Assessment of Tasmanian blue gum (*Eucalyptus globulus*)

California Invasive Plant Council (Cal-IPC)
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Introduction

The document is an expert-reviewed assessment of the ecological impacts of *Eucalyptus globulus* in California. Of some 1,800 non-native plants that grow outside of cultivation in California, Cal-IPC has rated approximately 200 as Limited, Moderate, or High level invasive plants based on severity of impact, ability to spread, and extent. (For more information, see www.cal-ipc.org/ip/inventory.) Cal-IPC ratings are designed to inform those managing lands for ecological values (such as native wildlife habitat) about the potential impacts of a given plant. Ratings are informative, not prescriptive; they are generalized, not site-specific. Ratings do not determine the overall value of particular plants in particular places, and the term "invasive" should not be construed as a universal condemnation.

Eucalyptus globulus, Tasmanian blue gum, was last assessed by Cal-IPC in 2006 as part of a major initiative to update and document assessments for some 200 plant species. In 2014, Cal-IPC reassessed *E. globulus*. This new assessment revises scores for some criteria and results in a change in overall score from "Moderate" to "Limited." To large degree this change is due to evaluating *E. globulus* across the entire state, rather than focusing on coastal areas where it is most prone to spreading.

Blue gum eucalyptus is unique among naturalized non-native plant species in California. Its rich cultural history is documented in detail by Jared Farmer in *Trees in Paradise: A California History* (Norton, 2013). While most plants listed by Cal-IPC have spread into wildlands on their own, blue gum was actively planted in natural areas for timber, windbreaks and aesthetics. The stands existing today are those that were planted in an earlier time. *E. globulus* were most typically planted in grasslands, yet their most logical native analog habitat is oak or bay laurel woodland; this assessment aims to assess the most relevant comparison for each criterion.

Some stands were planted so densely that few other plants grow within the stand, while less dense stands often contain more plant diversity. Some stands are regenerating and expanding in size, while others in less favorable conditions are not. Some stands are within areas now being managed primarily for ecological values, others are not. Where stands do occur in areas being managed for ecological values, it makes clear sense to assess their ecological impact as an invasive plant. Plantations that are not regenerating or expanding are not considered "invasive" in the customary use of the term. Management decisions for stands in urban areas will necessarily involve consideration of a range of factors, such as recreational and aesthetic values and the trees' much-debated role in wildfire risk. For these stands, the information provided in this assessment can help assess impacts on native habitat, which may also be a factor in management decisions.

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[For information on Cal-IPC's scoring system, see www.cal-ipc.org/ip/inventory/pdf/Criteria.pdf]

Overall Rating: Limited

Section scores:

1. **Impacts: B**
2. **Invasiveness: C**
3. **Distribution: B**

Criteria scores and rationale:

1.1 Abiotic ecosystem processes

Score: B. Moderate alteration of an ecosystem process.

E. globulus alters fire regime and groundwater availability. (Potential for allelopathy was examined but is not included.) These impacts can be significant in circumstances where blue gum were planted at high density and growing conditions are favorable for the species, and less significant in other places.

Alteration of fire regime:

In comparing wildfire parameters in blue gum stands versus native oak woodland (a comparable native habitat structure) fuel loads are significantly greater. *E. globulus* stands can accumulate significantly higher fuel loads than native woodlands. One study found fuel loads of 31 tons/acre in E. globulus stands as compared to 19 tons/acre in California bay forest and 12 tons/acre in coast live oak woodlands (National Park Service 2006). (Factors of ignition and relative flammability are not considered here.)

Wildfire in grasslands is typically more frequent and less intense than wildfire in heavily wooded areas (whether native or non-native). Higher fire intensity can impact soils as well as seed mortality in the soil seed bank.

Alteration of groundwater availability:

The high water consumption of *E. globulus* is well known (Rejmanek & Richardson 2011) and eucalyptus species have been used by development agencies to drain swampy areas in efforts to reduce malaria (see for instance the Wikipedia entry for Eucalyptus). *E. globulus* and *E. camuldensis* (red gum) are used in environmental remediation projects. An example of this is PG&E's 30 acre plantation in Lake County, California. At that site the trees are used to provide hydraulic control of groundwater beneath a landfill. The object of this remediation is to suppress groundwater and keep it from contacting geothermal wastes placed in the landfill (Deutsch 2015).

