Nipomo Mesa Lupine
(*Lupinus nipomensis*)

5-Year Review:
Summary and Evaluation

Nipomo Lupine (*Lupinus nipomensis*) blooming at Black Lake Canyon, San Luis Obispo County, California March 2019 (occurrence 10). *Kristie Scarazzo, U.S. Fish and Wildlife Service*

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June 2019

GENERAL INFORMATION

Species: *Lupinus nipomensis*; 50 CFR 17.12 – Endangered and Threatened Plants
Date listed: March 20, 2000
FR citation: 65 FR 14888
Classification: Endangered
Critical habitat: None

Methodology used to complete the review:

In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a 5-year review is to assess each threatened species and endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service (USFWS) evaluated the biology and status of the Nipomo Mesa lupine (Nipomo lupine – *Lupinus nipomensis*) as part of a comprehensive assessment of the species.

This 5-year review was conducted by the Ventura Fish and Wildlife Office (VFWO), which is in the USFWS Pacific Southwest Region, Region 8. VFWO staff and several other key project partners conducted numerous field surveys, censused, mapped and monitored all the known Nipomo lupine occurrences to collect and update the species information for the assessment. Data for the 5-year review were also solicited from a variety of species experts who actively work with Nipomo lupine across its occupied range including: the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) staff, state resource agencies such as the California Department of Fish and Wildlife (CDFW) and the California Department of Parks and Recreation Oceano Dunes State Vehicular Recreation Area (Parks), and other local and regional experts such as the San Luis Obispo Chapter of the California Native Plant Society (CNPS), the Land Conservancy of San Luis Obispo County (LC-SLO), the Coastal San Luis Resource Conservation District (RCD), and other private stakeholders and academic researchers. This 5-year review represents our evaluation and synthesis of the best available scientific information.

FR Notice citation announcing the species is under active review: U.S. Fish and Wildlife Service. 2018. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 50 Species in California, Nevada, and the Klamath Basin of Oregon. 83 (117) CFR 28251-28254.

REVIEW ANALYSIS

Updated Information and Current Species Condition

Species Biology: Nipomo Mesa lupine (Nipomo lupine – *Lupinus nipomensis*) is a small, annual species in the Fabaceae (legume; pea and bean) family restricted to stabilized coastal sand dunes associated with the Nipomo Mesa in southwestern San Luis Obispo County, California. The species is known from only a single population comprised of relatively few colonies and the number of individuals that appear in any given year is highly variable. The entire species range consists of approximately 5.2 square kilometers (two square miles) that are located

approximately five kilometers (three miles) directly inland from the Pacific Ocean, and are situated along the backside of the Callender Dunes (USFWS 2009, p. 2 and CDFW 2019, website).

Species Description. This small, hairy annual lupine reaches approximately 10 to 20 centimeters (four to eight inches) tall (Sholars and Riggins 2012, website). The stems are decumbent (reclining close to the ground, but with the tips ascending) and the leaves are distinctively palmately compound with five to seven leaflets that radiate out from a single point of origin, like fingers of a hand (Harris and Harris 1994, p. 35 and 79). The leaves are succulent and covered with downy, white hairs. Nipomo lupine inflorescences are dense racemes (unbranched and arranged along a main, central axis called a rachis, where the bottom flowers mature and open first) and compact (Sholars and Riggins 2012, website and Harris and Harris 1994, p. 96). The peduncle (stalk of the inflorescence) is also decumbent, but bends abruptly upward at the base of the raceme (Harris and Harris 1994, p. 81 and Sholars and Riggins 2012). This characteristic has been described by many authors as a right angle bend just below the lowest flower, and is often considered diagnostic for the species (Hoover 1970, p. 167 and 171 and Walters and Walters 1988, p. 7). The flowers are spirally arranged and the rachis is thickened and inflated. It is often described as being denser than the peduncle. This characteristic is also considered diagnostic in some older treatments (Hoover 1970, p. 167 and 171). The flowers are bilaterally symmetric and composed of five purplish to pink petals (Baldwin et al 2012, p. 25). The upper petal is called the banner and it often has a white to yellow spot on the center, closer to the base. The two lower petals are called the wings and these are partially fused. The wings enclose another set of fused petals called the keel that generally has glabrous (smooth, hairless) margins and this is another important characteristic used to differentiate it from other closely related species (Sholars and Riggins 2012, website and Harris and Harris 1994, p. 80). Nipomo lupine fruits are legumes (like a conventional pea pod). They are green, and succulent and open along two vertical seams. The fruits are hairy, but may become glabrous with age. Each fruit typically produces three to five seeds, with as many as 30 fruits per inflorescence. A single individual can produce up to 900 fruits in a season, but most produce fewer (Sholars and Riggins 2012, website and Walters and Walters 1989, p. 12).

Taxonomy. Nipomo lupine is one species within the large, diverse genus *Lupinus* that is thought to contain 280 species worldwide (Eastwood et al 2008, p. 346). The genus is part of the Fabaceae (pea or legume) family that is classified under the order Fabales. Under the current treatment in the Jepson eFlora, the genus *Lupinus* is part of the group, or subfamily, Papilionoideae and is one of 104 species that occur in California (Baldwin et al. 2012).

Nipomo lupine appears to be most closely related to bajada lupine (*L. concinnus*) and some maintain that the two species intergrade. The taxonomic association of the two species is based solely on their morphological similarities, as opposed to their phylogenetic relationship because this has never been analyzed. Bajada lupine is much more wide ranging than Nipomo lupine and has never been collected within the Guadalupe-Nipomo Dunes region, which is the only place where Nipomo lupine occurs (CCH Database 2019, website). The geographic range of bajada lupine is much larger than Nipomo lupine and extends from the east side of the San Francisco Bay south throughout all of southern California, excluding the Central Valley, and as far north as Tehama County along the east side of the Sierras. Other than the geographic distinctions between

the two species, each occurs in decidedly different habitat types. Nipomo lupine occurs exclusively on stable dunes, while bajada lupine is found in a wide variety of open, disturbed, or burned areas. The main morphological distinction between the two species is that Nipomo lupine has decumbent peduncles; whereas bajada lupine has an erect central peduncle, with the laterals often appearing decumbent (Sholars and Riggins 2012, website). Such subtle characteristics may only be readily observable in the field with live materials.

Nipomo lupine was first described by Alice Eastwood in 1939 as a quite distinct, low, fleshy, almost prostrate annual that grows in sandy soil on the Nipomo Mesa (Eastwood 1939). The taxonomic history since that time is long and convoluted because Nipomo lupine was ignored, reduced to synonymy, and maintained as a distinct species by several authors (Walters and Walters 1989, p. 4). A few of the most important taxonomic highlights since Eastwood's original 1939 description of the species are summarized below:

- Munz and Keck (1959, p. 812) publish a new California flora and list *L. nipomensis* as a synonym of *L. concinnus*, with no further explanation.
- Dunn and colleagues publish a new treatment for the *L. concinnus*-*L. sparsiflorus* complex and ignore the taxon *L. nipomensis* (Dunn et al. 1966).
- Munz produces a supplement to the California flora that incorporates and cites the Dunn et al. (1966) treatment of *Lupinus*, thus perpetuating non-acknowledgement of the species (Munz 1968, p. 114).
- Hoover publishes the Vascular Plants of San Luis Obispo County, California in 1970 and recognizes Nipomo lupine as a distinct taxon (p. 167). He states that it is a remarkable and rare local species that occurs on dry sandy flats on the Nipomo Mesa just behind the dunes and that the species is entirely distinct from *L. concinnus* in several respects (p. 171).
- Smith publishes A Flora of the Santa Barbara Region, California in 1976. In the description included for *L. concinnus* he says *L. nipomensis* is a related endemic species that occurs on sand flats of the Nipomo Mesa (p. 173).
- The Jepson Manual: Higher Plants of California is published in 1993. The treatment includes a description of *L. nipomensis* and states that it intergrades with *L. concinnus* (Hickman ed. 1993, p. 623 and 633).

