Dudleya nesiotica
(Santa Cruz Island dudleya)

5-Year Review:
Summary and Evaluation

H. Abbey, United States Fish and Wildlife Service

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
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5-YEAR REVIEW

Dudleya nesiotica
(Santa Cruz Island dudleya)

I. GENERAL INFORMATION

Purpose of 5-Year Review:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

As summarized in the recovery plan for this species, Thirteen Plant Taxa from the Northern Channel Islands Recovery Plan (Service 2000), Santa Cruz Island dudleya (*Dudleya nesiotica*) is a succulent, basal rosette-forming perennial plant in the stonecrop family (Crassulaceae). This species of *Dudleya* dies back to the ground annually before resprouting in the spring. *Dudleya nesiotica* is restricted to one isolated population, the type locality at Fraser Point, covering approximately 13 hectares (32 acres) of land in the western portion of Santa Cruz Island, California. The population size ranged from approximately 4,000 to 260,000 individuals between 1994 and 2006 (Service 2000, McEachern et al. 2009). *Dudleya nesiotica* grows on gently sloped marine terraces containing rocky, clay soils derived from Quaternary alluvium in elevations ranging from 15 to 50 meters (m) (49 to 164 feet (ft)) above sea level and is associated with grassland habitats (California Natural Diversity Database (CNDDB) 2009). This species is threatened by competition from nonnative grasses, collection for horticultural use, trampling by humans, soil loss, and stochastic events (Service 2000).

Methodology Used to Complete the Review:

This review was prepared by the Ventura Fish and Wildlife Office (VFWO), following guidance issued by Region 8 in March 2008. In preparing this review, we used information from the recovery plan, survey information from experts who have been monitoring various localities of this species, and the CNDDB maintained by the California Department of Fish and Game. The

recovery plan and personal communications with experts were our primary sources of information used to update the species' status and threats. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing or the last 5-year review. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information:

Lead Regional Office: Diane Elam, Deputy Division Chief for Listing, Recovery, and Habitat Conservation Planning, Pacific Southwest Region (Region 8), (916) 414-6464; and Jenness McBride, Fish and Wildlife Biologist; Pacific Southwest Region (Region 8), (916) 414-6464.

Lead Field Office: Heather Abbey, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, (805) 644-1766, extension 290; and Connie Rutherford, Listing and Recovery Coordinator for Plants, Ventura Fish and Wildlife Office, (805) 644-1766, extension 306.

Federal Register Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register (FR) on March 25, 2009 (74 FR 12878). No information was received in response to this request.

Listing History:

Original Listing
FR Notice: 62 FR 40954
Date of Final Listing Rule: July 31, 1997
Entity Listed: *Dudleya nesiotica*
Classification: Threatened

Associated Rulemakings: N/A

Review History: N/A

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for *Dudleya nesiotica* is 8, according to the Service's 2000 recovery plan for this species, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that the taxon is a species that faces a moderate degree of threat and has a high potential for recovery.

Recovery Plan or Outline

Name of Plan or Outline: Thirteen Plant Taxa from the Northern Channel Islands Recovery Plan

Date Issued: September 26, 2000

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy:

The Act defines species as including any subspecies of fish or wildlife, or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition limits listing as distinct population segments to vertebrate species of fish and wildlife. Because the species under review is a plant and the DPS policy is not applicable, the application of the DPS policy to the species' listing is not addressed further in this review.

Updated Information on Current Species Status, Biology, and Habitat:

Species Biology and Life History

Dudleya nesiotica is a long-lived, succulent, basal rosette-forming perennial herb in the stonecrop family (Crassulaceae) that is native to California and endemic to Santa Cruz Island (Service 2000, California Native Plant Society (CNPS) 2009). In California there are 39 different species and subspecies within the *Dudleya* genus, which fall under three subgenera (*Dudleya, Hasseanthus,* and *Stylophyllum*), with *D. nesiotica* belonging to the subgenus of *Hasseanthus* (Moran 1953, McCabe in litt. 2009b). Species that fall within the subgenus *Hasseanthus* have unbranched subterranean stems; widely spreading free petals; and soft vernal leaves that are either narrowly linear, oblanceolate, or terete and generally die back prior to flowering (Abrams 1944, Thiede 2004, Dorsey 2007). *Dudleya nesiotica* will hybridize with some of the other *Dudleya* species (e.g., *D. greenei* and *D. candelabrum*), which is typical of the *Dudleya* genus (McEachern et al. 2009). In the most recent survey conducted in 2006, there were three reported occurrences of hybrids of *D. nesiotica* and *D. greenii* located just to the northwest of the pure *D. nesiotica* population (McEachern et al. 2009).

