U.S. Fish & Wildlife Service

Draft Recovery Plan for *Clarkia imbricata* (Vine Hill Clarkia)

Photo courtesy of Josh Hull, U.S. Fish and Wildlife Service

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Region 8
U.S. Fish and Wildlife Service
Sacramento, California

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Regional Director, Pacific Southwest Region, Region 8,
U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXX

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An electronic copy of this draft recovery plan is available at:
http://www.fws.gov/endangered/species/recovery-plans.html

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EXECUTIVE SUMMARY

The Draft Recovery Plan for *Clarkia imbricata* (Vine Hill Clarkia) addresses the endangered *C. imbricata,* as well as two species of concern; *Arctostaphylos densiflora* (Vine Hill manzanita) and *Ceanothus foliosus* var. *vineatus* (Vine Hill ceanothus). All of these species are endemic to the Vine Hill area of central Sonoma County, which has been impacted by land conversion for agriculture and urban development. *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* are included in this draft recovery plan because including a community-based component to the strategy provides for conservation of species with similar habitat requirements to those of *Clarkia imbricata*, and because recovery actions implemented for *C. imbricata*, that do not consider these other rare species, may negatively affect the community.

Species Current Status

Clarkia imbricata is an annual herb in the evening primrose family (Onagraceae). It was listed by the State of California as endangered in 1978, and listed by the Service as federally endangered in 1997 (Service 1997). It is a narrow endemic, historically known from three locations in central Sonoma County, all three of which may be extirpated. Currently, the species is only known to exist as a single introduced and now established population on the 0.6 hectare (1.5 acres) Vine Hill Preserve, owned and managed by the California Native Plant Society (CNPS). Between 2007 and 2012, the population has fluctuated from approximately 500 to 8,781 plants.

Arctostaphylos densiflora is a shrub in the Ericaceae family and is endemic to the Vine Hill area. It was state-listed as endangered in 1981. At this time, it is only found in its native habitat at the Vine Hill Preserve, and most of the 47 or more plants growing there were cloned from plants growing at the Vine Hill Preserve and planted sometime between the 1980s and 2006.

Ceanothus foliosus var. *vineatus* is a shrub in the Rhamnaceae family and is endemic to the Vine Hill area. This variety is not listed as threatened or endangered by the state of California or the Federal government, but is designated by the CNPS with a California Rare Plant Rank of 1B, which indicates the species is rare throughout its range and has declined significantly over the last century. There are two known extant populations, 28 plants at the Vine Hill Preserve and 10 plants along a bike trail north of the City of Sebastopol in Sonoma County.

Clarkia imbricata, *Arctostaphylos densiflora*, and *Ceanothus foliosus* var. *vineatus* are historically known only from a small area referred to as the "Sonoma Barrens" in Sonoma County, California, which includes the Vine Hill area. The Sonoma Barrens consist of acidic and sandy soil that forms a hard soil crust when dried, which may conserve moisture during the dry and warm summer months.

Threats and Stressors

The existence of only one small population of *Clarkia imbricata* makes this species extremely vulnerable to extinction by stochastic events. *C. imbricata* is also threatened by competition with native species, including *A. densiflora* and *C. foliosus* var. *vineatus*, and non-native invasive species for light and space.

Arctostaphylos densiflora, with one population, and *Ceanothus foliosus* var. *vineatus*, with two populations, are also stressed by stochastic events. As shade intolerant species, they are susceptible to vegetation

community succession to oak woodland, and *A. densiflora* and *C. foliosus* var. *vineatus* may compete with each other and non-native invasive species for light and space.

Arctostaphylos densiflora and *Ceanothus foliosus* var. *vineatus* are obligate-seeding plants. Obligate-seeding *Arctostaphylos* and *Ceanothus* usually tend to be adapted to a fire regime and require fire for natural seed germination. However, *C. foliosus* var. *vineatus* has reproduced by seed at the Vine Hill Preserve over the past decade in the absence of fire. Reproduction of *A. densiflora* by seed has not been observed under experimental conditions or at the Vine Hill Preserve since 1967. Due to the close proximity of the Vine Hill Preserve to houses, the use of fire to stimulate seed germination is limited. In addition, *Arctostaphylos densiflora* is affected by a native fungal pathogen that has been observed intermittently over the last 50 years.

Recovery Strategy
To ameliorate the threats to *Clarkia imbricata*, additional populations must be established and secured, and dedicated funding for perpetual management of competing vegetation must be obtained for all populations.

Recovery Goal, Objectives, Criteria
To determine the threats to *C. imbricata* have been ameliorated and allow for the goal of downlisting, the following will have occurred: 1) all locations with *C. imbricata* are assured protection from incompatible uses; 2) three locations are occupied by the species, each consisting of 2 acres or more, each with a 10-year average of 4,000 plants or more; and 3) competing vegetation is controlled and there are monetary commitments to continue control in perpetuity. The delisting criteria for *C. imbricata* are identical to the downlisting criteria, except that five locations are required to be occupied by the species.

Actions Needed
Actions necessary to achieve delisting are described below and fall into the following general categories: 1) Establish additional populations of *C. imbricata,* 2) Monitor and manage competing native and non-native vegetation affecting *C. imbricata*, and 3) Conduct research.

Estimated Date and Cost of Recovery:
Date of recovery: 2030
Cost of recovery: $2,126,000 (or $2,436,000 including Community Conservation actions)

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I. BACKGROUND

Recovery plans focus on restoring the ecosystems on which a species is dependent, reducing threats to the species, or both. A recovery plan constitutes an important U.S. Fish and Wildlife Service (Service) document that presents a logical path to recovery of the species based on what we know about the species' biology and life history, and how threats impact the species. Recovery plans help to provide guidance to the Service, States, and other partners on ways to eliminate or reduce threats to listed species and measurable objectives against which to measure progress towards recovery. Recovery plans are advisory, not regulatory documents, and rely on voluntary implementation.

Clarkia imbricata, and the two species of concern addressed in this draft recovery plan, *Arctostaphylos densiflora* (Vine Hill manzanita) and *Ceanothus foliosus* var. *vineatus* (Vine Hill ceanothus), historically coexisted together. *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* are included in this draft recovery plan because a community-based recovery strategy provides for conservation of species with similar habitat requirements to those of *Clarkia imbricata*, and because recovery actions implemented for *C. imbricata*, that do not consider these other rare species, may negatively affect the community.

A. Clarkia imbricata

Clarkia imbricata (Vine Hill clarkia) was listed by the Service as endangered throughout its entire range on October 22, 1997 (Service 1997), and was listed by the State of California as endangered in 1978. At the time the species was listed, the Service determined that designating critical habitat would not benefit the species due to previous incidents with over-collection by rare-plant collectors and the potential for vandalism. The most recent 5-year status review for *C. imbricata* was issued September 8, 2011 (Service 2011), and recommended the species remain listed as endangered due to small population size and poorly understood biological and ecological limiting factors. The recovery priority number for *C. imbricata* is 5; this number indicates the taxon is a species with a high degree of threat and low recovery-potential.

1. Species Description and Taxonomy

In 1953, Frank H. Lewis and Margaret Lewis described *Clarkia imbricata* from specimens collected on July 10, 1951, along Vine Hill Road, near Pitkin Ranch in Sonoma County, California. *Clarkia imbricata* is an erect annual herb in the Onagraceae (Evening primrose) family, growing up to 60 centimeters (2.5 feet) tall, with unbranched or numerous short branches in the upper parts. This plant is densely leafy, with entire (smooth leaf margins), lanceolate leaves (tapering to a point at the apex and sometimes at the base) 2.0 to 2.5 centimeters (0.8 to 1.0 inches) long and 4 to 7 millimeters (0.2 to 0.3 inches) broad that are ascending and overlapping. Showy inflorescences appear from late June through July. Flowers are grouped closely together and each flower has a conspicuous funnel shaped tube at its base and four fan-shaped, lavender petals 2.0 to 2.5 centimeters (0.8-1.0 inches) long with a V-shaped purple spot extending from the middle to the upper margin of the petal. *Clarkia imbricata* is distinguished from other morphologically similar *Clarkia* species by the broad, overlapping, ascending leaves.

2. Population Trends, Range, and Distribution

Clarkia imbricata is known from Sonoma County, in the area of Vine Hill Road between the cities of Forestville and Santa Rosa, and has never been known to be common (Figure 1). Only three locations with naturally occurring *C. imbricata* plants have been known and all three are likely extirpated: (1) along the roadside of Vine Hill Road north of Guerneville Road (Lewis-type locality; locality where the species was first identified); (2) east of Vine Hill Road, off of Sequoia Circle (Sequoia Circle); and (3) along a path to Pitkin Marsh and on a dry slope bordering Pitkin Marsh (Pitkin Ranch). None of these three locations are more than 0.6 kilometer (0.4 mile) from each other. Prior to agricultural and suburban development, the Vine Hill area may have supported a much larger population or clusters of populations of this species. However, very little is known about historical abundance at any of the three historical sites.

By 1974, the Lewis-type locality was believed to be extirpated, the Pitkin Ranch population had declined, and the Sequoia Circle population was threatened by the proposed construction of the Russian River-Cotati Intertie Project. As a result of increasing threats to these three natural populations, seeds from the Sequoia Circle occurrence were planted to a 2.3 square meter (24.7 square foot) plot at the Vine Hill Preserve in 1974 and propagated plants were planted at the site in 1974 or 1975. Vine Hill Preserve is an approximately 0.6 hectare (1.5 acres) north-facing slope, approximately 0.8 kilometer (0.5 mile) from Sequoia Circle and Pitkin Ranch. A fence occurs along the eastern, northern, and western borders. Residential housing units border the site to the east and west; to the north are a vineyard and a residential home; and to the south is Vine Hill School Road. Vine Hill Preserve is owned and managed by volunteers of the Milo Baker Chapter of CNPS.

Because the physical address of the Lewis-type locality no longer exists, it is difficult to ascertain from which property the type locality came. Based on unsuccessful roadside searches in the vicinity of the Lewis-type locality, it is believed this occurrence was extirpated before 1974, as a result of a change in land use or roadside maintenance (B. Guggolz, personal communication 1993). The Pitkin Ranch locality was likely extirpated sometime between 1981 and 1984, after land use conversion to a Christmas tree farm around 1976. Survey efforts in 1977, 1978, and 1981, at Pitkin Ranch found a few *Clarkia imbricata* plants growing in between the rows of Christmas trees, but no plants were observed in the weed-controlled rows during surveys in 1984, 1986, and 1987.

