REVIEW DRAFT: Assessment of *Eucalyptus Globulus*

California Invasive Plant Council (Cal-IPC)
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Introduction

Cal-IPC is a non-profit organization established in 1992 to protect California's wildlands from invasive plants through science, education and policy. One of Cal-IPC's efforts is to assess naturalized non-native plants using a criteria system to determine relative level of risk to California wildlands. Results are presented in the California Invasive Plant Inventory. For more information, see www.cal-ipc.org/ip/inventory.

Eucalyptus globulus, bluegum eucalyptus, 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 has undertaken a reassessment of *E. globulus*. This review draft has been produced to solicit further input from ecologists, land managers, and stakeholders.

Please submit comments or questions to info@cal-ipc.org by July 31, 2014. At that point, a review committee will finalize the assessment, making adjustments as appropriate based on any new information presented.

Scoring changes from the 2006 version include:

1.1 Abiotic ecosystem processes, changed from B to A.

2.1 Role of anthropogenic and natural disturbance on establishment, changed from A to C.

2.4 Innate reproductive potential, changed from B to C.

2.5 Potential for human-caused dispersal, changed from B to C.

Details on these assessments are found in this document.

These individual scores change the Section 1 score (for impact) from a B to an A, and the Section 2 score (for biological invasiveness—overall ability to spread) from a B to a C. The score for Section 3 (distribution) remains the same (B). The overall rating for *E. globulus* remains at Moderate.

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1.1 Abiotic ecosystem processes

Score: A. Severe, possibly irreversible, alterations or disruption of an ecosystem process. (Changed - was B before.)

Eucalyptus globulus severely alters fire regimes in grasslands and when growing in mixed stands with native tree species. Changes to groundwater consumption are also significant.

Changes to fire regime:

Eucalyptus globulus was most frequently planted in grasslands, although some exist mixed within native tree stands (Griffiths & Villablanca 2013). The intensity and frequency of natural grassland fire regimes is very different when compared with those of eucalyptus stands (Bossard et al. 2000, FEMA 2013, LSA Associates 2009). (Woody plant encroachment into grasslands in general is a concern for changes to fire regime (Russell & McBride 2002)). Where eucalyptus has spread into native forests, fire regimes are likely altered significantly as well, given the differences described below.

Ignition/Flammability: Dickinson & Kirkpatrick (1985) found that while live eucalyptus leaves had intermediate flammability in comparison to other species evaluated, dead leaves were the most energy-rich component. Hanging bark strips can carry fire into the crowns, while leaves contain volatile oils that produce a hot fire (Skolmen & Ledig 1990). The East Bay Parks Vegetation Management Plan (LSA Associates 2009) states that species with oily resins, such as eucalyptus, are far more ignitable than those that lack such characteristics. Eucalyptus is given a high fire hazard rating in comparison with native grass and tree species, which are given low to moderate ratings. Ignition potentials are comparatively low for eucalyptus (meaning it is easy to ignite): on a scale of 1-10, with 1 being most easy to ignite and 10 most difficult, eucalyptus scored 1-2; for comparison, oak/bay woodland 6-8, redwood 8, scrub vegetation 4-8, and grassland vegetation 1-3.

The 2013 Environmental Impact Statement for the FEMA Hazardous Fire Reduction grant in the East Bay Hills uses flame length as a proxy for flammability. *Eucalyptus globulus* flame length was estimated at 6-21 feet (7-31 feet in young eucalyptus forests); for comparison, flame length in feet for oak/bay woodland is 1-34, Monterey pine 2-16, redwood 7-31, Northern coastal scrub 14-32, and non-native grasslands 2-10 (FEMA 2013). The wide range of flame lengths/flammability is related to fuel volumes, stand structure, treatment history, and slope.

E. globulus has the potential to send firebrands some distance from a fire front to ignite new spot fires. Some trees develop a multiple-stem structure that creates a "basket" that catches dead materials which burn easily and intensely. Ignited leaves and bark can be lofted into the air by updrafts and distribute embers over long distances. Because leaves and bark are large, embers are generally still burning when they land, increasing fire spread (Bossard et al. 2000, LSA Associates 2009).

Fuel Loads: *Eucalyptus globulus* accumulates higher fuel loads due to dropped limbs, bark and leaves than do grasslands and native woodlands. Eucalyptus accumulates 30.84 tons/acre, California bay produces 18.93 tons/acre, and coast live oak accumulates 11.82 tons/acre (National Park Service 2006). Grasslands accumulate significantly less fuel, on the order of 2 tons/acre (USDA Forest Service 2009).