Mature *Dudleya nesiotica* individuals range in height from about 8 to 15 centimeters (cm) (3 to 6 inches (in)) (Klinger et al., in prep.), and have an underground corm-like stem and aboveground succulent caudices (the base of the stem of a perennial plant, from which new leaves and flowering stems arise) that are 1 to 3 cm (0.4 to 1 in) long, with 8 to 16 oblanceolate leaves (Junak et al. 1995). *Dudleya nesiotica* seeds sprout in late fall or early winter when there is ample precipitation and continue to grow throughout the rainy season (Dorsey 2007). There is evidence that mosses and lichens aid in seed germination and recruitment by providing nutrients, moisture, substrate, and protection against herbivory by snails and slugs (Riefner and Bowler 1995). This species blooms in late spring (April through June), forming one to five flowering stems that are 3 to 10 cm (1 to 4 in) long with pale white flowers consisting of five petals and fruits that are erect to ascending (Bartel 1993, Service 2000, Center for Plant Conservation (CPC) 2007). The species has a flat-topped flower cluster, with main and branch stems ending in

a flower that opens before the ones below or to the side of it (cymose inflorescence) (Wilken 1996). Each plant forms between 7 and 15 flowers on each flowering stem (CPC 2007).

A study was conducted on *Dudleya nesiotica* both *in situ* and *ex situ* by Dieter Wilken (1996); during the study period, plants grown *ex situ* in an insect-free greenhouse were manually pollinated to test self-compatibility. The results indicated that *Dudleya nesiotica* is self-compatible (capable of self-fertilization), but in the absence of human-assisted pollination, the species must be pollinated by insects. *Dudleya nesiotica* plants do not flower during the first year of propagation from seed and individuals do not always produce a flowering stem from each caudex every year. Flowering occurs over a 6- to 8-week period and fruit maturation takes an average of 8 to 10 weeks. Furthermore, each flower generally produces an average of 22 to 27 seeds. The number of seeds produced per flower represents only 28 to 39 percent of the ovules available for fertilization, which is a relatively low reproductive output based on capability, but does not necessarily indicate a deficiency in overall pollination based on the fact that these numbers were similar for both natural *in situ* and manual *ex situ* pollination (Wilken 1996).

Pollination and reproductive strategies vary among the *Dudleya* taxa. Pollination of the various *Dudleya* taxa depends on characteristics such as corolla size, color, and petal fusion. The *Dudleya* species that have small yellow to white flowers (including *D. nesiotica*) are well adapted to being pollinated by bees and flies, while species with larger red flowers are adapted to pollination by hummingbirds (Aigner 2004). Furthermore, *Dudleya* flowers pollinated by hummingbirds tend to produce more nectar than those pollinated by bees and flies, which is a characteristic directly related to the degree of auto-fertility (the proportion of flowers that will set fruit, without mechanical aid, in an insect-proof greenhouse). Plants with a lower nectar content, such as *D. nesiotica*, tend to exhibit a higher degree of auto-fertility and subsequently have been found to be prone to pollinator unreliability, short and unpredictable reproductive seasons, small population size, and high population turnover (Dorsey 2007).

Because it is such a long-lived species, not much is known about the life span of *Dudleya nesiotica*. One plant in cultivation is reported to be more than 10 years old (McCabe in litt. 2009a) and likewise, individuals growing *in situ* have been reported to live 10 years or more (Wilken 1996). *Dudleya nesiotica* does not appear to be an obligate summer-dormant species (Junak et al. 1995, McCabe in litt. 2009a); however, *D. nesiotica* generally dies back to the ground annually around July, before resprouting from the corm in the following spring (Service 2000; Klinger et al., in prep.).

Historic and Current Distribution

Dudleya nesiotica was first described by Reid Moran (1950) as *Hasseanthus nesioticus*, based on a specimen collected from a flat area at Fraser Point on the western edge of Santa Cruz Island in 1950. In 1953, Moran published a revision classifying the species as *Dudleya nesiotica* (Moran 1953). According to records available through the CNDDB (2009); recent studies (McEachern et al. 2009; Klinger et al., in prep.); the California Consortium of Herbaria (Consortium) (2009); and the recovery plan for the species (Service 2000), there is only one known occurrence of *D. nesiotica*, which constitutes a single population that is scattered in varying densities over approximately 13 hectares (32 acres) of land at Fraser Point in the western portion of Santa Cruz Island, California.