Since its publication in the 1993 Jepson Manual, recognition of the species has continued. The current treatment still associates Nipomo lupine with bajada lupine as an intergrade (Sholars and Riggins 2012, website). Other species experts insist that Nipomo lupine is morphologically distinct, genetically isolated, and biogeographically independent of bajada lupine (Walters and Walters 1988, p. 8 and Wahlert 2019a), while some maintain that the distinction between bajada and Nipomo lupine is tenuous (Riggins 2019 and CCH Database 2019, website).

Genetics. No genetic work has been conducted specifically on Nipomo lupine to date. Dr. Wahlert, the Shirley Tucker Curator of Biodiversity Collections and Botanical Research at University of California Santa Barbara, is in the process of sequencing the chloroplast trnT-trnL intergenic spacer and trnL intron of Nipomo lupine genes, along with the nuclear ribosomal

internal transcribed spacer (ITS) region to evaluate the placement and relatedness of the species with bajada lupine (Wahlert 2019a). We anticipate completion of this study and hope to gain useful, new insight into the genetic relationship between Nipomo lupine and bajada lupine.

Recent progress using DNA sequences from many nuclear and plastid genes has increased the understanding of the diversity and evolutionary history of the genus *Lupinus*. The genus is divided into two primary groups, the Old World species derived primarily from North Africa and the Mediterranean and the New World species derived from North America and the Andean Mountains of South America (Australian Government 2013, p. 3 and Eastwood et al 2008, p. 346). The recent and high rate of species diversification within the western New World lineages (particularly the montane Andes derived clade) is extraordinary and considered one of the fastest known within any group of land plants (Eastwood et al 2008, p. 353, Drummond 2008, p. 408 and Hughes and Eastwood 2006, p. 10,335 and 10,337). Assuming Nipomo lupine relatedness to bajada lupine, the species complex (*L. nipomensis/L. concinnus*) is part of the New World, strongly supported western North American clade, has 2n=48 chromosomes and is most closely related to another annual species, *L. truncatus*. The species complex is one of the more recently derived annuals and is estimated to have evolved approximately 2.5 million years ago (Drummond 2008, p. 414 Eastwood et al 2008, p. 349-351).

Life History: Germination of Nipomo lupine seed is believed to be stimulated by the first adequate rainfall event in the autumn, meaning that enough precipitation occurred to saturate the soil and stimulate imbibition (uptake of water) of the dry seed. This may occur as early as November during normal rainfall years, but maybe delayed into December or January (Walters and Walters 1989, p. 17). In germination experiments, Nipomo lupine seed was soaked in warm water for approximately 12 to 15 hours prior to sowing in successful germination. In the ex situ experiments, most seed germinated within 10 to 14 days. However, a small percentage was delayed and did not germinate for up to several weeks or months after sowing. Seeds that were scarified with sandpaper prior to soaking had the highest germination in experimental trials (Chapman 2014, p. 1-4). After germination, the species produces a pair of deciduous purplish, green and succulent cotyledons. Individuals grow in stature, begin producing leaves and begin branching until the first flowers appear between the months of March through May (Scholars and Riggins 2012, website).

Little is known about Nipomo lupine's breeding system. There is consensus among researchers that it is likely capable of both selfing and outcrossing, although a specific pollinator has yet to be identified. Walters and Walters (1988, p. 22-23) observed a variety of arthropod herbivores consuming Nipomo lupine, but never detected a pollinator interaction. Similarly, no pollinators were ever observed on plants grown in early ex situ germination trials (Chapman 2013, p. 7). In 2017, researchers collected and identified 214 different arthropod specimens interacting with the plant. Of these, most were determined to be herbivores, but several species were observed interacting within and around Nipomo lupine flowers. In particular, the study showed some potential for non-traditional arthropod pollination by *Thrips* sp. and possibly from spider mites within the suborder Acari. However, no specific pollinator was identified or directly observed (Luong et al 2017, p. 6-8 and 12-13). If arthropods did aid in pollination of Nipomo lupine, they would likely be collecting pollen directly for food and incidentally assisting in fertilization (Dunn 1956, p. 446). Lupine pollen is sticky, which could aid in this process and is therefore not

suitable for wind distribution (Australian Government 2013, p. 17). Most of the species experts continue to assume that Nipomo lupine is predominantly self-pollinated because most annual lupine species are self-compatible and mainly self-pollinated, but no lupine species have been found to be strictly self-pollinated (Chapman 2019, Luong 2019a, Wilken 2019, Wahlert 2019b, Australian Government 2013, p. 15 and 17, and Snell and Aarssen 2005, p. 2 and 12).

Assuming the selfing mechanism for Nipomo lupine is the same as other selfing annual lupine species, fertilization occurs within the earliest stages of floral development when the flowers are still closed (Australian Government 2013, p. 17 and Dunn 1956, p. 444). When the flowers are closed, the pollen on the five longer filaments (stalk that supports the pollen-forming anther) matures first and is shed into the fused keel that surrounds all the reproductive structures where it eventually forms a mass around the style (stalk above the ovary on the female reproductive structure). Then the shorter filaments elongate as their pollen matures and this ends up pushing the pollen mass upward and into the tip of the fused keel, depositing it onto the stigma (sticky, receptive tip found at the end of the style) and this is how self-fertilization is likely achieved. As the pollen on the smaller five stamens matures, the keel bulges outward and opens above. This unguided pressure also causes the banner to reflex and the flower is opened (Dunn 1956, p. 444-445).

Most plants typically start to form fruits between the months of April and June and do not stop fruiting until the plants die. The fruits are succulent and this allows the seeds to continue to ripen even if they are broken off or if the plant is pulled out (Walters and Walters 1988, p. 19). Like other members of the Fabaceae family, Nipomo lupine pods eventually dry out, which results in explosion of the fruits as a dispersal mechanism. More lateral fruits can disperse seed as far as two meters (6.6 feet). Since the plant is relatively decumbent, many of the fruits will hit the leaves of the parent plant and fall close to it on the ground. Earlier studies showed that Nipomo lupine plants can produce as many as 900 fruits per individual and that each fruit produces approximately three to five seeds (Walters and Walters 1989, p. 12 and 19).

Nipomo lupine likely has a persistent seed bank. Most lupine species have a hard, orthodox seed that enables seed dormancy and a seed coat that is thick and impermeable below certain moisture thresholds. The seeds are generally able to remain dormant in the wild until softened by suitable moisture or other environmental conditions (Australian Government 2013, p. 19). To date, a single study evaluated the presence of Nipomo lupine seed within soil samples collected in a variety of sites throughout its range. Only two Nipomo lupine seeds were retrieved during the study and neither of them germinated (Luong 2013, p. 4). However, this work does provide evidence that Nipomo lupine is able to persist within the seed bank.