Changes to hydrology:

Eucalyptus globulus is adept at tapping into deep groundwater, even under drought conditions (DiTomaso & Healy 2007), altering water availability to depths of 45 feet and distances of 100 feet from the trunk. The water consumption of eucalyptus has been used by development agencies to drain swampy areas to reduce malaria (see for instance the Wikipedia entry for Eucalyptus). *E. globulus* is able to withstand prolonged dry summers by tapping into deep water reservoirs; they do not economize in the use of water but have far-reaching root systems and can extract water from the soil at even higher soil moisture tensions than most mesophytic plants (Pryor 1976, Florence 1996). Thus, in dry regions any benefits of planted eucalyptus can be outweighed by their negative impacts on groundwater due to their high water consumption (Rejmanek & Richardson 2011). Williams (2002) states that streams in Marin County had become dewatered by eucalyptus. The National Park Service is beginning to study groundwater response to eucalyptus removal, but data will not be available for several years (Power 2014). Strong competition for water is assumed to be one reason for the relative absence of other plant life below trees (HEAR 2007).

Allelopathy:

Natural unconcentrated fog drip from *Eucalyptus globulus* inhibits growth of annual grass seedlings (Del Moral & Muller 1969). Unconcentrated stemflow contains sufficient levels of allelopathic chemicals to inhibit germination of some herbs as well, and the volume of stemflow is greater from gum barked species (e.g., *Eucalyptus globulus*) than fibrous-barked species. The volume of water channeled down the stem is about eight times more than that of falling rain, so soil at the base of trunks receives relatively large quantities of water containing allelopathic compounds. The effects of allelopathy may be exacerbated in areas with low rainfall (Lange & Reynolds 1981). Thick litter layers also suppress germination of both *E. globulus* seedlings and other plants (May & Ash 1990).

Watson (2000) found that germination of native *Achillea millefolium* and *Elymus glaucus* seeds was significantly less in the *Eucalyptus globulus* treatment than in the control and oak (*Quercus agrifolia*) treatments. (*Bromus carinatus* germination and root length were not affected by the eucalyptus treatment relative to the control.) Germination of *Achillea* in the eucalyptus treatment was only 11% in comparison to the control and 8% in comparison to the oak treatment. Watson concluded that "...restoration projects intended to replace eucalyptus infested habitats with native plants should consider that the possible effects of allelochemicals persisting in the soil may interfere with recruitment and establishment of native species." A separate experiment with soil from under eucalyptus showed no significant inhibition of germination (although germination was lower) relative to the control. The author indicates that winter rains may have leached out allelochemicals and suggests samples should be taken in multiple seasons; this hypothesis is supported by Lange & Reynolds (1981). Molina et al. (1999) also found allelopathic properties of *E. globulus* in Spain, although their results may be different in California (Lacan et al. 2010).

Changes to light availability

*S*hading is a significant factor when comparing eucalyptus groves to native grassland, and perhaps a minor factor when comparing to native woodlands. Shading compounds factors of thick litter and allelopathy in inhibiting understory vegetation (DiTomaso & Healy 2007; Bossard et al. 2000; Warner 2004).

Changes to erosion and sedimentation:

Poorly developed understory vegetation due to allelopathy, a thick litter layer, and competition for water may result in forests on drier hillsides becoming an erosion risk (HEAR 2007).

Changes to nutrient dynamics:

In riparian areas where eucalyptus was present, Lacan et al. (2010) found no difference in litter breakdown between eucalyptus and native vegetation. In contrast, Aggangan et al. (1999) reported a reduction in nitrogen mineralization rates in the soil below eucalyptus litter. Observation in drier areas suggests that leaves and branches decompose very slowly (DiTomaso & Healy 2007).

1.2 Impact on plant community

Score: A. Severe alteration of plant community, composition, structure or interactions.

Eucalyptus globulus was primarily planted in grasslands not previously known to support tree cover, representing a sweeping change to community composition.

In grasslands supporting livestock and native ungulates, E. globulus has a considerable competitive advantage in that its juvenile foliage is seldom browsed by cattle, sheep or wildlife. This condition made it a popular tree for planting in open grasslands years ago, and it permits new seedlings to survive in the presence of grazing animals alongside planted stands (Skolmen & Ledig 1990).

While many Eucalyptus globulus stands form monocultures, this generally only occurs where they were planted at high densities for firewood and timber (Griffiths & Villablanca 2013). Displacement of native species is pronounced in dense stands (Warner 2004), perhaps at least partly due to allelopathy (Del Moral & Muller 1969, Molina et al. 1991, Watson 2000). Sources indicate that E. globulus outcompetes native vegetation as it naturalizes in mesic areas (see review by Griffiths & Villablanca 2013). Native tree species on Angel Island in San Francisco Bay were only found where eucalyptus planting had been widely spaced, and the surviving individuals were “not vigorous” (McBride, Sugihara, and Amme 1988).