The Sequoia Circle occurrence was distributed between two private properties, with one of the properties containing the majority of plants. As a result of outreach efforts by CNPS and The Nature Conservancy, the owner of the property with the largest concentration of plants mowed the grassland area that contained *Clarkia imbricata* before the plants were tall enough to be cut by mowers. Under this management, the population fluctuated annually between 2,000 and 5,000 plants. Sometime in the late 1990s, the ownership of Sequoia Circle changed and outreach was attempted; but the new owners were not interested in managing the site to conserve *C. imbricata* (G. Cooley, personal communication 2013). Based on the management practices observed in the late 1990s during the last outreach attempt and the poor condition of the few *C. imbricata* plants that remained, it is possible the site no longer supports this species.

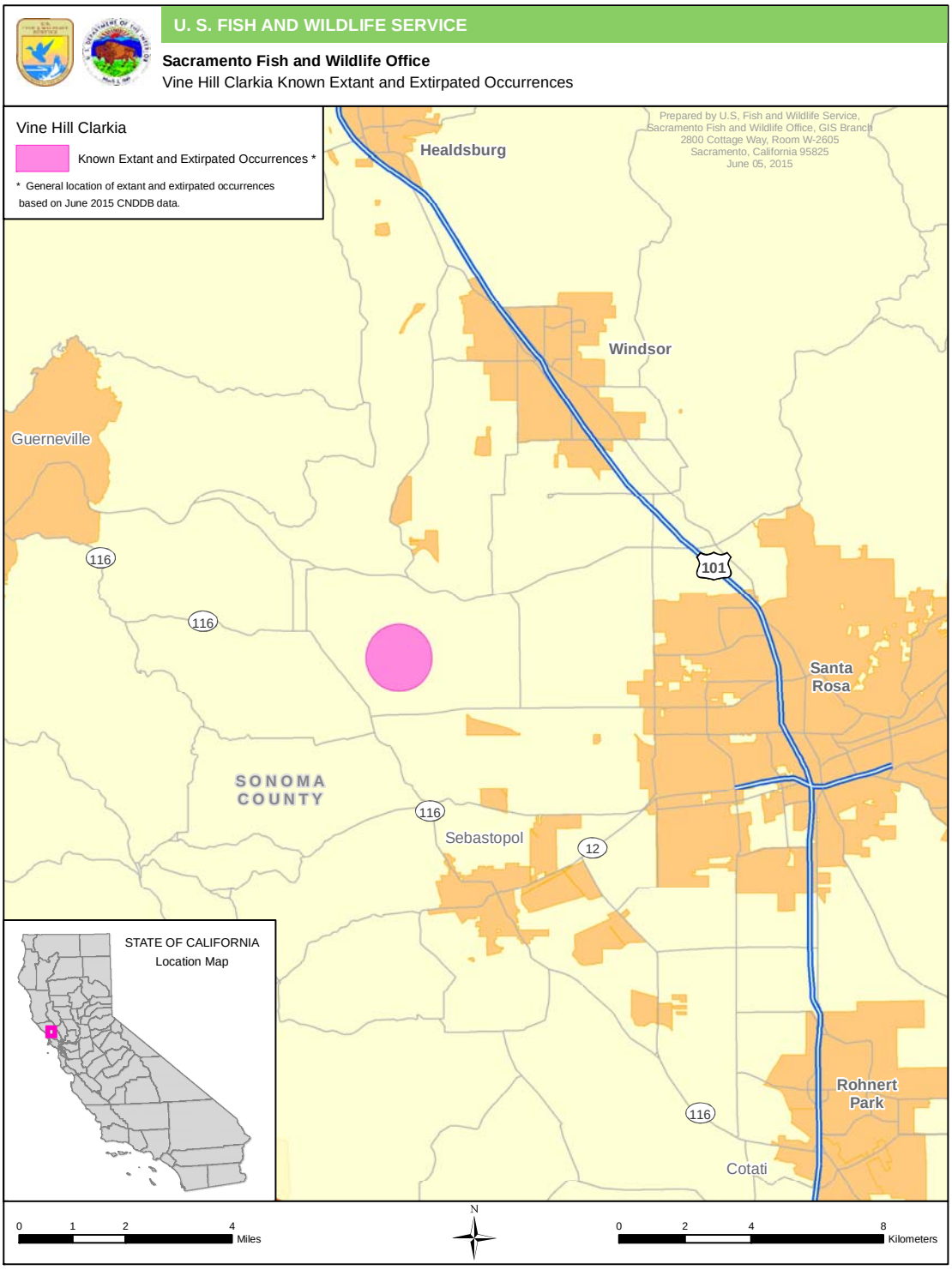

Figure 1. Distribution of Clarkia imbricata (Vine Hill clarkia).

Since its introduction to the site in 1974, the population of *Clarkia imbricata* at the 1.5-acre Vine Hill Preserve has steadily expanded from the 2.3 square-meter planting, and is now growing across the width of the parcel and occasionally onto an adjacent parcel to the east. Based on monitoring by The Nature Conservancy and CNPS, in 1978, 60 plants were observed; from 1988 to 1993, the population fluctuated from about 200 to 300 plants; and, from 2007 to 2012, the population fluctuated from approximately 500 to 8,781 plants. In 2013, the population of *C. imbricata* at Vine Hill Preserve was estimated at 908 individuals (S. Gordon, personal communication 2013). The number of *C. imbricata* plants on the property to the east of the Vine Hill Preserve fluctuates from zero to 100 plants, depending on property maintenance activities. In 2010, the area occupied by *C. imbricata* on the Vine Hill Preserve was measured at 1,540 square meters (16,576 square feet), up from 1,467 square meters (15,791 square feet) in 2009.

3. Life History and Ecology

All known populations of *Clarkia imbricata* have been found between 60 to 75 meters (197 to 246 feet) elevation, on what has been mapped as Goldridge acidic sandy loams, in an area sometimes referred to as the Sonoma Barrens. The ability of *C. imbricata* to persist naturally outside of Sonoma Barrens conditions is unknown. The Sonoma Barrens are an area within Sonoma County located halfway between maritime and inland climates, in a pronounced fog gap that makes it subject to peculiar climatic fluctuations (Roof 1972). In one summer hour, the temperature can, and often does, increase from 12.8 to 32.2 degrees Celsius (55 degrees to over 90 degrees Fahrenheit), and then quickly decline as the fog moves in. Other than summer fog, the area receives little dry-season moisture from late spring through early fall.

There is not a widely-accepted definition of "Sonoma Barrens," but it is postulated that the soils of the Sonoma Barrens are unique in relationship to the Goldridge series (J. Herrick, personal communication 2013); whether this uniqueness is a result of particular Goldridge series soils horizon depths, the absence of one or more Goldridge series soil horizons, or a soil inclusion (distinct soil within a larger stratum) is not known at this time. Roof (1972) created a coarse map of what he considered to be the probable margins of the Sonoma Barrens, an area approximately 2 kilometers (1.2 miles) from east to west and 4 kilometers (2.5 miles) from north to south, centered just south of the intersection of Vine Hill School Road and Laguna Road. According to Roof (1972), the soil of the Sonoma Barrens is pale yellow in color. When wet in winter, it is a slick colloidal mud, and when left undisturbed, the dry spring and summer sun bakes the soil surface to a firm crust approximately 5 centimeters (2 inches) thick. Because *C. imbricata* is a late-summer annual that blooms in late June and into July, long after the end of the rainy season, it is hypothesized the soil crust, which often includes a layer of algae (J. Herrick, personal communication 2013), provides a barrier that reduces evaporation below the crust, conserving soil moisture for the plant's shallow roots. If this hypothesis is accurate, activities that break the crust would increase evaporation and decrease soil moisture, allowing the roots to become dehydrated and the plants to gradually die before reproduction is complete (Guggolz 1993).

Historically, before conversion to agriculture, the vegetation of the Sonoma Barrens was mainly a mixture of chaparral and Douglas-fir/oak (*Pseudotsuga menziesii*/*Quercus* spp.) woodland and mixed evergreen forest in the canyons and freshwater marsh and riparian habitat along Pitkin Marsh, Green Valley Creek, and Atascadero Creek in Sonoma County. Sonoma Barrens plant associates may include *Piperia elegans* (rein orchid), *Frangula californica* (California coffeeberry), *Q. agrifolia* (coast live oak), *Q. kellogii* (California black oak), *Pseudotsuga menziesii* (Douglas-fir), *Baccharus pilularus* (coyote

brush), *Arctostaphylos manzanita* (common manzanita), *Prunella vulgaris* var. *lanceolata* (self-heal), *Danthonia californica* (California oatgrass), *Solidago elongata* (west coast Canada goldenrod), *Horkelia tenuiloba* (thin-lobed horkelia), *Adenostoma fasciculatum* (chamise), and possibly *Xerophyllum tenax* (bear grass) and *Gaultheria shallon* (salal).

Clarkia imbricata is self-compatible (capable of self-fertilization). Plants begin to flower in June, and often bloom through August. Seeds generally set in early September. It is not known when seeds germinate or how flowers are pollinated. As with many annual plants, numbers can vary substantially from year to year, depending on seasonal weather variations. The relationship between seasonal weather variation, germination, and number of adult plants is unclear.

In 2009, mature seeds were collected from the Vine Hill Preserve and stored at Rancho Santa Ana Botanic Garden, and some germination trials were conducted. From these trials it was determined that *Clarkia imbricata* produces non-dormant seeds that germinate readily in the presence of light and water. It is thought that the seed bank may remain viable for several years. It is unknown how the seed bank would respond to fire, as no fire trials have been conducted (M. Wall, personal communication 2011).

4. Critical Habitat

Critical habitat has not been designated for *Clarkia imbricata*. At the time the species was listed, the Service determined that designating critical habitat would not benefit the species due to previous incidents with over-collection by rare plant collectors and the potential for vandalism.

