. The available information suggests that Camatta Canyon amole is moderately to highly vulnerable to climate change including severe drought and increased temperatures.

5.2.3 GOPHERS

Gophers are a secondary threat to Camatta Canyon amole. They cause extensive disturbance to habitat on Red Hill Ridge, especially where invasive grasses are abundant. Gophers make holes in the flat soil surface and also throw soil into mounds (see Appendix C for photos). Our biologists have seen only a few Camatta Canyon amole growing in soil turned by gophers, and the disturbed soil appears favored by invasive plants. Kofron et al. (2013a, p. 43–45) previously reported gophers causing extensive disturbance to the habitat, especially where invasive plants were abundant. They considered it a new threat since listing, first identified in 2010. In the 1990's, Borchert (2001, p. 1) observed a substantial amount of gopher activity surrounding but not within the habitat of Camatta Canyon on Red Hill Ridge. However, Koch (1997a, p. 9) reported gopher mounds near her study site on Red Hill Ridge with "nothing growing on them but amole plants. Amole seedlings would also be visible on these disturbed mounds that had less competition from other plants."

5.2.4 OFF-HIGHWAY VEHICLES

The area occupied by Camatta Canyon amole on Los Padres National Forest is in the Pozo-La Panza Unit (70 kilometers^2/27 miles^2), which is best known for off-highway vehicle recreation where Red Hill Road at State Highway 58 is a main entrance (U.S. Forest Service 2005, p. 70). Magney (1987, p. 15) and Koch (1997b, p. 1) recognized off-highway vehicles as a threat. Lopez (1992, p. 3) observed that off-highway vehicles on Red Hill Mesa resulted in major soil compaction and the probable loss of many plants. More recently, Kofron et al. (2013a, p. 45) reported that habitat on Red Hill Ridge was effectively protected from off-highway vehicles by fencing, signs and ranger patrols. In 2020, habitat on Red Hill Ridge continues to be effectively protected from off-highway vehicles, especially by the welded pipe fence installed in 1990/1991 and maintained by the U.S. Forest Service (see Appendix C for photos). However, the southernmost ridge of occurrence 1 is open to motorcycles and all-terrain vehicles (U.S. Forest Service 2018 entire; 2019, p. 1), which comprise a secondary threat. Specifically, the Burnout Trail extends through two occupied areas on this ridge (Kofron and Rutherford 2015b entire; Yost 2019b entire), and Camatta Canyon amole is immediately next to and away from the trail. A welded pipe fence with relevant signs (educational and regulatory) should be installed here also to protect Camatta Canyon amole and its habitat. In addition, the relevant signs (educational and regulatory) at the entrance to Red Hill Road from State Highway 58 should be improved.

5.2.5 ROAD MAINTENANCE ALONG RED HILL ROAD

The adverse effects of road maintenance along Red Hill Road, in particular grading of the dirt road after the wet season, is ongoing. Although some Camatta Canyon amole grow between the road and pipe fence, we consider road maintenance to be a minor threat. Also relatively minor are effects of road vehicles running over plants in and near the dirt roads (Red Hill Road, private property south of State Highway 58) and State Highway 58, and road vehicles throwing up dust that settles on plants along Red Hill Road.

5.2.6 HEAVY CATTLE GRAZING

Red Hill Ridge and Red Hill Mesa are in the Camatta Special Interest Area (22 hectares/55 acres), and also in the Navajo Allotment (1103 hectares/2725 acres) where a permittee used to graze cattle from February to May (U.S. Forest Service 2005, p. 70, 102), which overlaps in time with flowering and fruiting of Camatta Canyon amole (April to June). All known areas for the threatened plant on national forest are in this grazing allotment. Lopez (1992, p. 3) observed that heavy cattle grazing on Red Hill Ridge resulted in major soil compaction and the probable loss of many plants. Since the Service began monitoring in 2010, cattle grazing occurred here in 2010 (see Appendix C for photos) but not 2011 to 2020. Kofron et al. (2013a, p. 45) reported that in 2010 the soil surface was imprinted with hoof depressions from cattle when the soil was wet and soft. McLeod (1983, p. 2) stated that light to medium grazing appeared to benefit Camatta Canyon amole on Red Hill Mesa. Magney (1987, p. 15) considered heavy cattle grazing a likely threat but light cattle grazing an acceptable land use. Kofron et al. (2013a, p. 45) speculated that strategic cattle grazing (adding and removing cattle on demand to control density and timing at a particular location) may benefit Camatta Canyon amole by reducing the presence of invasive plants and thatch.

Cattle can cause physical damage to Camatta Canyon amole by trampling, along with disruptions to the flat soil surface, soil compaction and erosion, damage to biological soil crusts, addition of manure, reduced presence of native plants and increased presence of invasives (Fleischner 1994 entire; DiTomaso 2000 entire; Belnap and Eldridge 2001 entire; Kimball and Schiffman 2003, p. 1683). In central California, Germano et al. (2001 entire; 2012 entire) recommended strategic cattle grazing for reducing invasive grasses and benefiting native plants and wildlife, and Gennet et al. (2017, p. 16) determined that strategic cattle grazing can reduce thatch and invasive plants while benefiting native plants and birds. In consideration of all factors, we suspect that strategic cattle grazing, and if not practicable then light cattle grazing, would likely benefit Camatta Canyon amole by reducing invasive plants and thatch. In particular, we recognize that ranching can benefit listed species, and the Service previously led efforts to establish the California Rangeland Conservation

Coalition (Barry et al. 2007, p. 33). With more than two-thirds of California in private ownership, the future of the State's native plant and wildlife habitats is largely dependent on the conservation practices of private landowners (Service 2019, p. 1).

5.2.7 FARMING

The private property north of State Highway 58 is primarily a cattle ranch (Lazy Arrow Adventures 2019 entire), and Lopez (1992, p. 3) described the area with Camatta Canyon amole near Red Hill Road (Gaskin 1990 entire) as heavily grazed. Although the distribution and abundance of Camatta Canyon amole on this private property are not known, the plant likely has greater abundance and distribution here than on national forest (Yost 2019a, p. 1). However, we have no additional details. A large area of the ranch was previously dry farmed for barley and wheat. While recognizing that ranching along with wildlife habitat may be the best agricultural use of the property, Weitkamp and Graves (1998, p. 37) suggested that rotation with commercial legumes and grains (including tilling and fertilizing) could improve the soil and increase livestock and grain production. If this farming is conducted in habitat of Camatta Canyon amole, its habitat would be destroyed and the plant eliminated. In brief, dry farming on the private property north of State Highway 58 is a potential threat to Camatta Canyon amole.

5.2.8 ROAD MAINTENANCE ON PRIVATE AND STATE PROPERTIES

Road maintenance is a potential threat on the private property north of State Highway 58 (occurrence 1), and also in the right-of-way of State Highway 58 (occurrences 1 and 2) and on the private property south of it (occurrence 3). Road maintenance could remove individual plants.

5.2.9 WILDFIRE

The effect of wildfire on Camatta Canyon amole is unknown, however, it would likely include loss of the annual seed crop, and it seems that intense wildfires with greater fuel loads could kill the underground bulbs. A lack of wildfire allows accumulation of thatch and proliferation of potentially competitive species (invasive and native), whereas fire could possibly benefit Camatta Canyon amole by removing thatch and potentially competitive species. During 2011 and 2012, Kofron et al. (2013a, p. 45) observed accumulated thatch and potential competition with invasive grasses (e.g., slender wild oat, red brome, soft chess) and possibly chamise. In general but not quantified, our biologists observed fewer Camatta Canyon amole in plots with thatch and tall grasses, which were especially abundant near blue oaks likely because of moisture conservation afforded by shade (see Appendix C for photos). Kofron et al. (2013a entire) reported one incident of wildfire likely benefiting Santa Lucia purple amole on Fort Hunter Liggett. A wildfire along Red Hill Ridge in 1980 (Red Fire: Borchert 1981, p. 2) burned chamise, but no Camatta Canyon amole were subsequently observed in the burned stands in May 1981. The last wildfire here was in 1996 (Highway 58 Fire; Koch 1997a, p. 8).

CAMATTA CANYON AMOLE CONCEPTUAL MODEL

The influence diagram reflects the many interactions between the taxon’s threats and its needs (Figure 12). The influence diagram does not take into account management actions, which may reverse the effects of threats or eliminate them all together. Plausible management activities are addressed in the Future Scenarios Section (Section 7).

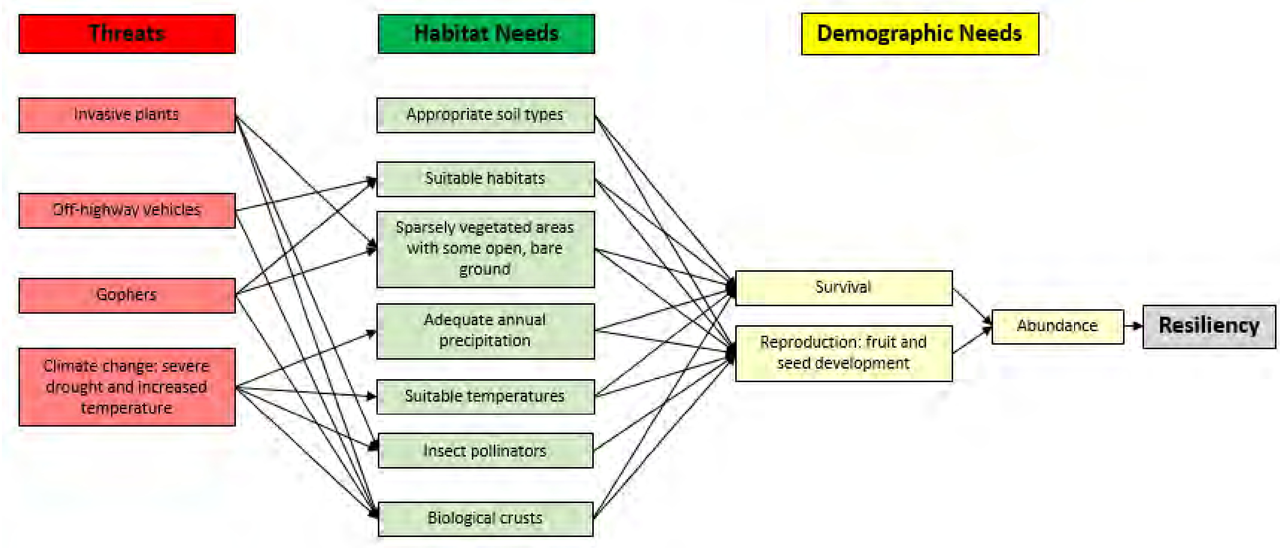

Figure 12. Influence diagram for Camatta Canyon amole. Red boxes represent the primary and secondary threats to the taxon, green boxes are the habitat needs and yellow boxes are the demographic needs. Black arrows are interactions that show how the different factors influence resiliency.