Habitat Description: Nipomo lupine is restricted to a specific set of stabilized back dunes within the Guadalupe-Nipomo Dunes complex that is located in the southwestern portion of San Luis Obispo County. This complex extends from approximately Pismo State Beach (north of Pismo Creek in San Luis Obispo County) south, along the coast to Point Sal (west of the Casmalia Hills in Santa Barbara County) and is comprised of three separate dune sheets: the Callender Dunes, the Guadalupe Dunes, and the Mussel Rock Dunes. The entire extant range of Nipomo lupine is situated behind the more northern Callender dune sheet, which extends from the open sand along the coast to the base of the Nipomo Mesa (Chipping 1987, p. III-3). Nipomo lupine occurs in the

stabilized, vegetated areas behind the open sand and the species does not occur anyplace else throughout the Guadalupe-Nipomo Dunes complex. The historic range of the species is illustrated in Figure 1.

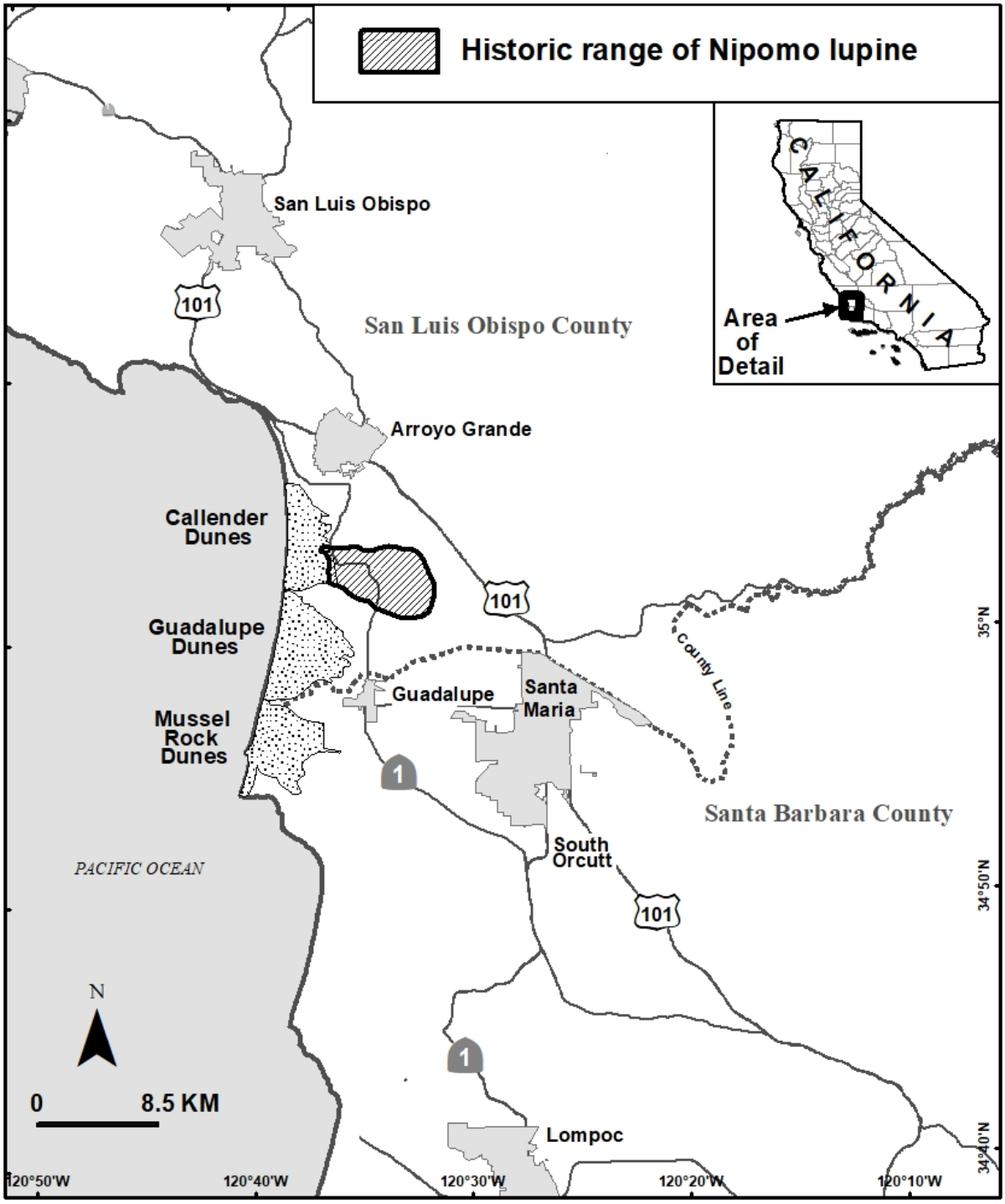

Figure 1. Historical distribution of Nipomo lupine (*Lupinus nipomensis*) in San Luis Obispo County, California

Geology. Geologic processes and edaphic (the physical, chemical, and biological properties of soil) factors are often indicated in instances of plant rarity and endemism (Kruckeberg and Rabinowitz 1985, p. 463-465 and Rajakaruna 2004, p. 471). Nipomo lupine and its narrow restriction to the stabilized back dunes behind the Callender dune sheet is no exception. Substrates mapped beneath the population are derived from Quaternary Deposits that are less than 2.6 million years old. Almost all the colonies occur in areas that are of beach and sand dune origin and are described as being extensive marine and non-marine sand deposits, generally found near the coast or desert playas. A few colonies located in close proximity to a small freshwater pond, called Jack Lake, are on alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated (California Department of Conservation 2019, website).

Formation of the coastal dunes of California is attributed to several episodes of dramatic sea level rise caused by melting of the North American and Eurasian ice sheets during the Holocene glacial retreat approximately 18,000 and 4,000 years ago. Most of California's dunes were deposited at this time and are called Flandrian dunes, including the entire Guadalupe-Nipomo Dunes complex (Cooper 1967, p. 7 and 113). A few isolated localities have higher elevation and more interior dune formations emerging beneath the outer Flandrian dunes, coined the pre-Flandrian dunes, which formed approximately 2.6 million and 11,700 years ago. The Nipomo Mesa is one of only four locations in the state that has this intact formation and it is the oldest and most extensive remaining pre-Flandrian terrace deposit. The Nipomo Mesa is a local plant biodiversity hotspot that supports Nipomo lupine and 19 other special status taxa (Cooper 1967, p. 8, 76-77 and 114-115 and Haydu 2012, p. 42-45).

Nipomo lupine is restricted to the interface zone between the outermost limits of the Flandrian Callender dune sheet and western slope of the pre-Flandrian Nipomo Mesa (Cooper 1967, Plate 6). On this substrate, it requires patches of bare, open sand to persist. In the stabilized back dunes, these openings are created by natural aeolian (wind-driven erosion, transportation and deposition of sand) processes that serve to scour and disrupt established vegetation and other disturbance from small mammals, such as pocket gopher (*Thomomys bottae*, Walters and Walters 1989, p. 11). Disruption of the natural dynamic processes inherent to the functioning of coastal dune systems, particularly premature stabilization of dune sand movement from veldt grass (*Ehrharta calycina*) invasion, may result in exclusion of Nipomo lupine, canopy closure and persistence of later successional communities (Holland and Keil 1995, 9. 149 and Whitaker 2016, p. 34).

Soils. According to the web soil survey of San Luis Obispo County, California, Coastal Part, Nipomo lupine occurs on three sandy soil types: 134 – Dune Land, 184 – Oceano sand, zero to nine percent slopes, and 185 – Oceano sand, nine to 30 percent slopes. All of these soils are associated with dune land forms, are excessively well-drained, have a high rate of water transmission and relatively low nutrient content. Since the water holding capacity of these sandy soils is low, soil moisture is lost quickly. Therefore, Nipomo lupine (and any other species growing on them) is largely dependent on adequate rainfall to satisfy its hydric requirements. Soils from the Oceano sand units are derived from aeolian (wind deposited) parent materials (NRCS 2019, website and Walters and Walters 1988, p. 9).