5. Reasons for Listing and Current Threats

The following is a summary of the interacting influences of physical, chemical, and biological factors that continue to threaten *Clarkia imbricata*. In determining whether to list, delist, or reclassify a species under section 4(a) of the Act, we evaluate the threats to the species based on the five categories outlined in section 4(a)(1) of the Act: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. At this time, the primary threats to *C. imbricata* are competition for light and space with native and non-native species and risk of extinction from stochastic environmental events associated with small populations.

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

At the time of listing, the most significant threat to *Clarkia imbricata* was extirpation through land use conversion and incompatible management practices. Of the two populations that existed at the time of listing, the naturally occurring plants at Sequoia Circle may have been extirpated due to incompatible management practices. The established population at the Vine Hill Preserve is owned by CNPS, and land use conversion and incompatible management activities at this site do not represent a threat within the preserve under the current ownership, as the site was acquired to protect rare plants. Therefore, with the possible extirpation of the Sequoia Circle occurrence, the threat of land use conversion and incompatible management practices may have been realized and no longer represents as great of a threat to the species as it did at the time of listing. The conversion

of much of the Sonoma Barrens to agriculture and residential uses, however, limits the recovery potential of the species. Although the Vine Hill Preserve and the *C. imbricata* plants occurring there are not threatened by habitat destruction from human-related activities currently, there is no legal easement in place to protect the property from development and the future sale of the property for non-conservation purposes could also threaten continuing conservation management. In addition, the small numbers of *C. imbricata* plants that occasionally grow on the property to the east of the Vine Hill Preserve are not protected, suffer from incompatible management practices, and remain threatened by land use conversion.

Trespassing and vandalism that damage habitat and plants also represent minor threats to the species. In the past, observations from neighbors of the Vine Hill Preserve indicated that people may have trespassed to recreate or view the rare plants. Foot traffic from trespassers may introduce non-native species, inadvertently crush *Clarkia imbricata* plants, break the soil crust and cause plants to prematurely dehydrate, and/or disturb the soil in such a manner as to create conditions that increase erosion. However, volunteers that manage the site take care to avoid crushing *C. imbricata* and minimize soil disturbance, and trespassing has not been documented within the last 10 years (P. Van Soelen, personal communication 2010)

Factor B*: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*
At the time of listing, the Vine Hill Preserve population of *Clarkia imbricata* was threatened by over-collection by recreational plant enthusiasts seeking not only *C. imbricata* plants and seeds, but *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* presumably for the nursery trade. However, no incidents have been observed within the last 10 years (P. Van Soelen, personal communication 2010), and over-collection currently represents a minor threat.

Factor C*: Disease or Predation*
At this time *Clarkia imbricata* is not known to be threatened by disease or predation (S. Gordon, personal communication 2010; P. Van Soelen, personal communication 2010).

Factor D*: Inadequacy of Existing Regulatory Mechanisms*
After Federal listing of *C. imbricata* in 1997 (Service 1997), regulatory mechanisms thought to provide some degree of protection to *C. imbricata* included: 1) listing under the Endangered Species Act; 2) the National Environmental Policy Act (NEPA); 3) listing under the California Endangered Species Act (CESA); 4) the California Environmental Quality Act (CEQA); and 5) the California Native Plant Protection Act (NPPA). The following is a summary of the existing regulatory mechanisms that may reduce some of the threats to *C. imbricata*.

Federal Laws and Regulations

Endangered Species Act (Act): The Endangered Species Act of 1973, as amended (Act), is the primary Federal law that provides protection for *Clarkia imbricata*. 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 species. Section 9 of the Act 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. Section 9 also makes illegal the international and interstate transport, import, export and sale or offer for sale of endangered plants and animals. The protection of Section 9 afforded to endangered

species is extended to threatened wildlife and plants by regulation. Federally listed plants may be included as covered species in habitat conservation plans (HCPs) prepared by non-Federal applicants as part of the terms and conditions for the issuance of an incidental take permit for federally listed wildlife under section 10(a)(1)(B). *C. imbricata* is not within any HCP boundaries.

National Environmental Policy Act (NEPA): NEPA (42 U.S.C. 4371 *et seq.*) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

State Laws and Regulations

California Endangered Species Act (CESA): The CESA prohibits the unauthorized take of State-listed threatened or endangered species. The CESA was enacted in 1984 and determined that any species listed by the California Fish and Game Commission as "endangered" on or before January 1, 1985, including *Clarkia imbricata*, is an endangered species under CESA. The CDFW is charged with enforcing the provisions of the CESA, which are found in Section 2050 et seq. of the Fish and Game Code. CESA prohibits take of wildlife and plants listed as threatened or endangered by the California Fish and Game Commission. Take is defined under the California Fish and Game Code as any action or attempt to "hunt, pursue, catch, capture, or kill."

CESA allows exceptions to the prohibition for take that occurs during otherwise lawful activities. The requirements of an application for incidental take under CESA are described in Section 2081 of the California Fish and Game Code. Incidental take of State-listed species may be authorized if an applicant submits an approved plan that minimizes and "fully mitigates" the impacts of this take and adequate funding is provided to implement the required minimization and mitigation measures and to monitor compliance with and the effectiveness of the measures.

California Environmental Quality Act (CEQA): The California Environmental Quality Act (CEQA) requires review of any project that is undertaken, funded, or permitted by the State or a local government agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project. Protection of a listed species through CEQA is dependent on the discretion of the agency involved.

In summary, the Federal and California Endangered Species Acts are the primary laws that provide protection for *Clarkia imbricata*. Other Federal and 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 Acts. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Federal and California Endangered Species Acts.

California Native Plant Protection Act (NPPA): Clarkia imbricata was listed by the State of California as endangered in 1978 under the NPPA. Under the NPPA, no person shall import into the State, or

take, possess, or sell within the State any native plant determined to be endangered. However, the NPPA includes some exceptions for agricultural and nursery operations; emergencies; and, after properly notifying CDFW, for vegetation removal from canals, roads, and other sites, changes in land use, and in certain other situations. In the event a landowner decides to change land use and has been notified by CDFW of the presence of an endangered plant on the property in question, the landowner is required to notify CDFW at least 10 days in advance of changing land use in order to allow salvage of listed plants. Salvaging is unlikely to be beneficial for the *C. imbricata* because it is an annual species, and no evidence exists that the species would survive transplantation. However seed collection would be beneficial to maintain genetic diversity if a suitable reintroduction site is identified.

Factor E*: Other Natural or Manmade Factors Affecting Its Continued Existence*

Small Population Size and Stochasticity

Due to the existence of a single population of *Clarkia imbricata*, this species is highly threatened by stochastic environmental events, normal but damaging environmental events and catastrophes such as storm damage and fires, from which large wide-ranging populations can generally recover, but which may lead to extirpation of small, isolated populations (Terborgh and Winter 1980, Diamond 1984, Primm *et al.* 1988, Morris and Doak 2003). At low population sizes, genetic and evolutionary effects can become increasingly important. Because the established population of *C. imbricata* at the Vine Hill Preserve was started from what has been described as a small number of plants from Sequoia Circle, genetic variability may be limited. Even though the number of plants has increased, it may not reverse the previous loss of genetic diversity. In addition, small populations are subject to increased genetic drift and inbreeding. Genetic drift (random changes in gene frequency) can lead to loss of variation, which may decrease a species' ability to persist as changes in its environment occur. Inbreeding depression is reduced fitness as a result of breeding of related individuals. Inbreeding depression may reduce fitness, for instance, by resulting in reduced fruit or seed set. However, the mating system of a species may influence the level of inbreeding depression. Populations of species, such as *C. imbricata*, which are capable of self-fertilization and which may have a long history of inbreeding, may be less vulnerable to inbreeding depression than typically outbreeding populations. However, some species that usually self-fertilize do have strong inbreeding depression (Ellstrand and Elam 1993 and references therein; Primack 1998, Groom *et al.* 2006).

Competition with Native and Non-native Invasive Species

Because *Clarkia imbricata* is a shade intolerant species and restricted to open areas, native and non-native species capable of shading or out-competing it for light, space, water or nutrients represent a significant threat. *Holcus lanatus* (velvet grass), a non-native invasive annual grass species, was absent from the Vine Hill Preserve in 2002, but has since invaded the site and increased over the last few years in all areas of the preserve (S. Gordon, personal communication 2012). Approximately 25 to 30 percent of the potential *C. imbricata* habitat at the preserve has now been invaded by *Holcus lanatus* (S. Gordon, personal communication 2013). *Holcus lanatus* has been known to form dense stands that exclude other plants and represents a significant threat to *C. imbricata*. Efforts by CNPS volunteers to remove *H. lanatus* by hand have been attempted, but the infestation continues to increase in density and extent. Other non-native invasive species, including *Rubus armeniacus* (Himalayan blackberry), *Genista monspessulana* (French broom), and *Spartium junceum* (Spanish broom) also occur at the Vine Hill Preserve. Efforts to control these species have been successful and continue.

In addition to non-native species, the Vine Hill Preserve is occupied and bordered on the east and west by numerous native shrub and tree species capable of invading the site and shading out *Clarkia imbricata*. By casting shade into the preserve, these species reduce the overall available habitat within the preserve for *C. imbricata*. Efforts by CNPS volunteers to reduce the amount of tree and shrub cover at the site are ongoing.

Of particular management interest is the current potential threat to *Clarkia imbricata* presented by the spread of native *Arctostaphylos densiflora* into areas occupied by *C. imbricata* at the Vine Hill Preserve, where space is limited. According to S. Gordon (personal communication 2013), approximately 25 to 30 percent of the potential *C. imbricata* habitat at the preserve is now occupied by *A. densiflora*, which is also shade intolerant, but outcompetes *C. imbricata* for space due to its size and perennial nature. It is likely that this threat from shading was not present historically, because fire routinely came through the system and cleared openings that *Clarkia imbricata* could utilize. Natural vegetative succession (the gradual process of change in an ecosystem brought about by the progressive replacement of one community by another) would have likely occurred where *C. imbricata* historically existed, favoring gradual encroachment of native and non-native scrub vegetation, likely including *Arctostaphylos densiflora* and *C eanothus foliosus* var. *vineatus*, until such time as fire came through the area periodically and reduced the biomass. At that time, under this regime, there would have been opportunities for *C. imbricata* to flourish, until the encroaching scrub vegetation again replaced *C. imbricata,* with repeated fire cycles maintaining populations on this small parcel over time. Since residential development of the Vine Hill area, fire suppression has been put in place which removes that means of natural vegetation management. With the absence of fire, there will likely be a perpetual battle to artificially maintain community succession in a way that supports *C. imbricata* at the Vine Hill Preserve (S. Gordon, personal communication 2014).

