PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION
SUPPORTING INFORMATION FOR

Morro manzanita (*Arctostaphylos morroensis)*

Dense stand of Morro manzanita *Arctostaphylos morroensis* in Montaña de Oro State Park.
In the background is a *Eucalyptus* grove.

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EXECUTIVE SUMMARY

We recommend that Morro manzanita *Arctostaphylos morroensis* be listed as endangered. This plant species is endemic to the Los Osos area, San Luis Obispo County, California, occurring predominantly on Baywood fine sand. The area has a Mediterranean climate, with cool moist winters and warm dry summers. Fog is common. Temperatures range from ~ 6.5º to 23.5ºC, and mean annual rainfall (recorded at Morro Bay Fire Station) is 42.1 cm, with 75% occurring between November and April (Tyler and Kofron 2024). Morro manzanita occurs at elevations <200 m (Parker et al. 2012). The historic geographic range was estimated to comprise 800 to 1,100 ha (USFWS 1994), and approximately 75% of this area is now developed (USFWS 2013). After a fire, Morro manzanita must re-establish from seeds in the soil seed bank, where the proportion of viable seeds to total seeds is very low with an average of 4% (Tyler and Odion 2020). The clearing of Morro manzanita and its habitat for residential development is the primary threat to Morro manzanita. This is an immediate threat. The Los Osos HCP and U.S. Endangered Species Act provide only limited protection for Morro manzanita on private land. Homebuilding would convert portions of the remaining, intact parcels into residential development, likely along with subsequent firebreaks for protection. Fragmentation of the remaining, high density, intact stands for residences, permissible under the Los Osos HCP, would be an irreversible loss of Morro manzanita and habitat (Tyler and Kofron 2024).

1. INTRODUCTION

Morro manzanita *Arctostaphylos morroensis* Wies. & Schreib. is a long-lived, perennial shrub endemic to San Luis Obispo County, southern California, USA. It is an erect evergreen shrub in the heath family, Ericaceae (Fig. 1). It can be distinguished from other species of manzanitas in the vicinity by its persistent shreddy gray bark, densely hairy lower leaf surfaces and leaf bases that are truncate to somewhat cordate (Kauffmann et al. 2021). Individuals, normally one to four meters in height, can become arborescent with old age (Fig 1). In some stands of maritime chaparral where it occurs, Morro manzanita can be the dominant shrub species, but its highly localized distribution has been further reduced to a small portion of coastal California in habitat that is fragmented by development.

The species was listed as threatened under the U.S. Endangered Species Act in 1994 (USFWS 1994) with identified threats being residential and urban development, including lack of protection on private land and lack of management on public lands, competition with invasive non-native plants, and risks of extinction associated with small and isolated populations. It is recognized also as a 1 B.1 rare plant (seriously threatened) by the California Native Plant Society. Research has been conducted on the reproductive ecology (Tyler et al. 2023), germination cues and seedbank dynamics (Tyler and Odion 2020), and early responses to prescribed burning (Odion and Tyler 2002). A recent comprehensive review summarizes what is known about the ecology and current conservation status of the species (Tyler and Kofron 2024).

A continuing threat to the persistence of Morro manzanita is clearing of habitat for conversion to residential development. USFWS (1994) stated "the restricted range and narrow habitat requirements of *A. morroensis*, coupled with continuing alteration, destruction, and fragmentation of habitat, make it vulnerable to becoming endangered in the near future." Although progress has been made in protecting maritime chaparral and coastal scrub with Morro manzanita through establishment of preserves, and federal listing under the ESA, threats by development on private lands remain. In addition, existing management to protect the species on public land is limited. In this petition, we present information to support listing Morro manzanita as an "endangered" species under the California Endangered Species Act (CESA). The protections afforded by CESA would be key to ensuring this species' persistence into the future.

2. RANGE, DISTRIBUTION, AND ABUNDANCE.

Morro manzanita is restricted to a small portion of coastal area in and near Los Osos, San Luis Obispo County, California (Fig. 2). Its distribution is predominantly correlated with the Pleistocene eolian sand mapped as Baywood fine sand (Carpenter and Storie 1928; Soil Conservation Service 1984; Wiegers 2009), where there is no slope to moderate slope (Fig. 3).

The current range of this species has been estimated to comprise ~ 350 ha based on mapped polygons that contain the species at various cover classes (Mullany 1990; LSA Associates 1992). However, Tyler and Odion (1996) pointed out this was an over-representation of the actual existing cover of Morro manzanita because individuals are often present in low-density patches

within a matrix of associated plant communities. In order to estimate the aerial cover of the species alone, Tyler and Odion (1996) recalculated to account for stands with a sparse cover having been equally weighted with stand with high cover. Using previously reported cover classes and estimated acreage of each (from Mullany 1990 and McGuire and Morey 1992) they estimated the species itself actually covered less than 162 ha (Tyler and Odion 1996). As a shrub with multiple stems at the base, sometimes present in dense stands, it is difficult to accurately determine counts of individual Morro manzanitas. However, LSA Associates (1992) used an estimated average individual size of 9 m^2 to propose a total population size of ~153,000. Crawford et al. (2004) estimated number of individuals range from 86,000 to 153,000.

The primary source of information on the geographic range of the species is the CNDDB (CDFW 2021). For Morro manzanita there are six known occurrences, each with an assigned number by CNDDB, which are not in sequence. As knowledge of the species' distribution improved, some previously recognized occurrences have been combined with other occurrences, maintaining the criteria that separate occurrences are >0.4 km from any other occurrence. Thus, the assigned numbers for Morro manzanita occurrences are 1, 4, 9, 18, 20 and 21 (Fig 2). Detailed information on these occurrences, and one new occurrence, were reported in Tyler and Kofron (2024) and summarized below.

For occurrence 1, Wieslander and Schreiber (1939) give the location for paratype specimen (UC1334951/Ben Bolt 644/VTM14631) as "Valencia Peak", collected 23 March 1936. They state the distribution of Morro manzanita as "sandy hills south of Morro Bay, 100 — 400 feet", but Valencia Peak (Montaña de Oro State Park) is 1,345 ft/410 m elevation with soils defined as Lopez very shaly clay loam, 30-75% slope (Soil Conservation Service 1984). Data in the pocket of the herbarium sheet give the following information: 1 mile east-northeast Valencia Peak; verbatim elevation as "400" ft; and habitat as woodland, north slope, and small type Monterey shale. CNDDB states "exact location unknown. mapped as best guess 1 air mile ENE of Valencia Peak". Recent field surveys, reported in Tyler and Kofron (2024), were unsuccessful in locating any Morro manzanita at this location. They suggest "Valencia Peak" or 1 mile east-northeast Valencia Peak are erroneous data and that the presence of Morro manzanita south of Valencia Peak should be investigated to determine if this occurrence remains valid.