6 CURRENT CONDITION

The current condition evaluation is used to assess viability under current state conditions. We used resiliency, representation and redundancy to evaluate the taxon's condition.

6.1 Santa Lucia purple amole

Four factors were used to evaluate resiliency of each Santa Lucia purple amole population: density, disturbance, productivity and occupied area (Table 7). Potential threats to the taxon have implications on all of these factors and when combined, they provide a practicable metric of its condition.

Density. Populations with higher density generally have greater relative abundance and are therefore more able to recover from stochastic events. The highest density in Santa Lucia purple amole observed over the 10-year time frame (2009 to 2019) was 48 individuals per m^2 within the Nacimiento River North population. Using this value as the high, we used a range of all possible variation from zero to 48 individuals per m^2 to set the density condition categories by dividing this range into thirds. The low condition category for density is 16 individuals per m^2 or less (score 1), the medium condition category is between 17 and 32 individuals per m^2 (score 2) and the high density condition category is greater than or equal 33 individuals per m^2 (score 3). Then we evaluated the average densities observed within each population over the two installations' monitoring time periods to determine the current density condition of each Santa Lucia purple amole population and where it falls within this range.

Disturbance. In general, disturbance, whether from anthropogenic sources (vehicles and military training operations) or wildlife (such as gopher, other rodents or feral pig), has a detrimental effect on Santa Lucia purple amole because it adversely modifies and disrupts the habitat mechanically and/or directly harms or kills individuals within a population. Disturbance is not the only factor that affects habitat quality. For example, an area may have no anthropogenic and wildlife disturbance, but is still low quality because the thatch from non-native annual grasses is overgrown. Some disturbance effects (such as fire) may be beneficial to habitat quality because at the right time of year and intensity, fire can remove accumulated thatch. Disturbance effects from fire are discussed separately (see Section 5.1.3).

We recognize that disturbance effects are context–dependent (meaning site–specific and contingent on the time of year that the disturbance occurs, the intensity, duration, etc.); so the effects are highly variable. At FHL, gopher disturbance is the most prevalent wildlife disturbance within areas occupied by the taxon. Yet it did not correlate to Santa Lucia purple amole density or abundance (Guretzky et. al 2005, p. 14). However, increased human disturbance was associated with a reduction in density (Guretzky et. al 2005, p. 12). In certain situations and thresholds, disturbance may function to improve habitat quality, (e.g., anthropogenic disturbances from light bivouac activities that could reduce thatch). Additional study on this subject is needed to better understand the effects of disturbance on the taxon because clear relationships are not yet apparent (Guretzky et. al 2005, p. 14). Currently, disturbance is a useful proxy to infer habitat quality because it remains one of the pervasive threats to the species.

Disturbance within areas occupied by Santa Lucia purple amole was evaluated at each of the two military installations. At FHL disturbance was assessed within various subsets of sampling plots (m^2 quadrats) at each population from 2009 through 2019. At Camp Roberts disturbance was evaluated in a similar manner between the years of 2015 through 2019. We calculated the average (percentage disturbed of total sampled) disturbance observed at each of the four populations over the two respective time frames. Then we set a disturbance condition category scale based partly on these observed disturbance averages and other basic, common sense considerations. If 50 percent or more of the sample area is disturbed the condition category is low and the habitat quality is likely poor (score 1). If between 16 and 49 percent of the sample habitat is disturbed, the condition category is medium (score 2). And if 15 percent or less of the sample area is disturbed the condition category is high and the habitat is likely more pristine (score 3).

Productivity. Populations with high productivity have higher growth rates and are able to recover from stochastic events more easily because numbers of individuals can rebound faster. We calculated the average productivity of each Santa Lucia purple amole population using counts of the number of fruiting individuals observed per m^2 from each military installation. The time frame used for FHL was 2009 to 2019 and from 2015 through 2019 for Camp Roberts because these are the years that this information is available. Then we evaluated the productivity trends of each population to determine if it is increasing, stable or decreasing, and compared it to the population average to assess the population's current condition. For example, if a population's productivity was higher than the average for several consecutive years, it would be considered increasing and this is the high condition category. If the productivity of a Santa Lucia purple amole population was consistently lower than the average for several consecutive years, it would be decreasing and this is the low condition category. Lastly, if there was no consistent change from the average productivity, that population would be considered stable and in a moderate condition. Each condition category was scored as follows: low (decreasing productivity) equals one, moderate (productivity is stable) equals two and high (increasing productivity) equals three.

Occupied Area. Larger populations are generally less affected by stochastic events, whereas small populations have a higher risk of extirpation from stochastic incidents, when considering size alone. A large occupied area is better than a small occupied area because the adverse effects of any unfavorable event are less likely to be experienced by all individuals. Thus, an occurrence of Santa Lucia purple amole with a large occupied area is more likely to survive and persist through time than an occurrence with a small occupied area. For this category, we considered populations that are greater than 100 hectares (247 acres) to be large and assigned this as the high condition category because in general, larger-sized populations have a higher ability to withstand stochastic events and a lower risk of extirpation. Populations that occupy areas between 11 and 99 hectares (27-244 acres) are considered to be moderately sized. These have a moderate risk of becoming extirpated from stochastic events and are assigned the medium condition category. Lastly, small populations are considered to occupy areas that are less than 10 hectares (25 acres) and these are assigned the low condition category because these are less likely to survive stochastic events and are at a higher risk of becoming extirpated. Large populations are assigned a score of three, medium sized are assigned a score of two and small populations are scored one.

Table 7. Factors and condition categories used to evaluate resiliency of the four Santa Lucia purple amole populations, throughout its range in Monterey and San Luis Obispo counties, California.

	Parameters			
Condition Category	**Density**	**Disturbance**	**Productivity**	**Occupied area**
Low = 1	≤16 individuals/m^2	≥50%	decreasing trend	≤10 hectares (25 acres)
Medium = 2	17–32 individuals/m^2	16–49%	stable, no consistent change from the average observed	11-99 hectares (27-244 acres)
High = 3	≥33 individuals/m^2	≤15%	increasing trend	≥100 hectares (247 acres)

We evaluated the taxon's current condition based on all the available monitoring data collected at all four Santa Lucia purple amole populations for these four parameters though 2019. For each factor, one of the following condition categories was assigned, depending on the particular condition or state of that population as follows: Low (score 1), Medium (score 2) and High (score 3). An occurrence with low resiliency has a low ability to sustain itself in the face of environmental variation and therefore a high risk of extirpation in the near future. An occurrence with moderate resiliency has a moderate ability to sustain itself in the face of environmental variation and therefore a moderate risk of extirpation in the near future. An occurrence with high resiliency has a high ability to sustain itself in the face of environmental variation and therefore a low risk of extirpation in the near future.

Density. The Jolon and Nacimiento River South populations both scored low (1) for the density parameter. Average density within the Jolon population was 13 individuals per m^2 and only six individuals per m^2 within the Nacimiento River South population. The Lockwood South and Nacimiento River North populations each scored at the medium (2) condition category for this parameter. The average density of plants observed within the Lockwood South population was 18 individuals per m^2 and the Nacimiento River North population had 25 individuals per m^2, which was the highest average density of all the populations.

Disturbance. Using the data available to us, the Nacimiento River North population had the highest disturbance with an average of 59 percent of the sampled quadrats disturbed over the monitoring period. Therefore, this population scored low (1) for this metric. More than half of this populations' sampled habitat was disturbed and the overall quality is likely lower than optimal for the taxon. The Jolon and Nacimiento River South populations had an average of 41 and 40 percent of the quadrats disturbed, respectively. These two populations scored at the medium (2) condition category for this factor. The Lockwood South population had the least amount of disturbance and it had an average of only 14 percent disturbance over the sampling period. This population scored high (3).

Productivity. The average productivity for the Jolon population was four individuals per m^2 over the monitoring period. The highest productivity for this population was six individuals per m^2 in 2011 and it has had a steadily decreasing trend since this year. Productivity within the Jolon population never exceeded the population average of four individuals per m^2 after 2013. As such, this population scored low (1) for this factor. The average productivity was three individuals per m^2 at the Lockwood South population throughout the monitoring period. The highest productivity for this population was five individuals per m^2, which occurred for two consecutive years in 2010 and 2011. However, productivity since 2011 showed a declining trend and the population only achieved its mean productivity one more time in 2016. The Lockwood South population scored in the low (1) condition category for productivity. Average productivity for the Nacimiento River North population was seven individuals per m^2. This is the most productive population of the four. The highest productivity ever observed within the Nacimiento River North population was 12 individuals per m^2 in 2011. This population's productivity also showed a declining trend since 2016 and its mean was not achieved or surpassed since 2014. Therefore, this population also scored in the low (1) category. Lastly, the average productivity of the Nacimiento River South population is three individuals per m^2. This population achieved its mean for two consecutive years in a row, 2017 and 2018. Then it increased slightly in 2019 to four individuals per m^2. Productivity in this population is showing an increasing trend in 2019 and for the purposes of our analysis, we assume this trend will continue into the near future because these data are not yet available. Therefore, the Nacimiento River South population scored in the high (3) condition for this metric.

Occupied Area. Two of the Santa Lucia purple amole populations are relatively large. The Jolon population is 248 hectares (612.8 acres) in size and the Nacimiento River South population occupies 216.2 hectares (534.2 acres). Therefore, each of these two populations is within the high (3) condition category for occupied area. The Lockwood South population is 31.6 hectares (78.1 acres) in size and it is within the medium (2) condition (between 11 to 99 hectares or 27 to 244 acres) for this factor. Lastly, the Nacimiento River North population received a low (1) score of one for the occupied area factor. This population occupies an area that is only 2.3 hectares (5.7 acres) in size, which is within the low condition category (less than or equal to 10 hectares or 25 acres).

Next we calculated a total score for each population by summing its parameter scores and dividing by four because each of the four condition categories have equal weight to quantify the resiliency of each population. A total score between two whole numbers is rounded to the nearest whole number according to standard mathematical convention. For example, a score of 1.5 is rounded to two. The results of the population resiliency analysis are provided in Table 8 below.

Three of the four purple amole populations (Jolon, Lockwood South and Nacimiento River South) have moderate resiliency under current conditions. These three populations have a moderate ability to sustain themselves when faced with environmental variation in the near future and have a moderate risk of becoming extirpated during stochastic events. The Nacimiento River North population is the only population that currently has a low total resiliency score. This population has a reduced ability to sustain itself when faced with future environmental variation and is at a high risk of becoming extirpated during stochastic events.

