Two eucalyptus selections yielded 23 cords of firewood per acre over a 43-month period.

Low-elevation foothill fuelwood plantation

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In March 1984, we established a test planting of selected eucalyptus and poplar species and clones in the Yuba County foothills. The main objectives were to evaluate survival and growth characteristics over a six-year period and to determine optimum harvest time of intensively managed hardwood trees grown as energy crops under foothill conditions.

The species, clones, and seed sources of the trees in this study (table 1) were chosen for their cold tolerance, fast growth, or both, based on previous research at the University of California Sierra Foothill Range Field Station and elsewhere in the state. This report summarizes the results after 3.5 years of growth.

Methods

Eucalyptus seedlings 6 to 10 inches tall, rooted eucalyptus cuttings, and poplar cuttings were planted in Auburn-Las Posas-Argonaut rocky loam soils with 7 percent slope at a 575-foot elevation at the Sierra Foothill Range Field Station.

Preplant preparation consisted of spraying with 1 percent Roundup (glyphosate) two weeks before planting to kill native annual grasses and forbs. Trees were sprinkler-irrigated during the first growing season, beginning within two weeks of planting and continuing until mid-September. A drip irrigation system was installed in 1985. Since then, trees have been drip-irrigated weekly from May through September at the rate of 80 percent of pan evaporation. Actual water applied ranged from 40 to 65 gallons per tree per week.

Herbicides and hand weeding were needed for successful weed control during the first year. Simazine at 0.5 pound active ingredient (a.i.) per acre) and Surflan (oryzalin) at 4 pounds a.i. per acre were applied in late May to control summer annuals. Even at this low rate of simazine, some herbicide injury occurred, especially to *Eucalyptus viminalis* (manna gum). Subsequent hand hoeing was required two or three times on most plots. Bermudagrass and bindweed were successfully controlled by spot-spraying with 1.5% glyphosate in late August and September. Surflan (4 pounds a.i. per acre) was applied in November 1984. In the summer of 1985, the canopy had mostly closed and no further weed control has been necessary.

Grasshopper damage was limited the first summer after planting by two applications of malathion spray and Sevin (carbaryl) bait. Light deer browsing occurred on several *Eucalyptus* species, but was extensive on many of the poplars during the first season and, to a lesser extent, the second year. Two commercial deer repellents were used in 1984. Their effectiveness was of short duration, possibly because of the sprinkler irrigation. Although early growth may have been slowed, the poplars survived the browse damage and, by the end of the second summer, all had grown too tall for deer to reach.

No fertilizer was used in 1984. Since 1985, a total of 75 pounds of nitrogen per acre as urea has been applied in equal monthly applications through the drip system from June through September.

Trees were planted in a randomized complete block design with four replications on a 6- by 6-foot spacing (1,210 stems per acre). Diameter at breast height (DBH) and total height were measured yearly in October after 1985. Diameter was also measured along the stem in 1986 and 1987 to calculate stem taper and volume. Only the interior nine trees of each 49-tree plot were measured to avoid an edge effect.

Results

Over the three years compared, *E. globulus* (blue gum) consistently had the greatest average height and diameter, and the

TABLE 1. Species or clones studied

Species or clone (and common name)	Seed source
Eucalyptus globulus (blue gum)	Barnback, Australia
E. camaldulensis (river red gum)	Lake Albacutya, Australia
E. camaldulensis, C-1 clone	Unknown - random selection
E. camaldulensis, C-2 clone	Improved Spanish seed
E. viminalis (manna gum)	South coast, New South Wales, Australia, 200-ft elevation,
E. dalrympleana (mountain gum)	Australia, longitude unknown, latitude 35 S, 800-ft elevation
Populus deltoides X *nigra* (poplar)	'Giacometti' hybrid clone

TABLE 2. Comparison of tree characteristic at various ages

Species/clone	Average DBH*			Average height*		
	19 mo	31 mo	43 mo	19 mo	31 mo	43 mo
	inches			feet		
E. globulus	2.45 a	3.22 a	3.93 a	25.6 a	36.5 a	46.5 a
E. camaldulensis	2.21 a	3.14 ab	3.48 c	19.5 cd	26.0 cd	31.9 c
E. camaldulensis C-2 clone	2.16 a	2.99 abc	3.90 ab	22.6 b	34.5 a	43.4 a
Poplar clone	1.82 b	2.84 bcd	3.50 bc	20.4 bc	29.7 b	38.2 b
E. dalrympleana	1.80 b	2.92 abcd	3.56 abc	17.6 de	27.1 bcd	34.2 bc
E. viminalis	1.79 b	2.81 cd	3.34 c	17.9 de	27.4 bc	34.1 bc
E. camaldulensis C-1 clone	1.65 b	2.64 d	3.32 c	15.8 e	24.4 d	31.9 c

* Treatments followed by the same letter are not significantly different, LSD (.05)

E. camaldulensis (river red gum) C-1 clone had the lowest. At 3.5 years, the C-2 clone had reached an average diameter equal to that of the *E. globulus* and was almost as tall (table 2).