Ritter & Yost (2012) found most naturalized (reproducing) stands of E. globulus are present along the coast in northern and central California; of 52 unique stands observed, 11 had extensive naturalization, 21 had not naturalized at all, and the remaining 20 fell somewhere in between (based on the number of non-planted individuals present). Naturalization was 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 supplements ground water, are most likely to support naturally reproducing eucalyptus populations (Jenn Yost, personal communication, 2014).

Reports of plant diversity within E. globulus stands are variable, ranging from depauperate and virtually free of other plant species (Esser 1993, DiTomaso & Healy 2007, Bean & Russo 2014), to reports of several native species being supported in the understory (LSA Associates 2009). Reports that vegetation is sparse under Eucalyptus globulus stands are more frequent, however (Esser 1993, Santos 1997, DiTomaso & Healy 2007, Bean & Russo 2014), and this is likely due to the combined effects of competition for water, tree density/shading, allelopathy, and a thick inhibitory litter layer. Metcalf (1924) reported that Lombardy poplar (Populus nigra), a rapidly-growing non-native tree planted between blue gums, was only able to persist within the stand for 15-20 years before it was overtopped by eucalyptus, and subsequently died out.

1.3 Impact on higher trophic levels

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

Eucalyptus alters habitat for wildlife, especially birds, when compared to either grassland communities or native woodlands.

Impacts on birds

At an Elkhorn Slough eucalyptus workshop, David Suddjian (2004) discussed bird habitat in eucalyptus stands and native oak woodlands. In the Monterey Bay region, over 90 birds make regular use of eucalyptus habitat, although many species that nest in eucalyptus appear to do so at lower densities than in native habitats. The nesting bird community is relatively depauperate in eucalyptus. Decay-resistant wood offers limited opportunities for nesting to woodpeckers and birds that excavate their own holes, and birds that glean insects from foliage are also present at notably lower densities. However, some other bird species nest in eucalyptus preferentially as compared to the remaining native trees, possibly due to the tall growth patterns and large limbs.

In Santa Cruz County, great blue herons, great egrets, and double-crested cormorants only nest in eucalyptus, while 85% of red-shouldered and red-tailed hawk nests were found in eucalyptus. However, Suddjian also notes that "...eucalyptus stands do not provide an equivalent tradeoff for the oak woodland and deciduous riparian that they have replaced. The breeding bird communities in these native habitats have much better representation by cavity nesting species, foliage-gleaning species, and those that nest on the ground or in understory vegetation. Many of the breeding species that are most representative of oak and riparian habitats make little or no use of eucalyptus in the Monterey Bay region."

Raptors may use eucalyptus for nesting in the spring (HEAR 2007, LSA Associates 2009, Rejmanek & Richardson 2011). In Santa Clara County, Rottenborn (2000) found that red-shouldered hawks nesting in eucalyptus and other non-native tree species had higher fitness due to better stability and cover provided by eucalyptus as compared to native trees. In contrast, Williams (2002) stated that while native birds do use eucalyptus groves, the Point Reyes Bird Observatory (PRBO) found that species diversity there drops by at least 70%. Moreover, Williams reported that PRBO found that 50% of the Anna's hummingbird nests are shaken out by the wind, while only 10% of nests are destroyed by wind in native vegetation. Moreover, the presence of non-native eucalyptus may alter native migratory bird patterns, as rare wintering species are attracted to the eucalyptus food sources, and might not otherwise visit the area (Suddjian 2004); however, no evidence as to whether this has positive or negative impacts was found.

There is no formal data on the suggestion that nectar from eucalyptus gums up the beaks and airways of birds to the point of suffocation, despite observations by a naturalist with decades of experience at the Point Reyes Bird Observatory (Stallcup 1997). Stallcup reported finding two dead warblers and "about 300 moribund warblers with eucalyptus glue all over their faces" over the years, including "a large number of gummed-up Townsend's warblers, yellow-rumped warblers, ruby-crowned kinglets, Anna's and Allen's hummingbirds, and a few Bullock's orioles. Anyone who birds around eucalyptus trees sees it all the time" (Williams 2002). Suddjian (2000) agrees that eucalyptus gum can be found on birds feeding on eucalyptus flowers, but doubts that this results in mortality, given that other birders have not reported finding dead birds.

