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**Number 1**

# EUCALYPTUS CONTROL

Pest Management Analysis and Planning Program

STATE OF CALIFORNIA
Department of Food and Agriculture
Division of Pest Management, Environmental Protection and Worker Safety
Branch of Environmental Monitoring and Pest Management
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# EUCALYPTUS CONTROL

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# EUCALYPTUS CONTROL IN CALIFORNIA PARKLANDS

## INTRODUCTION

The California Department of Food and Agriculture, under a contract with the California Department of Parks and Recreation, has produced a series of documents which concern select parkland pests and their integrated control. This paper deals with the genus Eucalyptus, and in particular Eucalyptus globulus Labill., or blue gum. Topics discussed include their history, description, biology, range, habitat, pest management need and pest management alternatives. For the purposes of this report, eucalyptus will refer to the genus in general; Blue gum will refer to E. globulus Labill. in particular. Pesticide profiles, control summaries and other pertinent materials are included in both the appendices at the end of this paper and thos comprising a separate volume in this series.

## PEST MANAGEMENT NEED

Boyd (1985) outlines several reasons for control of eucalyptus including the following: 1) Big trees bear very large near horizontal limbs which may fall, especially during storms, but also without warning on still warm days (Havlik 1987). Trees near buildings pose a significant threat to property. San Francisco foresters,for example, have numerous records of damage involving eucalyptus; 2) The trees shed large amounts of bark, leaves and litter. They are especially inappropriate for gardens or city streets (Clark 1967); 3) The litter and wood are highly flammable due to

the high oil content. It is one of the most flammable forest fuels in the world and will burn green as well as dry (although green fuel burns only as a result of prolonged and extreme heating (Nicoles 1987)). Eucalyptus are adapted to a "fire environment", young trees rapidly growing above the scorch height of average wildfires. Fuel loads of up to 64 tons/acre have been reported in old stands. Stringy bark shedding from trees acts as a ladder fuel, adding to the severity of a fire (Hastings1986). Mortenson (1984b) describes a fuelbreak management plan in the East Bay Regional Park District which was initiated as a result of a hard freeze in 1972 which killed the crowns of 2 to 3 million eucalyptus trees (Hamilton and McHenry 1982). This left a tremendous fire hazard in the vicinity of the East Bay Regional Park District in California; 4) Due to the physical and chemical nature of litter, understory vegetative diversity is generally low. This is due not only to the presence of phenols in fog drip from leaves and terpenes which leach from litter into the soil; but an oppressive depth of ground cover (litter), heavy shade and competition for water and nutrients (Havlik 1987), and; 5) Eucalyptus maintain disturbed areas such as bare ground and weedy patches under trees by attracting livestock to their shade (Jepsen Prairie Preserve Committee 1983).

## IDENTIFICATION

Eucalyptus are broad leaf, aromatic and evergreen trees and shrubs. There are about 540 species and 150 varieties, all of which are native to Australia. They range from shrubs 10 ft. high to trees over 300 ft. tall. They produce kino (a gum) and are thus known as gum trees.

Blue gum is a tall solemn tree "of grandeur" with a straight trunk and heavy mass of aromatic foliage. There are many lateral stems and roots. The tap root rarely grows more than 10 feet deep but surface laterals may spread to over 100 feet away from the trunk. The bark is deciduous and its color and texture change with time, turning from light yellow-brown to gray and from smooth to rough (Bean 1986).

Blue gum has both juvenile and mature leaves. Juvenile leaves are ovate, opposite, sessile (not stalked), glaucus (covered or whitened with a bloom) and occur on squared stems. They feel slippery and soft. Older leaves are narrowly lanceolate (lance shaped), often curved in a sickle shape, alternate and hang vertically. They are glossy, dark green, thick and leathery and average in length from 6 to 8 inches (Bean 1986).

Blue gum has creamy white to yellow flowers that are 1.5-2 inches wide. They are born on solitary axils on flattened stalks. Sepals and petals are united to form a lid which drops off the bud during anthesis. The flowers have many stamens and the ovary is four-loculed with many ovules. Flowers are most abundant from December to May. These flowers are pollinated by a variety of insects of which the honey bee is perhaps the most important. Wind plays a minor role in pollination. The flowers are not self pollinating (Bean 1986).

The fruit is about 1 inch across. It is a hard and woody capsule, globose in shape with a wide flat disc. The seed capsule is warty,

ribbed and blue-gray in color (Clark 1967). It dehisces along the boundaries of the locules (Bean 1986). Seed is disseminated by wind, water, erosion and birds; but most of the seed stays within 100 feet of the parent tree. Seeds germinate no later than 26 days after appropriate environmental conditions are met. Seed may remain dormant for several years under dry conditions (Jacobs 1955) (Figures 1,2 and 3).

There is also a smaller variety, E. globulus 'compacta' (the dwarf blue gum) which reaches heights of 60 to 70 ft. This species can be sheared to heights of 10 ft for management purposes (Clark 1967).