Climate Change

The most recent literature on climate change includes predictions of hydrological changes, higher temperatures, and expansion of drought areas, resulting in a northward and/or upward elevation shift in range for many species (Intergovernmental Panel on Climate Change 2007). A modeling study by Loarie *et al.* (2008) provides an evaluation of potential trends to California's floristic communities under climate change scenarios. In general, large numbers of plant species will tend to move to higher elevations, towards the coast, or northwards. The models suggest that climate change has the potential to break up local floras, resulting in new species combinations, with new patterns of competition and biotic interactions (Loarie *et al.* 2008). Based on these models, *Clarkia imbricata* plants would likely be unable to shift their range naturally because of their dependence on specific soil characters, climate, the presumably low dispersal-potential of the species, and natural and anthropogenic barriers to dispersal (agriculture and housing developments).

6. Conservation Efforts

Conservation efforts directed at *Clarkia imbricata* include maintenance and annual monitoring by CNPS volunteers of *C. imbricata* on Vine Hill Preserve, which is owned and protected in perpetuity by CNPS. Another focus of current conservation efforts is to identify sites for outplanting. *Clarkia imbricata* seeds are stored at the University of California Botanical Garden at Berkeley and Rancho Santa Ana Botanic Garden, and the species has been successfully planted and grown in horticulture.

B. Arctostaphylos densiflora

1. Species Description and Taxonomy

Arctostaphylos densiflora is a diploid evergreen shrub with a mounded to erect form, potentially reaching 1 meter (3.3 feet) in height (Parker *et al.* 2012), and plants can reach several meters in diameter through layering (when branches become partially buried in soil or leaf litter and produce roots). Branches are black, with branchlets having fine short hairs; the leaves are oblong, narrowed at the base, 1 to 3 centimeters (0.4 to 1.2 inches) long, 0.7 to 1.7 centimeters (0.3 to 0.7 inches) wide, bright green, and shiny. The terminal inflorescence is branched, with many white or pink flowers 4 to 5 millimeters (0.15 to 0.19 inches) long. The ovary is glabrous, and the fruit is a drupe that is 5 to 6 millimeters (0.19 to 0.24 inches) wide.

Arctostaphylos densiflora is a member of the Ericaceae (heath family). The genus *Arctostaphylos* is taxonomically complex, including over 100 taxa of evergreen shrubs and trees, only 8 of which are found outside the California Floristic Province (a biodiversity hotspot covering 70% of California, extending into southwestern Oregon, a small part of western Nevada and northern Baja California, Wells 2000). Species diversity is highest along the coast of California, from Mendocino County to San Luis Obispo County, with over 30 species (Boykin *et al.* 2005). *Arctostaphylos* diversification has been attributed to local adaptation to diverse soil types, microclimates, and an increased fire frequency associated with the emergence of a progressively more severe Mediterranean-type climate (Raven and Axelrod 1978; Axelrod 1981; Axelrod 1989). Polyploidy and diploid hybridization are considered to be significant evolutionary processes involved in the rapid speciation of the genus (Stebbins and Major 1980). Due to vegetative diversification in *Arctostaphylos*, with little divergence in floral characters, there have been varying taxonomic interpretations of the genus (Jepson 1922, Eastwood 1934, McMinn 1939, Adams 1940, Wells 2000).

Arctostaphylos densiflora was first described by M.S. Baker in 1932 from specimens collected from the roadside just west of Vine Hill Schoolhouse, along Vine Hill School Road, in Sonoma County, California (Baker 1932).

2. Population Trends, Range, and Distribution

When Baker (1932) described *Arctostaphylos densiflora*, it was noted that after extensive searches for the species in the Vine Hill area, there were three known locations that supported the species, including the type locality of about 100 plants along 152 meters (500 feet) of roadside along Vine Hill School Road, which today is the Vine Hill Preserve. In addition to the population at Vine Hill Preserve, there have been two other confirmed locations of *A. densiflora*: about six plants 0.5 kilometer (0.3 mile) west of the Vine Hill Preserve on the west side of Vine Hill Road; and a single plant on the "Frei Brother's Ranch" about 2.1 kilometers (1.3 miles) south of Vine Hill Preserve. Baker (1932) stated that the remaining *A. densiflora* in the Vine Hill area are, "a relict in a region where natural vegetation is fast disappearing through an intensive system of agriculture" and the species had been reduced from a population of unknown size to a little more than 100 individuals.

Between 1947 and 1957, Sonoma County Road crews had dripped used crankcase oil over the road margin where *Arctostaphylos densiflora* occurred along Vine Hill School Road (Roof 1972). Work crews completely denuded the roadside of vegetation along Vine Hill School Road and bulldozed

and bladed the roadside. The driveways of two newly constructed homes destroyed a portion of the Vine Hill School Road colony and a farmer removed a portion of the area. Protest from Santa Rosa Junior College students and faculty and growing neighborhood awareness of the rarity of *Arctostaphylos densiflora* slowed the destruction somewhat. However, by 1963, there were only "two shrubs and one not a good one" (Roof 1972). When Roof returned to the site in 1967, there were fourteen seedlings of about 2 to 3 years of age on the formerly disturbed slope (Roof, 1972). This regeneration occurred on the bare soil exposed by scraping the roadside. In 1971, Roof again visited the Vine Hill School Road site and counted 45 *A. densiflora* plants. In 1973, the Vine Hill Preserve property was purchased by The Nature Conservancy to preserve the *A. densiflora* occurring along Vine Hill School Road.

By the early 1980s, *Arctostaphylos densiflora* growing at the Vine Hill Preserve were declining. Beginning in 1982 and continuing until 2006, Phil Van Soelen (former Vine Hill Preserve Manager) collected cuttings from plants growing on the upper slope of the preserve and planted them on old grape vineyard mounds, at 3 meter (10 foot) intervals, in the lower portion of the preserve. By 1985, the few *A. densiflora* plants that had existed along Vine Hill Road had been destroyed from roadside maintenance activities. Sometime in the early 1990s, cuttings were taken from *A. densiflora* plants growing in the botanical collection at Rancho Santa Ana Botanic Garden, whose parentage was from the Vine Hill Preserve, and were planted at Vine Hill Preserve to increase genetic diversity at the site. Some of the early plantings are now 30 years old and have merged their canopies to form a natural-appearing drift of healthy low shrubs. In 2009 there were approximately 17 plants endemic to the site on the upper slope (S. Gordon personal communication 2013). Determining the exact number of propagated established plants is difficult due to the species growth habit of layering, but in 2010 there were believed to be at least 46 individuals. Although *A. densiflora* is only known to occur at the Vine Hill Preserve and all other occurrences are believed extirpated, it is possible dormant viable seed banks still exist within the Vine Hill area (J. Herrick, personal communication 2013). In addition to the *A. densiflora* plants growing at the Rancho Santa Ana Botanic Gardens, there are several plants at the University of California Botanical Garden at Berkeley.

3. Life History and Ecology

Arctostaphylos densiflora has only been known to naturally occur on Goldridge series soils in an area referred to as the Sonoma Barrens in Sonoma County, California (see *Clarkia imbricata* section *4. Habitat* for a description of the Sonoma Barrens). *Arctostaphylos densiflora* often grows widely spaced, flowers from February through March, is bee pollinated, and hybridizes with closely related species.

Arctostaphylos densiflora is an obligate seeding species, based on its lack of a basal burl. Two basic life history patterns are found within the genus *Arctostaphylos*; plants either survive wildfire and resprout from a basal burl (sprouter) or plants are killed by fire and regenerate from seeds stored in the soil (obligate seeder). Obligate seeding *Arctostaphylos* species may require 5 to 25 years before substantial seed crops are produced (Keeley 1986). Seeds typically suffer high rates of predation (Kelly and Parker 1990). Seeds that are not consumed are slowly added to the soil seed bank, eventually reaching depths at which they can survive fire (Parker 2007). Obligate seeding *Arctostaphylos* species tend to have fire-dependent seedling recruitment, and mature stands tend to be even-aged, exhibiting little to no regeneration during fire-free intervals (Safford and Harrison 2004). A substantial proportion of the seed pool of some chaparral community species is unlikely to germinate in the absence of fire, and dormancy mechanisms minimize seed germination during

periods of low survival probability; however, a portion of the seed bank is potentially capable of germinating in the absence of fire (Keeley and Keeley 1989).

Sexual regeneration has not been observed since seedlings germinated along Vine Hill School Road in the late 1950s, as a result of the scarification of seed coats from roadside vegetation management activities. Attempts to propagate seeds using various techniques have failed (T. Robertson, personal communication 2011). Techniques included fire (seeds did not germinate), embryo rescue (seed coat was too hard to permit successful extraction of the embryo), and scarification with sulfuric acid (2% of seeds germinated consistently but died in seedling stage). When Baker described the species in 1932, it was noted that *A. densiflora* spreads by numerous seedlings as well as vegetatively through layering, and that seedlings were observed along the roadside where grading occurred. No attempts to germinate *Arctostaphylos densiflora* using fire under natural conditions have been made. However, as is the case with other obligate seeding *Arctostaphylos* species (Odion and Tyler 2002), *A. densiflora* may require fire-free periods greater than 40 years to establish a deeply buried seed bank with enough viable seeds to compensate for fire-related mortality. At this time, it is not known if *A. densiflora* seeds require fire cues such as heat, smoke and/or charate for germinating, as no seedlings have been observed as a result of fire.

4. Current Stressors

Habitat Destruction from Human Activities

The vast majority of the Sonoma Barrens had been converted to agriculture and residential housing prior to the formal description of the species in 1932. The Vine Hill Road location of *Arctostaphylos densiflora* was extirpated sometime in the early 1980s as a result of roadside maintenance activities, and the *A. densiflora* plants that occurred along Vine Hill School Road, adjacent to the Vine Hill Preserve, were also lost to roadside maintenance activities. Although the only extant location with *A. densiflora* occurs at the Vine Hill Preserve, which is not impacted by habitat destruction from human related activities, the almost complete conversion of the Sonoma Barrens to agriculture and residential housing limits the species' ability to expand.

