Western Leatherwood (*Dirca occidentalis*)

Climate Change Vulnerability Assessment for the Golden Gate Biosphere Region

This document represents an evaluation of climate change vulnerability for western leatherwood in the Golden Gate Biosphere (GGB) region of California. The following information is based on stakeholder input provided during and following a winter 2022 vulnerability workshop as well as sources from the scientific literature.

Species Description

Western leatherwood is an endemic plant species found only in the San Francisco Bay region. It is listed as a rare species by the state of California (California Rare Plant Rank 1B.2), and has likely been rare since before European colonization (McMinn & Forderhase 1935; Vuln. Assessment Worksheets, pers. comm., 2022; Calflora 2023). It exists in relict populations from what was likely a greater abundance and distribution in cooler, wetter paleoclimatic periods (Kriewall 2001; Vuln. Assessment Worksheets, pers. comm., 2022). Populations on Marin Water lands grow on greenstone-derived friable (loose and crumbly) soils (Williams & O'Herron 2019), while populations in other areas appear to also grow on volcanic or other metamorphic-derived soils (Calflora 2023).

Western leatherwood is a slow-growing shrub that grows to heights between one and three meters, with a lifespan of approximately 50 years (Kriewall 2001; Vuln. Assessment Worksheets, pers. comm., 2022). It is characterized by flowers that emerge mainly between January and March, before or with deciduous leaves (Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022). Western leatherwood is capable of producing through rhizomes and by self-pollination, but its primary mode of reproduction is open pollination which is associated with higher rates of fruit set and germination compared to self-pollination (Graves 2004; Graves & Schrader 2008; Graves & Gimondo 2021). Although not a lot is known about western leatherwood pollinators, hummingbirds and honey bees have both been observed to pollinate the speices (Graves & Schrader 2008). It is thought to be pollinator-limited and some researchers believe the species may have outlived some of its historical pollinators (Kriewall 2001; Graves & Gimondo 2021).

Western leatherwood is found primarily on cool, north-facing, often shaded slopes and hilltops within mixed evergreen forest, oak woodland, chaparral, or coastal scrub ecosystems in the fog-dominated maritime climate of the Golden Gate Biosphere (GGB) region (Ackerly et al. 2002; Vuln. Assessment Worksheets, pers. comm., 2022). Western leatherwood is found in four genetically isolated populations: in the Salmon Creek area of Sonoma County; in coastal mountains of Marin County; subpopulations in the East Bay hills; and on the San Francisco Peninsula in San Mateo County and immediately adjacent in Santa Clara County (Figure 1; Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022). The Salmon Creek and North Bay populations appear to have the lowest genetic diversity and are considered the most vulnerable to extirpation of the four populations,

but all are considered relicts relative to historic distribution and are threatened by slow rate of growth, limited seed dispersal and germination, and habitat loss (Kriewall 2001; Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022).

Figure 1. Western leatherwood distribution within the GGB region (map provided by the National Park Service

Species Vulnerability → Moderate *(moderate confidence)*

Vulnerability is evaluated by considering the species' sensitivity and exposure to various climate and non-climate stressors as well as the species' adaptive capacity (i.e., ability to cope with these stressors), and is given a ranking of low, moderate, or high. The confidence ranking represents confidence in the accuracy of the ranking based on available scientific knowledge, and is similarly ranked on a scale from low to high.

Summary of species vulnerability

Western leatherwood may be sensitive to climate stressors that alter temperature and moisture, including changes in air temperature, amount and timing of precipitation, soil moisture, and drought. Climate-driven changes in disturbance regimes (e.g., wildfires and disease) have the potential to decrease leatherwood health and increase mortality, though leatherwood's vulnerability to these stressors remains largely unquantified. Non-climate stressors, including residential and commercial development and roads can further exacerbate the sensitivity of this species through fragmentation and destruction of its habitat, which is likely to create even greater isolation and reduction in genetic diversity in what are already relict populations of this plant species.