## BIOLOGY

### HISTORY and USES

Blue gum is the most popular eucalyptus species grown in California. The first trees established in the U.S. were planted in California in 1853 and were popular ornamentals. Later in the nineteenth century, the shortage of lumber and fuel, resulting from the indiscriminate use of native timber and an increasing population, created an intense interest in this fast growing genus (Groenendaal 1983). By the early 1900's about 50,000 acres of eucalyptus had been planted. However, its use as lumber was abandoned because of its tendency to crack when cured. Eucalyptus is now planted for wood oil and cordwood for home heating (Boyd 1985). It is for the latter use that plantations are still being established (Standiford et al. 1983) and the need for weed management within these plantations exists (Cudney et al. 1986). In the United

States as of 1973, there were almost 200,000 acres of eucalyptus, 60% of which were in plantations (FAO 1979). Worldwide production ranges from 85-980 $ft^3$/acre/yr of wood, depending on factors such as climate, soil type and insect damage. For example, because there are many natural enemies of eucalyptus in Australia, growth rate (stemwood production) there can be as much as 20 % less than in other countries (FAO 1979). In California, one year old E. globulus plantations can produce 1.1 cords/acre while 40 year old stands can produce 156 cords/acre (Rinehart and Standiford 1983). Some species can grow 10 to 15 ft./year in the early stages and can live for over a century, especially those both properly planted and cared for.

Blue gum is also used for windbreaks, paper and rayon pulp and mining timbers and as an ornamental along highways and on other property (Bean 1986). Its desirability as a landscape plant stems from it's beauty, tolerance to diverse climates, lack of pests due to importation by seed, which excluded natural enemies, and fast growth habit (Clark 1967).

**HABITAT**

Natural distribution of blue gum is confined to Tasmania, Victoria and New South Wales and is commonly in association with other eucalyptus species. Eucalyptus are adapted to a wide range of environments and adapts especially well to countries with a Mediterranean climate. It does not thrive in areas with severe winters, in the tropics where

temperatures are uniformly high and where there are long hot and dry seasons.

Eucalyptus groves have been reported to have expansion rates of 10 to 20 feet per year (Bean 1986), although in most cases this expansion is considerably lower. In one instance, a long and narrow one acre site planted to 1,000 eucalyptus trees expanded to 94 acres in 75 years (Hastings 1986).

Blue gum does well on soils derived from granite or grano-diorite and especially on moderately fertile loams or heavy, well drained soil. Blue gum does not occur naturally on either poorly drained soils or strongly calcareous or alkaline soils (Bean 1986). Usually however, the limiting factor for successful growth is not soil but temperature (FAO 1979). Although this genus differs widely in tolerance to differing climates, it is generally found in areas having from 23 to 44 inches precipitation and from sea level to altitudes of about 4,000 feet (Bean 1986). Blue gum grows especially well in lowlands as far north as Humboldt Bay, where average rainfall is 21 inches and there are normally 62 rainy days, and the mean temperature of the warmest and coldest months (July and January) is 72 F and 43 C respectively (FAO 1979). They resist, to a degree, damage due to frost (6 days average per year).

## CONTROL ALTERNATIVES

### PHYSICAL and CHEMICAL CONTROL

A prioritized listing of control procedures acceptable to and provided by CDPR is found in the Appendicies of this paper. Hornor et al. (1986) of the Golden Gate National Recreation Area (GGNRA) proposed an eight point guide for control/eradication of eucalyptus in a park setting, including identifying site specific impacts of removal and rehabilitation of these sites by native vegetation. The highlights of this are given below:

1) Each site should be surveyed for raptor nesting in the spring, and for monarch butterfly overwintering sites in the fall. Sites where raptors nest and monarch butterflies overwinter should be removed in late summer, after nests are abandoned and prior to the arrival of monarch butterflies (mid to late September). Where adjacent vegetation would be inadequate as a monarch butterfly habitat, eucalyptus removal should be done in phases to allow gradual replacement with other appropriate vegetation, and to allow butterflies to adapt to the change without adverse impact. The Monarch Project should be consulted for site specific recommendations.

2) Slope is an important criterion in eucalyptus control and methods will vary depending on the steepness. Sites with slopes should be surveyed for indications of instability. When possible, this should be done both by ground surveys and through the use of aerial photography.

Specific measures to address slope stability should be identified for each site where necessary, emphasizing planting, mulching and other biotechnical approaches rather than engineered structures.

3) The site should be mapped; the boundaries, drainages and access routes to the site for heavy equipment identified, and native trees to remain marked. Temporary haul roads also should be identified. Existing ranch roads and trails should be used for access and haul roads wherever possible. Skid trails, landings, and roads should be located according to the least gradient feasible and their location should be approved by certified personnel (Hastings 1986). Areas where no heavy equipment can be used, such as riparian zones, should be designated. The type of equipment that can or cannot be used should be specified. There is some debate as to whether removal operations should be restricted to the use of rubber tired vehicles. Soil compaction may be much greater in these vehicles compared with tracked ones (Nicoles 1987). Where slopes are too steep for such vehicles, trees should be cabled out to haul roads.