Climate. The Central Coast, like much of California, is characterized as having Mediterranean

climate, meaning that it has cool, wet winters with sporadic to abundant rainfall events and warm, dry summers with little to no rain. Average temperatures throughout coastal San Luis Obispo County are moderated by its proximity to the ocean and moisture inputs from coastal fog (Holland and Keil 1995, p. 52-55). The nearest weather station to the Callender Dunes is located approximately eight kilometers (approximately five miles) north, near the City of Arroyo Grande. Average annual precipitation for the region is between 35 and 38 centimeters (14 and 15 inches), with the majority of precipitation occurring between the months of November through March. Average maximum and minimum temperatures for the region are 20.7 and 8.3 degrees Celsius (69.2 and 46.9 degrees Fahrenheit), respectively (WRCC 2019, website and Cal-adapt 2019, website).

Local weather conditions within dune habitats are highly variable and environmental factors such as topography, aspect, and wind exposure can influence and alter local microclimates. Nipomo lupine has an affinity for cooler temperatures and is often found near the bottom of north and east-facing slopes and in the lower basins of shallow dune swales (Walters and Walters 1988, p. 9 and Luong 2019b, p. 4). Further studies showed that aspect was a more important abiotic variable than slope influencing reproductive output in Nipomo lupine and that plants grown on north-facing slopes had higher seed output than those grown on south-facing slopes or those with no aspect at all. East-facing slopes were not evaluated in this analysis (Luong et al 2019, p. 6). Such sloped and north or east-facing areas are slightly cooler and thus able to hold moisture for longer periods of time. In ex situ experiments, Nipomo lupine had greater seed germination with cold stratification (soaking seeds in cold water and/or placing them in a freezer) and temperature may be an important cue for seed germination (Luong 2019a, p. 4 and Reilly and Luong 2016, p. 2-3).

Vegetation Communities. The stabilized back dunes where Nipomo lupine occurs are dominated by coastal dune scrub vegetation with the primary indicator species being mock heather (*Ericameria ericoides*). Presence of this species signals that enough stabilization has occurred to facilitate development of a later-successional plant community. This habitat type is extremely dynamic and diverse, and the species composition is highly variable depending on the amount of annual rainfall, level of disturbance, current land use and/or management regimes, successional stage of development and degree of infestation from non-native invasive species, especially perennial veldt grass.

Coastal dune scrub vegetation with a relatively high diversity of native forbs appears to be the ideal habitat for Nipomo lupine. All of the extant Nipomo lupine colonies occur in coastal dune scrub vegetation with at least some mock heather as the dominant shrub overstory. A few of the sites are relatively pristine and also support a diversity of annual forbs including, but not limited to: sand verbena (*Abronia umbellata*), fiddleneck (*Amsinckia spectabilis*), dune baby blue eyes (*Phacelia douglasii*), miniature lupine (*L. bicolor*), cryptantha (*Cryptantha* spp.), purple owl's clover (*Castilleja exserta*), miniature sun cup (*Camissoniopis micrantha*), cardionema (*Cardionema ramosissimum*) and pygmy-weed (*Crassula connata*). Other non-native species often found in areas along with Nipomo lupine include: filaree (*Erodium cicutarium*), brome grasses (*Bromus* spp.) and false ice plant (*Conicosia pugioniformis*).

Historical Range, Distribution and Abundance: At the time of federal listing (2000), Nipomo

lupine was known from a single population comprised of as many as seven colonies with fewer than 700 plants; at least three of the historical localities were extirpated (65 FR 14888). The species range, encompassing all the known colonies was reported to extend no more than 2.4 kilometers (1.5 miles) within stabilized back dune habitat of the Guadalupe dunes, in southwestern San Luis Obispo County.

Given the unique geologic history of the area, it is likely that the species has always been a narrow, edaphically restricted endemic. It is likely to have been slightly more widely distributed throughout its range historically, based on the locations of past collections and regional land use and development trends. Population sizes of annual plant species typically fluctuate from year to year and can be highly variable depending on ecological variables, such as amount of annual rainfall. Assuming Nipomo lupine was historically more widely distributed throughout its range, it is also likely that it was somewhat more abundant in the past. More information about the species historical range, distribution and abundance is provided below.

Range. Regional prevailing winds generally flow from the northwest to the southeast and the overall Nipomo lupine range follows this directional pattern. The species is restricted to the intergrade zone between the higher elevation Nipomo Mesa and the Callender open dune sheet. Black Lake Canyon bisects the Nipomo Mesa in a nearly horizontal line and the species range has likely always been restricted to the south side of this feature. Similarly, the extent of the Santa Maria Valley delineates the bottom edge of the Nipomo Mesa to the south. This valley restricts Nipomo lupine with its rich alluvium; thus, the species only occurs to the northwest of this feature. The open sands of the Callender Dune sheet limit the extent of Nipomo lupine to the west and the species does not occur within the higher elevations of the Nipomo Mesa, which limit its range to the east. There is no historic evidence that the species ever extended beyond these narrow geographical limits.

Distribution. Eastwood and Howell first collected Nipomo lupine in 1937 on the south side of Black Lake Canyon, close to the eastern end, on the Nipomo Mesa. They made a second collection of the species in 1940, within the same area, but further east and south of the original collection site. Both of these collection sites have since been developed and are associated with what is now the Black Lake Canyon Golf Resort and residential development. This development is located approximately four kilometers (2.5 miles) east of California State Route 1, on the north side of Willow Road. These two collections are the only documentation of the species being distributed this far east, (although still restricted to the south side of Black Lake Canyon) and provide evidence that Nipomo lupine was historically more widely distributed throughout its range (CCH Database 2019, website).

Abundance. Species abundance in annuals is notoriously variable from year to year. There is no historic abundance data available for Nipomo lupine. We know that the amount of available habitat within the historic range has been reduced due to land use changes and development. Therefore, we can speculate that the total species abundance has been reduced from what it was historically because of land use change and development.

Current Conditions: The last 5-year review of Nipomo lupine was conducted by the VFWO in 2009 (USFWS 2009). At this time, the species was still known from the same, single population

identified at time of listing (2000) with several colonies. The colonies were divided by convention into seven occurrences to correspond with the CDFW Natural Diversity Database (CNDDB – CDFW 2019, website). Annual census data was available from 2006 through 2009. During this time period the maximum number of individuals counted was 771 in 2006 and the lowest count of 139 was made in 2008.

Distribution. Currently, there is still only one known population of Nipomo lupine comprised of numerous colonies now divided by convention into three known occurrences (Figure 2). All of the extant colonies are located west of State Route 1. Occurrence 1 is the primary Nipomo lupine population and several colonies within it have become extirpated from development and land use conversion to agriculture. Most of Occurrence 1 occurs on the privately owned 1,780-acre Santa Maria Oil Refinery, owned and operated by the Phillips 66 Company. Several sections of the property are grazed by cattle throughout the year and other sections are grazed outside of the Nipomo lupine growing season. Approximately 64 acres of the site, located on the west side of the central infrastructure and development is leased to the Oceano Dunes State Vehicular Recreation Area (ODSVRA) for alternate access and evacuation purposes. ODSVRA does conduct some management activities, such as veldt grass removal within the lease parcel. A small section of the occurrence is located within the California Department of Transportation District 5 right of way and another small portion of the occurrence is located at the Callender Substation that is owned by the Pacific Gas and Electric Company.