Since the time of listing, no new occurrences of genetically pure *Dudleya nesiotica* have been recorded; however, the existing population of the species was previously recorded as two separate occurrences (Element Occurrence (EO) 1 and EO 2) within CNDDB, but was recently combined into one occurrence (EO 1) (CNDDB 2009). These occurrences exist within less than 0.25 mile (402 m) of one another and therefore are considered to be a single population of the species. There has been no significant change in the geographic range of the species since the species' listing in 1997.

Seventy-six percent of Santa Cruz Island is owned by The Nature Conservancy and designated as protected and generally closed to the public; the entire portion of the *Dudleya nesiotica* population occurs within this area. Access to this portion of Santa Cruz Island is granted only for research and other special uses through a permit system. The remaining 24 percent of Santa Cruz Island is owned and managed by the National Park Service and is open to limited use by the public.

Abundance and Population Trends

The population boundaries and numbers for *Dudleya nesiotica* exhibit a high degree of annual fluctuation based mostly on precipitation levels (McEachern et al. 2009); however, other than a few hybrids, the species has generally remained in the same suitable habitat areas noted at the time of listing in 1997. A reconnaissance survey performed in 1990 indicated that *D. nesiotica* individuals are not evenly distributed throughout the type locality at Fraser Point and that the population can be categorized into areas of high, medium, and low density (Klinger et al., in prep.). Since the time of listing, the number of documented individuals within the population has fluctuated, overall showing a slightly decreasing trend (Wilken 1996, CNDDB 2009, McEachern et al. 2009). It is difficult to accurately track annual fluctuations in the number of individuals of *D. nesiotica* due to the vernal nature of the leaves and the fact that the species does not always bloom annually, making it hard to find for at least several months of the year (Wilken 1996).

Dudleya nesiotica continues to exist as a single population at the type locality (CNDDB 2009) and the number of individuals within this population has ranged from approximately 260,000 to 3,500 between 1994 and 2006 (CNDDB 2009, Consortium 2009, McEachern et al. 2009), showing an overall decrease in numbers within the last few years. However, data from the McEachern et al. (2009) study shows that there is evidence of recent recruitment within the population, based on the presence of vigorous individuals with good seed production and a range of size classes.

Table 1: Population Records for *Dudleya nesiotica* extracted from McEachern et al. 2009, CNDDB 2009, and Consortium 2009.

Identification Number	Name	Current Trend	Year Collected/ Observed	Year Surveyed	Population Size	Reference	Site Owner
CNDDB EO 1 (includes former EO 2)	Fraser Point in western Santa Cruz Island	Unknown	1950 (Moran)	1994 (Wilken) 1995 (Klinger) 1996 (Wilken) 2000 (Wilken) 2006 (McCabe)	~165,000 200,000 ~260,000 >3,500 41,000 to 75,000	CNDDB 2009, Consortium 2009, McEachern et al. 2009	TNC

CNDDB identification # = occurrence number assigned by the California Natural Diversity Database (CNDDB 2009)
TNC = The Nature Conservancy

Habitat or Ecosystem Conditions

On a broad scale, suitable habitat for *Dudleya nesiotica* is comprised of grassland and coastal bluff scrub with rocky clay soils derived from Quaternary alluvium, at elevations ranging from 10 to 50 m (33 to 164 ft) above sea level (Service 1997, CNPS 2009, CPC 2007) on marine terraces with little to no slope (Dorsey 2007, Klinger et al., in prep.). Specifically, there are two main soil types which occur at Fraser Point; sandy marine sediments and shallow basaltic rock (Klinger et al., in prep.). This species is extremely localized in its distribution, exhibiting a high degree of habitat specificity, as do most of the other federally listed taxa on Santa Cruz Island.

The western portion of the *Dudleya nesiotica* population is associated with the coastal bluff community and includes the following species: California sagebrush (*Artemisia californica*), iceplant (*Mesembryanthemum nodiflorum*), goldfields (*Lasthenia californica*), alkali heath (*Frankenia salina*), and pickleweed (*Salicornia subterminalis*). The eastern portion of the population is associated with grassland community and includes species such as: Australian saltbush (*Atriplex semibaccata*), soft brome (*Bromus hordeaceus*), goldfields, purple needlegrass (*Nasella pulchra*), vulpia (*Vulpia myuros*) (Junak et al. 1995), Cleveland's cryptantha (*Cryptantha clevelandii*), blue dicks (*Dichelostemma capitatum*), common tarweed (*Hemizonia fasciculata*), meadow barley (*Hordeum brachyantherum*) (Klinger et al., in prep.), ripgut brome (*Bromus diandrus*), wild oats (*Avena fatua*) and ryegrass (*Lolium* spp.) (H. Abbey, Service Biologist, pers. obs. 2009).