Occurrence 4 is in north Los Osos. It is comprised of the Elfin Forest Preserve, the adjacent part of Morro Bay State Park, and private land (CDFW 2021). It is mapped as 16 polygons, mostly according to data from 1980 and 1990 to 1992. Where Morro manzanita is present in this occurrence it is at very low cover, from <1% to 25% cover (Mullany 1990). Estimates of abundance are not available. The majority of private land are residential parcels; here some individual Morro manzanitas are incorporated into residential landscaping (CDFW 2021) but total numbers are likely substantially reduced and their ecological function is unknown.

Occurrence 9 is west of Pecho Valley Road, and south of the west end of Los Osos Valley Road extending to ridges south of Hazard Canyon. This occurrence includes multiple preserve properties as well as private land. It is mapped as 15 polygons, mostly according to map data from 1980 and 1990–1992, with an estimate of >152,200 plants. It comprises the largest occurrence (CDFW 2021).

Occurrence 18 is in Morro Bay State Park. We observed ~ 12 individuals on 28 January 2023. We also observed here Oso manzanita *A. osoensis*. This is the northmost occurrence for Morro manzanita. The rocky, volcanic exposure of porphyritic dacite (igneous rock; Wiegers 2009) is an unusual substrate for the species. The underlying substrate is mapped as Rock outcrop-Lithic Haploxerolls complex (Soil Conservation Service 1984). The only previous observation here was in 1989 (Mullany 1990) with one or a few individuals reported.

Occurrence 20 is/was at coordinates 35.31398, -120.81615, as mapped by Mullany (1990) at the eastern terminus of Freeman Lane in east Los Osos. Tyler and Kofron (2024) reported that this occurrence is now likely extirpated as a result of house and facilities construction at this site in 2005

Occurrence 21 is in Morro Bay State Park. It is 19 m south of the Crespi Trail, on a south facing outcrop of shale (Nelson 2015). Soil Conservation Service (1984) mapped the underlying substrate as Rock outcrop-Lithic Haploxerolls complex. In 2023 Tyler and Kofron (2024) observed ~ 20 individuals at this occurrence, some with flowers and growing with Oso manzanita. The only previous observation of this occurrence was by Nelson (2015), who reported many plants.

Tyler and Kofron (2024) reported one new occurrence in their 2023 field surveys. They confirmed the presence of Morro manzanita along the Manzanita Trail and East Boundary Trail in Montaña de Oro State Park (described in Mullany 1990) at three localities not recorded in CNDDB (CDFW 2021). These were: 35.29106, -120.85267; 35.28797, -120.84735; and 35.29085, -120.84406. The first new locality with ~ 10 individuals is 0.37 km from occurrence 9, and thus would be included in this occurrence. The latter two (eastmost) comprise a new occurrence. The second new locality is 0.59 km from occurrence 9 (thus a new occurrence), and the third with one individual is 0.66 km from occurrence 9. At the second locality, which was at the periphery of a rocky outcrop, we observed ~ 12 individuals of Morro manzanita and several brittle leaf manzanita *A. crustacea* subsp. *crustacea*. The underlying soil type for all three new localities is mapped as Santa Lucia shaly clay loam (Soil Conservation Service 1984). Data for these localities were submitted through online field survey forms to CNDDB, and voucher specimens were deposited in the herbarium at UC Santa Barbara's Cheadle Center for Biodiversity and Ecological Restoration.

Summarizing the findings based on data for all occurrences of Morro manzanita from the CNDDB (CDFW 2021) and their field surveys, Tyler and Kofron (2024) proposed that the location of occurrence 1 was based on erroneous data, and that occurrence 20 is no longer extant. Three of the remaining three occurrences - 18, 21 and the one new occurrence - are small but significant outlying stands at the edges of the species' range. Occurrences 9 and 4 represent at least 98% of this species' area of occupancy, but these include land that has been converted to residential development. This is especially evident in occurrence 4 where many polygons mapped as Morro manzanita in north Los Osos are clearly lined by streets and dominated by houses (Fig 4.) This is also the case for some outlying polygons in occurrence 9 east of Morro Dunes Ecological Reserve Bayview Unit, and west of the Broderson Site. However, occurrence 9 also includes the largest remaining contiguous stands with highest cover (75 to 100%) of Morro manzanita (Mullany 1990). Especially noteworthy from a conservation perspective is that most

of these intact high cover stands are on private land south of the Broderson Site and southwest of Cabrillo Estates.

3. POPULATION TRENDS

The historical geographical range of Morro manzanita was estimated to comprise 800 to 1,100 ha (USFWS 1994). However, by the early 1990's, the area of occupancy was estimated to remain at only ~ 350 ha (Mullany 1990; LSA Associates 1992). This represented a loss of two-thirds of the species' historical geographic range, due to removal of individuals and habitat elimination (Odion and Tyler 2002). By 2013~ three-fourths of the historical habitat had been converted for residential use, resulting in highly fragmented populations (USFWS 2013) (Fig. 4).

Tyler and Odion (1996) Using previously reported cover classes and estimated acreage of each (Mullany 1990; McGuire and Morey 1992), they estimated the species area actually covered less than 162 ha (Tyler and Odion 1996). Whether considering area occupied by the species alone (~162 ha) or the habitat area of occupancy (~350 ha), it is clear that this is a significant reduction from the historical range for Morro manzanita. This substantial reduction in extent of the species, as well as the planned residential development that would lead to further local extirpation, was highlighted in the listing of the species as threatened in 1994 under the US Endangered Species Act (USFWS 1994).

4. LIFE HISTORY

4.1 Species Description. Wieslander and Schreiber (1939) first named and described Morro manzanita, referencing specimens collected in 1936 and 1938 in and near Hazard Canyon south of Morro Bay, an area now in Montaña de Oro State Park. The three collections, including holotype, are filed in the Herbarium at the University of California Berkeley (Wieslander and Schreiber 1939). Additional specimens used by Wieslander and Schreiber (1939) to verify the range are in the herbaria at Stanford University and the California Academy of Sciences.

Morro manzanita is an erect spreading shrub, generally 1 to 4 m in height (Parker et al. 2012), with some older individuals reaching 8.5 m tall. This manzanita species lacks a basal burl, which is both a distinguishing taxonomic characteristic, and indicative of its postfire recovery response (Jepson 1916; Wieslander and Schreiber 1939; Keeley and Zedler 1978). Some woody or shrub species - those with underground/basal burls - have the ability to resprout following fire, while others are non-sprouters that rely on postfire establishment of seedlings from a long-lived dormant seed bank (Wells 1969; Keeley 1991; Whelan 1995). The latter are "obligate seeders", a relatively uncommon life history type found mostly among shrubs in semiarid areas in California, Australia, and South Africa (Bond and van Wilgen 1996). Since the adults are consumed by fire, the persistence of populations of obligate seeders is dependent on the sufficient accumulation of viable seed in the soil seed bank in the interval between fires. Morro manzanita is an obligate-seeding species.