Occurrence 2 is listed as Occurrence 10 in the CNDDB (CDFW 2019, website). This occurrence is the product of successful outplanting efforts and a series of experiments conducted by LC-SLO and CCBER, in collaboration with VFWO. This outplanted colony is on a 160-acre site that is owned and managed by LC-SLO for conservation and to directly benefit local wildlife and rare, endemic plant species. The first seeding activities at this site were initiated in December of 2014 and again in 2015 and the occurrence has been monitored continuously ever since. It remains viable with consistent and ongoing coordination and management, especially with vigilant efforts by the LC-SLO to suppress veldt grass. The seed used for the outplanting was collected on the south side of Jack Lake and in other areas behind the open dune sheet located between Black Lake Canyon and Jack Lake, on the west side of the Phillips 66 central infrastructure and development, in several accessions stored at the Santa Barbara Botanic Garden.

Occurrence 3 is considered extirpated and historic because the accuracy of the mapping for the occurrence is unresolved. Many botanists have surveyed this area and not detected the species (CDFW 2019, website). We have conducted a few recent surveys at this location and no Nipomo lupine has been found. Most of the mock heather shrubs within the mapped area are mature and the site is relatively overgrown. The LC-SLO recently acquired 55 acres of coastal dune scrub habitat that encompasses all of the area mapped as Occurrence 3 and are planning a subsequent restoration and outplanting of Nipomo lupine at this location.

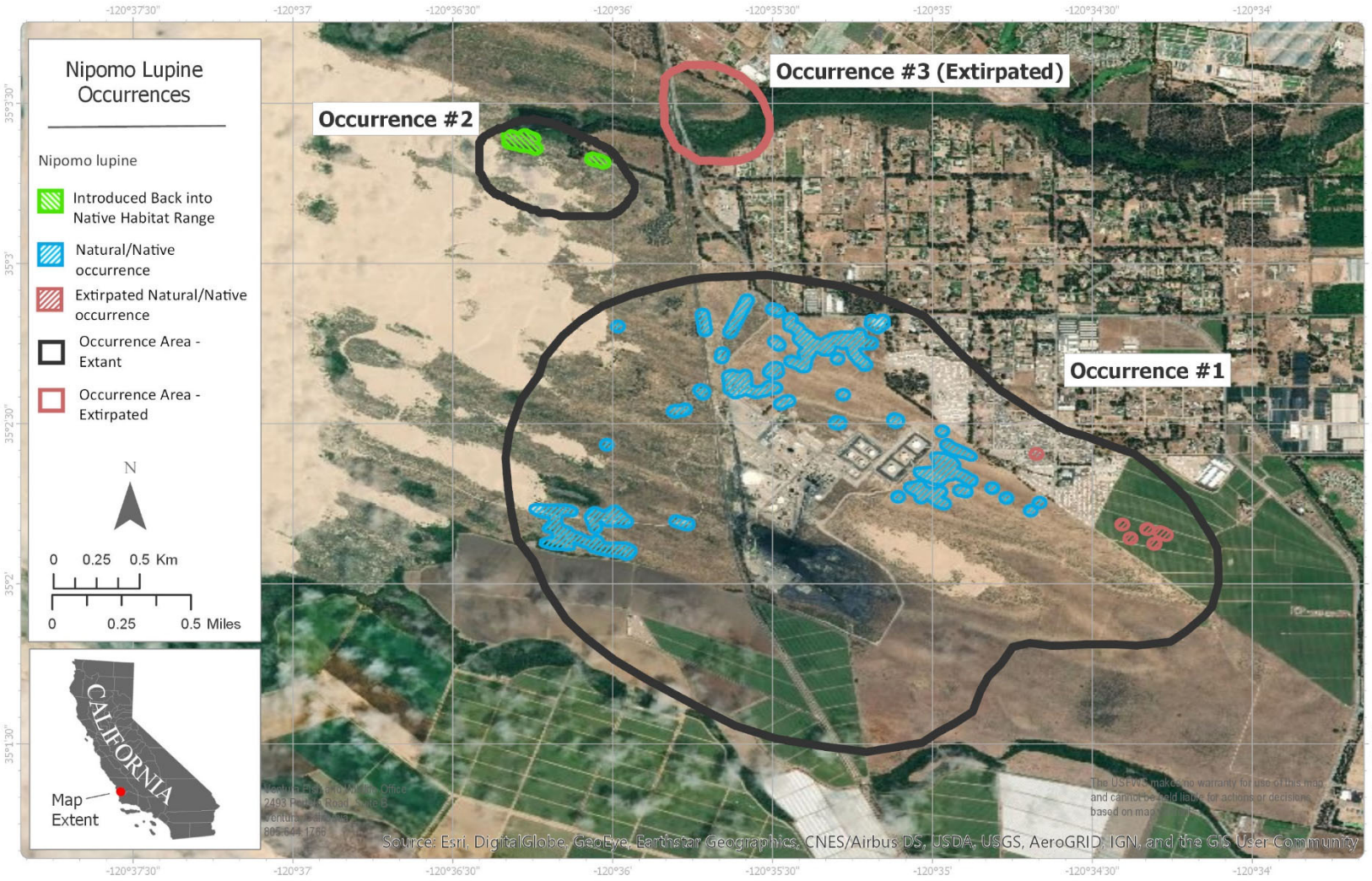

Figure 2. Geographic distribution and status of the three known occurrences of Nipomo lupine (*Lupinus nipomensis*) in San Luis Obispo County, California

Abundance. The LC-SLO has conducted annual census surveys of the Nipomo lupine colonies within Occurrence 1 from 2007 to 2017. The total number of individuals counted in 2017 was 911. Of these, 465 individuals set seed indicating that 51 percent of the population from 2017 was reproducing. Approximately 8,104 total fruits were produced, averaging 17 fruits per plant. The most successful individual produced 343 fruits (LC-SLO 2017, p. 2). Table 1 below provides a summary of the LC-SLO Nipomo lupine annual census monitoring data from 2007 through 2017.

Table 1. Nipomo lupine annual census monitoring data at Occurrence 1

Monitoring Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017***
Number of Individuals	780	139	531	1,195	986	295	1,677	252	633	181	911
Number of Reproducing Individuals	515	86	324	442	187	180	759	83	64	63	465
Reproductive Population (Percent)	66	62	61	37	19	61	45	33	10	35	51

* 2017 data includes additional areas not previously monitored because of restricted access.
(LC-SLO 2017, p. 2)

There is a smaller dataset for annual census monitoring at the experimental outplanting site established at Black Lake Canyon, Occurrence 2, from 2015 through 2018. These data are provided in Table 2 below.

Table 2. Nipomo lupine annual census monitoring data at Occurrence 2 (Luong 2018, p. 8)

Monitoring Year	**2015**	**2016**	**2017**	**2018**
Number of Individuals	118	343	81	89
Number of Reproducing Individuals	2	21	43	14
Reproductive Population (Percent)	2	6	53	16

A complete, range-wide Nipomo lupine census survey was conducted in 2017 and a total of 992 individuals were documented for the population (Occurrences 1 and 2 combined). The number of reproducing individuals for that year was 479, meaning that 49 percent of the total population set seed in 2017. This is the most accurate assessment of the species abundance to date.