Changes in Taxonomic Classification or Nomenclature

No change since the time of listing.

Genetics

No new studies concerning the genetics of this taxon have been conducted since the time of listing.

Five-Factor Analysis

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

When *Dudleya nesiotica* was listed in 1997, we discussed that the species was threatened by the ongoing soil loss occurring on Santa Cruz Island. The introduction of non-native sheep and pigs in the early 1800's contributed to a significant increase in the rate of soil loss. Soil loss is considered a substantial threat to *D. nesiotica* because it precludes seedling establishment and recruitment. The introduction of ranching to Santa Cruz Island in the 19th century spurred the introduction of many non-native mammals such as pigs (*Sus scrofa*), cows (*Bos taurus*), and sheep (*Ovis aries*), which facilitated the spread of non-native, invasive plant species and led to high levels of erosion, soil compaction, sedimentation, and habitat type conversion. During the periods where Santa Cruz Island was heavily overstocked with sheep, many patches of barren land developed in the areas of highest use. The establishment of non-native grass species, which have relatively weak root systems compared to most of the native vegetation, and the creation of barren patches of land further increased the levels of erosion that were already occurring. Furthermore, the overall health of the soil (i.e., nutrient cycling, water retention capability, and

soil fertility) was compromised by the introduction of the non-native mammals due to the resulting soil compaction and loss of leaf litter, plant cover, and cyanobacterial lichen crusts. The introduction of non-native mammals to the island also led to increased levels of dust, which covers the foliage of the local plants, thus reducing the levels of photosynthesis, respiration, and transpiration that can occur (Service 1997, 2000).

Sheep and cattle were removed from the western portion of Santa Cruz Island (where *Dudleya nesiotica* occurs) in 1986, prior to the Federal listing of the species in 1997. Since listing, non-native pigs and turkeys were also completely removed from the island in 2006 (McEachern et al. 2009). The removal of sheep and cattle from Santa Cruz Island has helped to greatly reduce soil erosion and some of the direct impacts to rare plants (Klinger et al. 1994) and will benefit *D. nesiotica* over the long-term; however, soil loss on the island continues to occur and is still considered one of the primary threats to the *D. nesiotica* population (Service 2000, McEachern et al. 2009). Until the overall health of the soil has been rejuvenated, this soil loss will likely continue at higher than normal rates due to the fact that in most locations, the poor quality of the soil resulting from years of damage precludes the establishment of native seedlings (Clark et al. 1990, Halvorson 1993).

Because Santa Cruz Island is owned by two conservation-oriented entities (The Nature Conservancy (TNC) and the National Park Service (NPS)), *Dudleya nesiotica* does not face any threats from development at this time and none are expected in the near future. Likewise, because the portion of Santa Cruz Island that contains *D. nesiotica* is generally closed to the public, the species does not face any significant threats from human recreation at this time.

In summary, the types of threats affecting *Dudleya nesiotica* and its habitat remain similar to what they were at the time of listing. However, the intensity of these threats may have decreased since listing because of the many beneficial conservation management steps, especially removal of most of the non-native mammals, that have been implemented over the last few years.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

In the listing rule for the species, we discussed that species of *Dudleya* are collected by professional horticulturalists as well as amateur collectors and gardeners (Service 1997). A special issue of the Cactus and Succulent Journal was published by the Cactus and Succulent Society of America (CSSA) that focused on *Dudleya* in 2004 (CSSA 2004). In a recent San Francisco Chronicle newspaper article (Eaton and Sullivan 2009), the popularity of collecting plants from the wild, specifically species of *Dudleya*, and the respective potential consequences for collecting these plants from the wild were discussed. We do not have specific reports of unauthorized collection of *D. nesiotica* and we believe that the relative inaccessibility of the *D. nesiotica* population to the general public helps to decrease the threat of collection and/or removal; therefore, Factor B is not considered a significant threat to this species at this time.