Other distinctive morphological traits include its bark and leaf morphologies. The grayish-brown bark on mature stems is shreddy but persistent. Its leaves are oblong to oblong elliptic (1.5 to 3 cm long), truncate to subcordate at the base (not auriculate clasping), with short petioles (2 to 5 mm). Notably, the leaf surfaces are unlike: dark green, shiny and lacking stomata above, while gray-tomentose on the lower surface (Hoover 1970; Wells 2000; Parker et al. 2012). Wells (1968) determined that Morro manzanita has a base chromosome number of 13 and it is diploid (2n = 26).

4.2 Lifespan. Morro manzanita is slow-growing and long-lived. While maximum lifespan has not been reported, Tyler and Odion (1996) estimated stand ages using historical aerial photographs from the collection in the Map and Imagery Library at the University of California, Santa Barbara. They examined images from 1949 to 1992 to identify areas that had been cleared and/or burned. In addition, cross-sections of co-occurring wedgeleaf ceanothus were collected from the areas where stand age was estimated; this species is an obligate seeder and thus would have germinated following fire, at the same time as the manzanitas present in the stand. The annual ring counts from cross-sections confirmed the minimum stand ages based on aerial photos. In 1996, the stand ages ranged from 37 to >47 years old, with the large tree-like (arborescent) individuals in the Elfin Forest Preserve estimated to be substantially older than 47 years; as described above, some of these individuals are exceptionally large. Since that 1996 report, there has been only one fire in all sites surveyed, a prescribed burn conducted in 1998. Thus, at present the youngest stand is 25 years old, and the oldest stand is a minimum of 74 years old (though most likely it is much older).

4.3 Flowering and pollination. One of the distinctive and distinguishing characteristics of species in the genus *Arctostaphylos* are the "nascent" or immature inflorescences, developed many months before flowering (Jepson 1938; Keeley 1997). In Morro manzanita, these immature panicles are pendent and campanulate (Wieslander and Schreiber 1939; Parker et al. 2012). Small urn-shaped flowers, which are white and occasionally tinged with pink, appear in January through March.

Similar to other obligate-seeding manzanita species (Keeley 1977; Fulton and Carpenter 1979; Mahall et al. 2010), Morro manzanita produces abundant flowers. Tyler et al. (2023) recorded an average of 50 to 135 flowers per stem across a two-year period. Flower production (number of flowers per stem) varies among sites and among years with much higher (two times the average) flower production across sites in a very wet year (1998) compared to a year with below- average rainfall (1999) (Tyler et al. 2023). In Morro manzanita flower production was most strongly related to present year resources (rainfall) (Tyler et al. 2023), which is similar to observations reported for pointleaf manzanita *A. pungens* (Richardson and Bronstein 2012).

Reproduction of Morro manzanita is **dependent on pollinators**. Tyler et al. (2023) found that when inflorescences were bagged to exclude animal pollinators, fruits were not produced. Bees are the most common pollinators of Morro manzanita, and include yellow-faced bumblebees *Bombus vosnesenskii*, the common anthophorid bee *Anthophora urbana*, halictid bees, *Colletes* sp., and European honey bees *Apis mellifera*. Other pollinators observed visiting Morro manzanita flowers include syrphid flies, monarch butterflies *Danus plexxipus*, bee flies

Bombylius sp. and Anna's hummingbird *Calypte anna* (Tyler et al. 2023). This is consistent with research on congeners that demonstrated self-compatibility and reliance on pollinators for successful reproduction – pink bracted manzanita *A. pringlei* var. *drupacea* and *A. glauca* (Brum 1975) and *A. pungens* (Richardson and Bronstein 2012). Bees have also been found to be important pollinators of other manzanita species (Gankin and Major 1964; Brum 1975; Fulton and Carpenter 1979). Morro manzanita's dependence on pollinators, especially insects, has important implications for conservation. The impacts of habitat loss and fragmentation are both direct and indirect, as small populations or isolated stands may experience pollinator limitation and low seed production (Agren 1996; Cunningham 2000; Tyler et al. 2023).

4.4. Fruiting. Fruit set, or the percent of flowers producing a fruit, varies among sites and years, ranging from an annual average of 10 to 18% (Tyler et al. 2023). These data were reported for two adjacent years (1998, 1999), with fruit set being consistent across years for some sites, and varying significantly (5 times higher in one year) at another site. To our knowledge, the only other reported data on fruit set in manzanitas are for *A. pungens* (Richardson and Bronstein 2012), in which highest values for fruit set in control/natural conditions was 36% in 1998, and no fruit set observed in the following year. Thus, although we suspect fruit set is comparatively low in Morro manzanita, longer-term data and data on congeners are lacking in order for this to be confirmed. Seed set, as determined by viable seed to ovule ratios, has been investigated in several species of manzanita by Kelly and Parker (1991). They reported that Morro manzanita has an average of 7.3 ovules per ovary/fruit (each flower contains one ovary in the Ericaceae), and that seed set is relatively high at 73% (Kelly and Parker 1991). This suggests that once pollinated, Morro manzanita successfully produces viable seeds, and that low fruit set may indicate pollinator limitation (Tyler et al. 2023.)

The fruits mature in spring-summer. They are reddish-brown and spherical to slightly flattened, or depressed globose. Morro manzanita fruits are drupes, covered by a thin exocarp, and containing a dry, mealy mesocarp surrounding multiple hard stones or "nutlets" (Meyer 2008; Parker et al. 2012). They contain an average of five (Kelly and Parker 1991) to eight (Tyler and Odion 1996) nutlets (i.e., seeds) per fruit. The nutlets are free to strongly adherent (i.e., partially fused.) Fruit drop occurs in late spring to late fall, though the timing can vary annually. Tyler et al. (2023) found that the majority of fruits fell from the plants during June and early July one year (1998), and August to early October in the following year (1999.)

4.5. Fruit predation. Dropped fruits of Morro manzanita are removed quickly by predators. Tyler et al. (2023) conducted studies of fruit removal rates by vertebrate predators, carried out in two years (1998, 1999). They found that in both years, predators, most likely small mammals and birds, removed a majority of fruits and did it relatively quickly. From 60 to 70% of fruits were removed within 1.5 months in both years. High predation rates have been reported for other species of manzanita (Keeley 1977; Kelly and Parker 1990).

Fruit removal alone does not mean all seeds are eliminated from the site, as some animals may scatter-hoard or cache seeds that could be incorporated into the soil seed bank (Parker 2015; Crowe and Parker 2023). However, in Morro manzanita it is unknown if such a mutualistic relationship exists, and some evidence points to consumers as seed predators rather than planters. For example, sites where seed bank density is exceptionally low (Elfin Forest) have the highest

rates of fruit removal (Tyler and Odion 2020; Tyler et al. 2023). In addition, relatively few Morro manzanita seeds are found in the soil away from the shrub canopies, and overall viable seed densities can be very low (Tyler and Odion 2020), suggesting that predation of a large fraction of fruits, even if some were buried and forgotten, could have a net negative impact.