Lateral roots can extend 30 m or more from the trunk, and in deep soils with high water tables, roots can penetrate to depths of 14 m (DiTomaso & Healy 2007). According to DiTomaso & Healy (2007) *E. globulus* are able to withstand prolonged dry summers by tapping into deep water reservoirs as well as by economizing water use through stomatal control. Their far-reaching root systems can extract water from the soil at even higher soil moisture tensions than most mesophytic plants (Pryor 1976, Florence 1996). The National Park Service is beginning to study groundwater response to eucalyptus removal, for instance on the Channel Islands (Power 2014).

In coastal zones, fog drip under blue gum stands can be substantial, which accounts for the ability of coastal stands to regenerate (Yost 2014). A study in San Francisco found fog drip from eucalyptus

drip can add as much as 42 cm of water during a single summer (Clarke et. al. 2008). This amount is comparable to annual rainfall and in such areas fog drip may significantly mitigate groundwater consumption.

1.2 Impact on plant community

Score: B. Moderate alteration of plant community composition.

E. globulus stands displace native plant communities. Plant communities can be severely altered in circumstances where blue gum was planted at high density and growing conditions are favorable. Plant communities in other places can be significantly less impacted.

Conditions are most favorable for blue gum growth and regeneration along the coast in northern and central California (Ritter and Yost 2012). Capacity for regeneration is based on environmental conditions; areas with reliable year-round moisture, such as along riparian corridors and along the coast from Monterey Bay north where summer fog drip provides seedlings with some moisture, are most likely to support naturally reproducing eucalyptus populations (Yost 2014). Juvenile foliage is seldom browsed by livestock or wildlife, aiding seedling survival (Skolmen and Ledig 1990).

E. globulus stands can form near monocultures in areas where they were planted at high densities (Griffiths & Villablanca 2013). On Angel Island in San Francisco Bay, native trees were only found in eucalyptus plantings where the blue gums had been widely spaced, and these natives were "not vigorous" (McBride, Sugihara, and Amme 1988).

Reports of plant diversity within *E. globulus* stands vary, reflecting the range of conditions, including original planting density, suitability of the microclimate for eucalyptus growth and regeneration, composition of native seed bank, size of the stand and diversity of the surrounding vegetation. Some studies report depauperate plant communities (Esser 1993, DiTomaso & Healy 2007, Bean & Russo 2014) limited by shading and a thick litter layer, while other studies report some native plant species being supported in the understory (LSA Associates 2009, San Francisco Recreation and Park Department 2006).

1.3 Impact on higher trophic levels

Score: B. Moderate alteration of higher trophic level populations, communities or interactions.

E. globulus alters habitat for birds. Effects on terrestrial vertebrates and arthropods were reviewed but are not included in this assessment. Some blue gum stands provide habitat for monarch butterflies.

Impacts to birds

Many of the breeding bird species that are most representative of oak and riparian habitats make little or no use of eucalyptus. Decay-resistant wood offers limited nesting opportunities for woodpeckers and birds that excavate their own holes. Birds that glean insects from foliage are also present at notably lower densities than in native oak woodlands (Suddjian 2004, Williams 2002).

Eucalyptus stands do provide nesting habitat for large roosting birds such as herons, egrets, and cormorants and raptors such as red-shouldered and red-tailed hawks (Suddjian 2004, LSA Associates 2009). They also provide a nectar source for bees and hummingbirds (Rejmanek & Richardson 2011).

Depending on the abundance and health of grassland and oak woodland near blue gum stands, these stands may be considered to be damaging or complementing native habitat.

Monarch butterfly habitat

Some eucalyptus stands provide overwintering sites for Monarch butterflies, along with native trees such as coast redwoods, Monterey pine and Monterey cypress (Griffiths & Villablanca 2013).