4) The acceptable removal season should be identified based on soil moisture, slope, results of wildlife surveys and visitor use needs. Days and hours of operation should be based on minimizing the disturbance caused by sawing, chipping and hauling.

5) Detailed removal practices should be specified for each grove. Trees 18" in diameter or greater should be felled by fallers using chain saws, and hauled by skidder or cable to the site where it can be chipped or

hauled away. All trees should be cut flush with the ground where possible to minimize the visual impact of the stumps. Stumps should be left in the ground to minimize soil disturbance and provide shear strength while the root systems of replacement vegetation become established. Perhaps more importantly, reasons for leaving stumps in the ground are to avoid problems with refilling holes and stump disposal (Nicoles 1987). Herbicides should be applied to the cut stump immediately after cutting to prevent sprout back of the tree. Herbicide application should be done by hand, using a dye to monitor application and to verify completion and the accuracy of treatment.

Removal of eucalyptus should be done in stages. This is to insure that sufficient habitat remains thus minimizing impacts to wildlife (Hastings 1986).

6) All temporary haul roads should be removed when the work is complete and the sites restored to their original topography. From 50 to 70% of the slash would be removed (perhaps more) and the remainder either spread evenly on the land surface (currently recommended by the GGNRA) or piled in windrows placed on the contour to reduce runoff and erosion. Spacing of windrows should be specified for each site, depending on the steepness of the slope (on steeper slopes, wind rows should be placed closer together) and degree of disturbance. Placement of water bars on trails that are to remain should be specified. Other site rehabilitation requirements should be specified. These may include disking to decompact the soil; correction of any pre-existing site

problems, such as runoff from adjacent development or roadways; seeding; straw mulching and installation of check dams in drainages.

7) Revegetation, such as seeding, and planting of tree and shrub species, should be done following to rehabilitate the site. Planting should include measures to protect seedlings from damage due to deer browsing and trampling.

8) Each site should be monitored by park staff for a minimum of 5 years after cutting to evaluate the success of the removal; to look for signs of sprout back; and invasion of exotic plants and to evaluate slope stability, additional erosion control needs and success of the revegetation. Follow-up measures can be taken as needed. The results of monitoring can also be used to assess and improve the methods used for tree removal and site rehabilitation.

## PHYSICAL and CHEMICAL CONTROL PROCEDURES

### Physical Control Procedures

Because of their great vigor, the control of re-sprouts after eucalyptus felling is an integral part of a removal program. Eucalyptus develop underground burls or lignotubers replete with buds kept dormant by apical dominance. When eucalyptus is burned, felled or frozen, these burl buds are released.

**Stump Shredding**

McHenry (1980) reports that stump shredding, using a commercial stump grinder, to 8 to 10 inches below the soil surface gave 100% control of eucalyptus resprouts. Apparently, these buds are located close to the soil line (Hamilton and McHenry 1982). Resprouting stumps would also be controlled by a conventional tractor with a blade which can knock a four foot diameter stump out of the ground (Jepsen Prairie Preserve Committee 1983).

**Feller buncher**

Feller bunchers are also used in eucalyptus control. The feller-buncher has a cutting mechanism which crushes the stem. It has been noted that a higher incidence of resprouting is associated with the use of a feller-buncher. It is postulated that this crushing disrupts the vascular system of the eucalyptus plant preventing applied herbicide from translocating to the roots, killing the plant. It is recommended that stumps of trees felled by this device not be treated with herbicide, but rather resprouts treateed several weeks following tree felling (Hastings 1986).

**Coppice removal**

Other mechanical means of control have been practiced in the East Bay Regional Park District. There, after initial felling and removal of eucalyptus, coppice growth (stump resprouts) was removed twice a year over a three year period. The most effective time of removal was when resprouts were 6 to 8 feet high and still a major net energy

investment for the tree. Another successful physical method used to halt eucalyptus grove spread was pulling seedlings and saplings less than 1" in diameter in winter (Havlik 1987).

### Burning

Burning eucalyptus has been practiced on the Jepsen Prairie Preserve. Factors apparently involved in this method's efficacy are burning when trees are water stressed (at a time of year when fire hazard may also be greatest) and burning resprouts and newly emerged saplings with a flame gun (Jepsen Prairie Preserve Committee 1983). If ground fuel is available, burning of new seedlings is effective at about 18 inches high. Green seedlings, however, will not carry a fire (Nicoles 1987). Diligence over time is required as it is in most physical methods.

## Chemical Control Procedures

### Introduction

Not all chemicals discussed in the following section are approved for use by the California Department of Parks and Recreation. Materials mentioned may not be registered or labeled for the specific use as cited in the literature reviewed. Appropriate supervisorial personnel and policy manuals should be consulted before any integrated pest management program, and especially those employing pesticides, is implemented.

The efficacy of herbicides in both stump and foliage treatments is, in general, dependent on several factors; species, stem size, height, location, size of grove, time of year and environmental factors such as wind speed, relative humidity, precipitation and temperature. As a rule of thumb, the optimum time of application of herbicides on eucalyptus is during the early summer months. Although there have been successful treatments, blue gum is still considered difficult to control with herbicides (Bachelard et al. 1965). Blue gum has further been considered by some as a "resistant species" requiring both concentrated treatments of herbicide and perhaps the use of more than one chemical to control a tree (Morze 1971).

