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Growth and Survival of Eucalyptus species as Windbreak Plantings in California's Central Valley



Figure 1. Eucalyptus planting at the CAPMC in 2019. Photo. Margaret Smither-Kopperl;

Abstract

Windbreaks are important in California's Central Valley. This study at the Lockeford Plant Materials Center (CAPMC) evaluated eucalyptus species (*Eucalyptus spp.*) with rapid early growth after 6 years and good survival after 34 years for use in windbreaks. In the late 1970s, germplasm of eucalyptus species was requested through the National Plant Materials Center, Beltsville, MD. Small quantities (~1 gram) of seed were supplied by the National Botanic Gardens, Canberra, Australia, for 300 accessions and 50 were supplied by domestic sources. Following initial screening, 58 accessions were planted in the spring of 1984 and deep surface irrigated for establishment. An assessment of survival, height and vigor after 6 years found 13 accessions with potential as windbreak species. Since the 1980s, concern about the invasiveness and negative attributes of eucalyptus species has increased, although there is still a need for hardy windbreak species that will survive in the Central Valley. Maintenance on the CAPMC planting was limited to annual weed control by mowing or herbicide use. In 2018, 34 years after planting, an assessment of the 13 species identified in 1990 and other surviving accessions was conducted. The accessions with full survival after 34 years were narrowleaf red ironbark (*E. crebra*), black box (*E. largiflorens*), red iron bark (*E. sideroxylon*) and black sally (*E. stellulata*). River redgum (*E. camaldulensis*) also survived but is listed as invasive in California (Cal-IPC, 2020).

Introduction

Eucalyptus species were introduced to California and extensively planted, initially for timber and later as windbreaks and ornamental trees (Bulmer, 1988; Ritter and Yost, 2009). The Lockeford Plant Materials Center (CAPMC) as part of the NRCS Plant Materials Program carries out systematic evaluations of plant materials for conservation use. In 1984, eucalyptus germplasm sourced from Australia was planted at the CAPMC to evaluate growth rate, drought tolerance and assess the suitability of eucalyptus species to function as windbreaks in the southern Central Valley.

The eucalyptus genus includes around 700 species, most of which are native to Australia (Penfold and Willis, 1961). Their resilience and drought tolerance have resulted in extensive plantings around the globe, primarily for timber, but also as shade and windbreak trees (Jacobs, 1981). Since 1860, when eucalyptus seedlings first became available for planting in California, they have become the most common non-native tree in the state (Ritter and Yost, 2009). Eucalyptus stands are associated with negative attributes including poor habitat for wildlife, allelopathic suppression of plants, high combustibility, and for some species the likelihood of dropping branches unexpectedly or blowing over in high wind events (Bullmer, 1988; Williams, 2002). A positive exception is sites, primarily of blue gum (*E. globulus*), along the Pacific Coast, which are important overwintering sites for the monarch butterfly (*Danaus plexippus*), although the butterflies prefer native trees (Griffiths and Villablanca, 2015). Several species of eucalyptus are recognized as naturalized in California with the ability to regenerate from seed (Ritter and Yost, 2009). Currently, two species of eucalyptus, river red gum (Figure 2) and blue gum, are listed as invasive with limited potential by the California Invasive Plant Council (2020), while a third, sugar gum (*E. cladocalyx*) is listed in the “watch” category (Cal-IPC, 2020).



Figure 2. *Eucalyptus camuldensis*, River red-gum listed as invasive in California. Photo Chimene Minshew.

Air quality is a major resource concern for the Central Valley, which due to its bowl-shaped topography traps particulate matter released during intensive agriculture operations (San Joaquin Valley, 2018). Concentrated animal feeding operations such as dairies and feedlots, are a major source of particulate matter (San Joaquin Valley, Air Pollution Control District. 2018). In the southern Central Valley, regulations reduce spread of dust around dairies. allow windbreaks to be planted for mitigation. California has a Mediterranean climate with a six-month dry season and very hot summers, in the lower Central Valley, the average rainfall is 7 inches during the winter months (WRCC, 2019). Survival of trees tends to be poor in this challenging environment

(NRCS staff observation). Identification of tree species that are vigorous and will survive under these conditions, without being invasive or weedy, is required.

