U.S. Fish & Wildlife Service

Species Biological Report for

Franciscan Manzanita
(*Arctostaphylos franciscana*)

Photo courtesy of Shelley Estelle

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Lead Authors:

Elizabeth Warne, formerly Sacramento Fish and Wildlife Office
Michael Chasse, National Park Service, Golden Gate National Recreation Area

Other Contributors:

Valary Bloom, Sacramento Fish and Wildlife Office
Jess Gambel, Presidio Trust
Dionisio Gamoso, Presidio Trust
Josh Hull, Sacramento Fish and Wildlife Office
V. Thomas Parker, San Francisco State University
Ben Solvesky, formerly Sacramento Fish and Wildlife Office
Lew Stringer, Presidio Trust
Ted Swiecki, Phytosphere Research
Kirsten Tarp, Sacramento Fish and Wildlife Service
Terri Thomas, Presidio Trust
Michael Vasey, San Francisco State University
Betty Young, Golden Gate National Parks Conservancy
David Yam, California Department of Transportation

This Species Biological Report is a comprehensive review of the biology of Franciscan manzanita (*Arctostaphylos franciscana*) and provides a scientific assessment of the species' status and viability, including those factors that impact or are likely to impact the species. This report informs the Draft Recovery Plan for Franciscan Manzanita (*Arctostaphylos franciscana*)(U.S. Fish and Wildlife Service (Service) 2018), which presents our strategy for the conservation of the species. A Recovery Implementation Strategy, which provides an expanded narrative for recovery activities and an implementation schedule, is available at https://ecos.fws.gov. This Species Biological Report and the Recovery Implementation Strategy will be updated on a routine basis as necessary.

EXECUTIVE SUMMARY

Franciscan manzanita was federally-listed as endangered under the Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 *et seq.*) (Act) in 2012 and has a recovery priority number of 5, indicating the taxon is a species, faces a high degree of threat, and has a low potential for recovery (Service 2012). Critical habitat was designated for Franciscan manzanita in 2013 (Service 2013)(Figure 1). No 5-year status reviews have been written by the Service for this species. The State of California has not listed or designated special status for Franciscan manzanita under the California Endangered Species Act. Franciscan manzanita has been known to occur only on the San Francisco peninsula in areas with serpentine soils, bedrock outcrops, greenstone, and mixed Franciscan rock. In addition to these serpentine soils, cool air temperatures, and summer fog are the primary habitat requirements for the species.

As stated in the final rule to list the species as endangered, there is a single wild Franciscan manzanita plant, and the Franciscan manzanita plants that exist in cultivation fall into three categories: (1) cuttings and rooted specimens collected from the Laurel Hill Cemetery and transplanted to various managed botanical gardens in San Francisco, Berkeley, and Claremont prior to 1947; (2) specimens currently propagated in greenhouses from cuttings and layers taken from the wild plant in 2010; and (3) specimens, some of which may be of unknown origin, sold in the nursery trade or transplanted into home gardens. We consider the single wild plant and plants identified in (1) and (2) above to be the listed entity under the Act. The Franciscan manzanita plants found in botanical gardens, in particular, may represent from one to six genetically distinct plants other than the single wild plant (Chasse *et al.* 2009, p. 7; Chasse 2011a, p. 1; Chasse 2011b, p. 1; Vasey 2011b, pp. 2, 3), and cuttings from those plants may contribute genetic material to efforts to expand the number of wild plants. We concluded that the third category of plants, those cultivated for private or commercial uses, would not aid in the conservation or recovery of the species in the wild because some cultivated plants may be hybrids and bred for landscape (ornamental) use and thus offer minimal contribution to conservation. Therefore, Franciscan manzanita plants in this third category are not considered to be listed and are not considered in the assessment of the species status.

The most significant threat to Franciscan manzanita is habitat loss from urbanization, which continues to impact remnant suitable habitat. Other threats include competition from invasive native and nonnative plants, potential infestation by *Phytophthora* sp., damage from herbivores such as the California vole, climate change, visitor use, vandalism, stochastic events and the effects of small population size, water stress, and possibly hybridization with closely related ornamental manzanita cultivars.

BIOLOGY AND LIFE HISTORY

Species Description and Taxonomy

Franciscan manzanita is a low, spreading-to-ascending, evergreen shrub in the heath family (Ericaceae) that may reach 0.6 to 0.9 meters (m) (2 to 3 feet (ft)) in height when mature (Chasse *et al.* 2009, p. 5). Its leaves are about 1.5 to 2 centimeters (cm) (0.6 to 0.8 inches (in)) long, are isofacial (have the same type of surface on both sides), and are oblanceolate (longer than they are wide and wider towards the tip) (Eastwood 1905, p. 201; Chasse *et al.* 2009, p. 39). Its mahogany brown fruits are about 6 to 8 millimeters (mm) (0.24 to 0.32 in) wide. The urn-shaped flowers measure about 5 to 7 mm (0.2 to 0.28 in) long (Wallace 1993, p. 552; Service 2003, p. 57). Flowering usually occurs from January to April (Parker *et al.* 2012). In the wild, Franciscan manzanita is an obligate-seeding species (it reproduces from seed rather than from burls) (Vasey *et al.* 2012, Vasey *et al.* 2014, Vasey and Parker 2014, Parker 2015a, Parker 2015b, Peterson and Parker 2016).

At one time, Franciscan manzanita and Raven's manzanita *(A. montana* ssp. *ravenii)*, a federally-listed species found only on the Presidio of San Francisco (Presidio), were both considered to be subspecies of Hooker's manzanita (*A. hookeri*). However, recent taxonomic revisions have established Raven's manzanita and Franciscan manzanita as separate species (Parker *et al.* 2012). These revisions have been based primarily on genetic comparisons. For example, Franciscan manzanita is diploid (having 2 sets of chromosomes) while Raven's manzanita is tetraploid (having four sets of chromosomes, 26 chromosome pairs) (Service 2003, p. 95; Parker *et al.* 2007, pp. 149, 150; Chasse *et al.* 2009, p. 6).

Franciscan manzanita was thought to be extinct until a wild plant found along Doyle Drive in October 2009 was confirmed to be Franciscan manzanita with 95 percent confidence based on morphological characteristics (Chasse *et al.* 2009, pp. 3, 4; Vasey and Parker 2010, pp. 1, 5). Additional tests indicate that the plant is diploid, which is consistent with Franciscan manzanita (Vasey and Parker 2010, p. 6). Molecular genetic data also indicate that the plant is Franciscan manzanita (Parker 2010).

The genus *Arctostaphylos* is taxonomically complex, including over 100 taxa of evergreen shrubs and trees which occur primarily or entirely in 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).

Population Trends, Range, and Distribution

<u>Wild Franciscan manzanita</u>

Historically, Franciscan manzanita was known from three locations: the Masonic and Laurel Hill Cemeteries in San Francisco's Richmond District and Mount Davidson in south-central San

Francisco (Chasse *et al.* 2009, p. 4). Unconfirmed observations were also noted at a possible fourth location near Laguna and Haight Streets (Chasse 2012, p. 1). By 1947, the Masonic and Laurel Hill Cemetery sites were removed and the grounds destroyed in preparation for commercial and urban development (Chasse *et al.* 2009, p. 7). The Mount Davidson and Laguna and Haight Streets locations were lost to urbanization as well. Until October 2009, Franciscan manzanita had not been recorded in the wild since 1947 (Chasse *et al.* 2009, pp. 3, 7), although no systematic surveys are known to have taken place to search for potential remaining individuals (Chasse 2010, p. 1). In October 2009, a local botanist identified a single specimen of Franciscan manzanita in a partially cleared area on Doyle Drive (San Francisco), immediately adjacent to an existing highway that was in the process of being replaced. That specimen was subsequently relocated, in January 2010, to a protected, undeveloped area of the Presidio that is managed as natural habitat.