**Frill Cut Technique**

A technique used to kill the tree before felling is the frill cut technique. This involves making cuts (either continuous or at 2 to 3 inch intervals) around the stump through the bark and cambium into the xylem with a hand axe, 1 to 3 ft. above ground line (Bean 1986). These cuts serve as reservoirs for the herbicide. This technique was discontinued by Mortenson because it exceeded the 2 minute time limitation (at 5 to 20 minutes per tree) for fresh-cut herbicide efficacy (Mortenson 1984b). Hamilton and McHenry (1982) however, reported 100% control from the axe frill method with a glyphosate treatments of 25 to 100% solution concentrations.

**Glyphosate**

In treatments with 30% glyphosate, mortality in unstressed trees where the herbicide was applied to the stump within two hours of felling was higher than in stressed trees where the herbicide was applied later than two hours after felling. Based on these results, felling live trees should be stopped in late hot months and resumed only after adequate rainfall has relieved tree stress (Mortenson 1984b).

Also determined in this study was the importance of applying herbicide onto the fresh cut horizontal top position of the stump at the cambium-bark interface within 2 minutes of felling. This is due to the heal-over activity in the stump that shuts down translocation and which starts immediately after felling. Translocation is also inhibited over time as air is drawn into the conducting tissue. Application of herbicide around the periphery of the cut stump is also important because little lateral movement of herbicide takes place. From 95 to 100% control was achieved using 25 to 50% glyphosate solution immediately after cutting (Mortenson 1984b).

Mortensen (1984a) reports topical treatments of eucalyptus resprouts were effective if sprayed with glyphosate when resprouts were 4 to 10 ft. tall. About 90% control was achieved with a 1% solution and 100% with 2 to 15% solutions. Resprouts which were only 0 to 4 ft. high were poorly controlled (10 to 15%) using 1% to 15% solution rates.

These trials were conducted in the East Bay regional Park District using backpack sprayers.

2,4-D

The use of 2,4-D in the water soluble (amine) form has been recommended for application to stumps within 1 to 2 hours of felling. The herbicide is applied, as with glyphosate, to the periphery of the cut surface (the cambial zone) (McHenry 1980). Control of 97% and 100% was obtained using both 50% and 100% solutions (Hamilton and McHenry 1982).

Cut stump treatments using 2,4-D water soluble amine, fosamine ammonium, glyphosate, dicamba, triclopyr ester and triclopyr amine were all effective in controlling eucalyptus resprouting (Eucalyptus camaldulensis). Eucalyptus were located near Riverside, California, were 12 inches in diameter, planted 4 feet apart, and well irrigated. The trees were cut in late October and immediately treated with the above herbicides in a 1:2 ratio of commercially available herbicide:water. The cut stump was completely soaked with the herbicide solution using a laboratory wash bottle (Cudney et al. 1987).

Basal herbicide treatments (3% herbicide in diesel oil) soaking an 18 inch band above the soil line were ineffective in controlling resprouts. Evaluation of both of the above studies took place ten months after treatments (Cudney et al. 1987).

**Picloram**

Picloram has also been used as a frill treatment for eucalyptus control. Mortality of 25 to 40% was achieved with a 0.5% solution of the potassium salt formulation. Frills were cut at three inch intervals 3 to 4 feet from the ground. A commercial mixture of picloram and 2,4-D, both as trisopropanolamine salts in a 12.5% solution, gave 90 to 100% mortality (Morze 1971).

**Ammonium Sulfamate**

Ammonium sulfamate (AMS) has been effective as a frill application at 5 lbs/gal or even as crystals. A 95% solution gave 89% control. AMS as 25% and 100% solutions gave 67% and 87% control under varying resprouting conditions (Hamilton and McHenry 1982). Applying AMS crystals to a cut stump and then covering the stump with black plastic has been reported to increase mortality (Bean 1986).

**Other**

The following techniques were unsuccessful in the control of eucalyptus (from Hamilton and McHenry 1982): 1) felling trees within one foot of ground only; 2) pruning off 1 to 1.5 year old sprouts of trees felled in winter/summer followed by 2,4-D amine and dichlorprop/ 2,4-D ester/diesel applications to fresh cuts; 3) pruning out 1 to 3.5 year old sprouts in November and June with and without 2,4-D fresh wound treatment, and; 4) applying glyphosate and phenoxy herbicides to the foliage in September.

Cudney et.al (1986) tested Eucalyptus camaldulensis for herbicide damage using herbicides for plantation weed control. They used various combinations of simazine, oxyfluorfen, oryzalin, norflurazon, sethoxydim, and fluazifopin in nineteen different treatments. None of these showed any damage to Eucalyptus camaldulensis. In another trial hexazinone was toxic to E. globulus (Elmore 1983).

**BIOLOGICAL CONTROL**

Blue gum is probably valued by too many people to consider a biological control program against it. For many people blue gum and the numerous other eucalyptus species which are widely planted, constitute part of the "California" character of the state, even though they are of Australian origin (Pemberton 1985).