Small Population Size and Stochasticity

With only a single population with few individuals, *Arctostaphylos densiflora* is stressed by small population size and stochastic events (See *Clarkia imbricata*, *5. Reasons for Listing and Current Threats, Factor E: Other Natural or Manmade Factors Affecting its Continued Existence, Small Population Size and Stochasticity* for additional information on this factor at Vine Hill Preserve).

Natural Reproduction vs. Cloning

An appropriate fire-return interval is typically essential to the natural regeneration and sustainability of obligate seeding *Arctostaphylos*. However, the Vine Hill Preserve is surrounded by housing development and agriculture, which severely limits the ability to experiment with the use of fire as a management tool to regenerate *A. densiflora* and limits the ability of a lightning or human ignited wildfire to reach the site. In addition, the presence of the only known occurrence of *Clarkia imbricata* and the unknown effects fire would have on this species also limit the ability to use fire as a management tool to regenerate *A. densiflora*. In general, burning on either too short or too long a time interval may represent a stressor to *A. densiflora*. Although Odion and Tyler's (2002) study of *Arctostaphylos morroensis* indicates a fire return interval of 40 years or less would eventually result in the extirpation of that obligate seeding species, too frequent a fire return interval does not represent a

significant stressor to *A. densiflora* at the Vine Hill Preserve, due to the matrix of agriculture and housing development surrounding the site, which limits the likelihood of wildfire.

Despite studies on obligate seeding *Arctostaphylos*, which found that long fire-free intervals (greater than 100 years) likely do not represent a significant stressor (Keeley and Zelder 1978; Odion and Davis 2000), this site experiences the compounding pressure of increased shading from encroaching non-native vegetation. Therefore, suppression of natural fires and the inability to use controlled fire as a management tool to naturally regenerate *A. densiflora* is itself a stressor to the species. At this time, *A. densiflora* at the Vine Hill Preserve have not reproduced from seed and the only successful propagation technique has been cloning. According to S. Gordon (personal communication 2013), some individual *A. densiflora* plants are easier to propagate from cuttings than others. As a result, cloning is resulting in a reduced gene pool (*i.e.*, only genes of plants that are easily cloned are passed along). Under this scenario, instead of a variety of genes being passed along due to survival and reproduction of plants under the natural array of environmental pressures, only genes of plants which make good cuttings are passed along. Over the long-term, if the species continues to be cloned and sexual reproduction does not occur, the ability of the species to evolve, adapt to changing climatic conditions, and reproduce naturally may be affected, ultimately resulting in further decline of the species.

Competition with Native and Non-native Invasive Species

Because *Arctostaphylos densiflora* is a shade-intolerant species and only occurs at the Vine Hill Preserve, competition with native and non-native invasive species represents a significant stressor (See *Clarkia imbricata, 5. Reasons for Listing and Current Threats, Factor E: Other Natural or Manmade Factors Affecting its Continued Existence, Competition with Native and Non-native Invasive Species* for additional information on this factor at Vine Hill Preserve).

Disease

A native fungal pathogen and a native bacterial infection are known to reduce the number of leaves of *Arctostaphylos densiflora* plants during exceptionally wet winters (P. Van Soelen, personal communication 2011). A sample of the cankers resulting from the pathogens was sent to the California Department of Food and Agriculture in 1984, and an unknown species of *Phomospsis* fungus was identified. Although these pathogens cause branch and stem dieback in *A. densiflora*, they have not been known to cause mortality. The susceptibility of *A. densiflora* to diseases could be exacerbated by other threats, such as shading by native and nonnative invasive species, lack of fire, and climate change.

The soil-borne pathogen, *Phytophthora cinnamomi*, has long been known to impact commercial and ornamental plants world-wide. *Phytophthora cinnamomi* is a fungus-like organism most closely related to diatoms and kelp (Kingdom Stramenopila). It is an introduced non-native pathogen in North America. In California, it is known to infect orchard trees, ornamental plants, and Christmas tree farms (Swiecki and Bernhardt 2003), is partially responsible for mortality in *Quercus agrifolia* (coast live oak) (Garbelotto *et al.* 2006), and is a primary pathogen of *Arbutus menziesii* (madrone), *Umbellularia californica* (California bay) and other species in a number of northern California plant communities where it has been introduced (Swiecki *et al.* 2011). *Phytophthora cinnamomi* also has been the cause of the decline and death of rare *Arctostaphylos* species, including the federally threatened *A. pallida* (pallid manzanita) in the Oakland Hills of the East San Francisco Bay region and the federally threatened *A. myrtifolia* (Ione manzanita) near Ione in the Sierra Nevada foothills. *Phytophthora cinnamomi* causes root and crown rot; and in *A. myrtifolia*, this pathogen causes decay of the root

system. The loss of functional roots causes the plant to desiccate (Swiecki and Bernhardt 2003). Because plants infected by *P. cinnamomi* become water-stressed, opportunistic pathogens such as *Botryosphaeria* spp. may also become more severe on these plants. This may lead to confusion as to which disease(s) may be affecting a given *Arctostaphylos* stand (Swiecki and Bernhardt 2003).

Phytophthora cinnamomi is primarily spread to new areas through the movement of infested soil by humans, particularly on vehicle tires, but also on shoes, tools, and equipment that become contaminated with infested soils (Swiecki and Bernhardt 2003). In addition, *P. cinnamomi* has been isolated from container stock purchased from several native plant nurseries; suggesting nursery stock used for restoration projects or for ornamental purposes in residential areas provides a vector for this disease (Swiecki *et al.* 2011). Many areas showing plant mortality caused by *P. cinnamomi* are associated with hiking trails and landscapes with ornamental plants. Swiecki *et al.* (in press, page 6) tested *A. menziesii* plants purchased from four nurseries and found them to be infested with four *Phytophthora* species that cause root infections or stem cankers, including *P. cinnamomi.*

Once the disease has been introduced into an area, the movement of the pathogen is facilitated by water flow, especially downhill. Swiecki *et al.* (2005) noted that the local spread of *P. cinnamomi* in *Arctostaphylos myrtifolia* occurs during the wet season at a cross slope and upslope rate of approximately 0.25 meter (0.8 foot) per year. Down slope spread has been calculated at 2 meters (6.5 feet) per year, presumably due to transport via flowing water (Swiecki *et al.* 2005). Over a longer time interval, Swiecki and Bernhardt (2012) have documented that *P. cinnamomi* has spread at average rates of about 1 meter (3.3 feet) per year in relatively level sites within *Arctostaphylos myrtifolia* stands.

The potential introduction of *Phytophthora cinnamomi* to Vine Hill Preserve represents a long-term and substantial stressor, as this pathogen can persist in the environment in the absence of susceptible hosts, surviving in the soil in infected roots, or as long-lived resident spores (Swiecki and Bernhardt 2003). Prevention of this disease depends on the exclusion of the pathogen from areas that contain host plants. Although there is no known cure for plants that have been infected, phosphite (neutralized phosphorous acid), a biodegradable systemic fungicide that, in part, potentiates plant defense mechanisms so that there is a more rapid and robust response to the pathogen, can be used to treat plants infected with *P. cinnamomi.* Phosphite stresses *P. cinnamomi*, causing it to release chemical signals that trigger the natural defense mechanisms of the host plant, thereby reducing the ability of *P. cinnamomi* to colonize and reproduce within the host (Suddaby and Liew 2008). The dosage of phosphite required to protect individual plant species is not universal. Applications that are too high for a particular plant species will have side-effects, such as leaf burning and a reduction in pollen viability, however, these effects may be temporary (Suddaby and Liew 2008). The efficacy of phosphite is not permanent and reapplication is required. The appropriate treatment regime (*i.e.*, season, dose, application type, frequency, etc.) for *Arctostaphylos densiflora* is not known, as no plants are known to be infected, but treatment frequency could be as often as once every 2 years.

Although *Phytophthora cinnamomi* has not been identified at the Vine Hill Preserve and the susceptibility of *Arctostaphylos densiflora* to this pathogen is not known, the site is managed by CNPS volunteers, people who tend to spend considerable time in garden and nursery settings, places where the potential for contact with soils contaminated with *P. cinnamomi* is relatively high. Thus, though CNPS volunteers are more likely than the general public to be aware of precautions necessary to prevent infections, they are also potential vectors of this pathogen if preventative hygienic measures are not implemented.

Hybridization

Hybridization naturally occurs between *Arctostaphylos* species, and hybridization has been cited as one of the mechanisms to explain the rapid speciation within the genus. *Arctostaphylos* species are bee-pollinated and often naturally hybridize with other *Arctostaphylos* species that occur within the foraging distance of the local bee community. Both Baker (1932) and Roof (1972) noted what they believed were hybrids between naturally occurring *A. manzanita* and *A. densiflora* in the Vine Hill Area. While most *Arctostaphylos* are diploid, about 30 percent are tetraploid. Differences in ploidy level are not a complete barrier to hybridization, and several diploid-tetraploid crosses have been observed in the field (Wahlert *et al.* 2006). Hybridization does occur between *A. densiflora* (diploid, n =13) and *A. manzanita* (tetrapoid, n = 26) at the Vine Hill Preserve; however, based on ploidy levels, these hybrids and backcrosses would most likely be infertile. Although the seed or offspring would likely be infertile, the pollination of *A. densiflora* by other species of *Arctostaphylos* would result in reduced seed crops of pure *A. densiflora*. This stressor would be particularly significant if pollination of *A. densiflora* by other *Arctostaphylos* species were at such a level that little to no pure *A. densiflora* seed were produced (pollen swamping).

5. Conservation Efforts

The publication of an article by Roof (1972) to garner support to save *A. densiflora* led to the purchase of the Vine Hill Preserve property by The Nature Conservancy and the deeding of the property to CNPS for the creation of the Vine Hill Preserve. Since then, CNPS volunteers have managed native and non-native species that compete with the rare plants at the site.