Management strategies that are likely to increase the resilience of western leatherwood in the face of climate change should include prioritization of conservation of its extant habitat. Active management and restoration techniques should be considered to enhance reproduction, including artificial propagation techniques to enhance fruit set and germination and consideration of trial introductions of genetically-unique plants to enhance diversity. Western leatherwood conservation would also be supported by further research into its ecology, including pollinator relationships and sensitivity to diseases, which could then benefit climate-informed management.

Sensitivity and Exposure → Moderate *(moderate confidence)*

Sensitivity *is a measure of whether and how a species is likely to be affected by a given change in climate factors, climate-driven changes in disturbance regimes, and non-climate stressors. By contrast,* ***exposure*** *is a measure of how much change in these factors a species is likely to experience. Sensitivity and exposure are combined here into one score representing both components of vulnerability, with high scores corresponding to increased vulnerability and low scores suggesting a species is less vulnerable.*

Sensitivity and future exposure to climate factors → High *(moderate confidence)*

- Climate-driven increases in **air temperature** and **heat waves** may impact the persistence of western leatherwood, given its known association with the cool, fog-dominated maritime climate of the coastal San Francisco Bay region. As a paleoendemic species with greater abundance and distribution in the cooler climate of California's past, this species is likely to be

vulnerable to increasing temperatures (Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022). Western leatherwood has minimal cold hardiness, with an observed lower limit for survival of -6°C (21°F; ;Graves et al. 2006). Fruit set has been found to be limited during periods of cold temperatures, which suggests that this species could be sensitive to cold snaps or increasing variability in temperatures (Graves & Gimondo 2021).

- Given its close association with cool, fog-dominated habitat, this species appears adapted to relatively mild and moist conditions and is likely vulnerable to **changes in soil moisture** and **increased drought** (Kriewall 2001; Vuln. Assessment Worksheets, pers. comm., 2022). Anecdotal reports suggest that western leatherwood may have experienced die-offs in some locations during recent droughts (Vuln. Assessment Worksheets, pers. comm., 2022). However, its association with north-facing, shaded slopes may offer it some protection from drying and drought (Graves & Schrader 2008).
- Climate-driven shifts in the **amount and timing of precipitation** may affect western leatherwood. Precipitation events in the GGB region tend to co-occur with its period of flowering in January- March, and research has suggested that heavy rainfall combined with cool winter temperatures may damage flowers and disrupt pollinators, reducing fruit set (Graves & Gimondo 2021). Over the coming decades, it is possible that warmer, wetter winters may lead to earlier flowering of western leatherwood that could result in mismatches with the life cycle of potential pollinators, leading to lower fruit set and recruitment of new plants (Graves & Gimondo 2021).

Sensitivity and future exposure to climate-driven changes in disturbances → Moderate *(moderate confidence)*

- Western leatherwood's response to **changes in wildfire regimes** is largely unknown (Vuln. Assessment Worksheets, pers. comm., 2022). However, its ability to resprout from the crown and propagate through rhizomes suggests it may be able to withstand fire, at least to some degree (Kriewall 2001). Because fire is such a dominant factor in shaping California's vegetative ecology and wildfire risk is increasing due to climate change and anthropogenic factors (Cornwell et al. 2012; Williams et al. 2019), the impact of altered fire regimes on the limited populations of western leatherwoods could be significant in terms of direct mortality as well as by removing the shading shrub and tree canopy cover this species prefers (Vuln. Assessment Worksheets, pers. comm., 2022).
- **Changes in the incidence and severity of pathogens** such as *Phytophthora ramorum*, particularly in association with high-rainfall years, is a growing concern for a wide range of native plant communities in the GGB region (Davidson et al. 2005; Kozanitas et al. 2022). To date, nothing is known about the susceptibility of leatherwood to these pathogens, but leatherwood's frequent co-occurrence with California bay laurel makes it likely pathogenicity would have become apparent already (Vuln. Assessment Reviewer, pers. comm., 2023).