Known historical occurrences and collections of Franciscan manzanita are from serpentine maritime chaparral, a plant community dominated by *Arctostaphylos* and *Ceanothus* (California lilac) species, on the San Francisco peninsula. The peninsula is part of a region that Willis Linn Jepson named the Franciscan Area, one of 10 areas he considered to have the highest concentration of endemic plant species in California (Jepson 1925, pp. 11–14). An endemic species is one that is native to, and restricted to, a particular geographical area. Native habitats on the San Francisco peninsula have been largely converted to urban areas of the City of San Francisco, and habitat that might have once supported Franciscan manzanita is now mostly lost to development or habitat conversion from the introduction of nonnative plant species (Chasse 2010, p. 2; Gluesenkamp 2010, p. 7; Chasse 2011c, p. 1).

Cultivated Franciscan manzanita

Between 1930 and 1947, prior to the loss of the wild plants, botanists collected cuttings and rooted specimens from confirmed wild Franciscan manzanita plants, possibly representing between one and six distinct genotypes (genetic constitutions), and propagated them in botanical gardens (Chasse *et al.* 2009, p. 7; Chasse 2011a, p. 1; Chasse 2011b, p. 1; Service 2003, p. 96; Vasey 2011b, p. 2). The number of distinct genotypes depends on whether the botanical garden specimens were started from cuttings of the same individual (which would mean multiple plants have identical genotypes), or whether each specimen originated from a separate plant (in which case they would have different genotypes) (Chasse 2011a, p. 1; Chasse 2011b, p. 1; Vasey 2011b, pp. 2, 3). Modern collections of this plant at East Bay Regional Park District's Botanical Garden at Tilden Regional Park, San Francisco Botanical Garden (formerly known as Strybing Arboretum), Rancho Santa Ana Botanic Garden, Claremont, and University of California Botanical Garden at Berkeley (UCBGB) include some of the original specimens from Laurel Hill, as well as specimens propagated vegetatively after the species was thought to be extinct in the wild (Chasse *et al.* 2009, pp. 6–8). Accession records for the botanical garden specimens indicate that some specimens collected and planted prior to 1947 did not survive and others are duplicates of original collections, leaving possibly only two specimens confirmed to have been original plants transplanted from Laurel Hill (Chasse 2011b, p. 1; Smisko 2012, p. 1). Further genetic work will verify whether plants with differing morphological features prove to be additional Franciscan manzanita individuals. Although some of the botanical garden specimens may have different genotypes, which is generally the result of sexual reproduction (recombination of genes resulting in seed production and germination) rather than clonal reproduction (vegetative reproduction from cuttings or plant parts other than seeds), all of the botanical garden specimens are considered to be Franciscan manzanita until further genetic work

can be conducted. The number of existing distinct genotypes cannot currently be determined because a suitable genetic sampling technique has not yet been developed (Chasse 2011a, p. 1).

In 2009, five Federal and State wildlife and land management agencies, including the Service, established a Memorandum of Agreement (MOA) and a Conservation Plan for the species (Chasse *et al.* 2009). Under the Conservation Plan for the relocated wild plant, cuttings and rooted specimens from the wild plant have been cultivated. Cuttings from the plant, both non-rooted stems and layering stems (stems that have rooted at their leaf nodes), were taken for vegetative propagation prior to translocation of the Franciscan manzanita plant in January 2010 (Chasse *et al.* 2009, pp. 10–16, 40–42, Young 2010, p. 1). This material was distributed to seven locations, including UCBGB, East Bay Regional Parks Botanic Garden at Tilden, UC Santa Cruz Botanical Garden, San Francisco Botanical Garden, Cal Flora Nursery, Presidio Nursery, and the Presidio Trust Forester (Young 2011, p. 1 of attachment 2). These rooted cuttings or layering stems have been planted in managed sites at the Presidio (M. Chasse, pers. comm., 2016), UC Santa Cruz Arboretum (B. Hall pers. comm., 2014); UCBGB (H. Forbes pers. comm., 2014); East Bay Regional Park Botanic Garden at Tilden (B. O'Brien pers. comm., 2014); Cal Flora Nursery in Fulton, California (P. Van Soelen pers. comm., 2014); and San Francisco Botanic Garden (D. Mahoney pers. comm., 2014). As of 2016, Doyle Drive wild-sourced Franciscan manzanita collections still survive at UCBGB, East Bay Regional Parks Botanic Garden at Tilden, and Santa Barbara Botanic Garden (B. O'Brien pers comm., 2016, H. Forbes pers comm., 2016, H. Forbes pers. comm., 2014; B. Hall pers. comm., 2014; D. Mahoney pers. comm., 2014; B. O'Brien pers. comm., 2014; P. Van Soelen, pers. comm., 2014). A total of 1,346 Franciscan manzanita seeds were collected from the plant in 2009, before it was transplanted; an estimated 2,100 seeds were collected in July and August 2010; and 19 seeds were collected in 2011 (Frey 2010, p. 1; Young 2010, p. 1; Young 2012, p. 1). No attempts have yet been made to germinate Franciscan manzanita seeds (Young 2012, p. 1). In 2013, 58 individual rooted cuttings were planted out in areas within the Presidio designated for habitat conservation, however, as of March 2016, only 32 were alive (M. Chasse, pers. comm., 2016).

The conservation plan calls for eventual propagation of seeds and for genetic testing of resulting plants. Additionally, because the roots of most *Arctostaphylos* individuals establish a mutually beneficial association with mycorrhizal fungi in the soil, the conservation plan establishes means by which the soil for propagating cuttings and seeds should be inoculated with spores from such fungi (Chasse *et al.* 2009, p. 9). Propagation of Franciscan manzanita seed and inoculation of seeds and cuttings by mycorrhizal fungi have not yet occurred. Soil surrounding the wild plant has been examined for presence of a seedbank, but no Franciscan manzanita seeds were found (Young 2011, p. 1; Young 2012, p. 1).

Life History and Ecology

In the wild, Franciscan manzanita is an obligate-seeding species (reproduces from seed rather than from burls (woody outgrowths on the trunk) (Vasey *et al.* 2012, Vasey *et al.* 2014, Vasey and Parker 2014, Parker 2015a, Parker 2015b, Peterson and Parker 2016). *Arctostaphylos* (manzanita) species are members of the chaparral plant community which have a variety of triggers for seed germination including heat, smoke, and light (Keeley 1987, p. 434). *Arctostaphylos* species have germinated after being exposed to charate (ground charred wood) (Keeley 1987, pp. 435, 440), which suggests that fire or conditions that simulate fire stimulate germination of the seeds. Based on work with other species of *Arctostaphylos*, the establishment of successful populations of Franciscan manzanita may

require the presence of a pollinator community (primarily bumblebees (*Bombus* spp.) but also other insects), a fruit dispersal community (primarily rodents), and a mutually beneficial soil mycorrhizal fungi community (Parker 2011, p. 1). Frequent pollinators seen on the wild plant have been bumblebees (most commonly *Bombus vosnesenkii* and *B. melanopygus*) and the European honeybee (*Apis mellifera*) (J. Gambel *in litt*., 2012). Hummingbirds and butterflies have also been observed visiting the flowers, likely because few other plants are blooming during the winter months when Franciscan manzanita blooms (M. Vasey, pers. comm. 2010). Most *Arctostaphylos* species form strong symbiotic associations with soil mycorrhizal fungi, which develop an external sheath surrounding the plant's roots. All water and nutrients pass first through this sheath rather than directly from the soil to the plant's roots (Chasse *et al.* 2009, p. 12). The seeds of *Arctostaphylos* are dispersed primarily by rodents that consume the fruits, but also by other mammals, including coyotes (*Canis latrans*) and foxes (T. Parker 2011, pers. comm.; Vasey 2011a, p. 1). Seed-eating animals such as coyotes, gray foxes (*Urocyon cinereoargenteus*), red foxes (*Vulpes vulpes*), raccoons (*Procyon lotor*), California quail (*Callipepla californica*), and rodents such as the California vole (*Microtus californicus*) are known to occur on the Presidio (National Park Service (NPS) 2012). Animals such as coyotes and foxes eat the *Arctostaphylos* fruit and may travel long distances before depositing their scat. Any undigested fruit left in the scat can then be harvested by rodents and either eaten or buried. Peterson and Parker (2016) found that 70 percent of the fruits buried by rodents were located deeper than 2 cm (0.78 in), which is the maximum soil depth at which seeds are typically killed by wildfire. Seed has been removed from the wild plant, and, although it has not been directly observed, California voles have been trapped near the wild plant and are likely responsible for the seed harvesting (Carlen 2012, p. 1; Estelle 2012b, p. 1).