Table 8. Current Condition – resiliency analysis for each of the four Santa Lucia purple amole populations, throughout its range in Monterey and San Luis Obispo counties, California.

	Parameter scores under 2019 current conditions				
Population	**Density**	**Disturbance**	**Productivity**	**Occupied Area**	**Total**
Jolon – FHL	1	2	1	3	2
Lockwood South – FHL	2	3	1	2	2
Nacimiento River North – FHL	2	1	1	1	1
Nacimiento River South – Camp Roberts	1	2	3	3	2

6.2 Camatta Canyon amole

We evaluated the resiliency of each occurrence of Camatta Canyon amole in 2020 using the following parameters: occupied area, protected status, land use, and number of primary threats present (Table 9).

Occupied Area. Larger populations are generally less affected by stochastic events, whereas small populations have a higher risk of extirpation from stochastic incidents, when considering size alone. A large occupied area is better than a small occupied area because the adverse effects of any unfavorable event are less likely to be experienced by all individuals. Thus, an occurrence of Camatta Canyon amole with a large occupied area is more likely to survive and persist through time than an occurrence with a small occupied area. Therefore, for the area of each occurrence, we assigned one of the following condition categories: ≤10 hectares (25 acres) = poor condition (score 1), 11-99 hectares (27-244 acres) = moderate condition (score 2), and ≥100 hectares (247 acres)= good condition (score 3).

Protected Status. For protected status of each occurrence, we assigned one of the following condition categories: not protected and with no management to benefit the species = poor condition (score 1); not protected and with some management to benefit the species, or a combination of condition categories 1 and 3 on two or more properties, = moderate condition (score 2); and protected and with some management to benefit the species = good condition (score 3).

Land Use. For land use at each occurrence, we assigned one of the following condition categories: potentially high disturbance (e.g. cattle ranching with heavy cattle grazing and exotic wildlife, potentially farming where dry farming for barley and wheat previously occurred over a large area of the property, roadside, and rural residential) = poor condition (score 1); combination of high and low disturbances (e.g. multipurpose on national forest, which is currently a combination of potentially high and low disturbances, including off-highway vehicles along the Burnout Trail) = moderate condition (score 2); and low disturbance = good condition (score 3).

Number of primary threats. For threats at each occurrence, we assigned one of the following condition categories: two primary threats present (both invasive plants and effects of climate change including severe drought and increased temperatures) = poor condition (score 1); one primary threat present (effects of climate change including severe drought and increased temperatures present) = moderate condition (score 2); and zero primary threats present = good condition (score 3).

Table 9. Parameters used to define condition categories for evaluating resiliency of each occurrence of Camatta Canyon amole in San Luis Obispo County, California.

Condition category	Parameters			
	Occupied area	Protected status	Land use	Number of primary threats
extirpated = 0	N/A			
poor =1	≤10 hectares (25 acres)	not protected and with no management to benefit the species	potentially high disturbance	2 (invasive species and effects of climate change including severe drought and increased temperatures)
moderate =2	11-99 hectares (27-244 acres)	not protected and with some management to benefit the species, or a combination of condition categories 1 and 3 on two or more properties	combination of potentially high and low disturbances	1 (effects of climate change including severe drought and increased temperatures)
good =3	≥100 hectares (247 acres)	protected and with some management to benefit the species	low disturbance	0 (none)

To quantify the resiliency of each occurrence of Camatta canyon amole in 2020, we calculated a total score by summing its parameter scores and then dividing by 4 because we used four parameters with equal weight. Resiliency levels are the following: total score 1 = low resiliency, total score 2 = moderate resiliency, and total score 3 = high resiliency. In accordance with standard mathematical convention, a total score between two whole numbers is rounded to the nearest whole number, and 1.5 is rounded up to 2. An occurrence with an overall low resiliency has a low ability to sustain itself in the face of environmental variation and therefore a high risk of extirpation in the near future. An occurrence with moderate resiliency has a moderate ability to sustain itself in the face of environmental variation and therefore a moderate risk of extirpation in the near future. An occurrence with high resiliency has a high ability to sustain itself in the face of environmental variation and therefore a low risk of extirpation in the near future.

Using this scheme for resiliency of Camatta Canyon amole in 2020, we found occurrence 1 to have moderate resiliency, and occurrences 2 and 3 to have low resiliency (Table 10). There is insufficient information to calculate a resiliency score for occurrence 4 because the area of the occurrence is not known. Camatta Canyon amole was reported at occurrence 4 in 1988 but without any details (Kofron 2008, p. 1). This occurrence has not been visited by a biologist since then, and it may be extirpated.

Table 10. Resiliency analysis for occurrences of Camatta Canyon amole in San Luis Obispo County, California under current conditions. To quantify the resiliency of each occurrence, we calculated a total score by summing its parameter scores and then dividing by 4 because we used four parameters with equal weight. Resiliency levels are the following: total score 1 = low resiliency, total score 2 = moderate resiliency, and total score 3 = high resiliency.

A Current Conditions in 2020		**Parameter scores under current conditions in 2020**					
Occurrence		Occupied area	Protected status	Land use	Number of primary threats	Total score	Resiliency level
1	private property N St Hwy 58 right-of-way St Hwy 58 Los Padres National Forest	2	2	2	1	1.75→2	moderate
2	right-of-way St Hwy 58	1	1	1	1	1.00→1	low
3	private property S St Hwy 58	1	1	1	1	1.00→1	low
4	private property N St Hwy 58	not known[A]	1	1	1	insufficient information	insufficient information

[A] Camatta Canyon amole was reported here in 1988 but without any details (Kofron 2008, p. 1). The occurrence has not been visited by a biologist since then, and it may be extirpated.

6.3 CURRENT CONDITION RESULTS

6.3.1 Resiliency

In summary, for Santa Lucia purple amole, the resiliency analysis shows that three of the four populations have moderate resiliency and one is low. For Camatta Canyon amole, the resiliency analysis shows that one occurrence has moderate resiliency and two occurrences have low resiliency; there is insufficient information to calculate a resiliency score for occurrence 4 because the area of the occurrence is not known. The populations/occurrences with moderate resiliency have a moderate ability to sustain themselves in the face of environmental variation and therefore a moderate risk of extirpation in the near future. The populations/occurrences with an overall low resiliency have a low ability to sustain themselves in the face of environmental variation and therefore a high risk of extirpation in the near future.

6.3.2 Representation

Representation describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Measures may include the number of varied niches occupied, genetic diversity, heterozygosity, or alleles per locus.

Given morphological and ecological differences between Santa Lucia purple amole and Camatta Canyon amole, representation across both varieties contributes to the species ability to adapt to changing environmental conditions over time. Both varieties have relatively small geographic ranges with mostly similar landscape features throughout. The Santa Lucia purple amole currently occupied area consists of approximately 500 hectares (1,230 acres). The known occupied area of Camatta Canyon amole in 2020 consists of greater than 36 hectares (89 acres). The niches and habitats each variety occupies have little heterogeneity. Therefore, each variety is a narrow, endemic taxon and the types of habitats or niches that it occupies are nearly uniform.

Although information is lacking regarding genetics of either Santa Lucia purple amole or Camatta Canyon amole, we consider each to comprise one genetic unit due to geography. While we are not aware of any extirpated locations or occurrences, or of any contraction in the geographic range, the productivity data for Santa Lucia purple amole suggest three of the four populations may be declining. The combined data from several studies suggest that the number of Camatta Canyon amole, where monitored, has declined. Thus, declining numbers of individuals may affect genetic diversity, and the spatial extent and associated ecological representation of both Santa Lucia purple amole and Camatta Canyon amole are inherently low.

6.3.3 Redundancy

Redundancy describes the ability of a species to withstand catastrophic events. Redundancy is characterized by having multiple, resilient populations distributed within the species' ecological settings and across the species' geographic range. It can be measured by population number, spatial extent, and degree of connectivity. Given sufficient redundancy, single or multiple catastrophic events are unlikely to cause the extinction of a species.

Purple amole is composed of two varieties, both narrow, endemic taxa with relatively small geographic ranges. Santa Lucia purple amole only has four populations located within approximately 280 $kilometers^2$ (108 square miles). Camatta Canyon amole only has four occurrences located within approximately 3 $kilometers^2$ (1 square mile). Because all four populations of Santa Lucia purple amole and all four occurrences of Camatta Canyon amole are situated close together, they could possibly be simultaneously affected by a catastrophic event. Given that the two varieties are approximately 61 km (38 miles) apart, a prolonged, catastrophic drought could affect both varieties simultaneously. However, the two varieties are far enough apart such that a large, intense wildfire is unlikely to deleteriously affect both varieties at once. Therefore, purple amole has inherently low redundancy due to being composed of two narrow endemic varieties, but having two spatially separated varieties does provide some protection for the species as a whole from extinction due to less expansive catastrophic events.

7 FUTURE SCENARIOS

We use 50 years as the approximate time frame to predict the species' response to two different future scenarios that incorporate likely environmental change and implementation of plausible management strategies. This timeframe is within a reasonable span to consider for purple amole based on what is known about how it currently interacts with its environment and the factors that presently influence its viability.

Climate Change. Temperatures in California have risen in consistent increments since the beginning of the 20th century and historically unprecedented warming is projected during the 21st century. Warming temperatures may exacerbate drought and increase the frequency, duration and intensity of wildfires throughout the state (Frankson et al. 2017, entire). Cumulative effects of climate change; including increased temperatures and extensive drought, are a threat to purple amole population persistence and abundance.

The current occupied range is included in Langridge (2018, entire), which is the fourth and most recent comprehensive assessment of climate change effects for California's Central Coast Region. The future climate change scenarios are based on the two Representative Concentration Pathways (RCPs) presented in this assessment. RCP 8.5 models several climate variables as if global greenhouse gas emissions continue to rise at the current rates throughout the 21st century and RCP 4.5 models the same climate variables in a mitigation scenario where global emissions are curtailed and eventually peak by 2040 (Langridge 2018, p. 12).

The species range spans two counties (Monterey and San Luis Obispo). Santa Lucia purple amole is predominantly within southern Monterey County; therefore, we use the Monterey County data in our two future scenarios for this taxon. Camatta Canyon amole is within San Luis Obispo County and therefore we use those data in our two future scenarios for it. Effects from climate change presented in the future scenarios may be conservatively low estimates for the actual effects within purple amole's occupied range given the diversity of climates within the Central Coast Region; but this is the best scientific information available.

Climate projections also show an increase in extreme dry events and increased drought conditions (Langridge 2018, p. 13). Projected changes in precipitation in California are more nuanced than projected changes in temperature and have less separation between RCP scenarios 4.5 and 8.5. Overall, there is a projected increase in year-to-year variability with wetter days during periods of precipitation, but with fewer total days with precipitation (Langridge 2018, p. 16). While average precipitation is expected to increase by a relatively small amount, the annual variability increases substantially by the end of the century. Across the region, projections show that the wettest day of the year will become wetter relative to historical conditions (Langridge 2018, p. 17).