FACTOR C: Disease or Predation

Disease was not considered a threat to the species at the time of listing (Service 1997), and is not necessarily considered a threat at this time. The listing rule for the species mentioned that *D. nesiotica* was threatened by herbivory and rooting damage from pigs. Because pigs have been removed from Santa Cruz Island, this is no longer considered to be a threat to the species.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, regulatory mechanisms thought to have some potential to protect *Dudleya nesiotica* included: (1) state listing within California as S1.2 (rare); (2) local land use laws and policies; and (3) the Federal Endangered Species Act (Act) in those cases where *D. nesiotica* occurs and is incidentally protected in habitat occupied by a listed wildlife species. The listing rule (62 FR 40954) provides an analysis of the level of protection that was anticipated from those regulatory mechanisms. This analysis appears to remain valid.

(1) California Endangered Species Act (CESA) and Native Plant Protection Act (NPPA): The CESA (California Fish and Game Code, section 2080 *et seq*.) prohibits the unauthorized take of state-listed threatened or endangered species. The NPPA (Division 2, Chapter 10, section 1908) prohibits the unauthorized take of state-listed threatened or endangered plant species. The CESA requires consultation with the California Department of Fish and Game for those activities that may affect a State-listed species and to mitigate for any adverse impacts to the species or its habitat. Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The state may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to otherwise lawful activities. This species was state listed under the S1.2 (rare) ranking in 1979, indicating that there are less than 6 occurrences of the species. This species is therefore also protected by the CESA.

(2) Local Land Use Policies
The Nature Conservancy (TNC): *Dudleya nesiotica* occurs on the portion of Santa Cruz Island that is managed and owned by TNC, which is a non-profit conservation organization that was established to help preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. This organization is actively managing Santa Cruz Island for the conservation of threatened and endangered species in general; however, currently, there is no official rare plant monitoring plan in existence and rare plant surveys are only conducted intermittently and usually by outside organizations, such as the United States Geological Survey (USGS) and NPS.

In summary, the Act is the primary Federal law that provides some level of protection for this species since its listing as threatened in 1997. With regard to federally listed plant species, section 7(a)(2) requires Federal agencies to consult with the Service to ensure any project they fund, authorize, or carry out does not jeopardize a listed plant species. Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the "take" of federally endangered wildlife; however, the take prohibition does not apply to plants. Instead, plants are protected from harm in two particular circumstances. Section 9 prohibits (1) the removal and reduction to possession (i.e., collection) of endangered plants from lands under Federal

jurisdiction, and (2) the removal, cutting, digging, damage, or destruction of endangered plants on any other area in knowing violation of a state law or regulation or in the course of any violation of a state criminal trespass law. Federally listed plants may be incidentally protected if they co-occur with federally listed wildlife species. The species is also listed as rare by the State of California. However, since there have been few, if any, proposed projects of a nature that would potentially impact the species, the limited protections afforded to species with that status (CNPS 2001) have not been called into play. Other state regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in the absence of the Act.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Fire and Invasive Species

At the time of listing, we discussed general threats to *Dudleya nesiotica*, including the effects of habitat type conversion from native grass and herb species to non-native, invasive plant species (Service 1997). Competition from non-native plants is a threat to *D. nesiotica* because these species tend to take over habitat for *D. nesiotica* and compete for the same limited resources (Klinger et al., in prep.).

Non-native plant species, including grasses and herbs, have been present on Santa Cruz Island for greater than 150 years (Service 1997; Klinger et al., in prep; McEachern et al. 2009). Some of the non-native plant species that compete directly with *Dudleya nesiotica* include iceplant, ryegrass, ripgut brome, and wild oats, among others. The fennel (*Foeniculum vulgare*) infestation that has taken over a substantial portion of the native habitat on Santa Cruz Island currently does not occur within the *D. nesiotica* habitat areas; however, it does occur in the vicinity, suggesting that it could pose a threat to *D. nesiotica* in the near future if not eradicated (H. Abbey, Service Biologist, pers. obs. 2009). The recent increase in overall cover of non-native herbaceous species was likely an indirect result of the eradication of sheep from the island in the 1980's (Klinger et al., in prep.). Non-native species often exist in high proportions on islands (Loope and Mueller-Dombois 1989). Within the Channel Islands, the proportion of non-native species ranges from approximately 20 to 48 percent of the total amount of species that exist there (Junak et al. 1995); the biological invasions caused by these non-native species are often considered one of the greatest threats to overall biodiversity (Loope and Mueller-Dombois 1989, Mooney and Drake 1989, Wilcove et al. 1998). The introduction and spread of non-native species is occurring at unprecedented levels (Service 1997, Di Castri 1989), leading to the alteration of species composition, extirpation of native species, and modification of community structure and function (D'Antonio and Vitousek 1992). Specifically, an invasion of non-native plants can lead to the alteration of the fire regime (D'Antonio and Vitousek 1992), hydrological processes (Bell 1997), and nutrient cycles (Vitousek 1990) of an ecosystem. Studies indicate that non-native plant species often compete with native species for light (Brown and Rice 2000) and water (Eliason and Allen 1997). Additionally, excessive buildup of organic matter may locally increase soil moisture and reduce light levels (Berendse 1999).