C. Ceanothus foliosus var. *vineatus*

1. Species Description and Taxonomy

Ceanothus foliosus var. *vineatus* is an evergreen shrub in the family Rhamnaceae (Wilken 2012). The species was first described in 1942 by McMinn from specimens collected along Vine Hill School Road (Vine Hill Preserve). *Ceanothus foliosus* var. *vineatus* is an open, mat- to mound-like spreading shrub, often less than 0.5 meter (1.5 feet) tall, but capable of reaching 0.8 meter (2.5 feet) in height. The petiole (the stalk attaching the leaf to the stem) is 1 to 3 millimeters (0.04 to 0.12 inch). Its leaves are alternate, with a leaf blade that is 5 to 20 millimeter (0.2 to 0.8 inch) long, 3 to 13 millimeter (0.12 to 0.5 inch) wide, widely elliptic to obovate (teardrop-shaped), and somewhat wavy. Undersides of leaves are glaborous (smooth), except the veins, with margins that are not thick and not rolled under, gland-toothed or not, with 31 to 42 teeth, and the glands are generally dark (Wilken 2012). The fruits are small capsules containing about 12 hard-coated seeds that are 3 to 4 millimeters (0.12 to 0.16 inch) wide.

2. Population Trends, Range, and Distribution

In the description of *Ceanothus foliosus* var. *vineatus*, McMinn (1942) noted that the species "occurs in a few scattered locations in Sonoma and Mendocino counties, California. It apparently was more abundant and had a wider range of distribution on the rolling hills before the planting of orchards." McMinn (1942) provides the location of the type specimen as "near Vine Hill School," which probably refers to what is now the Vine Hill Preserve. The 28 plants that currently exist at the Vine

Hill Preserve were established in their current location from cuttings taken from the small number of plants that once occurred near the southern boundary of the preserve (S. Gordon, personal communication 2013). Those plants were likely destroyed by the same roadside maintenance activities that resulted in the loss of many of the original *Arctostaphylos densiflora* plants that occurred along the roadside.

Although McMinn (1942) indicated that *Ceanothus foliosus* var. *vineatus* occurred near "Idol House," Mendocino County, we have been unable to locate any references to an "Idol House" in Mendocino County. According to the California Natural Diversity Database (2013), there is an occurrence approximately 3 kilometers (2 miles) southeast of the Vine Hill Preserve, along Guerneville Highway, about 6 kilometers (4 miles) west of the City of Santa Rosa. This occurrence dates to 1965, and the location is accurate to 0.6 kilometer (0.4 mile). However, based on aerial photographs, most of the area has been converted to agriculture and/or consists of wetlands; in addition, surveys of the area have not located any *C. foliosus* var. *vineatus*, and this population is believed extirpated (J. Herrick, personal communication 2013). In 2004, a population of *C. foliosus* var. *vineatus* was discovered just north of the City of Sebastopol in Sonoma County (Wahlert and Van Soelen 2005). This population consists of about ten individuals, distributed linearly along the northeast side of a bike trail, east of Hurlbut Avenue.

3. Life History and Ecology

Ceanothus foliosus var. *vineatus* is an obligate-seeding species (Parker 1984), and is shade intolerant. Flowers are bee pollinated. Flowering and most vegetative growth occurs from March to May. Floral primordia (the earliest recognizable stage of flower development) for the following year's flowers are produced in May. After pollination, fruits develop in late spring to early summer. Seed production varies from year to year, fluctuating by several orders of magnitude; Keeley (1977) observed that higher fruit production seemed to be correlated to higher precipitation the year prior to fruit production, likely related to floral primordial being produced the year prior to fruit production. Seeds are cast from June through August. Although *C. foliosus* var. *vineatus* is evergreen, many leaves are lost in the summer, probably due to water stress, and then eventually replaced.

As is the case with the genus *Arctostaphylos*, two basic life history patterns are found within the genus *Ceanothus*. Plants either sprout vegetatively from the root crown or regenerate from seeds stored in the soil following fire. Seeds typically suffer high rates of predation (Kelly and Parker 1990). Seeds that are not consumed are slowly added to the soil seed bank, eventually reaching depths at which they can survive fire (Keeley 1977). Obligate seeding *Ceanothus* species tend to have fire-dependent seedling recruitment and mature stands tend to be even-aged, exhibiting little to no regeneration during fire-free intervals (Keely and Zelder 1978). For *Ceanothus* species, seeds are stimulated by a heat pulse that travels through the soil column after a fire passes. The heat pulse collapses some cells in the area where it was attached inside the ovary, permitting water to enter the seed (Parker 2007). Once water enters the seed it expands rapidly, cracking open the seed coat and permitting the embryo to germinate.

A substantial proportion of the seed pool of some chaparral species is unlikely to germinate in the absence of fire, and dormancy mechanisms minimize seed germination during periods of low survival probability; however, a portion of the seed bank is potentially capable of germinating in the absence of fire (Keeley and Keeley (1989). Lawson *et al.* (2010) modeled the effects of altered fire

regimes on an obligate-seeding *Ceanothus* species and found that a fire return interval of 35 to 50 years would optimize population size, but below average intervals of 35 years, abundances declined rapidly and population trajectories became unstable and declined. These data suggest that a higher fire frequency than once every 35 years would not be conducive for species persistence. In contrast, with average fire return intervals exceeding 50 years, population trajectories were relatively stable (Lawson *et al.* 2010).

Ceanothus foliosus var. *vineatus* have hard waxy seed coats. Seeds have been sprouted using cold stratification (pretreating seeds to simulate natural winter conditions that a seed must endure before germination) as a pretreatment (P. Van Soelen, personal communication 2011). Additional successful germination trials were conducted at Rancho Santa Ana Botanic Garden using hot water as a pretreatment (M. Wall, personal communication, 2011). Natural regeneration by seed, as a result of soil disturbance not related to fire (*e.g.*, via rodent activity), is occurring at the Vine Hill Preserve. These individuals appear to have been derived from the portion of the seedbank able to germinate in the absence of fire.

4. Current Stressors

Habitat Destruction from Human Activities

The vast majority of the Sonoma Barrens had been converted to agriculture and residential housing prior to the formal description of the species in 1942. Although the population of *Ceanothus foliosus* var. *vineatus* that occurs at the Vine Hill Preserve is not impacted by habitat destruction from human related activities, the almost complete conversion of the Sonoma Barrens to agriculture and residential housing limits the ability of the species to expand. In addition, the *C. foliosus* var. *vineatus* plants that occur along the Sebastopol bike path could be impacted by vegetation management activities. Though no damage has been observed to date, Sonoma Valley Regional Park implements no management plan for protection of this species, so pathside routine maintenance (*i.e.*, pruning or herbicide use) could occur and result in damage to developing seed and/or loss of plant vigor leading to reduced fitness (S. Gordon, personal communication 2014).

Small Population Size and Stochasticity

With only two populations, each with few individuals, *Ceanothus foliosus* var. *vineatus* is stressed by small population size and stochastic events (See *Clarkia imbricata*, *5. Reasons for Listing and Current Threats, Factor E: Other Natural or Manmade Factors Affecting its Continued Existence, Small Population Size and Stochasticity* for additional information on this factor at Vine Hill Preserve).

Fire

An appropriate fire return interval is typically essential to the natural regeneration and sustainability of obligate seeding species of *Ceanothus*. However, the Vine Hill Preserve is surrounded by housing development and agriculture, which limits the ability to experiment with the use fire as a management tool to regenerate *C. foliosus* var. *vineatus* and limits the potential of a lightning- or human-ignited wildfire reaching the site. In addition, the presence of the only known natural population of *Clarkia imbricata* and the unknown effects fire would have on this species also limits the ability to use fire as a management tool to regenerate *C. foliosus* var. *vineatus*. Too frequent a fire return interval is often cited as a stressor to obligate seeding species of *Ceanothus* (Keeley and Zelder 1978, Lawson *et al.* 2010). Lawson *et al.* (2010) found that a fire return interval less than 35 years was near the lower average fire return interval threshold for the species persistence in *C. verrucosus*;

however, they also note that too long of a fire return interval may be encountered when very isolated small habitat patches are conserved within the most developed portions of urban landscapes. This creates a condition where vegetative succession leads to overcrowding, thereby representing a stressor to the species. This is likely the case for *C. foliosus* var. *vineatus* at the Vine Hill Preserve and Sebastopol bike path, as both locations consist of a small number of individuals on small habitat patches surrounded by agriculture and houses; therefore, it does not appear that too frequent a fire return interval represents a significant stressor at the Vine Hill Preserve.

Competition with Native and Non-native Invasive Species

Because *Ceanothus foliosus* var. *vineatus* is a shade-intolerant species and only occurs at the Vine Hill Preserve and along a bike path near Sebastopol, competition with native and non-native invasive species represents is a stressor for the species (See *Clarkia imbricata, 5. Reasons for Listing and Current Threats, Factor E: Other Natural or Manmade Factors Affecting its Continued Existence, Competition with Native and Non-native Invasive Species* for additional information on this factor at Vine Hill Preserve). The Sebastopol bike path occurrence is currently being shaded by trees and shrubs growing along the path and within the backyards of adjacent properties. These *C. foliosus* var. *vineatus* individuals could soon face decreased vigor and therefore reduced fitness, if shading continues with the growth of neighboring invasive species.

5. Conservation Efforts

Ceanothus foliosus var. *vineatus* occurs on the Vine Hill Preserve, which is managed by volunteers with the California Native Plant Society. Management at the site primarily involves the removal of competing native and nonnative vegetation.

II. Recovery Program

A. *Clarkia imbricata* Recovery Strategy

Clarkia imbricata, *Arctostaphylos densiflora,* and *Ceanothus foliosus* var. *vineatus* historically coexisted together on the Sonoma Barrens. A natural fire regime in the region likely created openings in the community for *C. imbricata* and played a large role in triggering germination of *A. densiflora* and *C. foliosus* var. *vineatus* seed. However, it is likely that the natural processes, such as fire, that created the Sonoma Barrens and supported native species have been permanently changed, largely due to land conversion and incompatible management.

The loss of these natural processes has resulted in unchecked vegetative succession and shading out of *Clarkia imbricata.* This places *C. imbricata* at odds with *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus*, as *C. imbricata* can be shaded out by these taller shrubs. Further, the introduction of non-native *Holcus lanatus* has provided additional stress on the species, by way of competition for light, space, nutrients and water. At this time, the primary threats to *C. imbricata* are: 1) small population size and stochasticity and 2) competition with native and nonnative plants. To ameliorate these threats, the most important component of this recovery strategy for *C. imbricata* is to establish and secure additional populations, and dedicate funding for perpetual management of competing vegetation for all populations. Also, research should be conducted to determine the extent of genetic variability of *C. imbricata.* A genetics management plan should then be developed to help guide seed multiplication efforts associated with future outplantings. Research addressing gaps in knowledge (such as demographics) should be carried out that allows a population viability analysis to be conducted on *C. imbricata* to determine the likelihood of persistence of the species into the future.