4.6. Seed input and seed banks. Based on seed drop, seed predation rates, and estimates of the number of seeds per fruit for Morro manzanita, Tyler et al. (2023), estimated annual seed input to the soil seed bank over two years (1998 and 1999). The relative addition of seeds across years was similar at all sites (i.e., about 1.5 times greater in 1998 compared to 1999). However, seed input varied considerably among sites, and **rates appear to decline with stand age**. Annual seed input was at least 4 times lower at the oldest-aged stand at the Elfin Forest (316 seeds per m^2 in 1998) compared to the youngest stand in Montaña de Oro State Park (1,608 seeds per m^2 in 1998). The intermediate-aged stand had an intermediate value with an estimated seed input of 912 seeds per m^2 in this same year.

Tyler and Odion (2020) examined soil seed banks in different-aged stands, predicting that seed densities would be positively correlated with stand age. Soil cores (10 cm depth) were collected under multiple shrubs across three sites. Morro manzanita seed density in the soil varied greatly among sites, from 1,326 to 62,251 seeds per m^2. However, contrary to expectations, the oldest had especially low seed densities (Tyler and Odion 2020). Since seed input, as described above, was particularly low in the oldest stand, seed densities in the soil seedbank may decline even further. There has been one other study (Parker and Ingalls 2022) that reported seed bank densities of Morro manzanita. In their comparative study of ten *Arctostaphylos* species to investigate the relationship between seed size and seed bank density, Parker and Ingalls (2022) collected Morro manzanita seed and estimated the seed bank density (for 5 cm deep cores) to be an average of 1,900 per m^2. Although the location of their collections is not reported, if this value is doubled to make an equivalent comparison to results reported by Tyler and Odion (2020), their finding of a seed density of ~ 3,800 per m^2 is within the same range. Further study is warranted to investigate change in soil seedbanks over time. In addition, understanding the dynamics of fruits and seed accumulation in the litter layer would be useful as this may be a potential seed source for restoration efforts.

4.7. Seed viability and germination cues. Percent viability of Morro manzanita seeds, i.e., the proportion of viable to total seeds, within the soil seed bank is **very low** across all stands, with an average of 4% (Tyler and Odion 2020). The oldest stand (the Elfin Forest) has exceptionally low seed viability averaging 2%. Viability of fresh seeds has not been recorded in the literature, so rates of change with seed age are unknown.

Morro manzanita is an obligate-seeder, meaning that it does not resprout when the crown and stem are burned, and thus must re-establish from seeds in the soil seed bank. Seeds of obligate-seeders are mainly or even completely refractory (Sweeney 1956; Keeley 1987; Keeley 1991); that is, germination is inhibited until primary dormancy is released by a specific mechanism. Fire-related cues such as heat and by-products of combustion have been identified as principal mechanisms that break seed dormancy of fire recruiters that rely on soil-stored seed (Keeley 1991). In other manzanita species, germination rates are low, but enhanced with smoke, charate, heat shock, or some combination of these treatments (Odion 2000; Keeley et al. 2005; Jurado et

al. 2011). Tyler and Odion (2020) examined germination of Morro manzanita seeds in response to various cues, and confirmed that germination, while very low on average (1 to 4%), was greatest in treatments that combined heat and charred wood. However, neither heat nor charred wood alone enhanced germination (Tyler and Odion 2020.) One factor responsible for low germination is that seed viability is very low – from 3 to 6%. Germination as a percentage of estimated viable seeds was found to be relatively high (23 to 100%). Unexpectedly, ~ 40% of viable seeds from the soil seed bank germinated with no fire treatments. Viability and germinabilty of fresh Morro manzanita seed has not been investigated. Although fresh and litter-stored seeds are unlikely to contribute to post-fire seedling establishment, as they would be consumed in a burn, this seed source might be used in restoration purposes; thus, study of its viability rates and germination cues is recommended.

4.8. Response to and recovery from fire. To assess the effects of burning on seedling establishment in Morro manzanita, a prescribed fire was conducted by California State Parks in Montaña de Oro State Park in 1998. At the time of the burn, the stand was 40 years-old. The total area burned was ~ 2.3 ha. Odion and Tyler (2002) recorded pre-burn seed densities and seed viabilities, seed mortality due to fire, and postfire germination and seedling survivorship for three years, to compare the population that established after the burn with the one present before.

Prior to the burn, there was abundant soil-stored seed, ~ 11,000 seeds per m^2, though seed viability in this stand (and all others) was low, resulting in an average of 334 viable seeds per m^2 before the fire (Odion and Tyler 2002). As was expected, seed mortality through the burn was high, and following the experimental fire only about a third remained, leaving an average of 99 viable seeds per m^2. Germination was recorded in the first two wet seasons after the fire, though most seedlings did not survive their initial summer drought. After three years, the density of Morro manzanita seedling was less than half the estimated density of the adult shrubs present before the fire. The authors speculated that the most likely factors responsible for the low number of seedling recruits were low numbers of viable seed in the soil, and relatively high mortality of both germinants and young seedlings. Based on early postfire observations, Odion and Tyler (2002) suggested that with further mortality of the remaining seedlings and no additional germination, the 40-year-old stand may not have had an adequate seed bank to compensate for mortality and thus prevent population decline.

To improve understanding of long-term post-fire recovery of Morro manzanita, Tyler and Kofron (2024) resampled the stand burned in 1998. Twenty-five years post-burn they found that cover of Morro manzanita along the original vegetation transects was high, ranging from 30% to 100%, with a median of 93%, and mean of 83% cover Morro manzanita. This was substantially greater than three years after the burn, when Morro manzanita seedlings accounted for < 1% cover. This longer-term survey suggests that this stand is recovering slowly but successfully from the fire, at least in terms of percent cover of Morro manzanita.

While this stand was relatively young (40 years old) at the time of the prescribed fire, seedbank densities and subsequent seedling recruits may have indeed been adequate to restore cover of adults killed in the burn. Findings reported by Tyler and Kofron (2024) highlight that while early post-fire sampling is appropriate and useful, to accurately determine the response to fire in long-lived obligate-seeding species, much longer time scales of observation, on the order of decades,

are required. Their recent survey also indicates that burning should not be avoided as a management tool in supporting restoration of Morro manzanita, though stand age should be an important factor in considering the appropriate use of fire for a particular area. Odion and Tyler (2002) and Tyler and Kofron (2024) recommend against burning stands that are much younger than 40 years; another decade or so of seed input may have substantially increased the viable seed and thus potential seedling recruits in the prescribed burn stand. At this time, since nearly all stands containing Morro manzanita are at least 74 years old, with the exception of the 2 ha area described above, prescribed fire may be one of the most effective tools in ensuring the regeneration of new individuals in aging stands. This approach may not be feasible in some sites where there is close proximity to residential development, such as the Elfin Forest Preserve, even though these oldest stands may be experiencing declining soil seedbanks over time (Tyler and Odion 2022). In such sites, exposing seedbanks to fire-related cues to stimulate germination, using small scale approaches such as burn boxes, or treating soil off-site could be suitable alternatives.