Suitable windbreak trees have a preferred growth habit of a columnar form and one to several trunks, with rapid growth in the first few years (Young, 1983). Data on the best adapted eucalyptus species was first collected in 1990 after six years of growth. An evaluation of the 34-year-old planting provides further information on long-term survival of these species in the Central Valley. The objective of this publication is to provide a short list of fast growing, non-weedy, long lived eucalyptus species that are adapted and would be suitable for further testing in windbreaks around dairies in the southern Central Valley.

Materials and Methods

The CAPMC is located on the eastern side of the San Joaquin Valley in central California and sits on a historical flood plain on the west bank of the Mokelumne River. The soil series is a Columbia fine sandy loam on 0-2 percent slopes. It is a very deep, well-drained soil with pH ranging from moderately acid to slightly alkaline. The mean annual maximum temperature in this area is 73.6°F and minimum temperature is 46°F (WRCC, 2019). The mean annual precipitation is 17.24 inches, mainly occurring between the months of December and March (WRCC, 2018).

Eucalyptus germplasm was requested through the National Plant Materials Center, Beltsville, MD in the late 1970s (Young, 1983). Small quantities (~1 gram) of seed were supplied by the National Botanic Gardens, Canberra, Australia, for reportedly 300 accessions with another 50 supplied from domestic sources. The 350 accessions represented 263 species. Species for the trial were selected based upon literature review of adaptations, requirements and physical properties (GRIN, 2019). A total of 58 accessions were used in the planting at the CAPMC (Table 1). Blue gum was the most widely planted species in California and was used as the standard or control.

In the spring of 1984, 6 eucalyptus seedlings for each accession were planted by hand at the CAPMC in rows with 10 foot within row spacing and 20 feet alleys between rows. The trees were arranged in alphabetical order by species and the study was not replicated. Trees were surface irrigated with deep irrigation during the first summer only (Young, 1983). Weed control was by chemical and mechanical means during the first two years. After establishment, the trees were large enough to suppress most weeds around the tree bases. Non-native annual grasses became the dominant vegetation between the trees. The planting received an annual mowing or herbicide weed control treatment in the alleys between the trees.

Between 1990 and 2018, the eucalyptus plots were left undisturbed, apart from yearly weed management. In August 2018, 34 years after the original planting, an assessment was made of the surviving trees.



Figure 2 Narrow-leaf red ironbark, *Eucalyptus crebra*.



Figure 3. Red iron bark, *Eucalyptus sideroxylon*.



Figure 4.. Black box, *Eucalyptus largiflorens*.



Figure 5. Black Sally, *Eucalyptus stellata*. All photos: Chimene Minshew.

Table 1. Eucalyptus species and accessions planted in 1984 at the CAPMC.

Accession Number	Scientific Name		Common Name
9053529	<i>Eucalyptus acaciiformis</i>	H. Deane & Maiden	wattle-leaf peppermint
9015403	<i>Eucalyptus albens</i>	Benth.	white-box
9019989	<i>Eucalyptus amplifolia</i>	Naudin	cabbage gum
9029281	<i>Eucalyptus blakelyi</i>	Maiden	Blakely's gum
9022931	<i>Eucalyptus botryoides</i>	Sm.	Bangalay
9015052	<i>Corymbia calophylla</i>	(Lindl.) K.D. Hill & L.A.S. Johnson	Southern mahogany
9031665	<i>Eucalyptus camaldulensis</i>	Dehnh.	river red gum*
9030721	<i>Eucalyptus camaldulensis</i>	Dehnh.	river red gum*
9044507	<i>Eucalyptus camaldulensis</i>	Dehnh.	river red gum*
9044507	<i>Eucalyptus cinerea</i>	F. Muell. Ex Benth.	Argyle-apple
9020512	<i>Eucalyptus crebra</i>	F. Muell.	narrowleaf red ironbark
9020514	<i>Eucalyptus dalrympleana</i>	Maiden	broadleaf kindlingbark
9020512	<i>Eucalyptus dealbata</i>	A. Cunn ex Shauer	tumbledown gum
9020546	<i>Eucalyptus delagatensis</i>	R.T. Baker	alpine ash
9020547	<i>Eucalyptus dives</i>	Schauer	broadleaf peppermint gum
9015069	<i>Eucalyptus dundasii</i>	Maiden	Dundas blackbutt
9020549	<i>Eucalyptus elata</i>	Dehnh.	river peppermint gum
9029315	<i>Eucalyptus fastigata</i>	H. Deane & Maiden	brown barrel
9020554	<i>Eucalyptus fibrosa</i>	F. Muell.	blue-leaf ironbark
9035332	<i>Eucalyptus glaucescens</i>	Maiden & Blakely	Tingaringy gum
9030724	<i>Eucalyptus globulus</i>	Labill.	blue gum*
9034849	<i>Eucalyptus globulus</i>	Labill.	blue gum*
9030725	<i>Eucalyptus gomocephala</i>	DC.	tuart gum
9023043	<i>Eucalyptus grandis</i>	W. Hill ex Maiden	grand eucalyptus
9023044	<i>Eucalyptus gunnii</i>	Hook. f.	cider gum
9015088	<i>Eucalyptus intertexta</i>	R.T. Baker	bastard coolibah
9015092	<i>Eucalyptus largiflorens</i>	F. Muell.	black box
9044508	<i>Eucalyptus longifolia</i>	Link	woollybutt
9020571	<i>Eucalyptus macroryncha</i>	F. Muell. Ex Benth.	red stringybark
9020572	<i>Eucalyptus macroryncha</i>	F. Muell. Ex Benth.	red stringybark
9020573	<i>Corymbia maculata</i>	(Hook.) K.D. Hill and L.A.S. Johnson	spotted gum
9030726	<i>Corymbia maculata</i>	(Hook.) K.D. Hill and L.A.S. Johnson	spotted gum
9015098	<i>Eucalyptus melanophloia</i>	F. Muell.	silverleaf ironbark