Impacts on terrestrial vertebrates

Many birds, mammals, and invertebrates utilize eucalyptus forests at some point, and there is no consistent trend across all species for relative use of eucalyptus compared to use of native woodlands. Some report significantly lower species diversity of arthropods and small mammals in eucalyptus stands (Warner 2004, Rejmanek & Richardson 2011). However, Sax (2002) found that species richness was similar for invertebrates, amphibians, and birds in native and eucalyptus forests but species composition was different between the two forest types for all groups. Macroinvertebrate species diversity did not differ between eucalyptus and native vegetation in riparian areas in California (Lacan et al. 2010). Approximately three times more California slender salamanders (*Batrachoseps attenuatus*) were found in eucalyptus vegetation than in native forests (Rejmanek & Richardson 2011).

Impacts on arthropods

Fork (2004) found that abundance of *Diptera* (flies) was higher in eucalyptus stands as compared to oak woodland, but that *Coleoptera* (beetles) abundance was higher in oak woodlands. Overall, total abundance of arthropod orders correlated fairly well in both oak woodland and eucalyptus habitats (i.e., either rare in both habitats, or abundant in both habitats). Order richness, total abundance, and diversity were not significantly different between the two habitats, although total abundance was slightly greater in eucalyptus (particularly on habitat edges), and diversity was slightly greater in oaks (particularly in habitat centers). These results corroborate those of Sax (2002), who found that species richness was approximately equal between the two habitat types.

Monarch butterfly habitat

Eucalyptus is a major source of nectar and pollen for honeybees and an important overwintering site for Monarch butterflies (Rejmanek & Richardson 2011). Historical records suggest that Monarch butterflies (*Danaus plexippus*) clustered on native trees prior to the introduction of eucalyptus (Riley & Bush 1881, Riley & Bush 1882, Shepardson 1914). Natural experimental evidence from mixed stands (native trees mixed with eucalyptus) show that Monarchs do not consistently cluster preferentially on eucalyptus, and at times, appear to prefer native trees in some seasons and locations. At overwintering mid-season (~Dec. 31), when conditions are the least favorable and Monarchs might be more likely to express a preference for the most favorable microclimate, they clustered disproportionately on native trees (Griffiths & Villablanca 2013), leaving the authors to recommend planting additional native conifers rather than planting (or removing) bluegum eucalyptus in order to enhance microhabitat conditions for Monarchs. The Xerces Society (2014a, 2014b) recommends that management of eucalyptus take into account the decline in Monarch butterfly populations which is increasingly believed to be due to declines in overwintering and milkweed habitat. Not all stands are created equal howerver; LSA Associates (2009) reports that young or small eucalyptus stands do not offer the same overwintering microhabitat conditions as mature or large stands, and as such there is little ecological reason to protect them (LSA Associates 2009).

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. (Changed - was A before.)

Eucalyptus 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). New populations independent of planting are rare in California. Australian historian Ian Tyrrell (1999) states that while eucalyptus bears abundant seed, it does not generally find appropriate conditions for germination, and as such, does not typically encroach into treeless areas without purposeful cultivation. About 40,000 acres were planted to eucalyptus in California, extending from Humboldt County in the north to San Diego County in the south, with best growth in the coastal fog belt in the vicinity of San Francisco (Skolmen & Ledig 1990). While establishment of individual eucalyptus seedlings in undisturbed forests and scrub has been observed in coastal areas (Warner 2004), long-distance dispersal is unlikely when eucalyptus is not located near waterways (Rejmanek & Richardson 2011). Fire promotes eucalyptus regrowth (Williams 2002) and seeds may germinate prolifically after logging or fire (Skolmen & Ledig 1990). 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. Increasing at a rate less than doubling in population size over ten years.

Eucalyptus stands are known to expand in moist coastal habitats, but not in dryer inland climates. Van Dyke (2004) used aerial photographs to estimate a 50-400% increase in eucalyptus stand size between 1930 and 2001 across six sites in coastal California. Potential to spread has been estimated at 10-20 feet per year under favorable conditions, but this was not documented as an actual observed rate of spread (Bean & Russo 2014), and is most likely to occur along the coast with summer fog drip (HEAR 2007). A quantitative assessment of changes in cover over a 58-year period at three parks in the East Bay hills (Chabot, Tilden, and Redwood Regional Parks) indicated a decline in eucalyptus cover at all three locations (Russell & McBride 2003), though it is unclear how management activities affected stand size in these locations. An earlier study by McBride, Sugihara and Amme (1988) found that bluegum had spread from all sites where originally planted on Angel Island, increasing coverage from the original 24 acres planted in the late 1800s and early 1900s to 86 acres in 1988 (Boyd 1997).