5. KIND OF HABITAT NECESSARY FOR SURVIVAL

Morro manzanita is found only along a small portion of the Central California coast at elevations <200 m (Parker et al. 2012), primarily on stabilized sand dunes of Baywood fine sand (Carpenter and Storie 1928; Soil Conservation Service 1984; Wiegers 2009), with few outlying locations on outcrop shale or volcanic igneous substrate. The climate is Mediterranean, with cool moist winters and warm dry summers. Fog is common, and has been found to play a key role in determining the physiological performance of *Arctostaphylos* species (Vasey et al. 2014). Temperatures range from ~ 6.5º to 23.5ºC, and mean annual rainfall (recorded at Morro Bay Fire Station) is 42.1 cm, with 75% occurring between November and April (Tyler and Kofron 2024). The factors influencing species composition in the community types hosting Morro manzanita have not been investigated, but likely include soil characteristics, fog frequency, patch size, time since fire, and extent of soil disturbance or mechanical clearing.

6. FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

6.1. Seedbank density and seed viability. Morro manzanita is an obligate-seeder, meaning that it does not resprout when the crown and stem are burned, and thus must re-establish from seeds in the soil seed bank. Percent viability of Morro manzanita seeds, i.e., the proportion of viable to total seeds, within the soil seed bank is very low across all stands, with an average of 4% (Tyler and Odion 2020).

6.2. Reproductive issues in isolated stands. Tyler and Odion (2020) found that seed from Morro manzanita in the most isolated stand, the Elfin Forest Preserve, had significantly lower seed viability compared to other stands, 2% vs. 4%, respectively. They hypothesized that low seed viability and high ‘‘infertility’’ (no evidence of embryo development) at the isolated stand may have been caused by inbreeding effects. Tyler et al. (2023) also reported especially low fruit

set at this isolated stand. Given the dependence of Morro manzanita on pollinators for successful reproduction (Tyler et al. 2023), the authors suggest that pollinator limitation may pose a threat to adequate fruit and seed production, particularly in small, isolated stands.

6.3. Clearing of habitat for residential development. Clearing of habitat for residential development, including the direct removal of Morro manzanitas is the **primary threat** to this species. Conversion of the remaining, high density, intact stands to residences under the Los Osos HCP would be an irreversible loss of Morro manzanita and habitat. In addition, clearing exacerbates the negative impacts of existing fragmentation by further reducing the patch sizes of and connections among the remaining stands (Tyler er al. 2023).

7. DEGREE AND IMMEDIACY OF THREAT

7.1. Clearing of habitat for residential development. A threat to the persistence of Morro manzanita and a primary factor in its Federal listing is clearing of habitat for residential development. USFWS (1994) stated "the restricted range and narrow habitat requirements of *A. morroensis*, coupled with continuing alteration, destruction, and fragmentation of habitat, make it vulnerable to becoming endangered in the near future." Although progress has been made in protecting maritime chaparral and coastal scrub with Morro manzanita through establishment of preserves, threats by development on private lands remain. One of the largest remaining intact areas with high cover of Morro manzanita is on private land. Conversion of these stands to residences would be an irreversible loss of both Morro manzanita individuals and habitat capable of supporting this species. Such loss of habitat exacerbates the current negative impacts of fragmentation including reduced movement of pollinators and other associated species.

In addition, alteration of the habitat on private land adjacent to housing, due to current fire management practices, extends negative impacts into intact Morro manzanita stands. California's new code section 51179 requires homeowners in areas at high risk of wildfire to maintain a defensible space around their homes, which is an area free of excess or dead vegetation. Ninety-five percent of occurrence 9 is an area designated very high risk, which is the most severe category. This includes the following housing estates in Los Osos: Vista Court, Cabrillo Estates, the Seascape Place/Rodman Drive area, Bayview Heights, and Marguerite Drive mobile homes area. A homeowner must maintain a combustible-free zone of 1.5 m from the house, a lean/clean/green zone within 9 m feet of the house, and reduce potential fuel within 30 m feet of the house (Kerstein 2021; Calif. Dept. Forestry Fire Prevention 2023). In 2019, a fire break (30 m wide) was constructed around the eastern edge of Cabrillo Estates, in which most vegetation was cleared and Morro manzanita severely pruned, removing the majority of shrub canopies and removing low branches contacting the ground. CA Department of Forestry and Fire Prevention is currently proposing to extend this firebreak to encompass the Seascape Place/Rodman Drive area along Pecho Valley Road, and construct another firebreak from Cabrillo Estates eastward to the vicinity of Los Osos Oaks State Natural Reserve. Such intensive removal of manzanita biomass converts this former maritime chaparral habitat to open landscaping with denuded shrub-like specimens. The functional ecological value of these pruned manzanitas is unknown, though without doubt their reproductive output will be substantially reduced and habitat for associated

wildlife will be altered. The original listing for Morro manzanita (USFWS 1994) acknowledged the past and future potential for such deleterious impacts stating that "in addition to direct removal of habitat, development has had secondary effects on quality of adjacent remaining habitat, such as fragmentation, deterioration of habitat due to increased recreational activity, and the introduction of non-native species." Clearing for firebreaks around residences that are adjacent to high cover Morro manzanita stands is another such secondary impact that poses a potential threat to the species. While maintaining defensible space is an important and valid public safety concern, it would be beneficial to explore alternatives to severe thinning of manzanitas beyond the 9 m requisite border, or to consider mitigation of impacts off-site.

7.2. Non-native, invasive plant species. Non-native, invasive plant species remain a threat to Morro Manzanita since listing in 1994 (USFWS 1994). Species include iceplant *Carpobrotus* sp., veldt grass *Ehrharta calcina*, and *Eucalyptus* spp. The latter is especially problematic. *Eucalyptus* plantations, as well as small stands, were planted in the early 1900's in Los Osos and within what is now Montaña de Oro State Park (Hook 1988). Based on soils, Baywood fine sands, and adjacent vegetation, it is very likely these were planted in sites formerly occupied by Morro manzanita (Mullany 1990). Where extensive *Eucalyptus* plantings abut dense Morro manzanita stands, few mature manzanitas remain under *Eucalyptus* canopy and there is no regeneration there, perhaps due to competition for water or other biotic factors (Mullany 1990.) Also concerning is that expansion of *Eucalyptus* has been documented. In 1949 *Eucalyptus* covered 48.3 ha, by 1986 it had expanded to 73.5 ha (Bicknell 1990), and by 2021 it had further expanded to 141.6 ha (McFadden 2021). Finally, the extensive *Eucalyptus* plantations in Montaña de Oro State Park are highly flammable, and thus pose a wildfire risk. While Morro manzanita is adapted to fire, burning at increased frequencies (i.e., fire intervals under 40 years) could lead to population declines. Dense cover of veldt grass poses a similar risk of altering fire regimes to the detriment of both Morro manzanita and other components of maritime chaparral and dune scrub; similar impacts of invasive species have been documented across a variety of plant communities (Brooks et al. 2004). At the same time, the current *Eucalyptus* plantations offer opportunities for restoration and expansion of Morro manzanita. Removal of at least portions of these plantations followed by seeding or planting with Morro manzanita would allow for re-establishment of this species into its former habitat. Potential locations for the initiation of such efforts would be the edges of *Eucalyptus* stands that have been recently thinned, such as along the East Cable Trail east of Pecho Valley Road in Montaña de Oro State Park. Here, intact Morro manzanita stands persist at the outer edges of the plantations, and removal of 10 to 20 *Eucalyptus* could provide 100 m^2 of area to replant manzanitas, gradually reducing the area occupied by the plantations along the accessible periphery.