Recently, an important pest of eucalyptus has accidentally been introduced into California. A discussion of the long horned borer Phoracantha semipunctata is important not strictly as a biological control, but to aid in an understanding of the total picture of eucalyptus in California. The reader is referred to the Appendix for more details.

**IMPACTS OF CONTROL**

The control of eucalyptus has the potential to impact many environmental, economic and aesthetic dimensions. The Golden Gate National Recreation Area has proposed methods of eucalyptus removal and control in order to reestablish natural plant communities in their

jurisdiction. Some of the impacts identified in the environmental assessment of this proposal are listed below (from Hornor et al. 1986):

**Visual Impact**

Removal of eucalyptus stands would result in a change in the appearance of the landscape. The short term effect would be a disturbed appearance including unnatural elements such as windrows, flush-cut stumps and straw mulch. Over time the site would return to its native appearance.

**Wildlife Impact**

An important consideration in eucalyptus eradication is its effect on wildlife habitat. In a study conducted in the East Bay Regional Park District, it was found that: 1) redwood and Monterey pine habitats were depauperate in vertebrate species; 2) eucalyptus habitat was far richer in vertebrates than either redwood or Monterey pine and vies with dry chaparral and grassland in species diversity and attractiveness; 3) oak-bay woodland is the richest in both species diversity and attractiveness, and; 4) grassland is somewhat less rich in species diversity and attractiveness than the other native habitats, but only slightly richer than eucalyptus habitat (Stebbins 1975).

Eucalyptus are richer than redwood and Monterey pine habitats in species diversity and attractiveness for the following reasons (from Stebbins 1975): 1) They generally have a less dense canopy and so more penetration of heat and light; 2) There is a tendency for more understory growth due to increased light, heat and moisture from fog

drip; 3) More log and bark litter accumulates among tree branches and on the forest floor providing cover for animals; 4) Eucalyptus flowers offer a rich source of nectar and pollen which attracts a great variety of insects. Birds and other animals feed on the insects and some of them directly on the nectar. Staggered blooming of blue and red gums temporarily extends the availability of the floral food, and; 5) The abundant seed crop produced by eucalyptus is at least as attractive to animals as the conifer seed. This seed is fed upon by a variety of birds, some mammals and invertebrates.

The overall use and attractiveness of eucalyptus habitat to vertebrate animals is higher than redwood and Monterey pine forests, but lower than dry chaparral, moist chaparral, grassland and oak-bay woodland. See Figure 4. According to this study in the East Bay Regional Park District, there were no resident species found in eucalyptus habitat. Great use of eucalyptus habitat was made by 9 bird species, 1 reptile species, one amphibian species and no mammallian species (cf. Stebbins 1975).

In Marin County, the Monarch butterfly is one species of concern. During the winter, this butterfly roosts from Marin County to Baja California in a variety of tree species including Monterey Cypress, Monterey Pine, chaparral, oak as well as eucalyptus. Blue gum is particularly suitable for overwinter roosting because of its habit of growing in tight protected clusters along the coast, thus providing a favorable microclimate for the Monarch butterfly (Cisero 1986).

Other species of concern in the GGNRA are the Great-horned Owl and Red-tailed Hawk. These species nest in eucalyptus, but not exclusively. Eucalyptus removal should be subject to a site by site evaluation of environmental impact so that no rare, threatened or endangered wildlife species would be affected.

**Noise and Traffic Impact**

The use of chain saws, heavy equipment and chipping equipment would result in a temporary increase in ambient noise levels which may disturb nearby residents, park visitors, and wildlife. Traffic would also increase depending on the type of equipment used.

**Hydrologic Impacts**

Due to loss of transpiration by eucalyptus, ground water and stream flow may increase. Although this may benefit some aquatic species and other surface water users, areas with steep slopes may experience some slippage due to the loss of shear strength provided by live roots.

**Soils and Geological Impacts**

Increased runoff, erosion, sedimentation, and gullying may occur as a result of temporary loss of vegetative cover. Steep slopes may be subject to shallow landslides as well.

**Microclimate Effects**

Removal of eucalyptus where it has served as a windbreak and where it has been planted on top of ridges in coastal areas may result in

microclimate changes, such as increased wind and frequency of fog (fog may be held back by a ridgetop barrier of eucalyptus). Fog drip or intercept may decline causing the site to become dryer. Havlik (1987) reports 16 inches of fog drip due to eucalyptus in Tilden Park one summer.

**Vegetational Impacts**

Partial removal of eucalyptus may increase the likelihood of blowdown in the remaining stand of trees.

**Safety Impacts**

Removal of eucalyptus would eliminate fire hazards associated with this tree. This would be significant in areas adjacent to houses or other structures as well as campsites, trails and picnic areas. It would also reduce the hazard of falling limbs and uprooting trees in these areas.

These impacts of eucalyptus removal in park settings may vary from site to site depending on several factors including: 1) size of site; 2) steepness and stability of slope; 3) proximity to residential areas; 4) visibility of the site from adjacent lands, and; 5) extent of the stand and amount of eucalyptus remaining on adjacent land outside of park boundaries (Hornor et al. 1986).