Threats: The primary threat to Nipomo lupine identified in the 2000 final listing rule was displacement by non-native, invasive species; especially veldt grass. An expanded list of threats was presented in the 5-year review VFWO conducted in 2009, including invasive species (veldt grass), development activities related to oil extraction and refinement, facilities maintenance, agriculture, and other infrastructure and suburban projects, herbivory and grazing, stochastic events, and climate change. The primary threats to Nipomo lupine in 2019 include: invasive species (veldt grass), development activities, seed predation, stochastic loss and extinction, and climate change. A discussion of each of these threats is provided below. We no longer consider

herbivory and/or grazing to be a threat to Nipomo lupine because the more long-term and cumulative effects of each appear to be neutral, and may be beneficial to the species. For example, pocket gophers are one of the more well studied Nipomo lupine herbivores, and can kill individuals at any time during its life cycle, but they also benefit the species via disturbance because their excavations can provide an optimal seed bed and they eat other potential competing plants (Walters and Walters 1988, 21-22). Similarly, grazing cattle can trample Nipomo lupine, but they can also effectively suppress veldt grass and this ultimately benefits the species.

Invasive Species (Veldt Grass). The veldt grass invasion has disrupted natural dune processes via stabilization, changing the disturbance regime to which dune species are adapted. Veldt grass also contributes large amounts of biomass to the system, and suppresses germination of native annual species, including Nipomo lupine, due to competition for space, sunlight, water and nutrients (Cal-IPC 2019, website). Perennial veldt grass was brought to the California coast in the 1930s or 1940s and again in the 1960s for use as erosion control and forage for cattle (Whitaker 2016, p. 32-33).Veldt grass is a prolific seeder, forms a persistent seedbank, and readily colonizes any open space across the dune landscape.

All existing Nipomo lupine colonies are invaded with veldt grass, some to such an extent that the areas currently support few (if any) annual forbs and only minimal, sparsely scattered shrubs. Nipomo lupine requires bare, sandy openings in a somewhat complex canopy structure within coastal dune scrub communities, where the woody species (like mock heather, silver dune lupine, and Blochman's ragwort [*Senecio blochmaniae*]) provide that structural heterogeneity. If allowed to persist, veldt grass can completely close the canopy and will dominate all of the open space within stands of coastal dune scrub vegetation, thereby reducing biodiversity by suppressing persistence of native, annual forbs (Whitaker 2016, p. 32).

Veldt is being actively managed by the LC-SLO at Occurrence 2, Black Lake, and by ODSVRA within the Phillips 66 lease parcel within Occurrence 1. Phillips 66 actively grazes the eastern portion of Occurrence 1 year-round with cattle, which does suppress veldt grass within this portion of the site. However, this area is relatively low quality habitat overall. They also graze the northern portion of Occurrence 1, but coordinate with LC-SLO to have the cattle removed during the active Nipomo lupine growing season (approximately June through November). The grazing regime suppresses veldt grass and also benefits the annual forbs within this region. Aside from Black Lake, this portion of the Nipomo lupine distribution is the highest quality habitat and supports an abundance of annual forbs. In spite of management efforts, spread of veldt grass is increasing rapidly throughout the entire Guadalupe-Nipomo Dunes region (Cal-IPC 2019, website). If veldt management activities cease, or there is a lapse in the funding mechanisms supporting these efforts, veldt grass could easily extirpate the extant Nipomo lupine population. We currently consider veldt grass the greatest threat to the species.

Development Activities. Colony extirpation, habitat loss and other alterations resulting from development continue to threaten Nipomo lupine. The extent of the historic species range, beyond where Nipomo lupine currently occurs, is developed (Figure 1). Most of the Nipomo Mesa, and nearly all of the area on both the northern and southern sides of Black Lake Canyon, has been converted to rural- residential, industrial and agricultural land use. The overall conversion of habitat within the species historic range resulting from changes in land use and the

widespread regional development trajectory supports conclusions that Nipomo lupine had a more widespread historic distribution.

Currently, Occurrence 1 is privately owned by Phillips 66 for the sole purpose of oil extraction and refinement. The company also conducts a variety of ongoing facilities maintenance, upgrades and other industrial operations onsite that if done inappropriately could have detrimental effects on the species. Phillips 66 proposed a highly controversial rail spur project that involved construction of a 1.3-mile section of railroad and other associated infrastructure onsite to support its operations that was denied by the San Luis Obispo County Planning Commission and Board of Supervisors in 2017, even after several appeals (County of San Luis Obispo 2017, website). They are likely to propose other development projects in the future. Based on aerial imagery and field surveys, we have seen extirpation of several colonies along the northeastern portions of Occurrence 1 due to agriculture and suburban development. Potential changes to the existing road alignments, (such as State Route 1 and the other nearby residential areas) and local infrastructure projects also have potential to adversely affect the species.

Seed Predation. Nipomo lupine seeds are relatively large in size and like other members of the Fabaceae family [which contains numerous human food crops such as alfalfa (*Medicago sativa*), chickpea (*Cicer arietinum*), peanut (*Arachis hypogaea*), soybean (*Glycine max*), lentil (*Lens culinaris*) and pea (*Pisum sativum*)] the seeds are likely to have high nutrient value. Granivores generally prefer larger sized seeds with high nutrient/energy content and such seeds are more vulnerable to the effects of seed predation (Wang and Yang 2014, p. 1, 4 and Bricker et al 2010, p. 91). Therefore, seed predation from small mammals, such as pocket gopher, kangaroo rat (*Dipodomys* spp.) and mice (*Peromyscus* spp.) is likely to adversely affect persistence of the Nipomo lupine seed bank and seedling recruitment. Adverse effects such as these have been seen with other members of the genus. Seed predation in dune habitats is more intense than in grasslands and rodent granivory on coastal bush lupine (*L. arboreus*) within dune systems drastically reduced both the seed bank and seedling recruitment (Maron and Simms 1997, p. 81-82 and Maron and Kauffman 2006, p. 118 and 120). Seed predation on silky lupine (*L. sericeus*) also lowered plant seedling recruitment and abundance in grassland systems, with denser cover (Bricker et al 2010, p. 91). Nipomo lupine is likely vulnerable to granivory within both pristine stabilized dune habitats and in areas that are more invaded by veldt grass.

Stochastic Loss and Extinction. Because Nipomo lupine is currently known from only a single population that extends over a relatively small geographic area, approximately 5.2 square kilometers (two square miles), the species is vulnerable to stochastic (random or unpredictable) loss and extinction. Examples of stochastic events that could result in colony loss or extinction include: fires, flooding, novel pests and diseases, anomalous climate extremes, and windstorms.

Climate Change. According to California's Fourth Climate Assessment for the Central Coast Region, several climate change effects are likely to occur along the Central Coast by the end of the century (Langridge 2018, p. 6-7 and 12). These include (but are not limited to): increased maximum and minimum temperatures, increase precipitation variability, accelerated sea level rise, increased exposure to flooding, increased period El Niño events, increased drought, higher frequency of wildfires and lengthened post-fire recovery times, narrowing of beaches, and water supply shortages (Langridge 2018, p. 6-7 and 12). Any of these effects are likely to adversely

impact Nipomo lupine because of its restricted range, limited distribution, annual life cycle, habitat requirements, and proximity to the coast. Nipomo lupine reproductive output and seed germination rates were negatively affected by experimental drought stress (Luong 2019b, p. 3-4). Increased flooding or wildfire could cause colony extirpation.