Dependency on habitat and/or other species → Moderate *(moderate confidence)*

Western leatherwood is dependent on habitats that provide sufficient moisture, such as north-facing slopes in fog-influenced coastal scrub and moderately-shaded oak woodlands (Graves et al. 2006; Vuln. Assessment Worksheets, pers. comm., 2022). This species' wider historical distribution during wetter paleoclimatic periods and its current endemism in coastal, foggy maritime habitats of the Bay area (Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022) suggests that western leatherwood may be vulnerable to increasing temperature and moisture variability expected with climate change (Diffenbaugh et al. 2015; Swain et al. 2018; Luković et al. 2021).

Western leatherwood shows the highest rates of germination and fruit set with open pollination, but relatively little is known about its pollinators, other than that hummingbirds and non-native honeybees have been observed visiting the flowers to unknown effect (Graves & Gimondo 2021; Vuln. Assessment Worksheets, pers. comm., 2022).

Sensitivity and current exposure to non-climate stressors → Moderate *(moderate confidence)*

Non-climate stressors can exacerbate ecosystem sensitivity to changes in climate factors and disturbance regimes, and/or can be exacerbated by these changes.

- **Residential and commercial development** and associated **roads, highways, and trails** have resulted in the loss and fragmentation of oak woodlands and chaparral systems with which western leatherwood is associated throughout the GGB region, particularly in more urbanized areas (Davis et al. 2016; Baumgarten et al. 2018, 2021). The California Native Plant Society lists road and trail development as one of the top threats to this rare species (CNPS 2023). Development and associated human activity can increase wildfire ignitions, and also drives fire suppression and exclusion in surrounding areas that can lead to a buildup of fuels that result in more extreme fires when they do occur; both processes exacerbate climate-driven shifts in wildfire regimes to which western leatherwood may be vulnerable (Davis & Borchert 2006; Mann et al. 2016).
- **Invasive species** such as French broom (*Genista monspessulana*) may alter the habitat of leatherwood (Williams & O'Herron 2019), either through direct competition or by increasing the risk of high-intensity fire.

Adaptive Capacity → Low *(moderate confidence)*

Adaptive capacity *is the ability of a species to respond to or cope with climate change impacts with minimal disruption. High adaptive capacity corresponds to lower overall climate change vulnerability, while low adaptive*

capacity means that the species will be less likely to cope with the adverse effects of climate change, thus increasing the vulnerability of the species.

Species extent, status, connectivity, and dispersal ability → Low (high confidence)

Western leatherwood is a rare, endemic plant whose distribution is limited to a handful of counties in the GGB region. However, its paleoclimatic distribution during cooler, wetter periods in California's history was likely far greater than the limited distribution it displays today (Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022). Although western leatherwood can reproduce through rhizomes and self-fertilization, its genetic diversity, fruit set, and germination rates are vastly reduced by these strategies relative to open pollination (Graves 2004; Graves & Schrader 2008; Graves & Gimondo 2021). What little is known of its pollinators suggests that the species may be pollinator-limited, and the pollinators that are known to visit leatherwood flowers have a fairly small foraging radius (within a few kilometers) that may limit cross-pollination, impacting genetic diversity (Kriewall 2001; Graves & Schrader 2008; Graves & Gimondo 2021). Extant populations are separated by habitat fragmentation and intense development, driving further isolation (Vuln. Assessment Worksheets, pers. comm., 2022).

Intraspecific/life history diversity → Low (high confidence)

Genetic and phenotypic diversity in western leatherwood is likely vastly reduced from when this plant was more abundant and widespread, and the remaining four populations are considered genetically isolated from each other (Graves & Schrader 2008; Vuln. Assessment Worksheets, pers. comm., 2022). In terms of total diversity across all populations, western leatherwood is thought to still maintain some genetic diversity , but its northern populations in Sonoma and Marin counties are considered to have low genetic diversity (Graves & Gimondo 2021).