Courtesy of S. Kelly

FIGURE 1. MAIDEN'S GUM (*E. globulus* subsp. *maidenii*)

Courtesy of S. Kelly

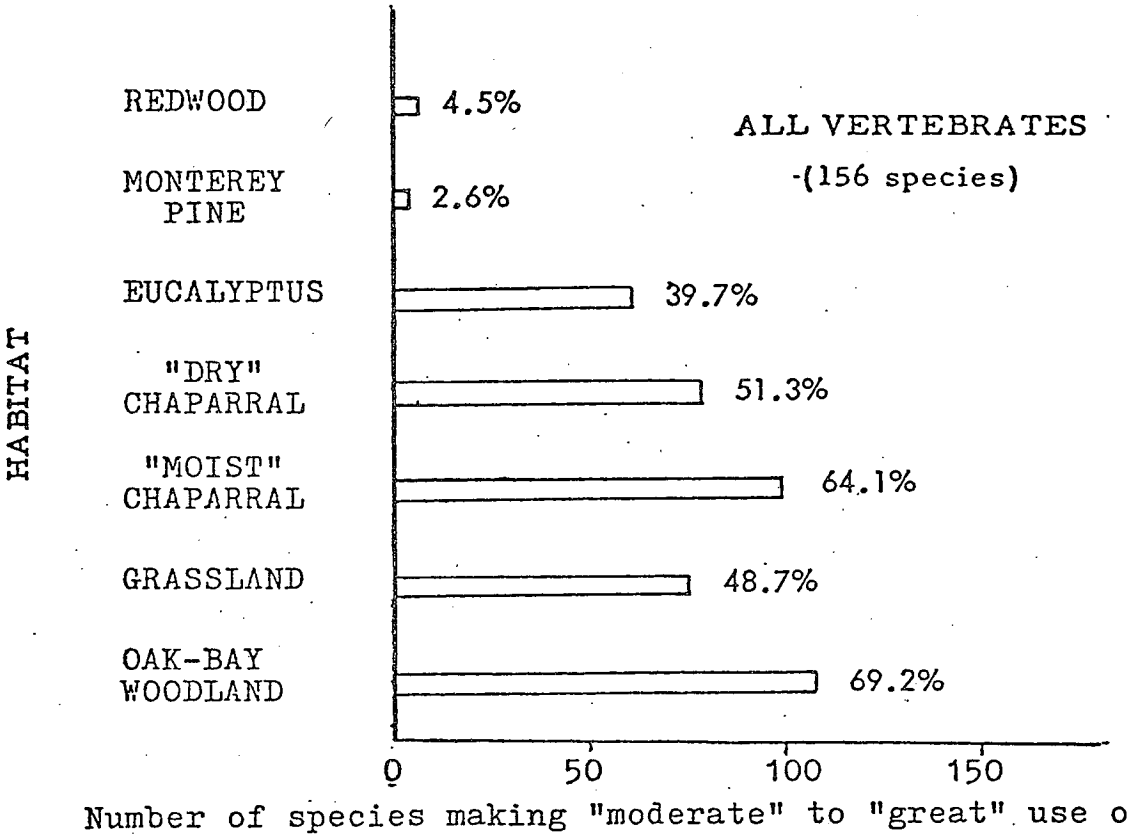
FIGURE 2. TASMANIAN BLUE GUM (*E. globulus* subsp. *globulus*)