Habitat Characteristics/Ecosystem

Franciscan manzanita is considered to be endemic to the San Francisco peninsula, and historically occurred in areas with serpentine soils, bedrock outcrops, greenstone, and mixed Franciscan rock, typically growing in mixed populations with *A. montana* ssp. *ravenii* (Chasse *et al.* 2009, p. 6). The Doyle Drive Franciscan manzanita site comprised disturbed soil over serpentinite (Chasse *et al.* 2009, p. 3). Serpentine soil restricts the growth of many plants due to its high nickel and magnesium concentrations, and thus tends to support unique plant communities because relatively few plant species can tolerate such soil conditions (Brooks 1987, pp. 19, 53; Service 2003, p. 16). These conditions generally result in semibarren soil and a lack of competing plants, which benefits serpentine-tolerant plants such as Franciscan manzanita (Bakker 1984, p. 79).

Some knowledge of the habitat requirements of Franciscan manzanita can be inferred from historic locations and information on voucher specimens. The historic sites were mostly underlain by serpentine or greenstone substrates (Roof 1976, pp. 20–24). Early records describe the species as growing "on rocky ground" (Eastwood 1905, p. 202), on "bare, stony bluff on Laurel Hill Cemetery [sic]" (Brandegee 1908), and with coast live oak (*Quercus agrifolia*), coast blue blossom (*Ceanothus thyrsiflorus*), and coyote brush (*Baccharis pilularis*) (Wieslander 1938). Franciscan manzanita was also observed "forming flat masses over serpentine outcroppings and humus-filled gravel and flopping down over the sides of gray and chrome rocks (Rowntree 1939, p. 121). According to Alice Eastwood (1905, pp. 201-202), coast live oak, coast blue blossom, coyote brush, toyon, mock heather, buckwheat and yarrow were listed on historic voucher specimens as occurring with Franciscan manzanita. Additionally, Raven's manzanita was found at nearly all Franciscan

manzanita locations. These observations, along with the geology and climate of historical sites, indicate that the species' historical community likely consisted of a mosaic of coastal scrub, barren serpentine maritime chaparral, perennial grassland, and occasional woodlands of coast live oak and toyon shrubs and small trees (Chasse *et al.* 2009, pp. 6, 7).

Historically, the maritime serpentine chaparral plant community, of which Franciscan manzanita is a part, may have been present in the southeastern portion of the San Francisco area (for example, Potrero Hill, Bayview Hill), but the cumulative effects of burning by native Americans, grazing during the Spanish/Mexican period and later more grazing and firewood gathering during the U.S. military period may have converted the maritime chaparral to grassland or depauperate coastal scrub (Chasse 2010, p. 2).

Critical Habitat

The final rule designating critical habitat for Franciscan manzanita was published in the Federal Register on December 20, 2013 (78 FR 77290)(Figure 1). Primary constituent elements (PCEs) are those physical and biological features that support the survival and reproduction of a species and are essential to the conservation of the species. For Franciscan manzanita, these elements are:

(1) Areas on or near bedrock outcrops often associated with ridges of serpentine or greenstone, mixed Franciscan rocks, or soils derived from these parent materials.

(2) Areas having soils originating from parent materials identified above in PCE 1 that are thin, have limited nutrient content or availability, or have large concentrations of heavy metals.

(3) Areas within a vegetation community consisting of a mosaic of chaparral or serpentine grassland characterized as having a vegetation structure that is open, barren, or sparse with minimal overstory or understory of trees, shrubs, or herbaceous plants, and that contain and exhibit a healthy fungal mycorrhizae component.

(4) Areas that are influenced by summer fog, which limits daily and seasonal temperature ranges, provides moisture to limit drought stress, and increases humidity.

The 18 critical habitat units are all located on the San Francisco peninsula within San Francisco County. The units are in three general locations: the Presidio, the Mount Davidson area, and southeast of Mount Davidson on either side of Highway 101.

Figure 1. Critical Habitat for Franciscan manzanita (2013).

REASONS FOR LISTING AND CURRENT THREATS

In determining whether to list, delist, or reclassify (change from endangered to threatened status, or *vice versa*) a species under section 4(a) of the Act, we evaluate five major categories of threats to the species: (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 the time of listing, the primary threat to Franciscan manzanita was loss of habitat. All original occupied habitat of the species had been lost, and its current range had been reduced to a single location that supported a single Franciscan manzanita plant. Furthermore, limited suitable habitat was available to support viable populations of the species. The remaining wild plant was vulnerable to overcollection or damage if visitors harvested cuttings or seeds. Potential infection by various species of the pathogen *Phytophthora* was also identified as a major threat (Service 2012). Additional threats included climate change, altered fire regime, soil compaction from visitor use, vandalism, loss of genetic diversity, loss of pollinators, stochastic events, effects of small population size, and possibly hybridization with closely related ornamental manzanita cultivars. Since listing, we have also identified water stress (dehydration of the wild plant) and infection by specific species of *Phytophthora,* including *P. cinnammoni, P. hedraiandra, P. ramorun,* and *P. cactorum*, as threats.

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

At the time of listing (Service 2012), all areas of habitat originally known to be occupied by Franciscan manzanita had been lost to urban development or to habitat conversion through the introduction of nonnative plant species (Chasse *et al.* 2009, pp. 4, 7; Chasse 2011c, p. 1). The largest historical occurrence was at the quarry area of the former Laurel Hill Cemetery in San Francisco (Chasse 2011c, p. 1). Most of this area was converted to residential housing and city streets after the late 1940s. A small remaining area of open space at Laurel Hill is dominated by ornamental shrubs and invasive understory plants, although serpentine rock is visible in several openings (Chasse 2011c, p. 1). Lawns, pathways, and buildings, part of the University of San Francisco campus, now occupy the location of the Masonic Cemetery occurrence (Chasse 2011c, p. 2). The precise location of the third historical occurrence of Franciscan manzanita at Mount Davidson is unknown but thought to be on one of the greenstone outcrops (Chasse 2011c, p. 2). The upper portions of Mount Davidson are covered with nonnative trees and invasive understory species; some grassland and scrub persist on the south and northeast sides (Chasse 2011c, p. 2). The species' range is now limited to the single transplanted location and the outplanted cuttings, all on the Presidio. In January 2010, after the newly discovered wild plant was moved to the Presidio, the plant's habitat at Doyle Drive was destroyed as part of a Caltrans highway improvement project.

Past urban development on the San Francisco peninsula has limited the remaining areas of potential habitat for Franciscan manzanita by habitat conversion and habitat degradation and, to a lesser degree, habitat fragmentation. Some of these small remnant areas may no longer be suitable for reestablishment of Franciscan manzanita due to factors such as dominance by other plant species (M. Chasse pers. comm., 2011). Currently, these small, isolated parcels are subject to edge effects,

such as changes in soil moisture, changes in light, and potential increased invasion of weed species that would compete with Franciscan manzanita for limited resources (water, nutrients, and space).

Urban barriers, such as streets and buildings, have been found to impose a high degree of isolation on chaparral species and, over time, to result in decreased numbers of native plant species and concurrent increased numbers of nonnative plant species in the habitat fragments (Alberts *et al.* (unpubl.) as cited in Soule *et al.* 1992, p. 41; Soule *et al.* 1992, pp. 41–43). The effects of urbanization on the San Francisco peninsula are expected to continue to affect these remnant parcels into the future. Urbanization poses a threat to the establishment of additional Franciscan manzanita plants without assistance to restore suitable habitat conditions and makes it difficult to restore plants to suitable locations.