A study of *Dudleya nesiotica* conducted from 1991 to 1998 on Santa Cruz Island (Klinger et al., in prep.) found that the overall decline of *D. nesiotica* within the survey plots over the study period was correlated with an increase in non-native plants and subsequent increase in leaf litter cover on the ground. This study also found an overall decrease in native herb cover and native species richness in the high-density *D. nesiotica* strata survey areas during this time period. Overall species richness (number of species in an area) increased, because the number of non-native species increased at a greater rate than native species decreased. However, the dominance of non-native grass in some of the high density plots resulted in an overall decrease in species diversity (number of species and relative abundance) and evenness (the measure of biodiversity showing the relative abundance at which each species is represented within an area). The exact mechanism underlying the relationship between the increase in non-native plant species cover and the subsequent decrease in *D. nesiotica* density is not known; however, it is likely attributed to the fact that as the abundance and cover of the non-native plant species increases, so does the competition for light and water (Klinger et al., in prep.; D'Antonio and Vitousek 1992).

During the study period from 1991 to 1998, there was little evidence of pig rooting or damage within the *Dudleya nesiotica* survey plots at Fraser Point; however, some pig rooting did occur in several of the plots for at least two of the years within the study period (Klinger et al., in prep.). Now that pigs have been fully eradicated from Santa Cruz Island, there may be some expansion of the boundaries of the existing *Dudleya nesiotica* population (McEachern et al. 2009). The eradication of non-native mammals from Santa Cruz Island has generally been considered a success in terms of achieving many of the overall long-term conservation goals for the island (Klinger et al. 1994). However, the study concluded that the changes in community structure and species composition at Fraser Point and the subsequent decrease in the abundance of *Dudleya nesiotica* was directly correlated with the end of the drought and the eradication of feral sheep, which led to an increased abundance of non-native plant species and organic litter (Klinger et al., in prep.). When the sheep and cattle were present on the island, there was likely a strong enough grazing pressure to keep some of the non-native grasses and fennel at lower levels of density and abundance; however, when the 5-year drought period ended in 1991 and there were no longer sheep and cattle present to graze on the island, the relative cover and abundance of many of these non-native species increased rapidly (Klinger et al. 1994). Ultimately, this explosion of non-natives has led to a decrease in diversity of native plant species throughout the grassland ecosystems over much of Santa Cruz Island (Klinger et al. 1994).

As discussed in the Channel Islands National Park Wildland Fire Management Plan (NPS 2006a), the Channel Islands, including Santa Cruz Island, have a relatively unique fire regime compared to the mainland. Although many of the plant species and habitat types on Santa Cruz Island are similar to those on the mainland, including some of the more fire-prone ecosystems such as grasslands and chaparral, the fire frequency and magnitude on the island are relatively low. This lowered fire risk is mostly due to a lack of ignition sources and the often cool and foggy climate that is associated with Santa Cruz Island. Likewise, fire magnitude and frequency may have been reduced over the last 200 years because of the decrease in fuel loading and vegetation cover due to the high intensity grazing that occurred on the island until recently. Prescribed fire is used as a management tool on Santa Cruz Island and has been the most common source of fire in the area over the last 10 years. The policy of NPS, for the portion of

Santa Cruz Island they own, is to suppress all wildfires that occur on the island in the interest of protecting natural habitat, people, and property.