A key factor in wildfire regimes for the Central Coast Region will be precipitation patterns. Climate models differ in predicted precipitation for this part of California (Langridge 2018, p. 31). Predicting changes in fire severity and frequency in the region is challenging, given uncertainty in predictions of precipitation and wind for this region and the high and complex sensitivity of wildfire regimes in Mediterranean ecosystems. However, the basic characterization of this system as dominated by fire is unlikely to change, and it is highly likely that the region will continue to experience large, severe wildfires (Langridge 2018, p. 31). Climate change and increased wildfire are also likely to favor increased spread of invasive, nonnative vegetation (grassland) in California into the future (Lenihan et al. 2008 entire).

7.1 Santa Lucia purple amole

7.1.1 FUTURE SCENARIO 1: RCP scenario 8.5 for climate change and with no additional conservation efforts for Santa Lucia purple amole

Future scenario 1 assumes effects of RCP 8.5 for climate change in the Central Coast region based on Langridge (2018, entire) for 50 years with no additional management actions for Santa Lucia purple amole.

Average annual maximum temperatures throughout Monterey County are projected to increase 4 to 5 °C (7 to 8 °F) by the end of the century under this future scenario. The annual average high temperature in King City, which is the closest town to FHL, is currently 24°C (75°F, see Section 5.4.1). In 50 years the expected average annual temperatures at the County scale are expected to be 28°C (78°F, Langridge 2018, p. 13); shown as a County-wide increase from 21°C (70°F). Average annual precipitation throughout Monterey County is currently 30.63 cm (12.06 inches). Overall precipitation is expected to increase by 7.62 to 25.4 cm (three to 10 inches) throughout the Central Coast under RCP 8.5. Models predict increases of year to year variability with wetter days during periods of precipitation, but with fewer total days of precipitation. When combined with higher temperatures, these changes are anticipated to create more serious flooding events and drier conditions overall. By the year 2070, Langridge (2018, p. 16) predicts that annual average precipitation will be 62 cm (24 inches) within Monterey County under RCP 8.5. This is an increase from historical amounts in the County, which are approximately 48 cm (19 inches).

Climate projections show an increase in extreme and prolonged droughts throughout the Central Coast for all scenarios with increased temperatures and only modest changes in precipitation (Langridge 2018, p. 21–23). Climate-based predictions of changes in fire severity and frequency throughout the Central Coast are complex and variable. However, all of the predictive models show that it is highly likely that the Central Coast will continue to see frequent large and severe wildfires and that post-fire recover times are likely going to be lengthened in the future (Langridge 2018, p. 30–32).

Thorne et al. (2016) used standardized global climate models to predict the climate vulnerabilities of California’s main vegetation community types under RCP 8.5. The vulnerability rank categories used include: High, Mid-high, Moderate and Low to scale the sensitivity of the vegetation type to changes in climate, given its adaptive potential. Highly sensitive macrogroups are considered more susceptible to portions of their current range becoming unsuitable as a result of climate changes over the next century and are less adaptable. Aspects of climate change including sensitivity to changes in temperature, precipitation and fire, as well as seed germination requirements, modes of dispersal, and reproductive life span were integrated into this analytical framework and used to assess vulnerability. The two macrogroups that support purple amole, California Foothill and Valley Forests and Woodlands and California Grassland and Flowerfields were found to be moderately and mid-highly vulnerable, respectively to the effects of climate change under RCP 8.5 (Thorne et al. 2016, p. 6–7, 34). Under RCP 8.5 between 32 and 59 percent of the current range of California Foothill and Valley Forests and Woodlands is expected to be no longer suitable, 41 to 68 percent is likely to remain stable and 27 to 34 percent is likely to become newly suitable (Thorne et al. 2016, p. 41). Between 34 to 48 percent of the current range of California Grassland and Flowerfields is expected to become no longer suitable, 52 to 66 percent is likely to remain stable and 21 to 52 percent is likely to become newly suitable under RCP 8.5 (Thorne et al. 2016, p. 140).

Density. Temperature and precipitation are two of the most important variables that affect abundance in the taxon. Both adequate annual precipitation and suitable temperatures are needed during the vegetative growth and flowering life stages (see Figure 8). Overall, conditions under Future Scenario 1 will be hotter and drier, with fewer total days of precipitation and increased severity and frequency of wildfires. Although overall precipitation is likely to increase somewhat, climate projections show an increase in extreme and prolonged droughts throughout the Central Coast for all scenarios with increased temperatures and only modest changes in precipitation (Langridge 2018, p. 21–23 and 30–32). Therefore, we forecast that density will decrease under RCP 8.5 conditions, when we expect an increase in extreme and prolonged droughts with increased temperatures and modest changes in precipitation. We estimate a 10 percent decrease in densities across all four of the populations, given the individual temperature and precipitation needs of the taxon for vegetative growth and flowering.

With a 10 percent decrease in density, the Jolon population was reduced from 13 individuals per m^2 to 12 individuals per m^2 under RCP 8.5 conditions. The Lockwood South population decreased from 18 to 16 individuals per m^2 under this future scenario. Similarly, the Nacimiento River North population decreased from 25 individuals per m^2 to 23 and the Nacimiento River South population was reduced from six individuals per m^2 to five and the under Future Scenario 1. This change, (a 10 percent decrease in density), under RCP 8.5 conditions did not result in a change to the density condition category of the Jolon and Nacimiento River South populations. They were both already low in their current conditions and these two populations remained low, and were even further reduced, under Future Scenario 1. The Lockwood South population dropped from the medium density condition category to the low under RCP 8.5 conditions. Given this change, this population also faces a high risk of becoming extirpated under Future Scenario 1. There was no change in the density condition category to the Nacimiento River North population. It was medium in its current condition and it remained medium under this future scenario.

Disturbance. Anthropogenic and wildlife disturbances are not expected to change under Future Scenario 1 and will likely remain similar to what they are under the current conditions. Increased temperatures and rainfall will not appreciably alter the current disturbance regimes. Military land uses will remain the same. With no change in land use, resident wildlife populations will also be similar to what they currently are. Therefore, the disturbance factor is not expected to change under this future scenario.

Productivity. We used a similar forecast to that conducted for density, to evaluate anticipated changes in the productivity factor under this future scenario because like density, annual precipitation and suitable temperatures contribute largely to productivity in the taxon. Again, the overall conditions under RCP 8.5 will be hotter and drier, with fewer total days of precipitation and increased severity and frequency of wildfires. Climate projections show an increase in extreme and prolonged droughts throughout the Central Coast for all scenarios with increased temperatures and only modest changes in precipitation (Langridge 2018, p. 21–23 and 30–32). Therefore, we forecast that productivity will also decrease under Future Scenario 1. We estimate a 10 percent decrease in productivities across all four of the populations, given the individual temperature and precipitation needs of the taxon for vegetative growth and flowering and these influences on overall abundance.

The average productivities per m^2 within the four populations were all relatively low in the current condition (See Section 6.1). Average productivity within the Jolon population remained the same with four individuals per m^2 under RCP 8.5 conditions. Average productivity within the Lockwood South population and the Nacimiento River South population also remained the same, with each population having only three individuals per m^2 under this future scenario. Average productivity decreased slightly in the Nacimiento River North and it changed from seven to six individuals per m^2 under Future Scenario 1.

The expected 10 percent decrease in productivity did not result in any changes to the productivity condition category in the Jolon, Lockwood South or Nacimiento River North populations. These three populations were in the low productivity condition category (Score 1 = decreasing trend) under the current conditions. They remain in the low productivity condition category because their average productivities did not change; so the decreasing productivity trend persisted under this future scenario. Therefore, the declining trend for each of these three populations continued under RCP 8.5 conditions. The average productivity in the Nacimiento River South population is three individuals per m^2 under both the current conditions and predicted RCP 8.5 conditions. Because the average productivity remains the same (three individuals per m^2), even with a 10 percent decline, we assume that the trend will continue. So productivity within the population is no longer increasing, but rather is staying consistent with the average under this future scenario. As a result, the productivity condition category for the Nacimiento River South population changed from high (Score 3 = an increasing trend) to the medium (Score 2 = stable, no consistent change from the average observed) condition category under Future Scenario 1.

<u>Occupied Area</u>. Occupied area is not expected to change appreciably under this scenario.
In general, temperatures and precipitation increase under Future Scenario 1 resulting in a higher frequency of drought and drier conditions overall. The frequency and intensity of wildfire events also increase under this scenario, which is expected to create environmental conditions that favor increased spread and abundance of invasive, nonnative species and thatch accumulation. These changes are expected to adversely affect survival of the populations and reduce the quality of their habitat. However, under RCP 8.5, there is also an anticipated net gain in potentially suitable habitat for purple amole because the extent of California Grassland and Flowerfields is likely to increase, even though California Foothill and Valley Forests and Woodlands are expected to decrease. The gains in grassland habitat are more than four times the loss of woodland habitat expected. This expansion may neutralize the other RCP 8.5 climate change-related effects on the occupied area of the taxon.

We applied the same methodologies described in Section 6.1 to evaluate the future condition of the Santa Lucia purple amole populations under the RCP 8.5 climate change scenario. The results for this analysis are presented below in Table 11. There were no changes in overall resiliency in any of the four populations under Future Scenario 1.

Table 11. Future Scenario 1 – resiliency analysis for each of the four Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*]) populations, throughout its range in Monterey and San Luis Obispo counties, California.

	Parameter scores under RCP 8.5 climate change conditions and no plausible management actions for the taxon				
Population	**Density**	**Disturbance**	**Productivity**	**Occupied area**	**Total**
Jolon – FHL	1	2	1	3	2
Lockwood South – FHL	1	3	1	2	2
Nacimiento River North – FHL	2	1	1	1	1
Nacimiento River South – Camp Roberts	1	2	2	3	2

7.1.2 FUTURE SCENARIO 2: RCP scenario 4.5 for climate change and with additional plausible conservation efforts for Santa Lucia purple amole

Future scenario 2 assumes effects of RCP 4.5 for climate change in the Central Coast region based on Langridge (2018, entire) for 50 years with implementation of plausible management actions for Santa Lucia purple amole.

In 50 years the average annual temperatures throughout Monterey County are expected to be 24°C (75°F), under RCP 4.5, which is an increase of approximately 3 °C (5 °F; Langridge 2018, p. 13). Like RCP 8.5, models predict increases of year to year variability with wetter days during periods of precipitation, but with fewer total days of precipitation; albeit under RCP 4.5 these effects would be less extreme. By the year 2070, Langridge (2018, p. 16) predicts that annual average precipitation will be 53 cm (21 inches) within Monterey County under RCP 4.5, which is an increase from historical amounts in the County of approximately 48 cm (19 inches).