The largest yields per acre at 43 months were the same for *E. globulus* and the *E. camaldulensis* C-2 clone (table 3). Both *E. globulus* and the C-2 clone yielded 23.2 cords (1,972 cubic feet) per acre over the 43-month period (fig. 1). All mortality occurred within the first growing season except for *E. globulus* and *E. dalrympleana* (mountain gum). Several small *E. globulus* trees died at 41 months, presumably from lack of sunlight and competition within the stand.

The *E. globulus* seedlings are fairly uniform, and most trees have single, straight stems, a desirable characteristic for fuelwood trees. The C-2 clone is even more uniform, as would be expected from a clonal population. It too has a very upright, single stem.

As an example of the lower variability in clonal populations, the coefficient of variation (CV) for 1987 DBH of the C-2 clone was 15.5 percent and of the hybrid poplar clone, 16 percent. In contrast, the CV for *E. globulus* seedlings was 51 percent and for *E. viminalis*, 76 percent.

The large growth differences between the C-1 and C-2 clones point out the seedling variability inherent within a species. Both clones were selected from *E. camaldulensis* seedlings. C-1, which has consistently performed poorly, was cloned from a random selection, whereas the superior performing C-2 was cloned from trees from improved Spanish seed.

All the *Eucalyptus* species have endured temperatures in the low 20s for several consecutive days, with a minimum of 16°F, showing virtually no frost injury. Minor tip dieback has occurred on the C-1 clone, *E. viminalis*, and *E. globulus*. The C-1 clone has suffered branch dieback from drought stress in the fall when the irrigation system was off.

Conclusions

Early rates of growth during these 43 months show that there is considerable promise for the production of large volumes of woody biomass from intensively managed plantations of exotic hardwood species on low elevation foothill rangeland sites. The high uniformity of the clonal blocks of both eucalyptus and hybrid poplars contrasts with the larger variability of the natural seedling stands. The uniformity of the clonal stands may be particularly useful in design of harvesting and processing technology.

We will continue this study for at least another two years to determine the age at which biological growth reaches a maximum. Annual measurement of DBH, height, and per acre volume will continue. At final harvest, specific gravity and other wood properties will be sampled, and actual volumetric and weight yields will be determined. Superior individual trees will be identified from the seedling blocks, and cuttings from these maintained for future genetic improvement work.

TABLE 3. Stand characteristics at two ages

Species/clone	Age	Survival*	Volume	MAI†
	mo	%	cu ft/ac	cu ft/ac/yr
E. globulus	31	94	1,075.18	416.74
	43	86	1,970.55	550.43
C-2 clone	31	100	1,040.57	403.32
	43	100	1,969.88	550.25
E. dalrympleana	31	97	837.56	324.64
	43	94	1,588.74	443.78
E. viminalis	31	83	778.41	301.71
	43	83	1,449.27	404.82
E. camaldulensis	31	100	754.21	292.33
	43	100	1,435.15	400.88
Poplar clone	31	100	659.43	255.59
	43	100	1,286.25	359.29
C-1 clone	31	100	566.33	219.51
	43	100	1,086.27	303.43

* Survival of interior nine trees of each plot from which data were taken.
† MAI = mean annual increment, the average annual growth in cu ft/ac/yr.

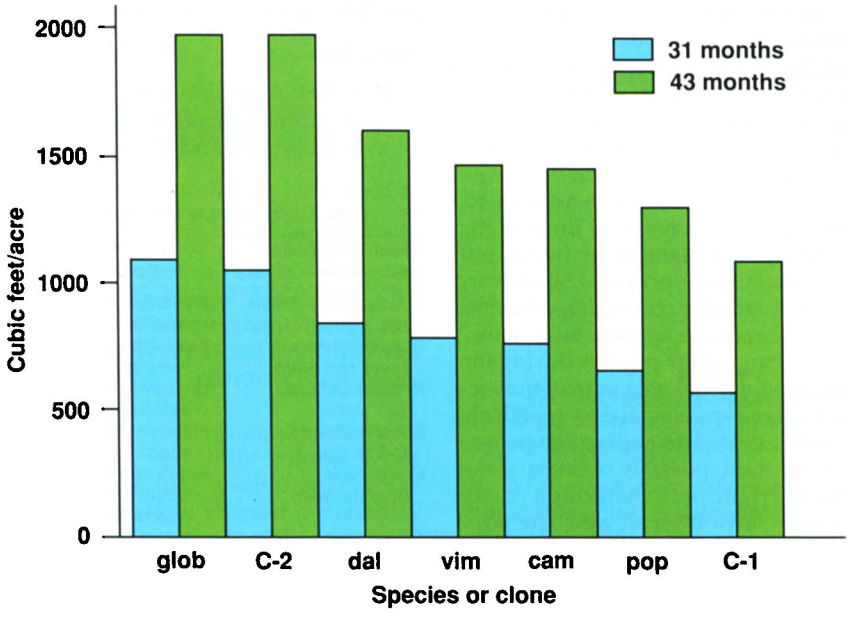

Fig. 1. *Eucalyptus globulus* and the *E. camaldulensis* C-2 clone produced the greatest volume at nearly 2000 cubic feet per acre at 3.5 years.

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