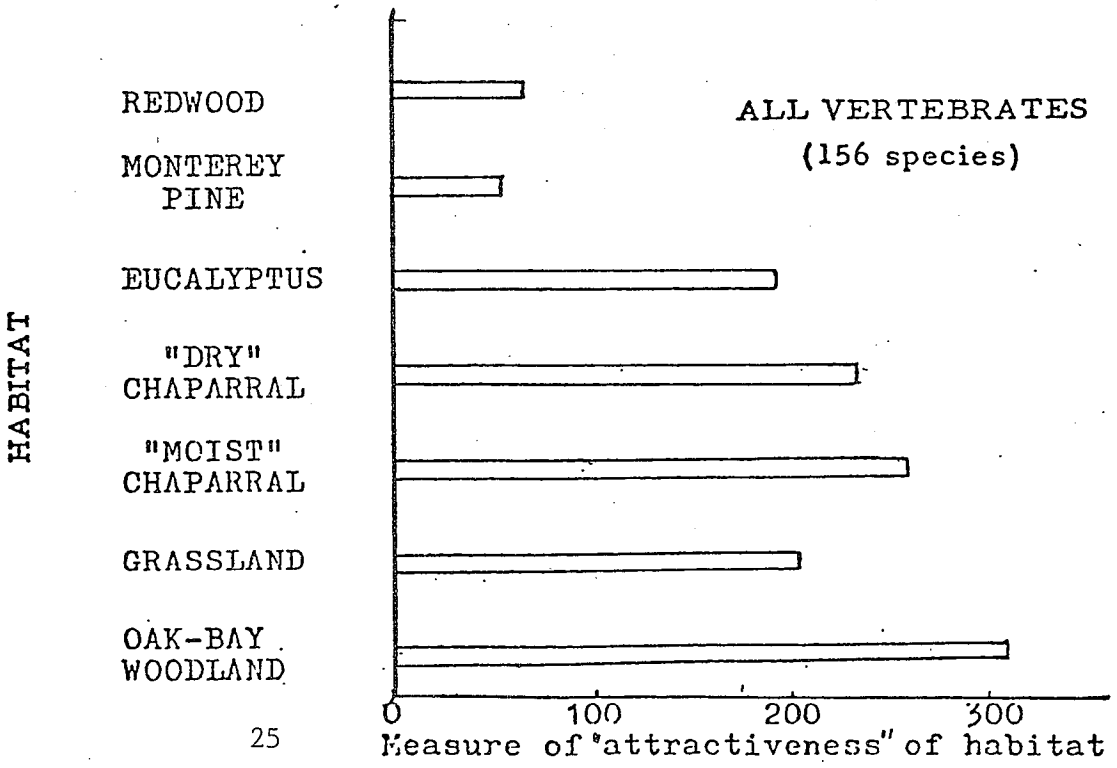
Courtesy of S. Kelly

FIGURE 3. SOUTHERN BLUE GUM (*E. globulus* subsp. *bicostata*)

Figure #4

OVER-ALL USE OF HABITATS
BY VERTEBRATES IN THE
EAST BAY REGIONAL PARKS



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# APPENDICES

# APPENDICES

## METHODS

The literature search was done using Dialog (version 2), Files 5, 10, and 53. Search strategies for these three searches are reproduced on the following pages.

Both primary and secondary sources were used, and are cited along with bibliographical material of general interest in the **BIBLIOGRAPHY** section.

The report was reviewed by several experts, both technicians and academicians, as well as in house by the California Dept. of Food and Agriculture Pest Management Analysis and Planning Branch.

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**THE LONG HORNED BORER**

A natural enemy of eucalyptus, the long horn borer Phoracantha semipunctata Fab. (Coleoptera:Cerambycidae), has been inadvertently introduced into the U.S.. A short discussion of the beetle's biology and control is presented because of the problems involved with the presumably unintentional introduction of this very virulent natural enemy of eucalyptus.

The long horn borer was first detected on October 1984 near El Toro, California (Scriven and Reeves 1986). From that time, it has spread from Long Beach to San Diego on the coast and from Van Nuys to Hemet inland and is now found in Los Angeles, Orange, Riverside, San Bernadino, and San Diego counties. The beetles are strong flyers which accounts for their rapid spread and great infestation potential.

The spread of this insect presents a serious threat to California landscape and woodlot (plantation) eucalyptus which have been virtually without natural enemies to this date. If the insect kills trees, the danger of fire and the cost of removal could be extremely high. The beetle also severely damages eucalyptus logs used for structural timber and telephone poles overseas (Scriven and Reeves 1986).

Beetle outbreaks are likely to occur during periods of severe or even brief stress. Eggs of the beetle are laid on the bark of trees, hatch and begin boring into the tree. On healthy trees, most of the larvae suffocate and die because of the gum which exudes from the eucalyptus.

However, larvae boring on stressed trees have a better chance of survival because trees exude much less gum. Larvae generally feed together in a limited area forming a lesion. Many such lesions can stop gum production which then allows for a massive attack by beetle larvae (Scriven and Reeves 1986). Susceptibility to beetle damage also varies with species. E. globulus is most susceptible and E. blakelyi is least, having a good gum defense. Thus, to prevent attacks, only species which will tolerate excessive drought stress should be planted (FAO 1979).

The long horn borer is 1" long and shiny black. It has a yellow band extending across the upper half of the forewing with a black line within this band. Adult males can mate upon emergence, females 48 hours after. Mating lasts 8 to 28 minutes. About 2 to 4 days after mating, females lay eggs (up to 300) at night. Eggs incubate for 10 to 14 days before hatching. Newly hatched larvae then begin to feed along the bark and then into the cambium. A single larva can tunnel several feet girdling and killing a tree. When the larvae mature, they tunnel to the surface, prepare an exit, and then tunnel several inches into the wood. The larvae develop in 70 days in fresh logs and 180 in dry ones. The pupal stage lasts 20 days. The beetle requires 3 to 4 months to complete its life cycle in the spring/summer and up to 9 months in the fall/winter. They are capable of producing 2 to 3 generations per year in California (Scriven and Reeves 1986).