Thorne et al. (2016) used standardized global climate models to predict the climate vulnerabilities of California's main vegetation community types under RCP 4.5. California Foothill and Valley Forests and Woodlands and California Grassland and Flowerfields (the two macrogroups that support purple amole) were found to be moderately and mid-highly vulnerable, respectively to the effects of climate change under RCP 4.5 (Thorne et al. 2016, p. 6–7, 34). This is the same result reported under RCP 8.5.

Plausible management. We use the term plausible management to mean the suite of reasonable human interventions that the two military installations and any other partnering resource agencies or conservation stakeholders are likely to carry out to benefit the taxon by ameliorating threats. Specifically, adverse impacts to Santa Lucia purple amole resulting from disturbance and invasive species may be reduced with implementation of these types of strategic management actions.

In Section 5 we mentioned that FHL has an INRMP from 2012 and that Camp Roberts has a draft INRMP from 2014. The FHL INRMP was effectively finalized and executed (FHL 2012, entire). The Camp Roberts' draft INRMP was never made final (ICF International 2014, entire). However, an update to the INRMP is in progress and it is expected to be completed as early as 2021. Each installation also has a Programmatic Biological Opinion (PBO) from the Service that includes a variety of measures required to avoid and minimize adverse effects to purple amole resulting from their ongoing military functions, operations, activities and other specified projects, and so that these activities do not jeopardize the continued existence of the taxon pursuant to Section 7 of the ESA. FHLs' PBO expired in May 2020 and Camp Roberts' expired in 2019 (Service 2010, entire; Service 2009, entire). Camp Roberts was granted a two–year extension, so it is therefore considered valid through 2021. Each of these agreements must be updated and consultations with the Service must be re-initiated before new PBOs will take effect.

The plausible management actions include:

1. Effectively finalize, sign and implement updated INRMP documents that include practicable and more robust conservation efforts for purple amole;
2. Obtain new PBOs for all installation functions, operations, activities and other specified projects likely to occur at both installations over the next 10 consecutive years and effectively comply with all the avoidance and minimization measures contained therein to avoid cumulative adverse effects to the taxon;
3. In numbers 1 and 2 above, include more modernized, proactive, science-based and updated measures to safeguard and protect existing purple amole populations from accidental and inadvertent anthropogenic disturbances resulting from ongoing military functions, operations, activities and other specified projects;
4. Update the current Santa Lucia purple amole monitoring programs being implemented at each installation in coordination with the Service to streamline these activities, ensure uniform data collection methods and techniques, so that the same data are collected at both installations and these data are more prudent and meaningful to long-term conservation of the taxon;
5. Conduct invasive weed management research to determine the most effective tools and procedures to control the effects of invasive weeds and thatch on the taxon;
6. Develop and implement invasive weed management plans for Santa Lucia purple amole and its habitat at both installations intended for threat abatement and long-term conservation of the taxon;
7. Develop and implement updated feral pig depredation programs for Santa Lucia purple amole and its habitat at each installation to safeguard and protect existing populations from disturbances resulting from wildlife and long-term conservation of the taxon;
8. Facilitate investments from both installations and other partnering agencies or stakeholders, in Santa Lucia purple amole conservation seed banking at a qualified facility; and
9. Conduct experimental outplanting research to determine the most effective methods and techniques to establish several new Santa Lucia purple amole populations in areas and habitats that may provide climate change refugia for the taxon.

<u>Density</u>. As with Future Scenario 1, conditions under Future Scenario 2 will generally be hotter and drier, with fewer total days of precipitation and increased severity and frequency of wildfires. These effects will likely be less severe than those expected under RCP 8.5 conditions. However, we forecast that density will still decrease under RCP 4.5 conditions, and the predicted decrease is likely to occur even with implementation of the plausible management actions (actions 1–9 above).

We estimate a five percent decrease in densities across all four of the populations, given the individual temperature and precipitation needs of the taxon for vegetative growth and flowering.

With a five percent decrease in density (and conventional rounding), the Jolon population was reduced from 13 individuals per m^2 to 12 individuals per m^2 under RCP 4.5 conditions. The Lockwood South population decreased from 18 to 17 individuals per m^2 under this future scenario and the Nacimiento River North population decreased from 25 individuals per m^2 to 24. The Nacimiento River South population was not appreciably reduced and stayed at six individuals per m^2 under Future Scenario 1. This change, (a five percent decrease in density), under RCP 4.5 conditions did not result in any changes to the density condition category of the populations. Therefore, the Jolon and Nacimiento River South populations are in the low density condition category under Future Scenario 1 and the Lockwood South and Nacimiento River north populations are in the medium density condition category under RCP 4.5 conditions.

Disturbance. Anthropogenic and wildlife disturbances within all four of the populations are expected to decrease under Future Scenario 2 and are likely to improve because of the plausible management actions included with this scenario. Specifically, updates to the installations' INRMP documents and obtaining the new PBOs will help ensure that most anthropogenic disturbances are avoided and minimized through the applicable regulatory mechanisms. Implementation of updated feral pig depredation programs are anticipated to decrease wildlife disturbance within the populations. We do not expect disturbance improvements to be greater than 10 percent in either the Jolon or Lockwood South populations given the current land uses, locations of existing roads, facilities and other development. For these reasons, anthropogenic disturbances, associated edge effects, and further geographic separation of the two populations are likely to persist. We expect disturbance improvements to be greater at the Nacimiento River North population because this population is small and located in a relatively remote area. Therefore, plausible management for this small population is expected to have a greater effect and we anticipate a 20 percent improvement under this future scenario. Lastly, we expect there to be a 10 percent improvement at the Nacimiento River South population under RCP 4.5. This population is more remote and relatively large. Implementation of plausible management will be more difficult in larger populations. It is not currently exposed to high levels of anthropogenic disturbance, but it does have a lot of disturbance from wildlife. With some management we expect improvement.

In summary, disturbance from anthropogenic sources and wildlife is expected to decrease within all four Santa Lucia purple amole populations under Future Scenario 2. It is expected to decrease 10 percent within the Jolon population changing from 41 percent to 31 percent. Disturbance is expected to decrease 10 percent in the Lockwood South population as well, changing from 14 percent to only four percent. It is anticipated to change 20 percent in the Nacimiento River North population with a decrease from 59 percent to 39 percent. And lastly, it is predicted to decrease 10 percent in the Nacimiento River South population, with a change from 40 percent to 30 percent. These decreases did not result in changes to any of the disturbance condition categories except for the Nacimiento River North. This population increased from the low to the moderate condition.

Productivity. Like density, annual precipitation and suitable temperatures contribute largely to productivity in the taxon. Conditions under Future Scenario 2 will generally be hotter and drier, with fewer total days of precipitation and increased severity and frequency of wildfires. These effects will likely be less severe than those expected under Future Scenario 1. However, we forecast that productivity will decrease under RCP 4.5 conditions, and the predicted decrease is likely to occur even with implementation of the plausible management actions. As with density, we estimate a five percent decrease in densities across all four of the populations, given the individual temperature and precipitation needs of the taxon for vegetative growth and flowering.

With low average productivity values in the current condition (See Section 6.1), the expected five percent decrease under RCP 4.5 conditions had minimal effects on the productivity outcomes, especially with conventional rounding. Average productivity within each of the four Santa Lucia purple amole populations remained the same under RCP 8.5 conditions and did not result in any changes. Therefore, the productivity condition categories for each of the four populations also remained the same under this future scenario. The Jolon, Lockwood South and Nacimiento River North populations all continue to be in the low productivity condition category and have decreasing productivity trends and the Nacimiento River South population continues to be in the high productivity condition category and has an increasing productivity trend under Future Scenario 2.

Occupied Area. Occupied area is expected to increase under this scenario. Effects of climate change for Future Scenario 2 may reduce the occupied area of the populations over time because of hotter, dryer conditions and increased severity and frequency of wildfire events. However, the extent of California Grassland and Flowerfields communities is expected to expand under this future scenario. It isn’t quite as much as expected under Future Scenario 1, but it is still more than double the anticipated loss of woodlands and savannas. In addition, outplanting efforts are part of the plausible management actions included with this scenario. Along with these efforts, establishment of several new Santa Lucia purple amole populations is expected to occur. Therefore, the total occupied area is expected to increase under this scenario because there will be net habitat gains and new populations established with implementation of the plausible management strategies.

Specifically, we expect a 10 percent increase in both the Jolon and Lockwood South populations because these sites are relatively spread out across the landscape, have some adjacent, lower topographic relief areas conducive to population expansion, are comprised of several smaller purple amole colonies that could enlarge, infill to connect with other colonies and otherwise support outplanting efforts under this future scenario. The Jolon population is currently 248 hectares (612.8 acres) in size and the Lockwood South population is 31.6 hectares (78.1 acres) in size. If they both increased by 10 percent, the new occupied areas would be 272.8 hectares (674.1 acres) and 34.8 hectares (86 acres), respectively. Increases in the occupied areas of the other two populations will be less and we anticipate expansion to be five percent within the Nacimiento River North and South populations. These sites are more constricted topographically, are comprised of mostly one primary colony and are both bounded by rivers or streams on one or more sides. For these reasons, potential expansion and outplanting is more limited. The Nacimiento River South population occupies 216.2 hectares (534.2 acres). With a five percent increase under RCP 4.5 conditions we expect an increase in its occupied area to be 227 hectares (561 acres). The Nacimiento River North population currently occupies an area of only 2.3 hectares (5.7 acres). With a five percent increase it would occupy 2.4 hectares (six acres) under this future scenario. None of the increases predicted under Future Scenario 2 resulted in a change to the occupied area condition category for any of the four Santa Lucia purple amole populations.

Using the same methodologies described in Section 6.1, we evaluated the future condition of the four Santa Lucia purple amole populations under the RCP 4.5 climate change scenario. This scenario includes implementation of all the plausible management actions outlined for the taxon previously. The results for this analysis are presented below in Table 12.

Resiliency changed in only one of the populations under Future Scenario 2. It increased from having low resiliency to medium in the Nacimiento River North population because disturbance decreased, which changed the condition category from low to medium under this future scenario. There were no other changes in any of the condition categories in any of the other three populations under RCP 4.5 conditions. Therefore, resiliency in the other three populations (Jolon, Lockwood South and Nacimiento River South) remained the same under Future Scenario 2.

Table 12. Future Scenario 2 – resiliency analysis for each of the four Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*]) populations, throughout its range in Monterey and San Luis Obispo counties, California.