1.4 Impact on genetic integrity

Score: D. No known hybridization with native plants.

2.1 Role of anthropogenic and natural disturbance on establishment

Score: C. Low invasive potential: this species requires anthropogenic disturbance to establish.

E. globulus was introduced to California in 1856 (Esser 1993) and is now naturalized in parts of California (Esser 1993, Ritter & Yost 2009). Purposeful cultivation was the primary mode of establishment (Skolmen & Ledig 1990, Esser 1993, HEAR 2007, LSA Associates 2009, Baldwin et al. 2012). *E. globulus* was planted on about 40,000 acres in California, extending from Humboldt County in the north to San Diego County in the south, with best growth in the coastal fog belt (Skolmen & Ledig 1990).

New populations independent of planting are rarely seen in California. Spread is typically limited to expansion along the periphery of an existing population. While eucalyptus bears abundant seed, it does not generally find appropriate conditions for germination (Tyrell 1999). Seeds germinate best on bare mineral soil so germination within dense forests is difficult (Bean & Russo 2014).

2.2 Local rate of spread with no management

Score: B. Increases, less rapidly than doubling in <10 years.

Though not all *E. globulus* stands are expanding, those in moist coastal habitats often expand at a significant rate. New populations are rare; spread is almost entirely along the periphery of existing stands.

Most naturalized stands of *E. globulus* are present along the coast in northern and central California (Ritter & Yost 2012). Aerial photographs show a 50-400% increase in eucalyptus stand size between 1930 and 2001 across six sites in coastal California (Van Dyke 2004). On Angel Island, blue gum "invaded areas adjacent to all sites where it was originally planted," resulting in an expansion from 24 acres to 86 acres, a 360% expansion, over a century (McBride, Sugihara and Amme 1988). Potential spread rate has been estimated at 10-20 feet per year under favorable conditions (Bean & Russo 2014).

Some studies show that this is not the case with all populations. An assessment of changes in cover over a 58-year period at three regional parks in the East Bay hills indicates a decline in eucalyptus cover at all three locations (Russell and McBride 2003), though it is unclear how management activities may have affected stand size in these locations.

California State Parks personnel submitted the following recent reports:

- Tim Hyland (2014) in the Santa Cruz District reports that nine coastal units have *E. globulus*

patches that have moved into riparian, coastal prairie, and coastal scrub habitats. Two units have *E. globulus* patches that exist in forested settings and show no signs of reproduction.

- Vince Cincero (2014) in the San Luis Obispo Coast District referred to a 1990 report compiled by Susan Bicknell of Humboldt State University on eucalyptus at Montana de Oro State Park in Los Osos. The report describes an original plantation established in 1907/08, with the earliest aerial photos from 1949 showing 7 species of eucalyptus covering 119 acres. Forty years later in 1989, the grove had expanded 52% to 181 acres, of which *E. globulus* covered 108 acres (the original portion comprising blue gum is unknown).
- Suzanne Goode (2014) in the Angeles District reports that: at Mulholland Highway and Pacific Coast Highway, *E. globulus* is spreading upslope; at Nicholas Flats Natural Preserve, *E. globulus* (and possibly other eucalyptus species) are spreading from an original plantation homestead; and at the Will Rogers State Historic Park *E. globulus* continues to spread from plantings into the hillsides.
- Michelle Forys (2014) in the North Coast Redwoods District reports that the few planted clumps of *E. globulus* located on district property are actively controlled to stop spread beyond the historical planted area. Additionally, she has observed a planting on the west side of along Highway 101 between Arcata and Eureka spreading across to the east side of the highway.

2.3 Recent trend in total area infested within state

Score: C. Stable.

Some stands of *E. globulus* along the California coast are regenerating and expanding, while others are stable or even shrinking. CalWeedMapper (2014) shows that E. globulus is thought (by local land managers) to be spreading in about 47% of the USGS quadrangles where it is present in the state, and stable in the rest (decreases are not documented in the system, other than through active management).

2.4 Innate reproductive potential

Score: C. Low reproductive potential (less than 3 points, fewer than 3 unknowns).