Additionally, nitrogen deposition from automobile traffic may modify habitat by increasing soil nutrients, thus posing a current and continuing threat to remnant habitat that might otherwise be suitable for Franciscan manzanita. Weiss and Luth (2003, p. 1) conducted research on the effects of nitrogen deposition along Highway 280 in a serpentine grassland south of the San Francisco peninsula. They found that nitrogen deposition within 100 m to 400 m from the highway was correlated with increased nonnative grass cover within these areas, resulting in competition for space for native plants. An increase in nonnative grass cover through changed habitat conditions could threaten the wild Franciscan manzanita by competing for soil moisture and nutrients and could inhibit successful germination of Franciscan manzanita seed. The entire northern San Francisco peninsula, with the exception of the Presidio and Golden Gate Park, has been urbanized, and four major highways (Highways 1, 101, 280, and 480) and other urban roadways dissect the peninsula.

The final rule to list the species noted that the Presidio Trust Act contains a sunset clause that could result in the transfer of Presidio holdings to the General Services Administration (GSA) for disbursement if the Presidio Trust operations were not self-sufficient by 2013 (the Presidio Trust Act is discussed under Factor D below). The unlikely event that the Presidio Trust would not be self-sufficient within that timeframe, presented the potential threat that lands could be transferred and become available for development resulting in additional habitat loss in the future. In 2013, the Presidio Trust operated entirely without taxpayer support (Presidio Trust 2013); therefore, transfer of Presidio holdings is no longer considered to be a threat.

Based on the best scientific and commercial information available, we consider the present or threatened destruction, modification, or curtailment of the species' habitat or range to be a high-magnitude and ongoing threat to Franciscan manzanita. The current fragmented and degraded condition of most remaining serpentine chaparral or serpentine/greenstone soil habitat on the San Francisco peninsula threatens the ability of Franciscan manzanita to naturally reproduce or expand its range.

Factor B*: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*

At the time of listing, overutilization of Franciscan manzanita was considered to be a threat due to its popularity for landscape use, as evidenced by the widespread use of cultivars of this species in the commercial nursery trade. Franciscan manzanita is specifically recommended for use in erosion control on steep slopes (Theodore Payne Foundation 2009, p. 1; Sierra Club 2011, p. 1).

The attention and media coverage generated by the discovery of a species thought to be extirpated in the wild was expected to result in efforts by the public to visit the plant and possibly collect cuttings or seed. Although the location of the transplanted plant has not been disclosed, it was planted in a heavily used area in the Presidio, near common-use trails with unrestricted access by the public. The Presidio is a National Park and is part of the Golden Gate National Recreation Area (GGNRA); it is open to the public and receives 5 million visitors annually. The Presidio receives heavy use because of its proximity to the City of San Francisco.

Trampling or the taking of cuttings could occur if the identification and location of the wild plant becomes known. Similarly, another extremely rare plant, Raven's manzanita, is also located on the Presidio. Although it was federally listed in 1979, its location has not been revealed to the public by the Presidio Trust or NPS in order to protect the plant from vandalism. There has been no evidence of damage or of cuttings being taken from Franciscan manzanita (D. Gamoso, *in litt*., 2014) or Raven's manzanita (Chasse 2011c, p. 3); however, the fact that the sole remaining wild Franciscan manzanita is located in a heavily used public area subjects this species to the threat of collection.

Based on the best scientific and commercial information available, we consider overutilization for commercial and recreational purposes to be a moderate threat to the wild Franciscan manzanita plant. Although nursery-grown Franciscan manzanita are available to residents for use in private gardens, collection of the wild plant is a threat to the species, and we expect it may be a threat in the future, particularly if the location of the plant becomes known to the public. This threat is considered moderate because the plant has been at its current location since 2010 and no vandalism has been observed.

Factor C*: Disease or Predation*

Disease

At the time of listing, transplantation was considered to be a possible cause of stress to the plant making it more susceptible to disease. In transplanted plants, stress and root damage may occur from a variety of factors, including soil compaction from foot traffic around the plant (Hammitt and Cole 1998, p. 52), too little or too much water, and improper planting depth; these stressors may result in increased susceptibility to disease (see further discussion in Visitor Use section below). A fungal infection called twig blight, usually caused by *Botryosphaeria* species in *Arctostaphylos,* is also a potential concern, particularly during wet years (Service 2003, p. 69). This fungus may be referred to as a separate genus, *Fusicoccum* spp., if sexual spore production has not been observed (Swiecki 2011). Twig blight was observed in the wild plant during the winter of 2009–2010, but it subsided during the dry summer months (Chasse 2010, p. 2). These fungi can cause both twig blighting and perennial branch cankers that can eventually kill large branches (Swiecki 2011, p. 1). While these pathogens would not likely pose a serious threat to a large population, they could threaten Franciscan manzanita because the wild population is limited to a single plant, and infection by this group of fungi is one of the major factors leading to the decline of older *Arctostaphylos* sp. plants (Swiecki 2011, p. 1). Additionally, cankers caused by *Botryosphaeria* are more severe in plants that are stressed by lack of water. The transplanted plant may have experienced water stress due to loss of roots during the transplanting process (Swiecki 2011, p. 1).

Franciscan manzanita is also threatened by various pathogens in the genus *Phytophthora*. *Phytophthora* is a fungus-like water mold most closely related to diatoms and kelp (Kingdom Stramenopila) rather than to the true fungi (Kingdom Fungi or Eumycota). An oak tree infected with sudden oak death disease, caused by *P. ramorum*, was discovered on the Presidio in 2010 (Fimrite 2011). Sudden oak death has so far been observed to cause only a foliar blight in species of *Arctostaphylos,* rather than the lethal bark cankers that occur on members of the black oak group (Swiecki *in litt*., 2012a, p. 1). However, a related species, *P. cinnamomi* has presented a serious threat to other *Arctostaphylos* species and is expected to be a serious threat to Franciscan manzanita. *Phytophthora cinnamomi,* a soil-borne pathogen, has long been known as a world-wide threat to commercial and ornamental plants. It is an introduced exotic pathogen in North America; its native range is unknown, but is suspected to be southeast Asia. Human-related activities, including the international plant trade, have facilitated the spread of *P. cinnamomi* into many habitats worldwide (Swiecki *et al.* 2011, p. 1). *Phytophthora cinnamomi* was introduced to California early in the 20th century, and recently has been identified as a serious threat to the State's native plants and their habitats (Swiecki *et al.* 2011, p. 1). *Phytophthora cinnamomi* has been the cause of the decline and death of rare *Arctostaphylos* species, including the federally threatened pallid manzanita (*A. pallida*) in the Oakland Hills of the East San Francisco Bay region and the federally threatened Ione manzanita (*A. myrtifolia*) near Ione in the Sierra Nevada foothills of Amador County. The pathogen is also noted in the decline of other woody native species in the San Francisco Bay area (Swiecki *et al.* 2011, pp. 3). The organism causes root decay but can also kill aboveground portions of some plants (Swiecki *et al.*2011, p. 1). *Phytophthora cinnamomi* is persistent in soil, and once introduced to native habitat it cannot be eradicated (Swiecki *et al.* 2011, p. 1). Actions that result in ground disturbance may have a high risk for introducing soilborne *Phytophthora* sp. *Phytophthora cinnamomi* is transmitted by contaminated shoes, tools, and infested soil clinging to tires, and by contaminated nursery stock, including native plant stock. Some nursery-grown cuttings from the wild Franciscan manzanita plant tested positive for another species of *Phytophthora*, *P. hedraiandra* (T. Swiecki *in litt*., 2014), and were destroyed. Increased soil moisture also increases the potential for root rots caused by *Phytophthora* sp. Crown rot, which is caused by *P. cinnamomi,* is known to occur in Ione manzanita (*A. myrtifolia)* and whiteleaf manzanita (*A. viscida*) (Swiecki *et al.* 2011, p. 3), and is a concern when planting nursery-grown plants to wild locations (outplanting) (Chasse *et al.* 2009, p. 17).