Resistance and recovery → Low (moderate confidence)

Western leatherwood's ability to use both clonal and sexual reproductive strategies suggests there is some flexibility that may benefit the species in the face of climate-driven shifts in temperature, precipitation, disease, and wildfire risk (Graves 2004; Graves & Gimondo 2021). However, this species is known to have a fairly narrow climatic association with habitats that offer sufficient refugia of mild temperature and sufficient moisture, and evidence suggests it is neither highly cold-tolerant nor tolerant of drought (Graves et al. 2006; Norris 2011; Graves & Gimondo 2021). Its small remaining population sizes, particularly in the northern end of its distribution, make it vulnerable to extreme events that could affect these relict populations (Kriewall 2001; Vuln. Assessment Worksheets, pers. comm., 2022).

Management potential → Moderate (moderate confidence)

Western leatherwood is well known among native plant enthusiasts, and its paleogeographic history is of great interest for those with a background in botany and science (Vuln. Assessment Worksheets,

pers. comm., 2022). This species is recognized as a rare endemic by the California Native Plant Society (CNPS 2023), and its rarity affords it some protection under the California Environmental Quality Act (Vuln. Assessment Worksheets, pers. comm., 2022).

The evolutionary history of this species suggests that western leatherwood is a paleoclimatic relic whose current habitat is likely the only refugia available to these populations; as such it will be important to focus on preservation of existing plants and their habitat (Vuln. Assessment Worksheets, pers. comm., 2022). There is significant room to learn more about its pollinators and processes of seed dispersal and germination (Norris 2011; Graves & Gimondo 2021; Vuln. Assessment Worksheets, pers. comm., 2022). Limited research into artificial propagation supports that pretreatment approaches including endocarp removal, cold stratification, and gibberelic acid application can support higher germination rates and may be useful for management and restoration efforts for this species (Schrader & Graves 2005). Trial introductions to appropriate habitat using local genotypes, particularly introducing genetically unique individuals to more clonally dominated patches, could also be useful in supporting the persistence of this species (Vuln. Assessment Worksheets, pers. comm., 2022). Some initial efforts are underway by the San Francisco Public Utilities Commission to introduce pollen from several miles away as well as to propogate seeds for outplanting (S. Simono, pers. comm., 2023).

Recommended Citation

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Further information on the Golden Gate Biosphere Region Climate Adaptation Project is available on the project page (www.ecoadapt.org/goto/GGBRClimateProject).

Literature Cited

Ackerly DD, Knight C, Weiss SB, Barton K, Starmer K. 2002. Leaf size, specific leaf area and microhabitat distribution of chaparral woody plants: Contrasting patterns in species level and community level analyses. Oecologia **130**:449–457.

Baumgarten S, Clark E, Dusterhoff S, Grossinger RM, Askevold R. 2018. Petaluma Valley historical hydrology and ecology study. San Francisco Estuary Institute, Richmond, CA. Available from https://www.sfei.org/PetalumaHE (accessed June 21, 2023).

Baumgarten SA, Hagerty S, Vaughn LS, Spotswood E, Grossinger RM, Beller EE, Salomon M, Clark E, Stoneburner L. 2021. Peninsula Watershed historical ecology study. SFEI Contribution No. 1029. San Francisco Estuary Institute, Richmond, CA. Available from https://www.sfei.org/documents/peninsula-watershed-historical-ecology-study (accessed March 28, 2023).

Calflora. 2023. *Dirca occidentalis*. Available from https://www.calflora.org/app/taxon?crn=2739 (accessed October 17, 2023).

CNPS. 2023. *Dirca occidentalis*. Available from https://rareplants.cnps.org:443/Plants/Details/567 (accessed October 17, 2023).