Reaches reproductive maturity in 2 years or less: No

Most sources estimate trees usually begin to produce seeds at 4 to 5 years and yield heavy seed crops in most locations at 3- to 5-year intervals (Skolmen & Ledig 1990, HEAR 2007). Metcalf (1924) stated that flowers and fruits could be found on sprouts only two or three years old, although not in great quantities.

Dense infestations produce >1,000 viable seed per square meter: Unknown, assume No

Sources indicate prolific seed production, but viable seeds produced per square meter are not given. There are 18 to 320 seeds per gram (500 to 9,100/oz) of seeds and chaff, or about 460 clean seeds per gram (13,000/oz) (Skolmen & Ledig 1990). Germination rates are typically very low: a 1% germination rate is good, given the more usual 0.1% germination success rate (Bean & Russo 2014). This does not indicate the amount of viable seed, as germination can be limited by other factors as well (e.g., allelopathy, thick litter layer, moisture, etc).

Populations of this species produce seeds every year: Unknown, assume No

Skolmen & Ledig (1990) indicate that *E. globulus* yields heavy seed crops in most locations at 3- to 5-year intervals. This does not indicate whether seed is produced every year and only heavily at several year intervals, or whether seed is produced only at 3- to 5-year intervals.

Seed production sustained over 3 or more months within a population annually: Yes

Blue gum eucalyptus in California flowers from November to April during the wet season. The fruit (a distinctive top-shaped woody capsule 15 mm long and 2 cm in diameter) ripens in October to March, about 11 months after flowering (Skolmen & Ledig 1990).

Seeds remain viable in soil for three or more years: No

Germination occurs readily (within 26 days) after seeds are released if conditions are suitable (Skolmen & Ledig 1990). When stored, seeds can remain viable for several years, but in field conditions, viable seed banks are not expected to be maintained beyond a year (Rejmanek & Richardson 2011).

Viable seed produced with both self-pollination and cross-pollination: No

When the cap covering the reproductive organs (the operculum) is shed, the anthers have mature pollen, but the stigma does not become receptive until some days later. This sequence impedes self-pollination of an individual flower. Flowers are pollinated by insects, hummingbirds, and other pollen and nectar feeders. There is no evidence that wind plays anything but a minor role in eucalypt pollination. The flowers of eucalypts are not highly specialized for insect pollination (HEAR 2007).

Has quickly-spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes: No

Blue gum eucalyptus can sprout from the bole, from stumps of all sizes and ages, from the lignotuber, and from the roots. The lignotuber can live for many years in the soil after stems die back (Esser 1993). This contributes to re-growth, but not spatial spread of the plant. One professional land manager reports that stand spread may arise from root sprouts in addition to seed sprouts (Heath 2014), but this has not been confirmed.

Fragments easily and fragments can become established elsewhere: No

No evidence found.

Resprouts readily when cut, grazed, or burned: Yes

Blue gum coppices readily from stumps of all sizes and ages when the tree is damaged. If the tree is cut down, lignotubers become active and each bud produce a shoot bearing foliage. Such shoots are commonly known as "sucker growth" or coppice shoots, and a large number are usually formed. *E. globulus* resprouts after being burned (Skolmen & Ledig 1990, Bean & Russo 2014).

2.5 Potential for human-caused dispersal

Score: C. Low: human dispersal is infrequent or inefficient.

Given the large seed size, there is very little potential for people to accidentally start new populations through unintentional seed “hitchhiking”.

Though some landowners may still plant *E. globulus* for windbreaks or ornamentals on a limited scale, the conclusion of the California Horticultural Invasives Prevention (Cal-HIP) partnership and the PlantRight campaign is that *E. globulus* is effectively no longer in the trade. Annual surveys of

retail nurseries around California indicate that few (<1%) nurseries now sell *E. globulus* and it has been moved to their "retired" list of plants because it is so rarely found for sale (PlantRight 2014).

2.6 Potential for long-distance dispersal

Score: C. Rare dispersal more than 1 km by animals or abiotic mechanisms.