Conservation proposals include recommendations that Franciscan manzanita cuttings taken from the wild plant and from other botanical garden specimens be planted with the transplanted Franciscan manzanita to facilitate cross-pollination of the different genotypes. Should the wild plant become contaminated with *P. cinnamomi* from contaminated cuttings*,* the result would be the decline and death of the wild plant and permanent contamination of the soil and seedbank beneath the plant. Any seedlings that germinate from this seedbank would also very likely be contaminated and not survive. Any cuttings that become contaminated are also expected to die of the pathogen. *Phytophthora cinnamomi* is not the only introduced soil-borne *Phytophthora* species that may threaten Franciscan manzanita. Swiecki (2011, p. 1; 2012b, p. 1) notes that at least five other species of *Phytophthora* associated with the decline and death of woody plants have been found in the Crystal Springs watershed 27 to 40 kilometers (km) (17 to 25 miles (mi)) south of the Presidio. These nonnative *Phytophthora* species include *P. cambivora, P. cactorum,* and *P. megasperma;* all are known to occur in natural and cultivated landscapes and are common in nursery stock (Swiecki 2011, p. 1). *Phytophthora cinnamomi* and *P. cambivora* have been detected in China Camp State Park, 22.4 km (14 mi) north of the Presidio, and *P. cinnamomi* has been found in the East Bay area 24 km (15 mi) east of the Presidio. Because several of these soil-borne pathogens have become established in the San

Francisco Bay area, the likelihood is increased that one or more could be introduced to the vicinity of the wild Franciscan manzanita plant (Swiecki 2011, p. 1).

Phytophthora sp. propagules can move large distances downhill with flowing water from rain or irrigation runoff. Development uphill of Franciscan manzanita may be a source of infection of the disease. *Phytophthora* species are commonly found in commercial nursery stock (including material from native plant nurseries), and soils may become contaminated through the planting of infested stock. Foot or vehicle traffic between infested areas and habitat can also introduce *Phytophthora*-contaminated soil (T. Swiecki, *in litt*., 2014).

Predation

The listing rule noted that a native leaf roller moth (*Argyrotaenia franciscana*) and the California vole are predators of the plant. After being transplanted, the wild plant became severely infested with the larvae of the leaf roller moth (Estelle 2010, p. 1). Treatment for the infestation was hand removal of the larvae and all infected leaves (Estelle 2010, p. 1; Young 2010, p. 1). A parasitic wasp emerged from one captured leaf roller moth larva, indicating that the moth had natural enemies (Frey 2010, p. 2). The moth was not known to kill plants and did not appear to be a serious threat at that time; however, the moth species was found to have five overlapping generations in a year (Estelle 2010, p. 1). Monthly removal of moth larvae and pupae was conducted as needed (Estelle 2012a, p. 1). The leaf roller moth infestation in early 2010 did not permanently damage the plant, and new growth was observed (Frey 2010, p. 2). Fewer leaf roller moth larvae were seen on the wild plant in 2011 than in 2010 (Estelle 2012a, p. 1). In 2014, no leaf roller moth larvae were seen (D. Gamoso 2014). Currently, the leaf roller moth is not considered to be a serious threat to the species.

Damage to Franciscan manzanita branches by California voles was observed by Presidio Trust staff in 2011 through 2012 (Chasse 2011c, p. 2, D. Gamoso 2014). Several voles have been observed in and around the wild Franciscan manzanita plant, and some branch dieback was attributed to gnawing by voles and other rodents in 2011 (Chasse 2011c, p. 2). Extensive tunneling by voles under and around the plant in 2013 coincided with a 70 percent die-back of the plant; however, it is not known to what degree the voles were responsible for the damage. Since 2013 there has not been substantial damage to the plant from voles, therefore predation by voles is not thought to be a serious threat to the species.

Factor D*: Inadequacy of Existing Regulatory Mechanisms*

At the time of listing (2012) regulatory mechanisms protecting Franciscan manzanita came primarily from the location of the single known wild plant on GGNRA lands on the Presidio, which are administered by the Presidio Trust. The Presidio Trust was established by the Presidio Trust Act of 1996 to manage the leasing, maintenance, rehabilitation, repair, and improvement of property within the Presidio (Presidio Trust Act, as amended, sec. 104 (a)). The Presidio Trust is directed to preserve the natural, scenic, cultural, and recreational resources on the Presidio, but also is directed to ensure that the Presidio becomes financially self-sufficient by 2013 (Presidio Trust 2002, pp. 1, 2, 12). The Presidio Trust Act directed the Presidio Trust to design a management program to reduce NPS expenditures and increase revenues to the Federal Government to the maximum extent possible (Presidio Trust Act, pp. 5, 6). The Presidio Trust Management Plan was published in May

2002. The Presidio Trust manages most of the Presidio (Area B), and NPS retains jurisdiction over Area A as defined in the Presidio Trust Management Plan (Presidio Trust 2002, p. 3). The Presidio Trust also coauthored the Presidio Vegetation Management Plan with NPS, which provides an objective to preserve and enhance rare plant habitats by evaluating species-specific habitat needs, giving high priority to actions that preserve and enhance those habitats (Presidio Trust 2001, Chapter 3, unpaginated).

Federal regulations for the Presidio Trust, which offer some protection to Franciscan manzanita, include prohibitions on disturbing, injuring, removing, possessing, digging, defacing, or destroying from its natural state, any plant or parts thereof. Unauthorized introduction of plants and plant seeds is also prohibited, offering limited protection against invasive, nonnative species. Additional regulations require that special events be permitted by the Presidio Trust, and provide for restricting visitor use to address resource conflicts (36 CFR 1002).

As noted in Factor A, the Presidio met the goal of being a self-sustaining National Park in 2013 (Presidio Trust 2013); therefore, the possibility of transfer to the public domain is no longer a threat to Franciscan manzanita.

The Conservation Plan and MOA noted above are not regulatory in nature and not legally enforceable by third parties (Caltrans 2009, p. 8; Chasse *et al.* 2009, p. 3), limiting their usefulness in enforcing protections for the plant. Although general protections are provided for plants on National Parks, no regulatory language in any National Park Service or Presidio Trust documents specifically addresses protection of Franciscan manzanita.

Federal Laws and Regulations

Endangered Species Act of 1973, as amended: The Act is the primary Federal law providing protection for this species. Since listing, the Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize adverse effects to listed species associated with a project.

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

The State's authority to conserve rare wildlife and plants is comprised of three major pieces of legislation: California Endangered Species Act (CESA), Native Plant Protection Act (NPPA), and California Environmental Quality Act (CEQA). Franciscan manzanita is not State-listed therefore CESA and NPPA do not apply to this species. However, CEQA provides protection for any species that can be shown to meet the criteria for state listing (CNPS 2001).

CEQA: CEQA requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

Based on the best scientific and commercial information available, we consider inadequacy of existing regulatory mechanisms not to be a threat to the wild Franciscan manzanita plant.

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

Potential Factor E threats to Franciscan manzanita include water stress, changes in environmental conditions resulting from climate change, trampling or disturbance by people visiting the Presidio, altered fire regime, loss of genetic diversity, stochastic (chance) events, and small population size.

Water Stress

After the wild plant was transplanted into the Presidio in January 2010, the plant produced healthy growth with annual floral displays in late winter with subsequent seed production. Starting in late summer or fall of 2012, however, the plant began to show signs of stress with yellowing leaves and leaf spotting. Soil tests conducted around the plant in December 2012 indicated that the level of soil moisture was low and that the plant was very water-stressed (T. Swiecki *in litt*., 2012). In addition, Dr. Swiecki found almost no healthy roots while collecting soil samples around the plant (T. Swiecki *in litt.,* 2012). By May 2013, at least 70 percent of the plant had died although the plant was continuing to produce flowers and fruit on the remaining healthy vegetation. In June 2013, irrigation of the plant was begun by Presidio Trust staff (D. Gamoso, 2013) and the plant responded with a small but steady amount of growth and reduced die-back. Moisture monitors were installed in the surrounding soil and the wild plant was irrigated when moisture level dipped below a certain threshold (M. Chasse, pers. comm., 2016). In 2014 and 2015, the plant continued to grow and has received water at least once per month (L. Stringer, *in litt*, 2015).