7.3. Stochastic events. Stochastic events was identified as a main threat for Morro manzanita at listing (USFWS 1994) because of the negative effects that impact small, isolated populations. Environmental stochastic events that could reduce abundance of Morro manzanita would include wildfires that occur at intervals too short for adequate seedbank stores to accumulate. Frequent fires have not been observed in the area, but increased spread of invasive grasses or flammable *Eucalyptus* species could alter the natural fire regime. Demographic stochasticity refers to random fluctuations in reproduction and mortality, and in small populations these fluctuations can result in reduced growth rates (e.g., allee effect). Although further study is warranted, Tyler and Odion (2020) found that seed from Morro manzanita in the most isolated stand, the Elfin

Forest Preserve, had significantly lower seed viability compared to other stands, 2% vs. 4%, respectively. They hypothesized that low seed viability and high ‘‘infertility’’ (no evidence of embryo development) at the isolated stand may have been caused by inbreeding effects. Small, fragmented plant populations are susceptible to increased genetic drift and inbreeding (Sampson et al. 2016), which compromises plant reproduction (Aguilar et al. 2006). This may be particularly true for Morro manzanita, which is dependent on localized insect pollination (Tyler et al. 2023).

7.4. Climate change. Climate change may present a new threat to Morro manzanita. Langridge (2018) provided a comprehensive assessment of how climate change will affect California's Central Coast, including increased maximum/minimum temperatures, uncertainty in fog, slightly increased precipitation with substantially increased variability, increased extreme rainfall events, accelerated sea level rise, increased drought, and frequent and sometimes large wildfires. Mortality and stem die-off of several large Morro manzanitas in the Elfin Forest Preserve were observed since 2015, which may have been associated with the extremely low rainfall (P. Sarafian pers. comm. 2021) The tolerance of Morro manzanita to climate change is unknown, however, it is a habitat specialist in the coastal zone with marine fog. Morro manzanita cannot disperse to distant locations because it has a small geographic range and endemic soil requirements.

7.5. Sudden Oak Death pathogen *Phytophthora ramorum*. Lee et al. (2019) and Frankel et al. (2020) reported the sudden oak death pathogen affecting multiple species of *Arctostaphylos*, including Morro manzanita in the botanic gardens of the University of California Santa Cruz in 2017 (M. Garbelotto pers. comm. 2022). In 35 years, this disease had killed more than 50,000,000 trees in California and Oregon, primarily tanoak *Lithocarpus densiforus* and coast live oak. Among eight species of *Arctostaphylos* tested for susceptibility, Morro manzanita was intermediate (Garbelotto et al. 2020). Although no infected plants of any species have been found in the wild in San Luis Obispo County, the nearest infections are 3 km north of the county line in Salmon Creek Canyon, southwest Monterey County (M. Garbelotto pers. comm. 2022), which is 72 km north of the nearest occurrence of Morro manzanita (occurrence 18). However, since 2019 the pathogen has been detected by polymerase chain reaction in four streams in coastal San Luis Obispo County: Santa Rosa Creek (also known as Old Creek), 14.8 km north of occurrence 18 (6.6 km northwest of Cayucos); 34 km northwest of occurrence 18; San Simeon Creek, 38 km northwest of occurrence 18; and San Carpoforo Creek, 63 km northwest of occurrence 18. Despite intensive searches, no infected vegetation has been found in the watersheds (K. Corella pers. comm. 2023). Continued monitoring for the presence of this pathogen would be prudent since the potential consequences could be substantial.

8. IMPACT OF EXISTING MANAGEMENT ACTIONS

Since the listing of Morro manzanita in 1994, California State Parks and CDFW have acquired substantial amounts of land for conservation in the vicinity of Morro Bay, including lands occupied by Morro manzanita. There are currently eight preserves that include significant cover of the species, and these are managed by three different agencies – California State Parks,

California Department of Fish and Wildlife, and the County of San Luis Obispo. The preserves are distributed across the Conservation Planning Areas. Approximately half of this area with Morro manzanita is managed by California State Parks, with their largest preserve (Montaña de Oro State Park) included within the South Los Osos and West Pecho Conservation Areas.

The private land south of the Broderson Site and southwest of Cabrillo Estates supports high cover (75 to 100%) of Morro manzanita (Mullany 1990). This encompasses the most substantial portion of remaining unfragmented, intact hectares of Morro manzanita outside of preserves. Protecting these existing core high-density stands from human-induced threats would contribute greatly toward conservation of this species. The Los Osos HCP and U.S. Endangered Species Act can provide only limited protection for Morro manzanita on private land. Homebuilding would convert portions of the remaining, intact parcels into residential development, along with likely subsequent firebreaks for protection. This is an **immediate threat**.

9. SUGGESTIONS FOR FUTURE MANAGEMENT

(1) Conserve and protect existing stands of Morro manzanita, with an emphasis on the largest remaining intact areas with high cover of Morro manzanita. The Los Osos HCP and U.S. Endangered Species Act can provide only limited protection for Morro manzanita on private land. The remaining, intact parcels with Morro manzanita in occurrence 9 should be acquired for conservation management by California State Parks, California Department of Fish and Wildlife, or local land trust.
(2) Encourage discussion with USFWS prior to fuel reduction impacting intact Morro manzanita stands in Los Osos, such as that conducted by CA Department of Forestry and Fire Prevention.
(3) Conduct field surveys to improve the data on current distribution and abundance for Morro manzanita. This should include verifying presence/absence of Morro manzanita in isolated patches mapped across Los Osos residential areas and others, as well as recording new locations. Submit these findings to CNDDB.
(4) Develop and implement site-specific management plans for Morro manzanita within preserves, including success criteria for evaluating effectiveness of management.
(5) Develop protocols for long-term restoration success of Morro manzanita. Conduct research on viability and germination requirements of freshly collected manzanita seed to aid in restoration efforts.
(6) Identify potential restoration sites across conservation planning areas both within protected areas to direct the management efforts there, and within private land to be considered within potential habitat conservation plans. Investigate options for restoring connectivity between fragmented stands, including re-establishment of associated native plant and animal species.
(7) Conduct research to describe the genetic diversity within and among existing stands/patches. If warranted by results of genetic diversity, when planting Morro manzanita for restoration, consider introducing some individuals, generated from seed or cuttings, from non-adjacent stands to enhance gene flow and genetic diversity, especially for isolated stands.
(8) Remove *Eucalyptus* and re-establish Morro manzanita where feasible in the southwest part of the range including sites along Pecho Valley Road. Potential *Eucalyptus* selected for removal