	Parameter scores under RCP 4.5 climate change conditions and implementation of the plausible management actions outlined for the taxon				
Population	**Density**	**Disturbance**	**Productivity**	**Occupied area**	**Total**
Jolon – FHL	1	2	1	3	2
Lockwood South – FHL	2	3	1	2	2
Nacimiento River North – FHL	2	2	1	1	2
Nacimiento River South – Camp Roberts	1	2	3	3	2

7.2 Camatta Canyon amole

Based on the best available information about future projections of factors influencing viability of Camatta Canyon amole, we developed two plausible future scenarios that capture the range of effects to the taxon over a 50-year period. Future scenario 1 assumes effects of RCP scenario 8.5 for climate change in the Central Coast Region based on Langridge (2018 entire) for 50 years and with no additional conservation efforts for Camatta Canyon amole. Future scenario 2 assumes effects of RCP scenario 4.5 for climate change in the region based on Langridge (2018 entire) for 50 years and with additional plausible conservation efforts for Camatta Canyon amole.

For San Luis Obispo County, average annual precipitation is 409 millimeters/16.1 inches. The projections for 2040 to 2069 range from 445 millimeters/17.5 inches under RCP scenario 8.5 to 447 millimeters/17.6 inches under RCP scenario 4.5 (Langridge 2018, p. 16).

7.2.1 FUTURE SCENARIO 1: RCP scenario 8.5 for climate change and with no additional conservation efforts for Camatta Canyon amole

Future scenario 1 assumes effects of RCP scenario 8.5 for climate change in the Central Coast Region based on Langridge (2018 entire) for 50 years and with no additional conservation efforts for Camatta Canyon amole. For San Luis Obispo County, average annual precipitation is 409 millimeters/16.1 inches. The projections for 2040 to 2069 are 445 millimeters/17.5 inches under RCP scenario 8.5 (Langridge 2018, p. 16). Therefore, we assume that temperatures will increase by 2.8 °C/5 °F, annual variability in precipitation will increase substantially, the region will continue to experience large, severe wildfires, and that conditions will favor increased spread of invasive, nonnative vegetation. Also under the environmental conditions projected under this future scenario, it is plausible to make the following assumption: occurrences 2 and 3 (small in area, 882 meters^2/1,055 yards^2 and 0.36 hectare/0.90 acre, respectively) become extirpated under stressful environmental conditions with no management.

Using the condition category table developed for resiliency of Camatta Canyon amole (Table 9), we found occurrence 1 to have moderate resiliency under this future scenario (Table 13). Occurrence 1 is the largest, comprising >36.02 hectares/89.01 acres, including 21.15 hectares/52.26 acres that are protected on Los Padres National Forest. We do not expect the area of this occurrence to change under this scenario with existing management to benefit the species; that is, signs and a welded pipe fence are maintained along Red Hill Road on Red Hill Ridge to prevent off-highway vehicles entering habitat, and rangers patrol. Occurrences 2 and 3 (small in area, 882 meters^2/1,055 yards^2 and 0.36 hectare/0.90 acre, respectively) become extirpated, by assumption, under this future scenario due to the increase in stressful environmental conditions, including increased temperatures, drought, and invasive nonnative vegetation. Regarding occurrence 4, no additional information is obtained and, thus, resiliency cannot be calculated under this future scenario.

Table 13. Resiliency analysis for occurrences of Camatta Canyon amole in San Luis Obispo County, California, future scenario 1 under RCP scenario 8.5 for climate change and with no additional conservation efforts. To quantify the resiliency of each occurrence, we calculated a total score by summing its parameter scores and then dividing by 4 because we used four parameters with equal weight. Resiliency levels are the following: total score 1 = low resiliency, total score 2 = moderate resiliency, and total score 3 = high resiliency.

Future Scenario 1		**Parameter scores under RCP scenario 8.5 for climate change and with no additional conservation efforts**					
Occurrence		Occupied area	Protected status	Land use	Number of primary threats	Total score	Resiliency level
1	private property N St Hwy 58 right-of-way St Hwy 58 Los Padres National Forest	2	2	2	1	1.75→2	moderate
2	right-of-way St Hwy 58	0					extirpated
3	private property S St Hwy 58	0					extirpated
4	private property N St Hwy 58	not known[A]				insufficient information	insufficient information

[A] Camatta Canyon amole was reported here in 1988 but without any details (Kofron 2008, p. 1). The occurrence has not been visited by a biologist since then, and it may be extirpated.

7.2.2 FUTURE SCENARIO 2: RCP scenario 4.5 for climate change and with additional plausible conservation efforts for Camatta Canyon amole

Future scenario 2 assumes effects of RCP scenario 4.5 for climate change in the Central Coast Region based on Langridge (2018 entire) for 50 years and with additional plausible conservation efforts for Camatta Canyon amole. The projections for 2040 to 2069 are 447 millimeters/17.6

inches under RCP scenario 4.5 (Langridge 2018, p. 16).Therefore, we assume that temperatures will increase by 2.1 °C/3.8 °F, annual variability in precipitation will increase, the region will continue to experience large, severe wildfires, and that conditions will favor increased spread of invasive, nonnative vegetation, albeit less so than under RCP scenario 8.5.

We anticipate that additional conservation efforts would include the following:

1. installation of signs (educational and regulatory) and a welded pipe fence with maintenance along relevant areas of the Burnout Trail in Los Padres National Forest to prevent off-highway vehicles entering habitat, and ranger patrols;
2. and surveys and censuses on the private property north of State Highway 58 for occurrences 1 and 4.

Also under this future scenario, it is plausible to make the following assumption: with additional survey efforts, biologists find additional locations and occurrences on the private property north of State Highway 58, as anticipated by Yost (2019a, p.1); occurrences 2 and 3 (small in area, 882 meters^2/1,055 yards^2 and 0.36 hectare/0.90 acre, respectively) become extirpated under stressful environmental conditions with no management; and occurrence 4, which was last visited by a biologist in 1988, is determined to be extant and with an area ≥30.1 hectares/74.3 acres (based upon viewing Google Earth aerial imagery).

Using the condition category table developed for resiliency of Camatta Canyon amole (Table 9), we found occurrence 1 to have moderate resiliency under this future scenario. Occurrence 1 is the largest, comprising >36.02 hectares/89.01 acres, including 21.15 hectares/52.26 acres that are protected on Los Padres National Forest. Existing management to benefit the species continues and new management will be implemented, including signs (educational and regulatory) and a welded pipe fence being installed (with maintenance) along relevant areas of the Burnout Trail in national forest to prevent off-highway vehicles entering habitat, and ranger patrols. Also, surveys and censuses would occur on the private property north of State Highway 58, with the finding of additional locations and occurrences, by assumption under this future scenario. Occurrences 2 and 3 become extirpated under this future scenario due to the increase in stressful environmental conditions, including increased temperatures, drought, and invasive nonnative vegetation. Occurrence 4 is determined to be extant and with an area ≥30.1 hectares/74.3 acres and to have moderate resiliency (Table 14).

Table 14. Resiliency analysis for occurrences of Camatta Canyon amole in San Luis Obispo County, California, future scenario 2 under RCP scenario 4.5 for climate change and with additional plausible conservation efforts. To quantify the resiliency of each occurrence, we calculated a total score by summing its parameter scores and then dividing by 4 because we used four parameters with equal weight. In accordance with standard mathematical convention, 1.50 is rounded up to 2. Resiliency levels are the following: total score 1 = low resiliency, total score 2 = moderate resiliency, and total score 3 = high resiliency.

Future Scenario 2		**Parameter scores under RCP scenario 4.5 for climate change and with additional plausible conservation efforts**					
Occurrence		Occupied area	Protected status	Land use	Number of primary threats	Total score	Resiliency level
1	private property N St Hwy 58 right-of-way St Hwy 58 Los Padres National Forest	2	2	2	1	1.75→2	moderate
2	right-of-way St Hwy 58	0					extirpated
3	private property S St Hwy 58	0					extirpated
4	private property N St Hwy 58	3	1	1	1	1.50→2	moderate

8 SYNTHESIS AND CONCLUSIONS

8.1 Resiliency

In summary, we evaluated the resiliency of Santa Lucia purple amole and Camatta Canyon amole under current conditions and under two future scenarios. Future Scenario 1 includes the effects of RCP 8.5 for climate change for 50 years with no additional management actions and Future Scenario 2 includes the effects of RCP 4.5 for climate change for 50 years with implementation of plausible management actions. For Santa Lucia purple amole, the resiliency analysis under current conditions shows that three of the four populations have moderate resiliency and one is low. Under Future Scenario 1 resiliency does not change. Under Future scenario 2 resiliency increases from low to moderate in one population, Nacimiento River North – FHL, such that all populations are moderately resilient. See Table 15. For Camatta Canyon amole, the resiliency analysis under current conditions shows that one occurrence has moderate resiliency and two occurrences have low resiliency; there is insufficient information to calculate a resiliency score for occurrence 4. Under Future Scenario 1, one occurrence remains in moderate condition and the two in low current condition become extirpated. Under Future scenario 2, one occurrence remains in moderate condition, the two in low current condition become extirpated, and occurrence 4 moves into a moderate condition. See Table 16.

A population/occurrence with high resiliency has a high ability to sustain itself in the face of environmental variation and therefore a low risk of extirpation in the near future. A population/occurrence with moderate resiliency has a moderate ability to sustain itself in the face of environmental variation and therefore a moderate risk of extirpation in the near future. A population/occurrence with an overall low resiliency has a low ability to sustain itself in the face of environmental variation and therefore a high risk of extirpation in the near future.

Table 15. Results of current and future condition resiliency analysis for the Santa Lucia purple amole. Future scenario 1 assumes effects of RCP 8.5 for climate change in the Central Coast region based on Langridge (2018, entire) for 50 years with no additional management actions for Santa Lucia purple amole. Future scenario 2 assumes effects of RCP 4.5 for climate change in the Central Coast region based on Langridge (2018, entire) for 50 years with implementation of plausible management actions for Santa Lucia purple amole. H = high resiliency; M = moderate resiliency; L = low resiliency; EX = extirpated; II = insufficient information.

Santa Lucia Purple Amole Populations	Current Conditions	Future Scenario 1	Future Scenario 2
Jolon – FHL	M	M	M
Lockwood South – FHL	M	M	M
Nacimiento River North – FHL	L	L	M
Nacimiento River South – Camp Roberts	M	M	M

Table 16. Results of current and future condition resiliency analysis for the Camatta Canyon amole. Future scenario 1 assumes effects of RCP 8.5 for climate change in the Central Coast region based on Langridge (2018, entire) for 50 years with no additional management actions for Camatta Canyon amole. Future scenario 2 assumes effects of RCP 4.5 for climate change in the Central Coast region based on Langridge (2018, entire) for 50 years with implementation of plausible management actions for Camatta Canyon amole. H = high resiliency; M = moderate resiliency; L = low resiliency; EX = extirpated; II = insufficient information.