Cornwell WK, Stuart SA, Ramirez A, Dolanc CR, Thorne JH, Ackerly DD. 2012. Climate change impacts on California vegetation: Physiology, life history, and ecosystem change. CEC-500-2012-023. California Energy Commission, Sacramento, CA.

Davidson JM, Wickland AC, Patterson HA, Falk KR, Rizzo DM. 2005. Transmission of *Phytophthora ramorum* in mixed-evergreen forest in California. Phytopathology **95**:587–596.

Davis FW, Baldocchi DD, Tyler CM. 2016. Oak woodlands. Pages 509–534 in Mooney H, Zavaleta E, editors. Ecosystems of California. University of California Press, Oakland, CA.

Davis FW, Borchert MI. 2006. Central Coast bioregion. Pages 321–349 in Sugihara NG, van Wagtendonk JW, Fites-Kaufmann J, Shaffer KE, Thode AE, editors. Fire in California's ecosystems. University of California Press, Berkeley, CA.

Diffenbaugh NS, Swain DL, Touma D. 2015. Anthropogenic warming has increased drought risk in California. Proceedings of the National Academy of Sciences **112**:3931–3936.

Graves WR. 2004. Confirmation that *Dirca* spp. (Thymelaeaceae) reproduce from rhizomes. Rhodora **106**:291–294.

Graves WR, Gimondo A. 2021. Phenology of annual dormancy release and its association with fruit set of *Dirca occidentalis* (Thymelaeaceae). Madroño **68**:416–424.

Graves WR, Schrader JA. 2008. At the interface of phylogenetics and population genetics, the phylogeography of *Dirca occidentalis* (Thymelaeaceae). American Journal of Botany **95**:1454–1465.

Graves WR, Schrader JA, Sharma J. 2006. Cold hardiness of the rare *Dirca occidentalis*: Comparisons to *Dirca palustris* from disparate provenances. Journal of Environmental Horticulture **24**:169–172.

Kozanitas M, Metz MR, Osmundson TW, Serrano MS, Garbelotto M. 2022. The epidemiology of sudden oak death disease caused by *Phytophthora ramorum* in a mixed bay laurel-oak woodland provides important clues for disease management. Pathogens **11**:250.

Kriewall J. 2001. Review of three *Dirca* species with special emphasis on *D. occidentalis*. Jasper Ridge Biological Preserve, Stanford, CA.

Luković J, Chiang JCH, Blagojević D, Sekulić A. 2021. A later onset of the rainy season in California. Geophysical Research Letters **48**:e2020GL090350.

Mann ML, Batllori E, Moritz MA, Waller EK, Berck P, Flint AL, Flint LE, Dolfi E. 2016. Incorporating anthropogenic influences into fire probability models: Effects of human activity and climate change on fire activity in California. PLoS ONE **11**:e0153589.

McMinn HE, Forderhase B. 1935. Notes on western leatherwood, *Dirca occidentalis* gray. Madroño **3**:117–120.

Norris KD. 2011. Horticultural & ecophysiological evaluations of leatherwoods (*Dirca* spp.). Master of Science thesis. Iowa State University, Ames, IA. Available from https://lib.dr.iastate.edu/etd/10183/ (accessed October 17, 2023).

Schrader JA, Graves WR. 2005. Seed germination of *Dirca* (leatherwood): Pretreatments and interspecific comparisons. HortScience **40**:1838–1842.

Swain DL, Langenbrunner B, Neelin JD, Hall A. 2018. Increasing precipitation volatility in twenty-first-century California. Nature Climate Change **8**:427–433.

Williams A, O'Herron M. 2019. Marin Municipal Water District Rare Plant Inventory Update. Marin Municipal Water District, Corte Madera, CA.

Williams AP, Abatzoglou JT, Gershunov A, Guzman-Morales J, Bishop DA, Balch JK, Lettenmaier DP. 2019. Observed impacts of anthropogenic climate change on wildfire in California. Earth's Future **7**:892–910.