would exclude those individuals identified as Monarch butterfly roost sites or important wind breaks.
(9) Coordinate and share information between agencies, researchers and citizen groups including the San Luis Obispo Chapter of the California Native Plant Society, and Friends of El Moro Elfin Forest, who are involved with outreach and conservation of Morro manzanita.
(10) Continue studies of the relationship of Morro manzanita with fire.
(11) Conduct prescribed burns of vegetation in Los Osos to reduce the risk of wildfire. This would also benefit Morro manzanita by stimulating germination and establishment of new seedlings.
(12) Conduct modeling to anticipate effects of climate change on distribution and abundance of Morro manzanita, including changes in temperature, precipitation, amount and extent of marine fog, and sea level rise.
(13) Collect seeds of Morro manzanita for conservation seed banking.
(14) Introduce Morro manzanita (with representative genetic diversity) into living collections at several botanic gardens.

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11. FIGURES AND DETAILED DISTRIBUTION MAPS

Figure 1. Morro manzanita *Arctostaphylos morroensis*: top, in coastal maritime community at Montaña de Oro State Park; and bottom, tree-like individual on the north-facing slopes of the Morro Dunes Ecological Reserve Bayview Unit. The person standing in the bottom photo is 1.86 m tall.

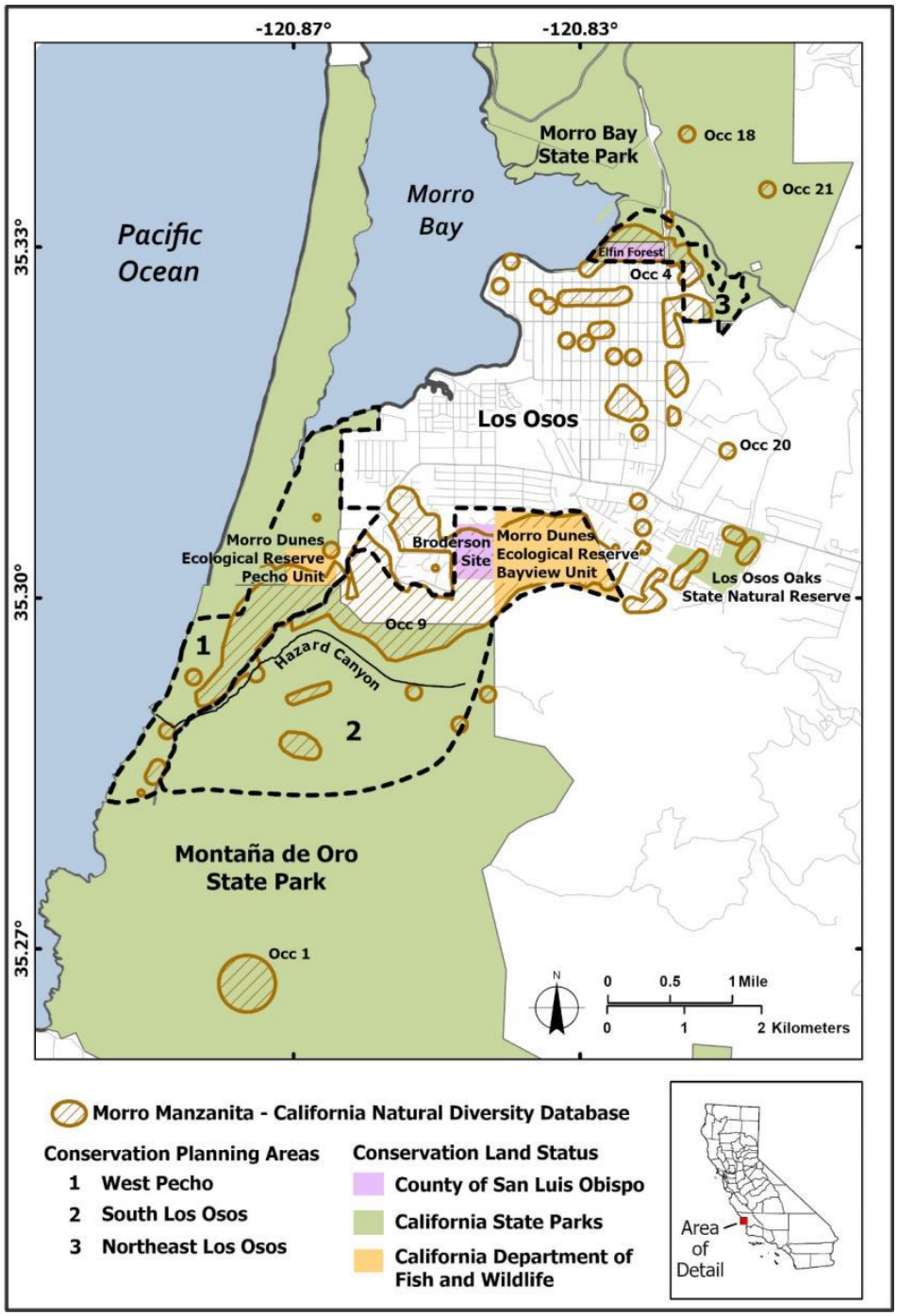

Figure 2. Geographic distribution of Morro manzanita *Arctostaphylos morroensis* in west San Luis Obispo County, California, showing conservation land status (i.e., managing agency). We used GIS map layers for species occurrences in the California Natural Diversity Database (CDFW 2021), which are mostly from maps dated 1980 and 1990 to 1992.