*Species that are labelled as invasive by Cal-IPC (2020).

Table 1 continued. Eucalyptus species and accessions planted in 1984 at the CAPMC.

Accession Number	Scientific Name		Common Name
9023050	<i>Eucalyptus melliodora</i>	A. Cunn ex Shauer	yellow-box
9020583	<i>Eucalyptus nitens</i>	(H. Dean & Maiden) Maiden	shining gum
9029287	<i>Eucalyptus obliqua</i>	L'Hér	messmate
9035334	<i>Eucalyptus obliqua</i>	L'Hér	messmate
9044509	<i>Eucalyptus occidentalis</i>	Endl.	flat-top yate
9029338	<i>Eucalyptus paniculata</i>	Sm.	gray ironbark
9029351	<i>Eucalyptus populnea</i>	F. Muell.	bimble box
9015113	<i>Eucalyptus populnea</i>	F. Muell.	bimble box
9020608	<i>Eucalyptus regnans</i>	F. Muell.	Victorian ash
9020613	<i>Eucalyptus sideroxylon</i>	A. Cunn ex Woolls	red iron bark
9026115	<i>Eucalyptus sideroxylon</i>	A. Cunn ex Woolls	red iron bark
9020615	<i>Eucalyptus stellulata</i>	Sieber ex DC.	black sally
9020620	<i>Eucalyptus tereticornis</i>	Sm.	forest redgum
9015123	<i>Eucalyptus torquata</i>	Leuhm.	coral gum
9029364	<i>Eucalyptus torquata</i>	Leuhm.	coral gum
9026119	<i>Eucalyptus transcontinentalis</i>	Maiden	redwood
9035340	<i>Eucalyptus urnigera</i>	Hook. f.	urn gum
9020627	<i>Eucalyptus viminalis</i>	Labill.	manna gum
9030729	<i>Eucalyptus viminalis</i>	Labill.	manna gum
9015127	<i>Eucalyptus woolsiana</i>	(Maiden) Maiden	grey box

*Species that are labelled as invasive by Cal-IPC (2020).

Results and Discussion

In 1990, after 6 years of evaluation, 49 of the original 58 accessions survived. Based upon survival, height and vigor thirteen accessions were selected for further trials for windbreaks in California (Table 2). Two of the accessions in the 1990 evaluation, river red gum and blue gum, are listed as invasive by the California Invasive Plant Council so should not be included in future windbreak trials.