B. Community Conservation Strategy

Similar to *Clarkia imbricata* at Vine Hill Preserve, the non-federally listed species, *Arctostaphylos densiflora* and *Ceanothusfoliosus* var. *vineatus,* are stressed by the lack of a disturbance mechanism (fire) to regenerate populations by seed, thereby potentially suffering reduced genetic diversity. Therefore, the most important conservation need of these two species of concern is to establish and secure additional populations of these species as well.

Reintroductions of these three species could occur in concert or separately. Ideally, management would promote a mosaic habitat similar to that in which the three species historically coexisted. Without fire to create this mosaic, and even potentially with fire, *Clarkia imbricata* may need management to control shading plants. Although *Arctostaphylos densiflora* and *Ceanothusfoliosus* var. *vineatus* may shade *C. imbricata* under some conditions, they are also preferred members of the native plant community coexisiting with *C. imbricata.* And these native species are not a significant threat to *C. imbricata* in a functioning community and in the absence of non-native plants. Therefore, management should be done in a manner to promote these and other native species at a community level while providing appropriate protections to *C. imbricata.* This can be accomplished through thoughtful preserve design along with ongoing management at the community level. If all three species are introduced at the same site, it will be important to secure tracts of Sonoma Barrens habitat, either where fire can be used as a management tool or where *A. densiflora* or *C. foliosus* var.

vineatus can be included as part of the managed community. Appropriate management tools will largely be determined by the size, configuration, and location of the preserve, but could include fire or routine weed management to remove non-native shrubs and create opportunity for native species. On a large parcel, it would also be possible to allow natural succession of habitat for a longer period of time before deciding whether to selectively thin native (and in some cases rare) shrubs if fire is not an option as a management tool.

Arctostaphylos densiflora is also impacted by hybridization with non-endemic *Arctostaphylos* species and the introduction of the pathogen *Phytophthora cinnamomi*. Therefore, in addition to managing competition with native and nonnative plants, management actions specific to alleviating the other stressors to *A. densiflora* and *Ceanothus foliosus* var. *vineatus* need to ultimately be developed.

C. Recovery Goal

The ultimate goal of this draft recovery plan is to reduce the threats to *Clarkia imbricata* and ensure its long-term viability in the wild, allowing for its removal from the list of threatened and endangered species. The interim goal is to sufficiently reduce the threats to *C. imbricata* and ensure the species is no longer likely to become extinct in the foreseeable future, allowing for the species to be downlisted from endangered to threatened status. The secondary goal is to sufficiently reduce the stressors to *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* so as to preclude the need for the protection provided by federal listing.

D. Recovery Objectives

To meet the recovery goals, the following objectives have been identified:

- Restore Sonoma Barrens habitat and establish *Clarkia imbricata*.
- Manage native and non-native vegetation that competes with *Clarkia imbricata*.
- Ensure locations with *Clarkia imbricata* are secure from incompatible uses.

E. Recovery Criteria

An endangered species is defined in the Act as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. When we evaluate whether or not a species warrants downlisting or delisting, we consider whether the species still meets either of these definitions. A recovered species is one that no longer meets the Act's definitions of threatened or endangered due to the alleviation of threats. Determining whether a species should be downlisted or delisted requires consideration of the same five categories of threats which were considered when the species was listed and which are specified in section 4(a)(1) of the Act.

Recovery criteria are conditions that, when met, are likely to indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Because the appropriateness of delisting is assessed by evaluating the five threat factors identified in the Act, the recovery criteria below pertain to and are organized by these factors. These recovery criteria are our best assessment at this time of what needs to be completed so that the

species may be removed from the list of threatened and endangered species. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is likely to change as more is learned about the species and its threats, it is possible that a status review may indicate that delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met but a status review may indicate that downlisting or delisting is still not warranted.

Recovery criteria are not developed for non-listed species. For the species of concern covered in this draft recovery plan, we assume that conservation efforts will be a success when viable, self-sustaining wild populations of these species are conserved in perpetuity.

Downlisting Criteria

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

Since all wild populations of *Clarkia imbricata* have been extirpated and the population at the Vine Hill Preserve is protected, habitat destruction, modification, or curtailment does not represent a significant threat to this species at this time. However, with the establishment of *C. imbricata* to meet the recovery criteria defined in E/1, habitat destruction, modification, or curtailment will need to be addressed as a threat to newly established locations.

To downlist *Clarkia imbricata,* sites where *C. imbricata* is newly established must be protected from Factor A threats. This will have been accomplished when the following has occurred:

A/1 All populations of *C. imbricata* counted toward recovery, as defined in E/1, are protected from incompatible uses with a binding legal commitment from the landowner, and funding has been secured for the perpetual implementation of the management plans defined in E/2.

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

Overutilization for any purpose is not known to threaten *Clarkia imbricata* at this time. Therefore, no recovery criteria have been developed for this factor.

FACTOR C: Disease or Predation

Neither disease nor predation is known to threaten *Clarkia imbricata* at this time. Therefore, no recovery criteria have been developed for this factor.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms is not known to threaten *Clarkia imbricata* at this time. Therefore, no recovery criteria have been developed for this factor.

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

Other natural or manmade factors believed to affect the continued existence of *Clarkia imbricata* include: 1) small population size and stochasticity, 2) competition with native and nonnative plants, and 3) climate change.

It is possible that threats to *C. imbricata* from climate change cannot be ameliorated. While other species may, over time, shift to adjacent (higher or more northerly) habitat to follow suitable climatic conditions, this cannot occur for species tied to a specific soil type, which is static. In addition, even if the species retains flexibility in regards to soil association, the historical range is now highly developed so migration of suitable habitat to nearby undeveloped lands is unlikely. The criteria presented here apply to reduction or amelioration of the other Factor E threats.

Additionally, very little is known about the historical abundance at any of the three historical locations of *C. imbricata* or of the distribution of its populations. Recovery criteria below pertaining to the number of populations and number of individuals per population were decided upon after much coordination with *C. imbricata* experts and comparison to species with similar life histories and constraints. However, they should be revisited and refined as necessary given results of recommended research on population viability, described in the stepdown narrative.

To downlist *Clarkia imbricata* the Factor E threats must be reduced. This will have been accomplished when the following have occurred:

E/1 There are **three separate locations** with *C. imbricata*, each consisting of **2 acres**[1] or more, and each with a 10-year average of **4,000 plants** or more. Due to the long-term persistence of the species at the Vine Hill Preserve (smaller than 2 acres) and the successful management of the site by CNPS, the Vine Hill Preserve may be counted as one of the three locations if it meets all other aspects of the downlisting criteria. For the purpose of meeting this criterion, a separate location is defined as a group of *C. imbricata* plants sufficiently separated from any other group of *C. imbricata* as to minimize the potential that a typical single stochastic event (e.g., fire or storm damage) would affect more than one location with *C. imbricata*.

E/2 Develop a management plan to control competing native and non-native vegetation. Competing native and non-native vegetation should be controlled at a level whereby years with less than 4,000 *C. imbricata* plants at each location counted towards recovery (as defined in delisting criterion E/1) cannot be attributable to competition with native and non-native vegetation. Also, there is a monetary commitment in place to continue control in perpetuity for all locations counted toward recovery (as defined in downlisting criterion E/1).

[1] Considering that the species has shown an ability to persist relatively well long-term on a small 1.5-acre parcel, we concluded that significantly larger parcels were not necessary for recovery. In addition, vegetation management to reduce competition is relatively easier on smaller parcels and there exists a scarcity of suitable undeveloped Sonoma Barrens habitat for future populations. Therefore, we determined that the target minimum size for additional populations should be 2 acres.

Delisting Criteria

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

To delist *Clarkia imbricata,* sites where *C. imbricata* is newly established must be protected from Factor A threats. This will have been accomplished when the following has occurred:

A/1 All populations of *C. imbricata* counted toward recovery, as defined in E/3, are protected from incompatible uses with a binding legal commitment from the landowner, and funding has been secured for the perpetual implementation of the management plans defined in E/4.

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

Overutilization for any purpose is not known to threaten *Clarkia imbricata* at this time. Therefore, no recovery criteria have been developed for this factor.

FACTOR C: Disease or Predation

Neither disease nor predation is known to threaten *Clarkia imbricata* at this time. Therefore, no recovery criteria have been developed for this factor.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms is not known to threaten *Clarkia imbricata* at this time. Therefore, no recovery criteria have been developed for this factor.

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

To delist *Clarkia imbricata* the Factor E threats must be eliminated. This will have been accomplished when the following have occurred:

E/1 There are **five separate locations** with *C. imbricata*, each consisting of **2 acres** or more, and each with a ten year average of **4,000 plants** or more[2]. Due to the long-term persistence of the species at the Vine Hill Preserve and the successful management of the site by CNPS, the Vine Hill Preserve (smaller than 2 acres) may be counted as one of the five locations if it meets all other aspects of the delisting criteria. For the purpose of meeting this criterion, a separate location is defined as a group of *C. imbricata* plants sufficiently separated from any other group of *C.*

[2] Recovery criteria specifying number and size of populations was suggested by species experts after considering the species' habitat requirements and what little is known about historic number and size of populations. Additional populations provide redundancy to provide a margin of safety for the species to be able to withstand catastrophic events.

imbricata as to minimize the potential that a single stochastic event (e.g., fire or storm damage) would affect more than one location with *C. imbricata*.

E/2 Competing native and non-native vegetation are controlled to a level whereby years with less than 4,000 *C. imbricata* plants at each location counted towards recovery (as defined in delisting criterion E/1) cannot be attributable to competition with native and non-native vegetation. Also, there is a monetary commitment in place to continue control in perpetuity for all locations counted toward recovery (as defined in delisting criterion E/1).