Camatta Canyon Amole Occurrences	Current Conditions	Future Scenario 1	Future Scenario 2
1: private property N St Hwy 58; right-of-way St Hwy 58; Los Padres National Forest	M	M	M
2: right-of-way St Hwy 58	L	EX	EX
3: private property S St Hwy 58	L	EX	EX
4: private property N St Hwy 58	II	II	M

8.2 Representation

Representation describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations or occurrences. Given morphological and ecological differences between Santa Lucia purple amole and Camatta Canyon amole, representation across both varieties contribute to the purple amole’s ability to adapt to changing environmental conditions over time. Both varieties have relatively small geographic ranges with mostly similar landscape features throughout. The Santa Lucia purple amole currently occupied area consists of less than 500 hectares (1,230 acres). The occupied area of Camatta Canyon amole currently consists of greater than 36 hectares (89 acres).

The niches and habitats each variety occupies have little heterogeneity. Therefore, each variety is a narrow, endemic taxon and the types of habitats or niches that it occupies are nearly uniform.

Although information is lacking regarding genetics of either Santa Lucia purple amole or Camatta Canyon amole, we consider each to comprise one genetic unit due to geography. While, we are not aware of any extirpated locations or occurrences, or of any contraction in the geographic range, the productivity data for Santa Lucia purple amole suggest three of the four populations may currently be declining. The combined data from several studies suggest that the number of Camatta Canyon amole, where monitored, has declined. Thus, declining numbers of individuals may affect genetic diversity, and the spatial extent and associated ecological representation of both Santa Lucia purple amole and Camatta Canyon amole are inherently low. Under future scenario 1, populations/occurrences are expected to decline further. Under future scenario 2 with increased management, resiliency of Santa Lucia amole populations improves somewhat, but two of the four occurrences of Camatta Canyon amole are forecast to become extirpated. Therefore, purple amole is characterized as currently and into the future having low representation across its two varieties, given the small spatial extent, habitat and environmental uniformity and likely lack of genetic diversity.

8.3 Redundancy

Redundancy describes the ability of a species to withstand catastrophic events. Redundancy is characterized by having multiple, resilient populations distributed within the species' ecological settings and across the species' geographic range. Purple amole is composed of two varieties, both narrow, endemic taxa with relatively small geographic ranges. Santa Lucia purple amole only has four populations located within approximately 280 kilometers^2 (108 square miles). Camatta Canyon amole only has four occurrences located within approximately 3 kilometers^2 (1 square mile). Because all four populations of Santa Lucia purple amole and all four occurrences of Camatta Canyon amole are situated close together, they could possibly be simultaneously affected by a catastrophic event. Given that the two varieties are approximately 61 km (38 miles) apart, a prolonged, catastrophic drought could affect both varieties simultaneously. However, the two varieties are far enough apart such that a large, intense wildfire is unlikely to deleteriously affect both varieties at once. Therefore, purple amole has inherently low redundancy due to being composed of two narrow endemic varieties and has low capacity to withstand widespread catastrophic events, but having two spatially separated varieties does provide some protection for the species as a whole from extinction due to less expansive catastrophic events. With increased management under future scenario 2, improved resiliency of Santa Lucia purple amole and increased distribution of Camatta Canyon amole may increase the protection for the species from extinction due to catastrophic events as compared to current conditions.

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10 Appendix A

Information regarding the four Santa Lucia purple amole (*Hooveria purpurea* var. *purpurea* [*Chlorogalum purpureum* var. *purpureum*]) populations and the associated CNDDB occurrences that comprise them throughout its range in Monterey and San Luis Obispo counties, California (CNDDB 2020, website).

Santa Lucia Purple Amole Populations	Associated CNDDB Occurrences	Additional Location Information
Jolon: Fort Hunter Liggett, Monterey County	Occurrence 1	Jolon, northwest of Jolon Road and Mission Creek Road, Fort Hunter Liggett Military Reservation; approximately 20 hectares (50 acres); elevation 299 m (980 ft); 35.97262° latitude/–121.18065° longitude.
	Occurrence 2	Just east of Hunter Liggett Airfield, along Infantry Road, about three mi northwest of Jolon, Fort Hunter Liggett Military Reservation; approximately 0.81 hectares (two acres); elevation 320 m (1,050 ft); 35.99105° latitude/–121.22250° longitude.
	Occurrence 5	Southeast of Jolon, along Bradley–Kings City Road, approximately 0.5– mi east of Mission Road, Fort Hunter Liggett Military Reservation; approximately 2.02 hectares (five acres); elevation 287 m (940 ft); 35.95832° latitude/–121.15972° longitude.
	Occurrence 6	East of Jolon, along Lockwood–Jolon Road, near old cemetery, Fort Hunter Liggett Military Reservation; approximately 4.05 hectares (10 acres); elevation 290 m (980 ft); 35.92336° latitude/–121.12081° longitude.
	Occurrence 11	East/southeast of Jolon, north of Bradley–Kings City Road, approximately 1.6 mi east of Jolon Creek, Fort Hunter Liggett Military Reservation; approximately 1.62 hectares (four acres); elevation 283 m (930 ft); 35.95214° latitude/–121.14157° longitude.
	Occurrence 12	East of Jolon, along Lockwood–Jolon Road, approximately 0.5– mi east of Jolon Creek, Fort Hunter Liggett Military Reservation; approximately 5.67 hectares (14 acres); elevation 290 m (980 ft); 35.96627° latitude/–121.16218° longitude.
	Occurrence 13	Northeast of Jolon, 0.9– mi north of Lockwood–Jolon Road and 0.6– mi east of Argyle Road, Fort Hunter Liggett Military Reservation; approximately 6.07 hectares (15 acres); elevation 335 m (1,100 ft); 35.97939° latitude/–121.15722° longitude.

Santa Lucia Purple Amole Populations	Associated CNDDB Occurrences	Additional Location Information
	Occurrence 14	West/northwest of Jolon, along dirt road approximately one mi west/northwest of the mouth of Ruby Canyon, Fort Hunter Liggett Military Reservation; approximately 2.02 hectares (five acres); elevation 329 m (1,080 ft); 35.99263° latitude/–121.21254° longitude.
	Occurrence 15	West/northwest of Jolon, east of Fort Hunter Liggett Airfield and approximately 1.4 mi west/northwest of Ruby Canyon, Fort Hunter Liggett Military Reservation; approximately 0.81 hectare (two acres); elevation 332 m (1,090 ft); 35.99629° latitude/–121.22254° longitude.
	Occurrence 17	Approximately 2.6 km (1.6 air mi) north/northeast of Jolon, near eastern boundary of Fort Hunter Liggett; Fort Hunter Liggett Military Reservation; approximately zero (less than one) hectare/acre; elevation 389 m (1,275 ft); 35.99143° latitude/–121.15736° longitude.
	Occurrence 18	Approximately 1.77 km (1.1 air mi) northwest of Jolon, Fort Hunger Liggett; Fort Hunter Liggett Military Reservation; approximately zero (less than one) hectare/acre; elevation 355 m (1,165 ft); 35.98297° latitude/–121.18902° longitude.
	Occurrence 19	Approximately 11.27 km (seven mi) north of Jolon, near the top of the grade; mapped along Jolon Road; location information unknown; record is based of 1979 Heckard herbarium collection; 48 hectares (119 acres); elevation none provided; 36.07578° latitude/–121.17953° longitude.
Lockwood South: Fort Hunter Liggett, Monterey County	Occurrence 8	Southeast of Jolon, along base of hills between Martinus Corner and San Antonio River, Fort Hunter Liggett Military Reservation; approximately 79 acres; elevation 299 m (950 ft); 35.97262° latitude/–121.18065° longitude.
	Occurrence 9	Southeast of Jolon, approximately 1.4 mi southeast of Martinus Corner, along Earl Reservoir, Fort Hunter Liggett Military Reservation; approximately 3.64 hectares (9 acres); elevation 299 m (950 ft); 35.92342° latitude/–121.10348° longitude.
	Occurrence 10	Southeast of Jolon, east side of Sam–Jones Road, Fort Hunter Liggett Military Reservation; approximately 3.24 hectares (eight acres); elevation 283 m (930 ft); 35.91956° latitude/–121.13144° longitude.

Santa Lucia Purple Amole Populations	**Associated CNDDB Occurrences**	**Additional Location Information**
Nacimiento River North: Fort Hunter Liggett, Monterey County	Occurrence 3	Junction of Sam Jones Road and Gabilan Road, east of the Nacimiento River, about seven mi south/southwest of Jolon, Fort Hunter Liggett Military Reservation; approximately 6.07 hectares (15 acres); elevation 305 m (1,000 ft); 35.87460° latitude/–121.21362° longitude.
Nacimiento River South: Camp Roberts, San Luis Obispo County	Occurrence 16	Both sides of the road C–25 and Tower Road, north of the Nacimiento River, Camp Roberts, California Army National Guard; approximately 102 hectares (251 acres); elevation 244 m (800 ft); 35.76914° latitude/–120.83294° longitude.