Currently, the plant appears to be unable to survive the dry summer months without regular irrigation. The cause of the water stress is not known but may be from a combination of factors including low rainfall during the last three years, possible root damage during excavation and transplanting in 2010, possible root damage from California vole (*Microtus californicus*) herbivory or from disease, or unsuitable soil at the transplant site. Several of these factors are included below in discussions of other threats.

Climate Change

Since the 1950s, the Northern Hemisphere has experienced warmer air temperatures and decreased snowfall (Ackerly *et al.* 2010, IPCC 2013). Changes in environmental conditions resulting from climate change may cause presently suitable habitat to become unsuitable for endemic California plants, due to projected changes in temperature and rainfall (Loarie *et al.* 2008, pp. 1–2). A U.S. Geological Survey (USGS) study in National Park lands in northern California and Oregon examined trends in climate, ocean conditions, and other features (Madej *et al.* 2010, p. 7). In these National Park lands, variation in abiotic factors (for example, precipitation, fog, and air and ocean temperatures) regulates many ecological processes, including the distribution of vegetation and frequency of disturbance from fires, floods, landslides, and pest species. The preliminary results of the USGS study show an increase in average maximum summer air temperatures at GGNRA, near the Presidio (Madej *et al.* 2010, p. 24).

Summer fog and overcast conditions along the California coast have been identified as ecologically important to endemic plant species by increasing water availability during the dry summer months, reducing loss of water from leaves (evapotranspiration), and decreasing the severity and frequency of drought stress (Fischer *et al.* 2009, pp. 792–795). Fog frequency along the Pacific coast is highest in north and central California and declines in Oregon and southern California (Johnstone and Dawson 2010, p. 4534). Climate change may be affecting the amount and duration of fog and cloud cover along the California coast including within the San Francisco Bay area. Mean fog frequency in the California region, quantified by cloud ceiling height measured at airports, has decreased since 1951 (Johnstone and Dawson 2010, p. 4535). Research by Vasey (2010, p. 1) suggests that most coastal endemic *Arctostaphylos* species are more vulnerable to drought stress than those found in interior California, and could be threatened by a decrease in coastal summer fog. He found that obligate-seeding *Arctostaphylos* species, such as Franciscan manzanita, are better hydrated in areas that receive fog. He also found that coastal obligate-seeding species are more vulnerable to vascular cavitation (blockage forming in water vessels in the plant) when the rate of water loss through the leaves becomes too great, such as during drought (Vasey *et al.* 2012, Vasey *et al.* 2014, Vasey and Parker 2014, Parker 2015a, Parker 2015b, Peterson and Parker 2016). This disruption of water flow can lead to branch death and possibly death of the entire plant (Vasey *et al.* 2012, Vasey *et al.* 2014, Vasey and Parker 2014, Parker 2015a, Parker 2015b, Peterson and Parker 2016).

Reduced soil moisture from decrease in summer fog may also result in reduced seed germination and seedling survival. Additionally, the ability of Franciscan manzanita to respond to future climate changes by establishing new plants in new habitat may be limited because of the plant's association with serpentine and greenstone bedrock outcrops (Service 2003, pp. 95, 96), and because soils derived from serpentine and greenstone bedrock on the peninsula are limited in area and largely fragmented (Chasse 2010, p. 1). Natural movement of the species by seed dispersal to reach cooler, moister areas to the north would be impeded by barriers such as the San Francisco Bay.

Increased temperatures within Franciscan manzanita habitat could also result in higher soil temperatures that would favor *Phytophthora cinnamomi,* which reproduces best at warmer soil temperatures. Higher temperatures would also increase the likelihood of water stress on Franciscan manzanita*,* increasing its susceptibility to other *Phytophthora* species (Swiecki 2011, p. 1).

Alteration of the Natural Fire Regime

In addition to soil type and climate, fire plays a critical role in the determination of plant distribution (Keeley 2007, p. 19). The chaparral plant community, of which *Arctostaphylos* is an important member, is adapted to specific fire regimes that vary in different parts of California. In the San Francisco East Bay region, the current fire return interval is estimated at about 100 years (Keeley 2007, p. 20). Factors that affect the fire frequency in the San Francisco Bay area include a short fire season, moist climate, the local human population density, and changes in human behavior. Due to prevailing ocean winds and frequent fogs, the average relative humidity along the coast is moderate to high throughout the year. The exceptions typically occur in the fall, when changing prevailing weather patterns allow dry northeasterly winds from the State's interior to reduce humidity in the coastal area to around 20 percent, thereby creating dry and windy conditions that typify high fire danger (GGNRA 2005, pp. 136, 140).

Fire frequency in the San Francisco Bay area has varied substantially in the last several thousand years. Not only have the fire regimes changed with changing climate, fire regimes have changed as patterns of human utilization of the landscape have changed. Disturbances by fire occurred at long intervals in the prehuman period, then at shorter intervals during the late Native American and Spanish-Mexican periods, and at moderate intervals during the European settlement period. Fire disturbance intervals since the 1900s have generally returned to long intervals in the modern period due to active fire suppression (GGNRA 2005, pp. 144–147). The natural fire regime has been heavily altered by the urbanization of San Francisco and fragmentation of remaining undeveloped lands. Nearly all land within the City of San Francisco has been developed, with the exception of small, isolated parcels and undeveloped hilltops. Lands administered by NPS and the Presidio Trust are surrounded by other land uses, and are close to the wildland-urban boundary where landscape plants and nonnative plants contribute to vegetative buildup (GGNRA 2005, pp. 130–131) that can increase fire danger. Additionally, fire suppression over the last 100 years has led to an increase in crown and surface fuels, which contribute to high-intensity fires (GGNRA 2005, p. 147). In spite of the increased fire danger on these managed lands, they could eventually be identified as suitable for outplanting Franciscan manzanita seedlings due to the limited amount of remaining habitat.

As stated above in the *Life History and Ecology* section, Franciscan manzanita is an obligate-seeding species and reproduces primarily from seed rather than from burls after a fire (Vasey *et al.* 2012, Vasey *et al.* 2014, Vasey and Parker 2014, Parker 2015a, Parker 2015b, Peterson and Parker 2016). Two opposing types of changes in fire frequency can threaten chaparral species such as Franciscan manzanita. First, "senescence risk" occurs when too little fire leads to the loss of a species dependent on fire for regeneration. The second, "immaturity risk," is a threat primarily to obligate-seeding species such as Franciscan manzanita. In this case, wildfires that occur too frequently may kill plants before they can reach reproductive maturity and produce seed (Keeley 2007, p. 18). Wildfire can substantially reduce the number of live seeds in the soil (Odion and Tyler 2002, p. 1). Odion and Tyler (2002 p. 1) found that a controlled burn in a 40-year-old stand of Morro manzanita (*A. morroensis*), a species also occurring in maritime chaparral, reduced the seedbank to 33 percent of that which had accumulated in the soil since the previous burn 40 years earlier. Three years after the burn, the new population of Morro manzanita that had germinated from the seedbank was less than half the size of the original population (Odion and Tyler 2002, p. 1). Odion and Tyler (2002 p. 2) concluded that if viable seed densities in the soil are low because fires are too frequent to allow seeds to accumulate in the soil, the population may risk extinction.

The fire return interval for the area that encompasses Franciscan manzanita's historic range is currently approximately 100 to 125 years (T. Parker pers. comm., 2011; Vasey 2011a, p. 1). The long fire return interval is not thought to be a threat to the mature Franciscan manzanita plant at the Presidio or to any seedlings likely to be outplanted on the Presidio in the future. Infrequent fire would allow the mature plant at the Presidio to produce seed and build up a sufficiently large seedbank to withstand seed loss from wildfire, and would allow the growth of outplantings in other suitable areas. However, if fire continues to be excluded from the plant's location at the Presidio and the fire return interval greatly exceeds the natural return interval, over time the loss of fire may also result in the loss of the mature plant and individual outplanted seedlings due to competition by other plants, including nonnative plants, that could encroach upon the manzanita.