In general, *E. globulus* seed is not easily dispersed over large distances (Skolmen & Ledig 1990, HEAR 2007, Rejmanek & Richardson 2011). *E. globulus* seeds are distributed by wind and gravity; calculated dispersal distance from a 40 m (131 ft) height, with winds of 10 km/hr (6 mi/hr), was only 20 m (66 ft) (Skolmen & Ledig 1990). Some seed may be moved by such agents as flood, erosion and birds, but usually seed is dropped within 100 feet of the parent tree (Bean & Russo 2014).

2.7 Other regions invaded

Score: C. Invades elsewhere but only in ecological types that it has already invaded in the state.

E. globulus has wide climatic adaptability, with the most successful introductions worldwide in locations with mild, temperate climates, or at somewhat higher elevations in tropical areas (*E. globulus* does not tolerate frequent freezes). Although it generally grows well in countries with a Mediterranean or cold season maximum rainfall, it grows well also in summer rainfall climates of Ethiopia and Argentina (Skolmen & Ledig 1990). In California, *E. globulus* populations already exist in the regions suitable to the species' naturalization (CalWeedMapper 2014).

3.1 Ecological amplitude/range

Score: A. Widespread: the species invades at least three major ecotypes or six minor types.

Invades five major habitat types: scrub and chaparral; grasslands; bog and marsh; riparian; and forest. These are ecotypes where blue gum stands are found in California, though that presence is typically due to intentional planting. Blue gum is unlikely to actively spread into dense forest vegetation. See Worksheet C.

3.2 Distribution/Peak frequency

Score: C. 5-20% is the highest portion of occurrences invaded in any of the invaded ecotypes.

See Worksheet C.

Worksheet C – California Ecological Types
(*sensu* Holland 1986, http://www.cal-ipc.org/ip/inventory/pdf/HollandReport.pdf)

Major Ecological Types	Minor Ecological Types	Code
Marine Systems	marine systems	
Freshwater and Estuarine	lakes, ponds, reservoirs	
Aquatic Systems	rivers, streams, canals	
	estuaries	
Dunes	coastal	
	desert	
	interior	
Scrub and Chaparral	coastal bluff scrub	
	coastal scrub	D. < 5%
	Sonoran desert scrub	
	Mojavean desert scrub (incl. Joshua tree woodland)	
	Great Basin scrub	
	chenopod scrub	
	montane dwarf scrub	
	Upper Sonoran subshrub scrub	
	chaparral	C. 5% - 20%
Grasslands, Vernal Pools,	coastal prairie	D. < 5%
Meadows, and other Herb	valley and foothill grassland	
Communities	Great Basin grassland	
	vernal pool	
	meadow and seep	
	alkali playa	
	pebble plain	
Bog and Marsh	bog and fen	
	marsh and swamp	C. 5% - 20%
Riparian and Bottomland habitat	riparian forest	D. < 5%
	riparian woodland	D. < 5%
	riparian scrub (incl.desert washes)	
Woodland	cismontane woodland	
	piÃ±on and juniper woodland	
	Sonoran thorn woodland	
Forest	broadleaved upland forest	C. 5% - 20%
	North Coast coniferous forest	C. 5% - 20%
	closed cone coniferous forest	
	lower montane coniferous forest	
	upper montane coniferous forest	
	subalpine coniferous forest	
Alpine Habitats	alpine boulder and rock field	
	alpine dwarf scrub	

Literature Referenced:

Note: All sources cited in the assessment are listed below. Additional sources were reviewed but not used in the assessment; these are also listed below.

Aggangan, R. G., A. T. O'Connell, J. F. McGrath, and B. Dell. 1999. The effects of *Eucalyptus globulus* leaf litter on C and N mineralization in soils from pasture and native forest. Soil Biology and Biochemistry 31:1481-1487.

Baldwin, B. G., D. H. Goldman, D. J. Keil, R. Patterson, T. J. Rosatti, and D. H. Wilken, eds. 2012. The Jepson manual: Vascular plants of California. 2nd ed. University of California Press, Berkeley and Los Angeles, CA.