Recovery Plan or Outline: None

Recovery Criteria
A recovery plan or outline for Nipomo lupine has not yet been prepared. We are in the process of developing a recovery plan for the species. Therefore, specific recovery criteria have not yet been established.

Synthesis

In summary, the approximately 5.2 square kilometers (two square miles) extent of the species geographic range is reduced from what it was historically due to agricultural, industrial and suburban development. The species range is restricted to stabilized areas associated with the Callender Dunes, in southwestern San Luis Obispo County. There are only three known occurrences of Nipomo lupine; Occurrence 1, the main population on the privately owned Phillips 66 Refinery site; Occurrence 2, the product of a successful outplanting effort at Black Lake Canyon that is managed by LC-SLO; and Occurrence 3, extirpated. The primary threats to Nipomo lupine are invasive veldt grass, development activities, seed predation, stochastic extirpation and extinction, and climate change. All of these threats are compounded by the species biology including: its apparent lack of an insect pollinator, selfing reproductive strategy, annual life cycle, dependence on adequate and seasonally-timed rainfall events to cue germination, and limited distribution of suitable habitat.

At present, we consider Nipomo lupine to have reduced resiliency, likely low representation, and low redundancy. The species resiliency is believed to be low because the single population is comprised of less than a thousand individuals and, the population shows no signs of increasing. The overall quality of the habitat is moderate due to the presence of invasive veldt grass. Nipomo lupine's representation is unknown because we do not have any genetic information about the species. However, one of three occurrences has been extirpated, resulting in a reduced distribution. We presume that because of its small population size and because it is a self-pollinated annual species that the species has low genetic diversity. Nipomo lupine does have a persistent seed bank. So greater representation may exist in the seedbank. Redundancy will always be limited for endemic species with a limited range. Outplanting at the extirpated Occurrence 3 location would increase redundancy. Any further loss of colonies will drastically reduce the species' chance of survival if faced with unpredictable and catastrophic events because it seems to have little adaptive capacity. The species is at risk of extinction, given its current condition and status.

After reviewing the best available scientific information, we conclude that this species remains endangered in 2019. Therefore, no change in status is recommended at this time.

RESULTS

Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist:
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X_ No change is needed

New Recovery Priority Number

Brief Rationale: The recovery priority number for Nipomo lupine is 5 according to the last Service Recovery Data Call in 2009. This rating is based off a ranking system from one to 19; where one is the highest recovery priority and 18 is the lowest (see 48 FR 43098 and 48 FR 51985). A score of 5 indicates that Nipomo lupine is a species that faces a high degree of threat and has a low potential for recovery. No change in ranking for the species was made in the 5-year review conducted in 2009. Similarly, no change is warranted as a result of the 2019 review.

Listing and Reclassification Priority Number

Reclassification (from Threatened to Endangered) Priority Number: ____
Reclassification (from Endangered to Threatened) Priority Number: ____
Delisting (Removal from list regardless of current classification) Priority Number: ____

Brief Rationale: None

RECOMMENDATIONS FOR FUTURE ACTIONS

Both near-term and long-term efforts are required to achieve recovery of the species. Several recommendations designed to halt the current trajectory and ultimately reverse it, so that Nipomo lupine can recover and persist well into the future, are provided below.

Near-term Recovery Actions:

- Conduct annual monitoring at the two extant occurrences;
- Continue to collect seed for banking and bulking;
- Conduct second outplanting of Nipomo lupine at extirpated Occurrence 3 and in other potentially suitable habitat locations;
- Continue to conduct habitat restoration and management at the two extant occurrences and any newly established sites (including but not limited to - invasive species management, manual disturbance such as removal of thatch and vegetation clearing, and

re-introduction of controlled grazing regimes and alteration of potentially detrimental grazing activities as a potential management tool);
- Conduct education and outreach; and
- Establish a Nipomo lupine Recovery Team with other potential recovery partners and stakeholders to facilitate ongoing collaborations.

Longer-term Recovery Actions:

- Establish living Nipomo lupine collections at botanic gardens;
- Pursue expanded site access to Occurrence 1 and other potentially suitable habitats on private properties for surveys and recovery projects; and
- Establish additional conservation easements on sites that have coastal dune scrub habitat to support Nipomo lupine recovery.

Research Needs:

- Habitat suitability modeling to identify potential outplanting sites throughout the species range;
- Evaluation of the role of disturbance and management techniques for species recovery;
- Genetics work; and
- Pollination studies.

U.S. FISH AND WILDLIFE SERVICE
5-Year Review of Nipomo Mesa Lupine

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (Indicate reasons for delisting per 50 CFR 424.11):
    ____ Extinction
    ____ Recovery
    ____ Original data for classification in error
__X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 6/6/19

REFERENCES

Australian Government. 2013. Department of Health and Ageing, Office of Gene Technology Regulator. The biology of *Lupinus L*. (lupin or lupine). Canberra, Australia.

Baldwin, B.G., D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilken, editors. 2012. The Jepson manual: vascular plants of California, second edition. University of California Press. Berkeley, California.

Bricker, M., D. Pearson and J.L. Maron. 2010. Small-mammal seed predation limits the recruitment and abundance of two perennial grassland forbs. Ecology. 91(1): 85-92.

Cal-adapt. 2019. Annual averages data viewer. Annual precipitation, maximum and minimum temperature data from 1961 through 2005 for 1/16 degree grid centered on 35.09375,
-120.59375. Available online at: https://cal-adapt.org/tools/, accessed May 16, 2019.

California Department of Conservation. 2019. California Geological Survey, Geological Data Map No. 2. Compilation and Interpretation by C.W. Jennings, 1977. Updated version by: C. Gutierrez, W. Bryant, G. Saucedo, and C. Wills. 2010 Geologic Map of California. Available online at: https://maps.conservation.ca.gov/cgs/gmc/.

(Cal-IPC) California Invasive Plant Council 2019. Online inventory of invasive species. Available at: https://www.cal-ipc.org/plants/inventory/, Accessed on May 1, 2019.

(CCH) Consortium of California Herbaria Database. 2019. Herbaria Portal 1. Data provided by participants. http://ucjeps.berkeley.edu/consortium/, Accessed on April 17, 2019.

(CDFW) California Department of Fish and Wildlife. 2019. California Natural Diversity Database. Government version dated March 31, 2019.
https://apps.wildlife.ca.gov/bios/, Accessed on April 16, 2019.

Chapman, W. 2013. Nipomo lupine report 2012-2013, first season. Unpublished technical report submitted to USFWS. Ventura, California.

Chapman, W. 2014. Nipomo lupine report 2013-2014, second season. Unpublished technical report submitted to USFWS. Ventura, California.

Chapman, W. 2019. Re: Nipomo lupine – 2009 in litt reference. Email from Wayne Chapman, Cheadle Center for Biodiversity and Ecological Restoration, Isla Vista, California to Kristie Scarazzo, U.S. Fish and Wildlife Service, Ventura, California. April 17, 2019.

Chipping, D.H. 1987. The geology of San Luis Obispo County: a brief description and field guide. California State Polytechnic University. San Luis Obispo, California.

Cooper, W.S. 1967. Coastal dunes of California. The geological society of America – memoir 104. Geological society of America, Inc. Boulder, Colorado.

County of San Luis Obispo. 2017. Administrative Office – Announcements and News. Available online at: https://www.slocounty.ca.gov/Departments/Administrative-Office/Announcements-and-News/Board-Upholds-Planning-Commission%E2%80%99s-Phillips-66-De.aspx, Accessed on May 13, 2019.