California State Parks personnel submitted the following personal observations:

- Tim Hyland (2014) indicates that E. globulus patches in nine coastal units in the Santa Cruz sector have patches that have invaded arroyo willow 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) 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. By 1989, the grove had expanded 52% to 181 acres, of which E. globulus covered 108 acres (the original portion of eucalyptus that was bluegum is unknown).
- Suzanne Goode (2014) indicate that at Mulholland Highway and Pacific Coast Highway, E. globulus is spreading upslope, and at Nicholas Flats Natural Preserve, E. globulus and possibly other eucalyptus species are spreading from an original plantation homestead. At the Will Rogers State Historic Park E. globulus plantings continue to spread into the hillsides.
- Michelle Forys (2014) reports that the few planted clumps of E. globulus located in the North Coast Redwoods District are actively spreading beyond the planted area, but are removed as much as possible to curb spread beyond the historical planting. Additionally, along Highway 101 between Arcata and Eureka a planting on the west side of the highway has spread across to the east side of the highway.

2.3 Recent trend in total area infested within state

Score: C. Stable.

Most naturalized stands of *E. globulus* are present along the coast in northern and central California (Ritter & Yost 2012). The online tool CalWeedMapper (2014) captures expert knowledge from land managers across the state to map the distribution and status of plants listed in Cal-IPC's Inventory, including *E. globulus*. Of the USGS quadrangles with reported occurrences, the populations in ~80 are reported as spreading (all of these occur along the coast) and those in ~90 quads are reported as stable. CalWeedMapper does not provide an option for reporting populations in decline (other than due to active management), and it is likely that some of the populations in dry areas are not regenerating. With some populations continuing to expand, and some likely not generating at all, it is reasonable to conclude that there is no significant net change in cover statewide (Warner 2004).

2.4 Innate reproductive potential

Score: B. Moderate reproductive potential (4-5 points). (Changed - was A before.)

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 may be limited by other factors as well (e.g., allelopathy, thick litter layer, moisture, etc).

Populations of this species produce seeds every year: Yes

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, but it is likely that seed is produced every year, and observations would corroborate this, but published evidence was not found.

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

Bluegum 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, seed soil banks are not 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: Yes

Bluegum eucalyptus can sprout readily 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). Stands can spread in California by shoots arising from roots (Heath 2014).

Fragments easily and fragments can become established elsewhere: No

No evidence found.

Resprouts readily when cut, grazed, or burned: Yes

Bluegum eucalyptus coppices readily from stumps of all sizes and ages. 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 (Skolmen & Ledig 1990, Bean & Russo 2014).

2.5 Potential for human-caused dispersal

Score: C. Low: human dispersal is infrequent or inefficient. (Changed - was B before.)

Although some landowners may still plant E. globulus as windbreaks or ornamentals on a limited scale, there is no evidence that recent plantings are extensive or common. The horticultural variety compacta is a dwarf form that was once widely used along California freeways (Skolmen & Ledig 1990). One California nursery was found that reportedly sells seeds (Dave's Garden 2014), but overall, the conclusion of the California Horticultural Invasives Prevention (Cal-HIP) partnership is that E. globulus is effectively out of the trade. Cal-HIP's surveys of retail nurseries around California indicate that few (<1%) nurseries now sell E. globulus and it is included in their list of "retired" plants because it is so rarely found for sale (Cal-HIP 2014).

2.6 Potential for long-distance dispersal

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

Most 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 is moved by such agents as flood, erosion and birds, but usually seed is dropped within 100 feet of the parent tree (Bean & Russo 2014). In studies of plantations in Florida and South Carolina, elevation was the primary predictor of seed dispersal and establishment (Callaham et al. 2013). Eucalyptus seeds can potentially be dispersed long distances by water (Rejmanek & Richardson 2011). In general, however, seed is not easily dispersed over large distances (Skolmen & Ledig 1990, HEAR 2007, Rejmanek & Richardson 2011).

2.6 Other regions invaded

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

Eucalyptus globulus has great climatic adaptability, with the most successful introductions worldwide in locations with mild, temperate climates, or at high, cool elevations in tropical areas. 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 regions suitable to its naturalization (CalWeedMapper 2014).

3.1 Ecological amplitude/range

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

Invades five major habitat types: scrub and chaparral; grasslands; bog and marsh; riparian; and forest (see Worksheet C).

3.2 Distribution/Peak frequency

Score: C. 5-20% of the occurrences of any of the invaded ecological types have been invaded (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	

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