Bean, C., and M. J. Russo. 2014. *Eucalyptus globulus*. Bugwood Wiki. Based on 1989 Elemental Stewardship Abstract for *Eucalyptus globulus (*revised). The Nature Conservancy, Arlington, VA. Accessed 22 Mar 2014 online at http://wiki.bugwood.org/Eucalyptus_globulus.

Bicknell, S. H. 1990. Montana de Oro State Park presettlement vegetation mapping and ecological status of eucalyptus. Humboldt State University, CA.

Bossard, C. C., J. M. Randall, and M. C. Hoshovsky. 2000. Invasive plants of California's wildlands. University of California Press, Berkeley, CA.

Boyd, D. 1997. Eucalyptus removal on Angel Island. Presentation to the California Exotic Pest Plant Council. Accessed 25 Mar 2014 online at http://www.cal-ipc.org/symposia/archive/pdf/1997_symposium_proceedings1936.pdf.

Callaham, Jr., M. A., J. A. Stanturf, W. J. Hammond, D. L. Rockwood, E. S. Wenk, and J. J. Obrien. 2013. Survey to evaluate escape of *Eucalyptus* spp. seedlings from plantations in southeastern USA. International Journal of Forestry Research 2013:1-10.

CalWeedMapper. 2014. *Eucalyptus globulus.* California Invasive Plant Council, Berkeley, CA. Accessed 28 Mar 2014 online at http://calweedmapper.cal-ipc.org/maps.

Cicero, V. 2014. Personal communication from Vince Cicero, California State Parks. Email received 4/11/2014.

Clarke, K. M., B. L. Fisher, and G. LeBuhn. 2008. The influence of urban park characteristics on ant communities. Urban Ecosystems 11:317-334.

Costa, E. Silva F., A. Shvaleva, J.P Maroco, M.H. Almeida, M.M. Chaves, J.S. Pereira. 2004. Responses to water stress in two *Eucalyptus globulus* clones differing in drought tolerance. Tree Physiology. 24(10):1165-72.

Daves Garden 2014. *Eucalyptus globulus*. Accessed 31 Mar 2014 online at http://davesgarden.com/guides/pf/go/62576/.

Del Moral, R., and C. H. Muller. 1969. Fog drip: A mechanism of toxin transport from *Eucalyptus globulus*. Bulletin of the Torrey Botanical Club 96:467-475.

Deutsch, P. 2015 Personal communication from Paul Deutsch, Amec Geomatrix, Inc. Email received 3/12/15.

Dickinson, K. J. M., and J. B. Kirkpatrick. 1985. The flammability and energy content of some important plant species and fuel components in the forests of southeastern Tasmania. Journal of Biogeography 12:121-134.

DiTomaso, J. M., and E. A. Healy 2007. Tasmanian blue gum. In: Weeds of California and other western states. Vol. 2 Geraniaceae-Zygophllaceae. pp.951-954. Regents of the University of California, Oakland, CA.

Esser, Lora L. 1993. *Eucalyptus globulus*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Accessed 28 May, 2014 online at http://www.fs.fed.us/database/feis/plants/tree/eucglo/all.html.

FEMA 2013. East Bay Hills hazardous fire risk reduction environmental impact statement. Accessed 24 Mar 2014 online at http://ebheis.cdmims.com/Documents.aspx.

Florence, R. G. 1996. Ecology and silviculture of eucalyptus forests. CSIRO Publishing, Victoria, Australia.

Fork, S. 2004. Arthropod diversity in native and exotic woodlands. Ecology and impacts of blue gum eucalyptus in coastal California, Moss Landing Marine Laboratories, Moss Landing, CA, June 3, 2004. Accessed 28 Apr 2014 online at http://www.elkhornsloughctp.org/uploads/files/1108146921S. Fork Presentation.pdf.

Forys, M. 2014. Personal communication from Michelle Forys, Environmental Scientist, North Coast Redwoods District, California State Parks. Email received 4/11/2014.

Goode, S. 2014. Personal communication from Suzanne Goode, Angeles District, California State Parks. Email received 4/11/2014.