Drummond, C.S. 2008. Diversification of *Lupinus* (Leguminosae) in the western New World: derived evolution of perennial life history and colonization of montane habitats. Molecular phylogenetics and evolution. 48: 408-421.

Dunn, D.B. 1956. The breeding systems of *Lupinus*, group Micranthi. The American midland naturalist. 55(2): 443-472.

Dunn, D.B., J.A. Christian and C.T. Dziekanowski. 1966. Nomenclature of the California *Lupinus concinnus-L. sparsiflorus* complex. Aliso: A journal of systematic and evolutionary botany. 6(2): 45-50.

Eastwood, Alice. 1939. New Californian plants. Leaflets of Western Botany 2(10): 186-188.

Eastwood, R.J., C.S. Drummond, M.T. Schifino-Wittmann, and C.E. Hughes. 2008. Diversity and evolutionary history of lupins – insight from new phylogenies. In Lupins for health and wealth. Proceedings of the 12th international lupin conference. Palta, J.A. and J.B. Brger, editors. International Lupin Association. Canterbury, New Zealand.

Harris, J.G. and M.W. Harris. 1994. Plant identification and terminology: an illustrated glossary, second edition. Spring Lake Publishing. Spring Lake, Utah.

Haydu (Scarazzo), K. 2012. Mapping plant biodiversity hotspots at the county scale: a new tool for establishing resource conservation strategies. California State Polytechnic University, San Luis Obispo, California. Unpublished Masters of Science thesis.

Hickman, J.C. (editor) 1993. The Jespon manual: higher plants of California. University of California Press. Berkeley, California.

Holland, V.L. and D.J Keil. 1995. California vegetation. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Hoover, R.F. 1970. The Vascular plants of San Luis Obispo County, California. University of California Press. Berkeley and Los Angeles, California.

Hughes, C. and R. Eastwood. 2006. Island radiation on a continental scale: exceptional rates of plant diversification after uplift of the Andes. Proceedings of the National

Academy of Sciences of the United States of America. 103(27): 10334-10339.

Kruckeberg, A.R. and D. Rabinowitz. 1985. Biological aspects of endemism in higher plants. Annual review of ecology and systematics 16: 447-479.

Langridge, R. 2018. California's Fourth Climate Change Assessment. Central Coast Summary Report. University of California, Santa Cruz. SUM-CCCA4-2018-006. Available online at: http://www.climateassessment.ca.gov/regions/docs/20180928-CentralCoast.pdf. Accessed May 3, 2019.

(LC-SLO) Land Conservancy of San Luis Obispo County. 2017. Guadalupe-Nipomo Dunes Nipomo lupine monitoring report. Unpublished technical study prepared for the Dunes Collaborative.

Luong, J.C. 2013. *Lupinus nipomensis* seedbank study. Unpublished report submitted to Ventura Fish and Wildlife Office. Ventura, California.

Luong, J.C. 2018.Lupinus nipomensis, Black Lake fourth year outplanting report. Unpublished technical report submitted to California Native Plant Society San Luis Obispo. San Luis Obispo, California.

Luong, J.C. 2019a. Re: selfing annual lupines. Email from Justin Luong, University of California at Santa Cruz, Santa Cruz, California to Kristie Scarazzo, U.S. Fish and Wildlife Service, Ventura, California. April 16, 2019.

Luong, J.C. 2019b. Maternal effects and drought sensitivity in *Lupinus nipomensis*. Unpublished report submitted to California Department of Fish and Wildlife. Sacramento, California.

Luong, J.C., M. Nolan and L. Stratton. 2019. The importance of pilot studies and understanding microhabitat requirements when reintroducing endemic plants during coastal dune restoration. Journal of Coastal Conservation. Available online at http://doi.org/10.1007/s11852-00684-0.

Luong, J.C., K.C. Seltmann and L. Stratton. 2017. *Lupinus nipomensis* arthropod interaction and ecology study at Phillips 66. Unpublished report submitted to Ventura Fish and Wildlife Office. Ventura, California.

Maron, J.L. and E.L. Simms. 1997. Effect of seed predation on seed bank size and seedling recruitment of bush lupine (*Lupinus arboreus*). Oecologia 111: 76-83.

Maron, J.L. and M.J. Kauffman. 2006. Habitat-specific impacts of multiple consumers on plant population dynamics. Ecology. 87(1): 113-124.

Munz, P.A. 1968. A California flora with supplement. University of California Press. Berkeley and Los Angeles, California.

Munz, P.A. and D. Keck. 1959. A California flora. University of California Press. Berkeley and Los Angeles, California.

(NRCS) Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. 2019. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov/. Accessed April 24, 2019.

Rajakaruna, N. 2004. The edaphic factor in the origin of plant species. International geology review 46: 471-478.

Reilly, C. and J.C. Luong. 2016. Seed bulking of *Lupinus nipomensis*. Unpublished report submitted to Ventura Fish and Wildlife Office. Ventura, California.

Riggins, R. 2019. Re: references – lupines of California, phylogeny. Email from Rhonda Riggins, American Society of Plant Taxonomists, San Luis Obispo, California to Kristie Scarazzo, U.S. Fish and Wildlife Service, Ventura, California. April 6, 2019.

Sholars, T. and R. Riggins. 2012. *Lupinus nipomensis*, in Jepson Flora Project (eds.) Jepson eFlora, http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=31836, accessed on April 16, 2019.

Snell, R. and L.W. Aarssen. 2005. Life history traits in selfing versus outcrossing annuals: exploring the time limitation hypothesis for the fitness benefit of self-pollination. BMC Ecology. 5(2): 1-14.

Smith, C.F. 1976. A flora of the Santa Barbara region. Santa Barbara Museum of Natural History. Santa Barbara, California.

(USFWS) U.S. Fish and Wildlife Service 2009. 5-Year review: summary and evaluation for Nipomo lupine (*Lupinus nipomensis*). Ventura, California.

Wahlert, G.A. 2019a. Re: Nipomo lupine genetics. Email from Dr. Greg Wahlert, Shirley Tucker Curator of Biodiversity Collections and Botanical Research, Isla Vista, California to Kristie Scarazzo, U.S. Fish and Wildlife Service, Ventura, California. April 20, 2019.

Wahlert, G.A. 2019b. Re: can we set up a call. Email from Dr. Greg Wahlert, Shirley Tucker Curator of Biodiversity Collections and Botanical Research, Isla Vista, California to Kristie Scarazzo, U.S. Fish and Wildlife Service, Ventura, California. March 26, 2019.

Walters, D.R. and B.K. Walters. 1988. Taxonomy, Demography, and Ecology of *Lupinus nipomensis*. California Polytechnic State University. San Luis Obispo, California.

Walters, D.R. and B.K. Walters. 1989. The natural history of the Nipomo Mesa lupine

(*Lupinus nipomensis*), Part I. Crossoma 15(3): 1-14.

Whitaker, L. 2016. Preservation and protection of native biodiversity in the Guadalupe Nipomo Dunes Complex. California State Polytechnic University, San Luis Obispo, California. Unpublished Masters of Science thesis.

Wilken, D. 2019. Re: Nipomo lupine – 2009 in litt reference. Email from Dieter Wilken, Santa Barbara Botanic Garden, Santa Barbara, California to Kristie Scarazzo, U.S. Fish and Wildlife Service, Ventura, California. April 16, 2019.

(WRCC) Western Regional Climate Center. 2019. Data for Arroyo Grande weather station, No. 040320, https://wrcc.dri.edu/summary/Climsmsca.html, accessed on April 25, 2019.