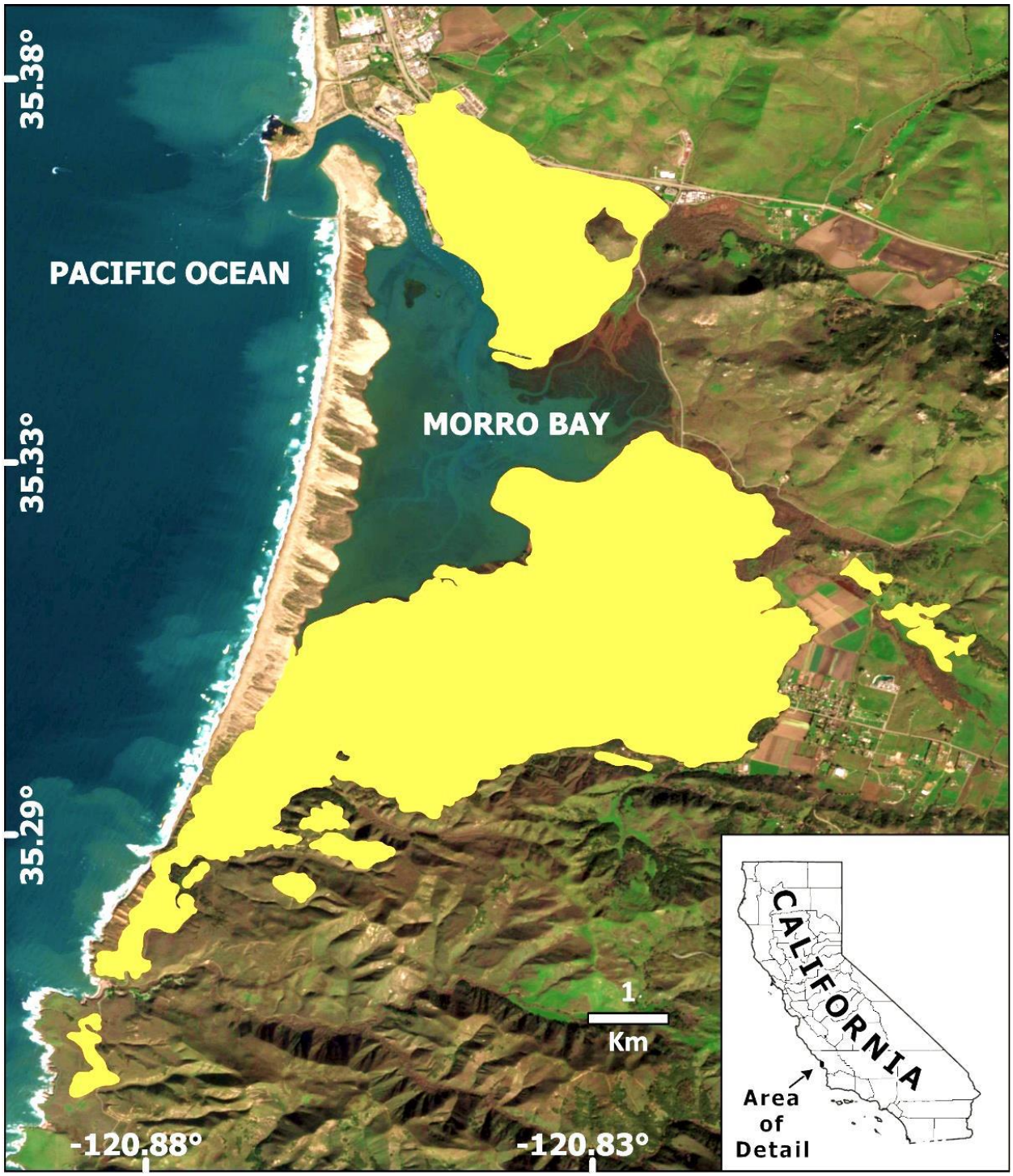

Figure 3. Distribution of Baywood fine sand (shown in yellow) in the Los Osos area, San Luis Obispo County, California.

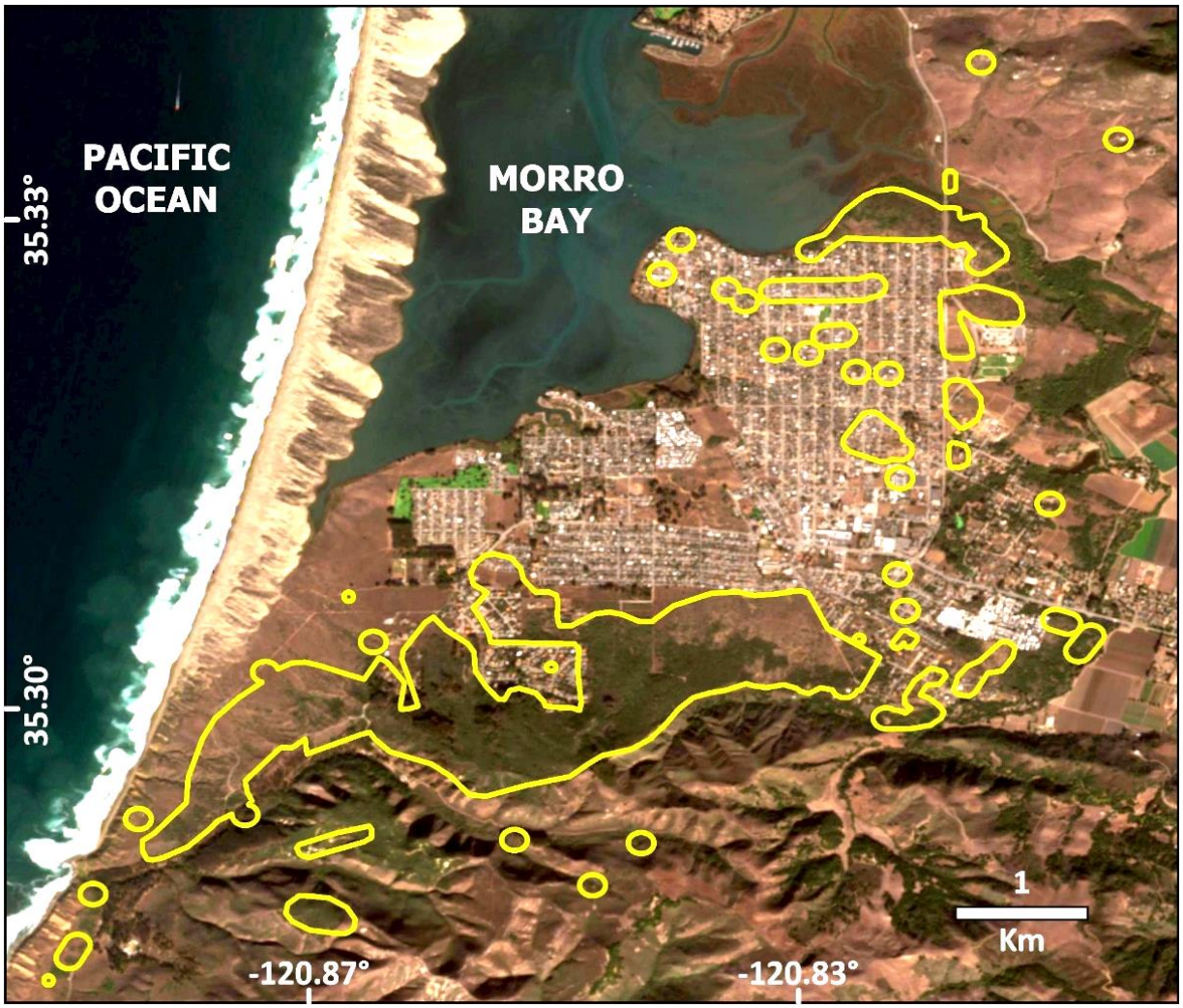

Figure 4. Geographic distribution of Morro manzanita *Arctostaphylos morroensis*, using GIS map layers of California Natural Diversity Database (CDFW 2021), excluding Valencia Peak, and underlain with 2023 Google Earth aerial image. Map credit: Mark Metevier, USFWS.