Griffiths, J., and F. Villablanca 2013. Management of monarch butterfly (*Danaus plexippus*) overwintering habitat: Recommendations based on patterns of tree use. Monarch Alert, California Polytechnic State University, San Luis Obispo, CA. Accessed 28 May 2014 online at http://monarchalert.calpoly.edu/pdf/Griffiths and Villablanca 2013 Eucalyptus White Paper.pdf.

HEAR 2007. *Eucalyptus globulus* Risk Assessment. Hawaiian Ecosystems at Risk. Accessed 22 Mar 2014 online at http://www.hear.org/pier/wra/pacific/eucalyptus_globulus_htmlwra.htm.

Heath, M. 2014. Personal communication from Mark Heath, Shelterbelt Builders, Inc. Email received 5/28/2014.

Hyland, T. 2014. Personal communication from Tim Hyland, Resource Ecologist, California State Parks. Emails received 4/15/2014 and 6/9/2014.

Lacan, I. V. H. Resh, and J. R. McBride. 2010 .Similar breakdown rates and benthic macroinvertebrate assemblages on native and *Eucalyptus globulus* leaf litter in Californian streams. Freshwater Biology 55:739-752.

Lange, R. T., and T. Reynolds. 1981. Halo effects on native vegetation. Transactions of the Royal Society of South Australia 105:213-214.

LSA Associates, Inc. 2009. Wildfire hazard reduction and resource management plan. V. Vegetation management plan. East Bay Regional Park District, Oakland, CA. Accessed 23 Mar 2014 online at http://www.ebparks.org/Assets/files/fireplan/ebrpd_whrrm_plan/5-VegMan.pdf.

May, F. E., and J. E. Ash 1990. An assessment of the allelopathic potential of eucalyptus. Australian Journal of Botany 38:245-254.

McBride, J.R., N. Sugihara, and D. Amme. 1988.The effects of eucalyptus establishment on native plant communities. In Focused Environmental Study: Restoration of Angel Island Natural Areas Affected by Eucalyptus. California Dept. of Parks and Recreation, Sacramento CA.

Meade, D. E. 1999. Monarch butterfly overwintering sites in Santa Barbara County, California. County of Santa Barbara Planning and Development Department, Santa Barbara, CA.

Metcalf, W. 1924. Growth of eucalyptus in California plantations. Bulletin No. 380. University of California Publications, Berkeley, CA.

National Park Service 2006. Eucalyptus. San Francisco Bay Area National Parks, Fire Education Office, Point Reyes Station, CA. Accessed 23 Mar 2014 online at http://biomass.forestguild.org/casestudies/1001/Eucalyptus.pdf.

PlantRight. 2014. California Horticultural Invasives Prevention website: Invasive plants in your region. Accessed 2 April 2014 online at http://www.plantright.org/regions.

Power, P. 2014. Personal communication from Paula Power, Ecologist, National Park Service, Channel Islands National Park. Email received 5/28/2014.

Pryor, L.D. 1976. The biology of eucalypts. Edward Arnold (Publishers) United, London, UK.

Rejmanek, M., and D. M. Richardson 2011. Eucalypts. In: Simberloff, D., and M. Rejmanek, eds. Encyclopedia of biological invasions, pp. 203-209. University of California Press, Berkeley, CA.

Riley, C. V., and A. E. Bush 1881. Trees attractive to butterflies. American Naturalist 15:572.

Riley, C. V., and A. E. Bush. 1882. The butterfly trees of Monterey again. American Naturalist 16:64.

Ritter, M., and J. Yost. 2009. Diversity, reproduction, and potential for invasiveness of *Eucalyptus* in California. Madrono 56:155-167.

Ritter, M., and J. Yost. 2012. Blue gum weediness in California is not genetically based. California Native Plant Society conference, January 10-14, 2012, San Diego, CA. Abstract available online at http://www.cnps.org/cnps/conservation/conference/2012/pdf/cnps2012-presentation_abstracts.pdf.

Rottenborn, S. C. 2000. Nest-site selection and reproductive success of urban red shouldered hawks in central California. Journal of Raptor Research 34:18-25.