Hybridization

As discussed previously in this review, *Dudleya nesiotica* hybridizes with several other *Dudleya* species, including *D. greenii* and *D. candelabrum*, which occur on Santa Cruz Island. There are three documented occurrences of *D. greenii* and *D. nesiotica* hybrids to the east of the main population of *D. nesiotica* at Fraser Point (McEachern et al. 2009). Because the current distribution of the *D. nesiotica* population at Fraser Point (EO 1) seems to have remained similar to what it was at the time of listing (CNDDB 2009, McEachern et al. 2009), it appears as though *D. nesiotica* is moving into and hybridizing within the areas where *D. greenii* occurs, rather than vice versa. There are not any documented occurrences of *D. nesiotica* and *D. candelabrum* hybrids within the population of *D. nesiotica* at Fraser Point (EO 1); however, a *D. candelabrum* plant on the bluff amongst the *D. nesiotica* population at Fraser Point was observed during a site visit to the island on May 25, 2009 (H. Abbey, Service Biologist, pers. obs. 2009). Further analysis is needed to determine if any hybridization between *D. nesiotica* and *D. candelabrum* has already occurred within the *D. nesiotica* population at Fraser Point.

Stochastic Extinction

At the time of listing, we noted that due to the limited number of individuals and geographic range of *Dudleya nesiotica*, this species was at risk of extinction from naturally occurring events, such as fire, drought, disease, or landslides (Service 1997). We believe that the existence of only one relatively isolated population of *D. nesiotica* places this species at risk of extinction from stochastic events. Likewise, the population has shown some instability in numbers of individuals over the last 15 years, adding to the potential risk of stochastic extinction. The conservation biology literature commonly notes the vulnerability of taxa known from one or very few locations and/or from small and highly variable populations (Shaffer 1981, Primack 2006, Groom et al. 2006). In particular, although the plants are apparently self-compatible, the small size of the population makes it difficult for this species to persist while sustaining the impacts of soil damage (compaction and erosion) and habitat alteration that favors non-native species.

Overall, there are three main factors that may cause *Dudleya nesiotica* to be at risk for stochastic extinction: fire, effects from climate change (such as those associated with sea level rise), and lack of genetic viability due to the existence of the species as a single isolated population. Although the plants have the ability to survive as underground rootstock during the dormant period and probably would not be significantly affected during a small, low-intensity fire, there is a high probability that even the dormant rootstock of the plants may not survive a larger, high-intensity fire (Sagar in litt. 2008). Because the population of *D. nesiotica* occurs on a cliff in close proximity to the ocean it is subject to a wide range of climatic conditions, such as occasional salt spray (Wilken 1996), which may directly affect the soils and plants at Fraser Point. Sea level rise and the continued erosion of the ocean-front cliffs at Fraser Point from high surf and storm events, in addition to climate variability, both from year to year and due to large-scale climate change, pose a threat to the relatively small and exposed *D. nesiotica* population (see discussion below under Climate Change). As a result of the limited range and the species' existence as a single population, the genetic viability and resilience of *D. nesiotica* to human-caused or natural disasters may be greatly reduced (Menges 1991, Ellstrand and Elam 1993).

Studies on Santa Cruz Island have shown that unexpected, complex interactions sometimes result in dramatic declines within endemic species populations that were assumed to be stable (Roemer et al. 2001).

Rainfall and Drought

The average annual rainfall on Santa Cruz Island is approximately 20 in (51 cm) (Erskine-Ogden and Rejma´nek 2005, NPS 2006b). Perennial plants such as *Dudleya nesiotica* may be better able to persist through short-term weather anomalies, because they may be able to simply "wait" for more favorable conditions. The apparent decline of *D. nesiotica* is likely not a direct result of highly variable rainfall conditions over the last 10 to 20 years alone; rather, it is most likely the result of the cumulative effects from the increase in non-native species abundance combined with climate variability (Klinger et al., in prep.).

Climate Change

Current climate change predictions for terrestrial areas in the northern hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field et al. 1999, Cayan et al. 2005, Intergovernmental Panel on Climate Change (IPCC) 2007). In addition, an increase in the rate of sea level rise has been predicted for the coast of California (California Coastal Commission (CCC) 2001, California Climate Change Center 2006). In particular, ocean bluffs along the coast will likely be subject to greater and more frequent wave attack, resulting in erosion and shoreline retreat (CCC 2001). Jeff Severinghaus, a professor of geosciences at the Scripps Institute of Oceanography in San Diego, recently estimated that for every foot (.3 m) that the sea level rises in California, approximately 100 ft (30.5 m) of shoreline might be lost (Scolari 2009). The Intergovernmental Panel on Climate Change (IPCC 2007) estimates that the sea level will rise anywhere from approximately 7 to 22 in (0.2 to 0.6 m) by the end of this century.