III. Recovery Action Narrative and Implementation Schedule

A. Recovery Action Narrative

The actions identified below are those that, based on the best available science, are necessary to bring about the recovery of *Clarkia imbricate* and ensure its long-term conservation. However, these actions are subject to modification as may be indicated by new findings, changes in species status, and the completion of other recovery actions. The most stepped down (detailed) action has been assigned a priority for implementation, according to our determination of what is most important for the recovery of these species based on the life history, ecology, and threats (see section I. Species Accounts of this document).

Key to Terms and Acronyms Used in the Recovery Action Narrative and Implementation Schedule:

Priority numbers are defined per Service policy (Service 1983) as:

Priority 1: An action that must be taken to prevent extinction or to prevent a species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline of the species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

The following Recovery Actions Narrative provides detail of the actions necessary to achieve full recovery. The priority assigned to each action is specified within parentheses at the end of the description. Following the Recovery Action Narrative are three community conservation actions that are recommended in order to improve vegetative community health as a whole and which may protect *A. densiflora* and *C. foliosus* var. *vineatus* to the extent that the need for protection through federal listing is precluded.

The numeric recovery priority system follows that of all Service recovery plans. Because situations change over time, priority numbers must be considered in the context of past and potential future actions at all sites. Therefore, the priority numbers assigned are intended to guide, not to constrain, the allocation of limited conservation resources.

1. Establish additional populations of *Clarkia imbricata*.

1.1 Determine how the soil of the Sonoma Barrens is associated with the Goldridge acidic sandy loam soil series and identify parcels within the Vine Hill area that exhibit Sonoma Barrens characteristics (**Priority 1**).

Although undeveloped parcels should be prioritized for the establishment of *C. imbricata*, it is not required that parcels identified as possessing Sonoma Barrens soil characteristics are currently

uncultivated, as demonstrated by the successful restoration of the Vine Hill Preserve from vineyard and the subsequent establishment of *Clarkia imbricata* at the site. Based on significant conversion of the Vine Hill area to agriculture and housing developments and the lack of public land in the area, it may be necessary to restore cultivated lands (such as orchards or vineyards) to meet recovery criteria E/1 and E/3.

1.2 Reintroduce *Clarkia imbricata*. Based on 1.1, purchase properties and/or work with land owners to restore sites to native vegetation compatible with *Clarkia imbricata* management and establish *C. imbricata* (**Priority 1**).

1.3 Survey *Clarkia imbricata* reintroduction sites annually to determine abundance and extent (**Priority 2**).

1.4 Secure binding legal commitments from landowners guaranteeing the protection of *Clarkia imbricata* reintroduction sites from incompatible uses **(Priority 1)**.

2. Monitor and manage competing native and non-native vegetation affecting *Clarkia imbricata*.

2.1 Develop and implement site-specific native and nonnative vegetation management plans for each *Clarkia imbricata* reintroduction site counted toward recovery (**Priority 1**).

Habitat management plans should focus on tracking and controlling vegetation that competes for light and space with *C. imbricata* and annual population monitoring of *C. imbricata*.

At sites where *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* are also present, plans should include balancing the available light and space appropriately for *C. imbricata* in consideration of needs of *A. densiflora* and *C. foliosus* var. *vineatus*.

2.2 Secure monetary commitments to ensure management plans are implemented in perpetuity (**Priority 2)**.

3. Conduct research.

3.1 Conduct research leading up to and including the development of a population viability analysis for *Clarkia imbricata* **(Priority 1).**

Topics of research should include determination of amount of seed set, seed viability, recruitment of plants from seed bank, seedling survival, likelihood of population persistence, population growth rate, factors that influence population viability, life stage most critical for population viability, and other factors that limit the establishment of populations.

3.2 Conduct research to determine levels of genetic diversity and inbreeding coefficients, and model the rate at which genetic diversity can be expected to be lost due to genetic drift under various population sizes of *Clarkia imbricata* (**Priority 3**).

3.3 Use results of Action 3.2 to develop a genetics management plan to maintain genetic diversity for *Clarkia imbricata* (**Priority 3**).

B. Community Conservation

1) Develop and implement *Phytophthora cinnamomi* introduction avoidance protocol for each site with *Arctostaphylos densiflora* or planned for *A. densiflora* establishment. Such a plan would include hygienic methods to sterilize and remove potentially contaminated soils prior to entering sites, avoiding entering sites during wet conditions, and clearly defining ingress and egress routes that would avoid spread to *A. densiflora.* Prior to entering sites with *A. densiflora* or planned for *A. densiflora* establishment, individuals should be educated as to the potential impact that *P. cinnamomi* may have on *A. densiflora*, how this pathogen is spread, and measures being implemented to avoid its spread.

2) Establish and manage stands of *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* at large sites within Sonoma Barrens habitat restored for *Clarkia imbricata,* where appropriate and in a manner that will discourage competition with *C. imbricata* for light or space. If techniques to germinate *A. densiflora* and/or *C. foliosus* var. *vineatus* from seed have been determined, attempts should be made to establish them from seedlings or seed. The location chosen for establishing *A. densiflora* should be chosen to minimize the potential spread of *Phytophthora cinnamomi* (*e.g.*, upslope of roads, trails, and areas where water accumulates). When possible, controlled use of fire (*i.e.,* a burn box) should be allowed to stimulate germination of the seed bank of *C. foliosus* var. *vineatus* and *A. densiflora* (should the research described above indicate this is appropriate). In the event regeneration of *A. densiflora* occurs from the seed bank, management should include the identification and removal of hybrids. Management should also include control of competing native and nonnative vegetation that threaten to reduce vigor or seed production of *A. densiflora* or *C. foliosus* var. *vineatus*.

3) Experiment with fire and/or soil disturbance to stimulate seed germination of *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* on Sonoma Barrens soils.

C. Implementation Schedule

The following implementation schedule outlines actions and estimated costs for this draft recovery plan. This schedule prioritizes actions, provides an estimated timetable for performance of actions, indicates the responsible parties, and estimates costs of performing

actions. Cost estimates are provided for the entire recovery period (estimated to be 15 years) as well as detailed for the first 5 years of the recovery period. These actions, when accomplished, should further the recovery and conservation of the listed species.

Key to additional terms and acronyms used in the Implementation Schedule:

Definition of action durations and costs:

Number: The predicted duration of the action in years or the cost of the action.

Ongoing: An action that is currently being implemented and will continue throughout the recovery period.

Continual: An action that is not currently being implemented but will be implemented continuously throughout the recovery period once begun.

Responsible Parties:

Responsible parties are those agencies who may voluntarily participate in any aspect of implementation of particular tasks listed within this draft recovery plan. Responsible parties may willingly participate in project planning, funding, staff time, or any other means of implementation.

USFWS – United States Fish and Wildlife Service
UCBG – University of California Botanical Garden
CDFW – California Department of Fish and Wildlife
CNPS – California Native Plant Society
CONS – Consultant
OWN – Entity that owns or administers subject land

Implementation Schedule for the Draft Recovery Plan for *Clarkia imbricata*

Action Number	Priority	Description	Duration	Responsible Parties	Cost Estimate (in $1,000 units)						Comments
					Total	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	
1.1	1	Determine how the soil of the Sonoma Barrens is associated with the Goldridge acidic sandy loam soil series and identify parcels within the Vine Hill area that exhibit Sonoma Barrens characteristics.	1 year	CONS	30	30	-	-	-	-	
1.2	1	Reintroduce *C. imbricata*. Based on 1.1, purchase properties and/or work with land owners to restore sites to native vegetation compatible with *C. imbricata* management and establish *C. imbricata.*	10 years	USFWS, CNPS, CDFW, OWN	700	-	-	-	-	-	$50,000/acre purchase; $20,000/acre to restore, times 10 acres.
1.3	2	Survey *C. imbricata* reintroduction sites annually to determine abundance and extent.	Ongoing	CNPS, CONS	100	10	10	10	10	10	10 days/year @$1,000/day, times 10 years
1.4	1	Secure binding legal commitments from landowners guaranteeing the protection of *C. imbricata* reintroduction sites from incompatible uses.	1 year	USFWS, CNPS, CDFW, OWN	10	-	-	-	-	-	Legal fees.
2.1	1	Develop and implement site-specific native and nonnative vegetation management plans for each *C. imbricata* reintroduction site counted toward recovery.	Continual	CNPS, OWN	120	30	10	10	10	10	$20,000 to develop; $10,000/year to implement, times 10 years.
2.2	2	Secure monetary commitments to ensure management plans are implemented in perpetuity.	10 years	CNPS, OWN	1,000	-	-	-	-	-	$200,000 endowment per site, times 5 sites.
3.1	1	Conduct research leading up to and including the development of a population viability analysis for *C. imbricata.*	1 year	CONS, USBG	31	31	-	-	-	-	

Action Number	Priority	Description	Duration	Responsible Parties	Cost Estimate (in $1,000 units)						Comments
					Total	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	
3.2	3	Conduct research to determine levels of genetic diversity and inbreeding coefficients, and model the rate at which genetic diversity can be expected to be lost due to genetic drift under various population sizes.	1 year	CONS	80	80	-	-	-	-	
3.3	3	Use results of Action 3.3 to develop a genetics management plan to maintain genetic diversity for *C. imbricata*.	1 year	CONS	55	55	-	-	-	-	

Focal Recovery Actions for *Clarkia imbricata* recovery= $2,126,000

Community Conservation

Description	Duration	Responsible Parties	Cost Estimate (in $1,000 units)	Comments
1) Experiment with fire and/or soil disturbance to stimulate seed germination of *Arctostaphylos densiflora* and *Ceanothus foliosus* var. *vineatus* on Sonoma Barrens soils.	1 year	CONS, OWN, USBG	50	
2) Establish and manage stands of *A. densiflora* and *C. foliosus* var. *vineatus* at large sites within Sonoma Barrens habitat restored for *C. imbricata*, where appropriate and only if it has been determined these species will not compete with *C. imbricata* for light or space.	10 years	USFWS, CDFW, CNPS, OWN, UCBG	200	$20,000/acre to restore, times 10 acres. However, no additional cost, if done in association with *Clarkia imbricata* introduction.
3) Develop and implement *Phytophthora cinnamomi* introduction avoidance protocol for each site with *A. densiflora* or planned for *A. densiflora* establishment.	Continual	CNPS, OWN	60	$10,000 to develop, $5,000/year to implement, times 10 years

Focal Recovery Actions plus Community Conservation Actions = $2,436,000

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