Table 2. Best performing eucalyptus accessions after 6 years at the CAPMC

Accession Number	<i>Eucalyptus Species</i>	Common Name	Average Height (ft)	Cal IPC invasive
9029281	<i>E. blakelyi</i>	Blakely's gum	33	Not-listed
9031665	<i>E. camaldulensis</i>	river red gum	40	Yes
9020512	<i>E. crebra</i>	narrowleaf red ironbark	24	Not-listed
9030724	<i>E. globulus</i>	blue gum	34	Yes
9023043	<i>E. grandis</i>	grand eucalyptus	25	Not-listed
9015092	<i>E. largiflorens</i>	black box	34	Not-listed
9044508	<i>E. longifolia</i>	woollybutt	30	Not-listed
9029338	<i>E. paniculata</i>	gray ironbark	28	Not-listed
9029351	<i>E. populnea</i>	bimble box	27	Not-listed
9020613	<i>E. sideroxylon</i>	red iron bark	28	Not-listed
9020615	<i>E. stellulata</i>	black sally	27	Not-listed
9020620	<i>E. tereticornis</i>	forest redgum	27	Not-listed
9020627	<i>E. viminalis</i>	manna gum	35	Not-listed

Between 1990 and 2018, the eucalyptus plots were left undisturbed, apart from yearly weed management. In August 2018, 34 years after the original planting, the number of surviving trees was assessed. Out of the original 58 accessions planted and the 49 present in 1990, 34 accessions remain and are represented by a total of 122 trees (Table 3). The accessions with the highest number of surviving trees were represented in the list of superior accessions from 1990. Interestingly, the invasive blue gum control had few surviving trees, this species typically grows better along the coast (Calflora, 2018).

Table 3. Surviving number of eucalyptus accessions after 34 years at the CAPMC.

Accession Number	Species	Common Name	2018 Survival Count
9030721	<i>E. camaldulensis</i> *	River red gum*	6
9020512	<i>E. crebra</i>	Narrowleaf red ironbark	6
9044508	<i>E. largiflorens</i>	Black box	6
9020620	<i>E. sideroxylon</i>	Red iron bark	6
9026119	<i>E. stellulata</i>	Black Sally	6
9029281	<i>E. blakelyi</i>	Blakely's gum	5
9031665	<i>E. camaldulensis</i>	River red gum*	5
9044507	<i>E. camaldulensis</i>	River red gum*	5
9020546	<i>E. dealbata</i>	Tumbledown gum	5
9029287	<i>E. melliodora</i>	Yellow-box	5
9035340	<i>E. tereticornis</i>	Forest redgum	5
9015403	<i>E. albens</i>	white-box	4
9035332	<i>E. fibrosa</i>	Blue-leaf ironbark	4
9020583	<i>E. melanophloia</i>	Silverleaf ironbark	4
9035334	<i>E. melliodora</i>	Yellow-box	4
9020608	<i>E. paniculata</i>	Gray ironbark	4
9020613	<i>E. populnea</i>	Bimble box	4
9026115	<i>E. populnea</i>	Bimble box	4
9030725	<i>E. globulus</i>	Blue gum*	3
9015092	<i>E. intertexta</i>	bastard coolibah	3
9023050	<i>Corymbia maculata</i>	spotted gum	3
9015113	<i>E. occidentalis</i>	flat-top yate	3
9020627	<i>E. viminalis</i>	manna gum	3
9034849	<i>E. globulus</i>	Blue gum	2
9023043	<i>E. gomocephala</i>	tuart gum	2
9030726	<i>E. macroryncha</i>	Red stringybark	2
9030729	<i>E. viminalis</i>	manna gum	2
9015127	<i>E. woolsiana</i>	grey box	2
9053529	<i>E. acaciiformis</i>	wattle-leaf peppermint	1
9019989	<i>E. amplifolia</i>	cabbage gum	1
9020512	<i>E. dalrympleana</i>	broadleaf kindlingbark	1
9030724	<i>E. glaucescens</i>	Tingaringy gum	1
9015123	<i>E. sideroxylon</i>	Red iron bark	1

*species ranked by number of surviving trees out of the 6 originally planted.

*Listed by Cal-IPC as an Invasive Weed (Limited invasive potential).

Table 4. Aggregate Data: Fastest Growing After Six Years and Survival After 35 Years

Accession Number	Species	Common Name	Survival 2018
9031665	<i>E. camaldulensis</i> *	River red gum*	6
9020512	<i>E. crebra</i>	Narrowleaf red ironbark	6
9015092	<i>E. largiflorens</i>	Black box	6
9020613	<i>E. sideroxylon</i>	Red iron bark	6
9020615	<i>E. stellulata</i>	Black Sally	6

*Listed as invasive according to Cal-IPC (2020)

Conclusion

Five eucalyptus species were identified for further evaluation as windbreak candidates based upon survival 34 years after planting. The five species are narrowleaf red ironbark, black box, gray ironbark, red iron bark and black sally.

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