Other aspects of the altered fire regime within the remaining undeveloped lands of San Francisco pose greater threats to the species. Alteration of the fire regime has led to an increase in crown and surface fuels in some areas, leading NPS fire planners to conclude that it is difficult to predict the effects of the changed fire regime, given the trend to warmer and drier climate conditions (Johnstone and Dawson, 2010, p. 4535; Madej *et al.* 2010, p. 24) and the relationship between climate and fire frequency (GGNRA 2005, pp. 147, 148). In the past, large fires have occurred within areas that are typically subject to maritime climatic conditions. Such fires include the 1923 Berkeley Fire, the October 1991 Oakland Fire (Keeley 2005, p. 286) that burned 607 ha (1,500 ac), the October 1995 fire at Point Reyes National Seashore that burned 4,999 ha (12,354 ac) (GGNRA 2005, p. 151), and the 1,133-ha (2,800-ac) 2009 Lockheed Fire north of the City of Santa Cruz (The Associated Press 2009). On the Presidio, fire history data show that 17 fires occurred between 2000 and 2009, with no fires in some years and as many as 5 fires in other years. All fires were contained at 0.04 ha (0.1 ac) or less (A. Forrestel, pers. comm., 2011a, 2011b). In the same period, approximately four wildfires occurred in the Marin Headlands, directly north of the Presidio across the Golden Gate, while recent fire history records for all areas of the GGNRA show the potential for larger wildfires in the maritime zone (GGNRA 2005, pp. 150–155).

Although the Presidio is located within a highly urbanized setting, substantial areas of open space within the Presidio itself and within the adjacent GGNRA lands contain an interspersed mixture of vegetative types, including native vegetation, landscaped grounds, and forest (GGNRA 2005, pp. 190–199; Presidio Trust 2011, unpaginated). Grasslands are now dominated by nonnative annual grasses and forbs, which burn with greater intensity and at a more rapid rate of spread than grasslands dominated by native species (GGNRA 2005, p. 192). According to a fire model prepared by the GGNRA, areas that they manage on the western and southwestern borders of Presidio Trust lands present a moderate and moderate-high fire hazard (GGNRA 2005, p. E-7). The altered fire regime may result in infrequent fires that burn larger and hotter than previously, with the potential for greater loss of the seedbank. Alternatively, the incidence of wildfire could increase, which would be detrimental to Franciscan manzanita by killing mature plants, seedlings, and seeds in the seedbank. In obligate-seeding species, such as Franciscan manzanita, fire normally kills the adult plants, which are then replaced by plants that germinate from seed in the soil seedbank. A wildfire that would kill the single wild Franciscan manzanita plant would be an especially serious threat to the future of the species because no Franciscan manzanita seedbank has been found in soil collected from the area beneath the wild plant (Young 2011, p. 1).

Visitor Use

Impacts due to visitor use could harm the wild plant. The translocated wild plant has been planted in an active native plant management area that receives heavy public use, although it is protected from public access by a post and cable fence and is monitored (Chasse *et al.* 2009, pp. 20–28). The post and cable fence is placed along an adjacent trail so that people do not enter the immediate area around the plant; however, an event in which a visitor treads on the plant could result in damage to the wild plant. Over time, incremental damage could result in irreparable harm to the plant. As noted under *Factor B*, the Presidio Trust and NPS have made serious efforts not to reveal the location of Franciscan manzanita because they are concerned that public knowledge of its location would attract large numbers of plant enthusiasts who may damage the Franciscan manzanita and compact the soil (T. Thomas, pers. comm., 2011). If trampling of the Franciscan manzanita occurs, the Presidio Trust could take three protective actions: a fence could be placed around the plant, interpretive signs could be placed near the plant, and volunteers or interns could be made available to talk to visitors (T. Thomas, pers. comm., 2012).

The wild Franciscan manzanita plant may be susceptible to damage from soil compaction due to foot traffic. Roots grow into soil to maintain stability and extract water and nutrients; however, soil compaction increases the resistance of the soil to root penetration and thus diminishes the plant's ability to extract sufficient water and nutrients (Hammitt and Cole 1998, p. 52). Soil compaction also reduces water infiltration rates and soil aeration by collapsing the larger pores in the soil. Reduced soil oxygen levels from loss of soil pores also can impact root growth, which would further reduce water and nutrient uptake (Hammitt and Cole 1998, p. 52). Additionally, soil compaction has been found to cause considerable damage to mycorrhizal fungi in seedling roots (Waltert *et al.* 2002, p. 1). Damage from soil compaction would not only impact the wild plant by reducing its ability to take up water and nutrients, but could also reduce the survival of seedlings near the wild plant.

Soil compaction also favors the growth of *Phytophthora*, since poor drainage resulting from compaction facilitates the dispersal of swimming zoospores that infect the host plant (Swiecki 2011, p. 2). Additionally, anaerobic (lack of oxygen) stress associated with saturated soil conditions increases the susceptibility of roots to *Phytophthora* infections (Swiecki 2011, p. 2).

Vandalism

The location of the Franciscan manzanita plant within the Presidio is near common-use trails and an area available for private and public events. Threats to Franciscan manzanita include damage from vandalism. The post and cable fence that protects the wild Franciscan manzanita plant is approximately 30 ft (9.1 m) from the plant and is not constructed to completely exclude visitors. No vandalism of the Franciscan manzanita has been observed (D. Gamoso *in litt.*, 2014); however, in the unlikely event that vandalism occurs, the results to the species could be serious because only one wild plant remains.

Stochastic Events and Small Population Size

Chance events constitute a serious threat to Franciscan manzanita. Because the known population of Franciscan manzanita in the wild is currently limited to a single plant, the species is extremely vulnerable to stochastic events—normal but damaging environmental perturbations and catastrophes such as droughts, storm damage, disease outbreaks, and fires, from which large, wide-

ranging populations can generally recover, but which may lead to extirpation of small, isolated populations (Gilpin and Soule 1986, pp. 25–31). The majority of the remaining habitat associated with Franciscan manzanita occurs within rock outcrops on hilltops or slopes surrounded by development or along coastal cliffs. These areas, because of their limited size and proximity to developed areas, are more likely to experience inadvertent fire or environmental degradation (altered hydrologic regime; increased introduction of nonnative, invasive plants; and increased spread of disease). The nature of the habitat associated with Franciscan manzanita may also increase the effects of drought. These habitats generally do not have the water-holding capacity of deeper soiled, level habitats and may be more susceptible to landslides or erosion during excessively wet precipitation events. As a result, we consider stochastic events to be of significant threat for this species.

Any new population that starts from the wild plant is likely to have reduced genetic variation compared to historical populations. Even if the number of plants increases, it is unlikely to reverse the previous genetic loss, known as the bottleneck effect (Allendorf and Luikart 2007, p. 158). Bottlenecks generally have a greater and more lasting effect on the loss of genetic variation in species with slow growth rates (long-lived species with few offspring) (Allendorf and Luikart 2007, p. 133). The age of the single wild Franciscan manzanita plant is estimated at 60 years, and no other Franciscan manzanita plants or seedlings were found associated with the wild plant. Reduced genetic variation may result in the inability of future generations of the plant to adapt to changes in habitat, such as decrease in fog and increase in temperature (see Climate Change discussion above) or loss of pollinators. While Franciscan manzanita may be capable of self-pollination, generally it results in decreased genetic variation in the offspring of a plant (Allendorf and Luikart 2007, p. 123). Therefore, continued depression of genetic variation is expected if Franciscan manzanita is dependent on self-pollination to produce seed. If new genotypes are discovered amongst the Laurel Hill Cemetery-sourced individuals growing at botanical gardens, it would be advantageous to plant their cuttings nearby the wild plant in hopes of sexual reproduction resulting in greater genetic diversity. Barring that situation, based on the above discussion, we have determined that continued depressed genetic variation is a significant threat for this species.