Russell, W. H., and J. R. McBride. 2002. Vegetation change and fire hazard in the San Francisco bay area open spaces. In: Blonski, K.S., M.E., and T. J. Morales. Proceedings of the California's 2001 wildfire conference: Ten years after the East Bay Hills fire; October 10-12, Oakland California. Technical Report 35.01.462, pp. 27-38. University of California Forest Products Laboratory, Richmond, CA. Accessed 24 Mar 2014 online at http://www.diablofiresafe.org/pdf/proceedings2001.pdf.

Russell, W. H., and J. R. McBride 2003. Landscape scale vegetation-type conversion and fire hazard in the San Francisco bay area open spaces. Landscape and Urban Planning 64:201-208.

San Francisco Recreation and Park Department. 2006. Significant Natural Resource Areas Management Plan. p6.2-2.

Santos, R. L. 1997. The eucalyptus of California. Section three: Problems, cares, economics, and species. Accessed 25 Mar 2014 online at http://www.library.csustan.edu/bsantos/section3.htm.

Sax, D. 2002. Equal diversity in disparate species assemblages: A comparison of native and exotic woodlands in California. Global Ecology and Biogeography 11:49-57.

Shepardson, L. 1914. The butterfly trees. The James H. Barry Company, San Francisco, CA.

Skolmen, R. G., and F. T. Ledig. 1990. Blue gum eucalyptus. In Burns, R.M. and B.H. Honkala, technical coordinators. Silvics of North America, Volume 2: Hardwoods. USDA Forest Service, Washington, DC.

Accessed 20 Mar 2014 online at http://na.fs.fed.us/pubs/silvics_manual/volume_2/eucalyptus/globulus.htm.

Stallcup, R. 1997. Deadly eucalyptus. Observer No. 108. Point Reyes Bird Observatory.

Tyrrell, I. 1999. True gardens of the gods: Californian-Australian environmental reform, 1860-1930. University of California Press, Berkeley.

USDA Forest Service. 2009. Sikkink, P.G., D.E. Lutes, and R.E. Keane. Field guide for identifying fuel loading models. Rocky Mountain Research Station. General Technical report RMRS-GTR-225. May 2009. Accessed 6 Jun 2014 online at http://www.fs.fed.us/rm/pubs/rmrs_gtr225.pdf.

USDA PLANTS Database. *Eucalyptus globulus* Labill. Accessed 23 Mar 2014 online at http://plants.usda.gov/java/charProfile?symbol=EUGL.

Van Dyke, E. 2004. Blue gum eucalyptus in the Elkhorn Watershed: 1930 - present. Ecology and impacts of blue gum eucalyptus in coastal California, Moss Landing Marine Laboratories, Moss Landing, CA, June 3, 2004. Accessed 28 Apr 2014 online at http://www.elkhornsloughctp.org/uploads/files/1108143446Vandyke Presentation.pdf.

Warner, P.J. 2004. Personal observations from 1980-2004 working in and adjacent to eucalyptus stands in Marin, Sonoma, and Mendocino Counties. 707/937-9172; pwarner@mcn.org.

Watson, K. 2000. The effect of eucalyptus and oak leaf extracts on California native plants. Masters Thesis, University of California, Berkeley. Accessed 31 Mar 2014 online at http://nature.berkeley.edu/classes/es196/projects/2000final/watson.pdf.

Xerces Society. 2014a. Western monarch Thanksgiving count data 1997-2013. Accessed 31 Mar 2014 online at http://www.xerces.org/wp-content/uploads/2011/04/WMTC-Data-1997-2013-Updated-30-Jan-2014.pdf.

Xerces Society. 2014b. Number of monarch butterflies overwintering in California holds steady, but still well below the 1990s. Accessed 31 Mar 2014 online at http://www.xerces.org/2014/01/31/number-of-monarch-butterflies-overwintering-in-california-holds-steady-but-still-well-below-the-1990s/.

Yost, J. Personal communication from Jenn Yost, Biological Sciences Dept., California Polytechnic State University. Phone call 4/29/2014.