11 Appendix B. The four known occurrences of Camatta Canyon amole.

Occurrence 1. This is the largest occurrence of Camatta Canyon amole (>36.02 ha/89.01 ac), with elevations from 584 to 632 meters/1,916 to 2,073 feet. It occupies the following areas:

- Red Hill Ridge—relatively flat and level open areas of the ridge top from 1.13 kilometers/0.70 mile north of State Highway 58 on private property (35.413525/–120.275893; >14.84 hectare/36.67 acre) to 1.76 kilometers/1.10 miles south of State Highway 58 on Los Padres National Forest (35.388873/–120.286331; 15.37 hectares/37.98 acres) including Red Hill Mesa, for total distance of 2.9 kilometers/1.8 miles; one small area in south right-of-way of State Highway 58 centered at 35.404001/–120.280411 (280 $meters^2$/334 $yards^2$); and several small areas in right-of-way of State Highway 58 at Red Hill Road (33 $meters^2$/39 $yards^2$); total area >30.2 hectares/74.6 acres; 584 to 633 meters/1,916 to 2,077 feet elevation. The stated areas do not include Red Hill Road on Red Hill Ridge (10 meters/32.8 feet wide by 1.76 kilometers/1.09 miles long = 1.76 hectares/4.35 acres) and State Highway 58.
- top of spur ridge east of Red Hill Ridge on national forest from 35.398554/–120.281274 northwest to 35.397641/–120.275781 for distance of 0.51 kilometer/0.32 mile (2.17 hectares/5.37 acres), 595 to 619 meters/1,952 to 2,031 feet elevation.
- top of another spur ridge east of Red Hill Ridge on national forest from 35.392162/–120.283337 northwest to 35.394308/–120.279801 for distance of 0.40 kilometer/0.25 mile (2.00 hectares/4.95 acres); 597 to 624 meters/1,959 to 2,047 feet elevation.
- top of a nearby ridge south of Red Hill Ridge on national forest from 35.387622/–120.283833 south to 35.383117/–120.283806 for distance of 0.50 kilometer/0.31 mile (2.49 hectares/6.15 acres) partly along Burnout Trail, 581 to 628 meters/1,906 to 2,060 feet elevation (Kofron and Rutherford 2015b entire); and a hilltop 174 meters/570 feet to the east, centered at 35.385386/–120.283641 (191 $meters^2$/228 $yards^2$) along Burnout Trail, 614 meters/2,014 feet elevation (Yost 2019b entire).
- top of another spur ridge west of Red Hill Ridge on national forest from 35.393976/–120.285645 to 35.396216/–120.285809 for distance of 0.25 kilometer/0.16 mile (0.64 hectare/1.58 acres), 621 to 627 meters/2,037 to 2,057 feet elevation.
- top of another spur ridge west of Red Hill Ridge on national forest from 35.398397/–120.283890 to 35.396270/–120.283523 for distance of 0.24 kilometer/0.15 mile (0.95 hectare/2.35 acres); 607 to 620 meters/1,991 to 2034 feet elevation.
- and a location 0.6 kilometer/0.4 mile east of Red Hill Road in south right-of-way of State Highway 58 at 35.404297/–120.272921, 597 meters/1,959 feet elevation. Edell (2007, p. 5) reported 1 plant here in 2005.

Camatta Canyon amole extends further north and west on the private property (129.5 $kilometers^2$/50 $miles^2$) north of State Highway 58. According to Yost (2019a, p. 1) who visited the property and observed Camatta Canyon amole, the plant likely has greater abundance and distribution here than on national forest, but we have no additional details.

Occurrence 2. 35.405102/–120.259602, 572 to 577 meters/1,877 to 1,896 feet elevation, along State Highway 58, 1.75 kilometers/1.09 miles west of Red Hill Road at major curve (just before postmile 27.5), two locations in north right-of-way and one location in south right-of-way (and just across north and south boundary fence lines on two private properties). The known occupied area comprises 882 $meters^2$/1,055 $yards^2$: south of outer curve, 728 $meters^2$/870 $yards^2$; and north of inner curve, 144 meters^2/172 yards^2 and 10 meters^2/12 yards^2. The coordinates and areas are from Edell (2007 entire) and Robbins (2019 entire). The occurrence is on a mesa extending east from Red Hill Ridge, and the soil is mapped as Arbuckle sandy loam with slope <10% (Natural Resources Conservation Service 2003, p. 116; 2018, p. 1). The occurrence likely extends further north of the curve where the private property is used for cattle ranching. Twenty two hectares/54 acres of a private property south and east of the curve have been cleared. The following numbers of plants have been reported: 2005, 101 plants (Edell 2007, p. 1); 2006, 90 plants (Edell 2007, p. 1); 2017, 426 plants (Robbins 2019, p. 1); 2018, 87 plants (Robbins 2019, p. 1); 2019, 279 plants (Robbins, 2019, p. 1); and 2020, 163 plants (Holland 2020, p. 1). This occurrence is 1.15 kilometers/0.72 mile east of occurrence 1.

Occurrence 3. 35.376584/–120.278528, 624 meters/2,047 feet elevation, on a hilltop on one private property immediately east of Navajo Creek and Red Hill Road, 3 kilometers/1.9 miles south of State Highway 58. This occurrence was first reported by Chipping (1997, p. 1), who estimated "probably several hundred plants." Kofron and Rutherford (2015c) visited the occurrence in 2015. During their non-exhaustive search/survey, they observed 15 plants in the hard dirt road on the hilltop, and a few of these may have been on the adjacent property. The known extent of this occurrence is 0.36 hectare/0.90 acre on one rural residential property (4.19 hectare/10.36 acre). Based upon similar landscape features observed in Google Earth aerial imagery dated 11 September 2018, this occurrence likely also includes the higher parts of this dissected ridge across multiple private properties from 35.380529/–120.280727 north to 35.369555/–120.275732 south, which spans a distance of 1.21 kilometers/0.75 mile. This occurrence is 0.86 kilometer/0.54 mile southeast of occurrence 1.

Occurrence 4. 35.436999/–120.284531, 488 meters/1,601 feet elevation, on a ridgetop, east side of Camatta Creek Road, 1.2 kilometers/0.75 mile north of State Highway 58. This occurrence is based solely on an observation by Clare Hardham in 1988 (Kofron 2008, p. 1): "east side of Camatta Creek Road, about 1 mile [1.6 kilometer] north of Highway 58, steep hills and a valley, where the cliffs get steep, about 20 years ago." Using Google Earth aerial imagery (dated 11 September 2018) and Natural Resources Conservation Service (2003, p. 116; 2018, p. 1), we determine this occurrence is at the stated coordinates, which is mapped as Arbuckle sandy loam with slope <15%. A house occupies the highest part of the ridge at the occurrence. Further, there is evidence of mowing, which likely indicates that invasive plants are a threat at this location. We could not gain permission to visit this occurrence on private property (129.5 kilometers^2/50 miles^2) that is used primarily for cattle ranching (Lazy Arrow Adventures 2019 entire). Based upon similar landscape features observed in Google Earth aerial imagery, this occurrence likely extends also onto nearby ridgetops to the north, east and west (across Camatta Creek). In addition, unidentified occurrences likely exist further afield in all directions. This occurrence is 2.72 kilometers/1.69 miles north of occurrence 1.

12 Appendix C

Appendix C1. Upper: Camatta Canyon amole (*Hooveria purpurea* var. *reducta*, Agavaceae) with well-developed basal rosette on Red Hill Mesa in Los Padres National Forest, San Luis Obispo County, California, 24 March 2010. Photo credit David J. Keil. Lower: Four Camatta Canyon amole with biological soil crust (black material) on Red Hill Ridge, 18 April 2017. The leaves and stems (of three plants) have been eaten by an unknown herbivore. Photo credit Christopher Kofron.

Appendix C2. Habitat of Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) along the top of a spur ridge, east of Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California, 18 April 2017. Key habitat characteristics are the relatively flat and level open areas with the hard, rocky red soil (mapped as Arbuckle sandy loam). Photo credit Christopher Kofron.

Appendix C3. Upper: Tall invasive grass (slender wild oat (*Avena barbata*)) in the shaded understory of a blue oak on Red Hill Ridge in Los Padres National Forest, San Luis Obispo County, California, 26 April 2016. Invasive grasses are often taller and denser in the shaded understories of blue oaks, and where Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) is usually absent. Plot 7 of Magney (1987, 1988) and Kofron and Rutherford (2014, 2015a, 2016, 2017, 2018, 2019, 2020) is in the foreground. Sixteen emergent Camatta Canyon amole are in the white circle (= $1m^2$). Photo credit Christopher Kofron. Lower: Dense invasive grass (25 centimeters/10 inches tall) in habitat of Camatta Canyon amole on Red Hill Ridge, 18 April 2017. The white circle denotes plot 7 as indicated above. The numbers of emergent Camatta Canyon amole in the plot have not declined since the 1980's: 1987–7, 1988–13, 2014–13.3, 2015–0.7, 2016–24.0, 2017–32.3, 2018–14.3, 2019–17.7, and 2020–27.7. Photo credit Christopher Kofron.

Appendix C4. Upper: Tall invasive grass (up to 55 centimeters/22 inches, slender wild oat (*Avena barbata*)) in habitat of Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) on Red Hill Mesa in Los Padres National Forest, San Luis Obispo County, California, 26 April 2016. The white circle denotes plot 2 of Magney (1987, 1988), and Kofron and Rutherford (2014, 2015a, 2016, 2017, 2018, 2019, 2020). The numbers of emergent Camatta Canyon amole have declined in the plot since the 1980's: 1987–3, 1988–7, 2014–0.0, 2015–0.0, 2016–0.0, 2017–0.3, 2018–0.0, 2019–0.0, and 2020–0.0. Photo credit Christopher Kofron. Lower: Welded pipe fence along Red Hill Road on Red Hill Mesa that prevents off-highway vehicles entering habitat of Camatta Canyon amole, 18 April 2017. Connie Rutherford's (Service, Ventura, California) outstretched hand is above plot 10 of Magney (1987, 1988), and Kofron and Rutherford (2014, 2105a, 2016, 2017, 2018, 2019, and 2020). The numbers of emergent Camatta Canyon amole in the plot have declined since the 1980's: 1987–9, 1988–11, 2014–1.0, 2015–0.0, 2016–0.0, 2017–0.0, 2018–0.0, 2019–0.0, and 2020–0.3. Photo credit Christopher Kofron.

Appendix C5. Upper: Rocky red soil (mapped as Arbuckle sandy loam) with tall invasive grasses being eaten by Botta's pocket gophers *Thomomys bottae* on Red Hill Mesa in Los Padres National Forest, San Luis Obispo County, California, 23 April 2019. The previously flat and level soil surface in habitat of Camatta Canyon amole *Hooveria purpurea* var. *reducta* is disturbed with holes, burrows, and mounds of soil. Photo credit Christopher Kofron. Middle: Plot 5 of Magney (1987, 1988) and Kofron and Rutherford (2014, 2105, 2016, 2017, 2018, 2019, 2020) on Red Hill Mesa, 26 April 2016. The photo shows recent disturbance by gophers and short invasive plants (storksbill *Erodium* sp.). The numbers of emergent Camatta Canyon amole in the plot have not declined since the 1980's: 1987–9, 1988–16, 2014–4.3, 2015–0.7, 2016–18.3, 2017–16.7, 2018–10.0, 2019–12.0, and 2020–17.5. Photo credit Christopher Kofron. Lower: Flat and level soil surface disturbed by gophers on Red Hill Mesa, and the disturbance favors invasive plants, 2 May 2012. Camatta Canyon amole requires a relatively flat and level soil surface. Photo credit Christopher Kofron.

Appendix C6. Habitat of Camatta Canyon amole (*Hooveria purpurea* var. *reducta*) disturbed by cattle grazing on Red Hill Mesa in Los Padres National Forest, San Luis Obispo County, California, 1 May 2010. The disturbance occurred when the soil was wet and soft. Strategic cattle grazing (adding and removing cattle on demand to control density and timing), and if not practicable then light cattle grazing, would likely benefit Camatta Canyon amole by reducing invasive plants and thatch. Photo credit Connie Rutherford.