Recently, the potential impacts of climate change on the flora of California were discussed by Loarie et al. (2008). Based on modeling, they predicted that species' distributions will shift in response to climate change and that the species will "move" to higher elevations and northward, depending on the ability of each species to do so. In the case of smaller island ecosystems, such as Santa Cruz Island, the opportunities to move to higher elevations or further north are limited. We lack adequate information to make specific and accurate predictions regarding how climate change, in combination with other factors such as limited geographical distribution, will affect federally listed species; however, small-ranged species such as *D. nesiotica* are more vulnerable to extinction due to these changing conditions (Loarie et al. 2008).

In summary, the combination of threats associated with soil loss and habitat degradation (discussed in Factor A), limited range, and existence of only a single population of *Dudleya nesiotica* make this species particularly vulnerable to dramatic declines as a result of random human-caused or natural events.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

The recovery plan indicates that delisting for *Dudleya nesiotica* can be considered when the following criterion has been achieved:

1. Maintain the existing population as stable with evidence of natural recruitment for a period of 20 years that includes the normal precipitation cycle (addresses Listing Factors A and E).

This criterion is relevant and up-to-date, except that it may become increasingly difficult to evaluate the population over 20 years that includes the normal precipitation cycle due to the fact that the normal precipitation cycle is already changing and is predicted to continue to fluctuate considerably under the effects of climate change (IPCC 2007). The most recent surveys of the *Dudleya nesiotica* population seem to show that the number of individuals has decreased somewhat since listing, with signs of some recent recruitment (McEachern et al. 2009); however, these observations only span the last 15 years and the precipitation cycles during this time period have not been normal (Levine et al. 2008); therefore, this criterion has been partially, but not fully met.

IV. SYNTHESIS

The status of *Dudleya nesiotica* has not changed substantially since the time of listing in 1997. At the time of listing, two occurrences (constituting one population) of *D. nesiotica* were known to exist. Currently, there is one known occurrence of the species (due to the combination of EO1 and EO2 within the CNDDB), which has exhibited some decline in the number of individuals over the last 15 years, but currently seems to be relatively stable and showing signs of recent recruitment.

The entirety of the *Dudleya nesiotica* population and suitable habitat occurs on the portion of Santa Cruz Island that is owned by TNC within a limited-use area that is only accessible by obtaining a permit for research or other special uses. As a result, development and direct anthropogenic pressures are not considered substantial threats at this time. Although the *D. nesiotica* population is currently fairly stable, continued invasion of the habitat by non-native plant species would likely lead to further decline of the species. Likewise, due to the fact that there is only one population of *D. nesiotica*, this species remains at risk of suffering dramatic declines as a result of stochastic events, especially given the possible changes that are predicted to occur as a direct result of climate change (e.g., sea level rise, etc.). Overall, this species remains threatened due to its existence as an isolated single population; limited geographic range; and ongoing threats to the species, such as soil loss and degradation, competition from invasive plant species, and other stochastic events. Therefore, we believe *D. nesiotica* still meets the definition of threatened, and recommend no status change at this time.

V. RESULTS

Recommended Classification:

_____ 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

New Recovery Priority Number and Brief Rationale: The recovery priority number should remain at 8 for *Dudleya nesiotica*. The recovery priority of 8 is the correct number for a species that faces a moderate degree of threat and has a high potential for recovery.

VI. RECOMMENDATIONS FOR FUTURE ACTIONS

1. Develop and implement monitoring and adaptive management plans for the existing population. Monitoring should occur at intervals of 1 to 2 years and include population abundance surveys, habitat condition assessment, and documentation of existing and potential threats.

    1a. Work closely with agencies such as TNC, USGS, and NPS to continue monitoring efforts for the species.

2. Develop and implement an integrated non-native plant control program for Santa Cruz Island.

3. Continue to research the species' life history requirements, especially with regard to the habitat conditions favorable to *Dudleya nesiotica*.

3a. Specifically, a follow-up study is recommended to evaluate the response of *Dudleya nesiotica* to the removal of the non-native mammals from Santa Cruz Island and whether recovery of the soil health and stability has occurred.

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Figure 1. Distribution of *Dudleya nesiotica* (Santa Cruz Island Dudleya)

U.S. Fish & Wildlife Service
Ventura Fish & Wildlife Office
May, 2009

Prepared for the 5-year Review

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of
Dudleya nesiotica
(Santa Cruz Island dudleya)

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Review Conducted By: Heather Abbey

FIELD OFFICE APPROVAL:

Field Supervisor, U.S. Fish and Wildlife Service

Approve Diane K Noda Date 8/7/09