The wild plant is also threatened by the Allee effect, a decline in population growth rate due to declining plant density (Akçakaya *et al.* 1999, p. 86). For the wild Franciscan manzanita plant, the Allee effect results from a lack of other available Franciscan manzanita plants with which to cross-pollinate and produce viable seed. The wild plant, the single remaining individual of its species in the wild, is currently dependent on its ability to self-pollinate, which may be limited, and the efforts of researchers and Presidio staff to provide additional plants of different genotypes (if they are proven to be Franciscan manzanita) from botanical garden specimens to cross-pollinate with the wild plant to produce new individuals and populations.

Hybridization

Cultivars of Franciscan manzanita are used in the commercial nursery trade. The cultivars (varieties of a plant produced and maintained by cultivation) are likely descended from some of the last wild Franciscan manzanita plants known to exist in the 1940s, and are located in at least four botanical gardens (Chasse *et al.* 2009, pp. 7, 8). Because hybridization between diploid species of *Arctostaphylos* is well recognized (Chasse *et al.* 2009, p. 5), there is a good chance that many of these commercially available specimens have resulted from hybrid seed. Because of the threat of cross-pollination from hybrids (ornamental manzanita cultivars) or other species (Allendorf *et al.* 2001, pp. 613, 618–621),

any propagation or reintroduction programs for Franciscan manzanita must account for potential hybridization of the Franciscan manzanita gene pool. The conservation plan takes this into account by recommending that future outplantings of nursery-raised cuttings or seedlings of the recently discovered Franciscan manzanita plant avoid areas that could facilitate cross-pollination (Chasse *et al.* 2009, p. 31). Appropriate outplanting areas will be determined by Franciscan manzanita experts, in cooperation with Service, NPS, the Presidio Trust, and the Golden Gate National Parks Conservancy (Conservancy; Chasse *et al.* 2009, p. 31). Although cross-pollination of the wild plant with hybrids and the production of hybrid seed is possible, we do not know if this is a substantial threat to the species.

Cumulative Impacts

Some of the threats discussed in this threats discussion may interact to create situations that potentially impact Franciscan manzanita beyond the scope of the individual threats we have already analyzed. In particular, climate change may exacerbate many of the threats discussed here. For example, warmer, drier conditions in the range of the species could result in not only less summer fog and increased water stress leading to plant death, but could also create more suitable conditions for infection by *Phytophthora* species and result in more fires. The loss of native habitat due to urban development within the range of Franciscan manzanita has likely reduced pollinator nesting areas and numbers of native plants that provide nectar and pollen. Climate change could increase the loss of pollinators if the abundance of flowers preferred by pollinators decreases and the synchrony of bloom periods and pollinator emergence is disrupted. Although there currently are no data available regarding changes in plant bloom periods or emergence dates of pollinators in the Presidio in response to climate change, Forister and Shapiro (2003, p. 1130) found that over a period of 31 years warmer and drier winter conditions were associated with earlier butterfly appearance in the Central Valley of California. The ability of Franciscan manzanita to self-pollinate may be limited (Parker 2011, p. 1); therefore, we expect that bumblebees, bees, and other insects are likely needed for Franciscan manzanita to produce seed. Nitrogen enrichment of the soil from atmospheric deposition may encourage the growth of nonnative, invasive grasses in the vicinity of the wild plant. The grasses could, in turn, provide additional habitat for rodents such as California voles that feed on the wild plant.

Many interactions that may arise between different threats as well as the magnitude of subsequent effects to the species are difficult to predict. Nonetheless, because of the extremely small population size of Franciscan manzanita, any interactions that increase impacts to the species may be significant.

CONSERVATION EFFORTS

The following are conservation efforts that have occurred since the single wild plant was discovered in 2009:

1) The Conservation Plan (Chassé *et al.* 2009) was written by members of six agencies and organizations who were directly involved in the translocation, propagation, management, and monitoring of the plant after its discovery in 2009. The objectives of the Conservation Plan are:

- To preserve for posterity the one wild individual.
- To establish and protect offspring from the wild plant both in the wild and ex situ in botanical gardens and nursery settings.
- To propagate other known genotypes of the Franciscan manzanita so that at least three wild, self-sustaining populations of the Franciscan manzanita can be established utilizing this diversity of genotypes to promote the long term viability of this species in the wild.

The involved agencies are National Park Service, the Conservancy, Presidio Trust, San Francisco State University, U. S. Fish and Wildlife Service, and California Department of Transportation. The duration of the Conservation Plan is 15 years from the date of signature, December 21, 2009.

2) The wild Franciscan manzanita plant was removed from its original location along Doyle Drive and transplanted to a secure, monitored location on the Presidio in January 2010. Critical habitat was designated for the species on December 20, 2013 (78 FR 77290).

3) Monitoring of the wild plant has been conducted monthly by Presidio Trust staff to identify any problems of predation, disease, and plant health.

4) In 2010, cuttings were taken from the wild plant by the Conservancy and distributed among several botanical nurseries and one commercial nursery to generate plants for starting new populations. By distributing the cuttings to multiple nurseries, the risk of loss of all the cuttings to disease or other causes was reduced. Over 300 rooted cuttings were made available by the Conservancy to be transplanted. All of these botanical gardens and the commercial nursery have planted multiple cuttings and rooted layers on their property. In addition, at least two universities- University of California, Santa Cruz and University of San Francisco- have also planted the species on their grounds. Unfortunately, it appears that none of these plantings have survived to date (M. Chasse, pers. comm., 2016)

5) In March 2012, 68 rooted cuttings were planted as demonstration plants in the Presidio near public areas such as trails and parking lots. As of March 2016, ten of these demonstration plants at the Fort Point/Battery East site, Inspiration Point Overlook, and West Crissy Bluffs Overlook have survived (M. Chasse pers. comm., 2016).

6) In March 2013, fifty-eight cuttings, in 1-gallon containers, were planted in the Presidio within critical habitat units. Thirty-two of these plants (55 percent) have survived as of March 2016. Annual monitoring of these plantings and the demonstration plantings is conducted, as well as photo documentation and GIS data collection (M. Chasse, pers. comm., 2016).

7) A study to develop a seed germination protocol for Franciscan manzanita using a surrogate species, Mount Tamalpais manzanita (*A. montana*) , was completed at the Conservancy Nursery in San Francisco in 2012 (Laskowski *et al.* 2012). Seeds have been collected from the wild Franciscan manzanita plant for germination trials using the protocol.

8) A study of the flowering periods and pollinators of Franciscan manzanita and Raven's manzanita was conducted between 2011 and 2012 by a Presidio Trust environmental education intern (J. Gambel *in litt*., 2012).

9) An infestation of the wild plant by leaf roller moths was discovered during monitoring by Presidio Trust staff soon after the plant was transplanted. The moth larvae and damaged leaves were removed by hand. Leaf roller damage was either minimal or did not occur after 2011; therefore, moth removal will likely not be necessary unless detected during monitoring.

10) Damage to the plant from California voles has been observed under and around the plant. Voles have been trapped and removed by Presidio Trust staff. Trapping of voles will be needed periodically when monitoring reveals that damage is occurring.

11) Irrigation of the wild plant was begun by Presidio Trust staff in 2013 after severe dieback was observed. Presidio Trust staff continue to monitor water stress via four soil probes and water the plant as needed. Monitoring will likely continue indefinitely. Watering will continue for the duration of the current drought or until the plant no longer needs additional water.

12) The National Park Service has successfully applied for funding to establish plantings of genetically distinct individuals of Franciscan manzanita in a maritime chaparral community within areas identified as suitable habitat on the Presidio (National Park Service 2013). The establishment of these new populations would involve three steps: 1) the collection and propagation of appropriate plant material of Franciscan manzanita and its maritime chaparral associates; 2) the preparation of suitable planting sites through invasive plant control and site protection measures; and 3) systematic plantings at multiple sites to allow for demographic monitoring over time. The objective of the project is to move from a single wild individual to establishment of self-sustaining populations of this species. Work will begin in 2016 with the identification and propagation of the known genotypes (M. Chasse pers. comm., 2016).

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