Control practices are difficult with this species. Eggs are laid under bark and are thus protected from pesticides. A long residual life insecticide is needed to kill the mature beetles. The insecticide treatment does not prevent it from laying eggs however. Although zinc chloride injections into logs kill larvae, it is slow and expensive . Removal of bark from felled logs also prevents infestation but labor costs are high (Scriven and Reeves 1986). Felling trees in the cold season and/or applying 0.5% lindane in cracked gas oil reduces attack on felled timber (FAO 1979). Fumigation of firewood is a possibility but methods and materials are not yet worked out. Tarp coverings may also protect wood. In Spain, trap logs treated with 2% lindane are used in wood lots to kill adults. These logs are destroyed every two weeks killing eggs and larvae (Scriven and Reeves 1986). Trap trees (10/ha) are also used in Tunisia. They are cut with a machete and leaned against other trees. Sex attractants are also used on these trees. The logs are disposed of every three weeks. From 900 to 1500 larvae are commonly found on each trap tree (FAO 1979). The beetle has hymenopterous and other predatory and fungal parasites which could possibly be introduced for effective control. Parasitoids and predators usually associated with the beetle in Australia, and which may mediate its influence, are apparently absent at this time in California (Scriven and Reeves 1986).

The Syrian woodpecker as a possible biological control agent of the borer has been studied by Mendel et al. (1986). They concluded that, despite damage that the woodpecker does to polyethylene irrigation pipes

(Moran 1977 and 1978), it is an efficient natural enemy of the long horned borer in Israel. It caused 28% of the total larval mortality and 78% mortality of larvae that survived **intraspecific** competition (i.e. death from competing against each other). The efficacy of this omnivore in California as a biological control agent is doubtful. Native woodpecker activity appears to be inconsequential in California (Scriven and Reeves 1986).

Biological control of blue gum using goats is not effective because goats do not eat its foliage. This is a benefit with intentional plantings because no fencing is required (FAO 1979).

Eucalyptus has many other natural enemies which could potentially be used for biological control; seed and seedling diseases, root rots, cankers and other pathogens; and defoliating, boring and sap-sucking insects. These are all mainly of Australian origin. Squirrels, notably on the U.C. Berkeley campus, are quite fond of blue gum seed, but are surely of little consequence in any biological control scheme (FAO 1979).

## EUCALYPTUS CONTROL SUMMARY

| Reference | Hamilton and McHenry 1982 | Hamilton and McHenry 1982 | Morze 1971 | Jepsen Prairie Preserve Committee 1983 |
|---|---|---|---|---|
| Location | East Bay Hills, CA | East Bay Hills, CA | | Solano County, CA |
| Control Type | | | | |
| Biological | | | | |
| Cultural | | | | |
| Physical | X | X | X | X |
| Chemical | X | X | X | |
| Control Method | fell trees, apply 2,4-D amine within 1-2 hrs to cambial surface. 50-100% solution. | fell trees, frill application of 95% AMS (ammonium sulfammate). crystals also effective. | fell trees, make frill cuts 3-4 ft. from ground. apply picloram + 2,4-D (Tordon 101 as a 12.5% solution). | burn water stressed trees. burn saplings with flame gun. |
| Timing | | | | |
| Efficacy | 97-100% control | 89% control | 90-100% mortality | mediocre control |
| Strengths/ Weaknesses | | | | presents a fire danger |
| Site Specifics | | | | |

## EUCALYPTUS CONTROL SUMMARY

| Reference | McHenry 1980 | Mortenson 1984 | Hamilton and McHenry 1982 | Mortenson 1984a |
|---|---|---|---|---|
| Location | East Bay Regional Park District, CA | East Bay Regional Park District, CA | East Bay Hills, CA | East Bay Regional Park District |
| Control Type<br>Biological<br>Cultural<br>Physical<br>Chemical | <br><br><br>X | <br><br><br>X<br>X | <br><br><br>X<br>X | <br><br><br>X<br>X |
| Control Method | fell trees, shred stump 8-10" below soil surface. | fell trees, apply 30% glyphosate to stump within 2 minutes of cutting | fell trees, make frill around stump w/ axe; apply 25-100% glyphosate. | spray resprouts of felled trees when they are 4-10 ft. tall w/ 2-15% glyphosate. |
| Timing | | do not fell trees in later hot summer | | |
| Efficacy | 100% control no regrowth | 95-100% control | 100% control | 100% control |
| Strengths/ Weaknesses | expensive- stumps may be inaccesible to machine. | | | |
| Site Specifics | | | | |

# EUCALYPTUS CONTROL SUMMARY

| | | | | |
|---|---|---|---|---|
| Reference | Bean 1986 | Bean 1986 | Cudney et al. 1987 | |
| Location | | | Riverside, California | |
| Control Type<br>Biological<br>Cultural<br>Physical<br>Chemical | <br><br><br>X<br>X | <br><br><br>X<br>X | <br><br><br>X<br>X | |
| Control Method | fell trees, apply AMS 1/4" thick to stump. cover with black plastic. | fell trees, remove coppice growth twice a year for f-three years when it is 6-8 ft. high. also pull saplings when less than 1" diameter. | fell trees (12" dia) immediately apply 1:2 mixture of commercially available herbicide:water. Herbicides include: fosamine ammonium, dicamba, triclopyr (both ester & amine) | |
| Timing | | | late fall | |
| Efficacy | | "effective" | none to very little resprouts after 10 mo | |
| Strengths/ Weaknesses | | | | |
| Site Specifics | | | trees were well irrigated, planted 4 feet apart, and about 12 inches in diameter. | |