Eucalyptus fuelwood growth rate improves with age

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In cooperation with local landowners in Napa County, we undertook a biomass project in 1977 to evaluate the potential of several tree species as energy crops on small acreages. This article updates tree growth information from two study areas near Calistoga, California, at the north end of the Napa Valley after two additional years of study (see *California Agriculture*, May-June 1982).

Study areas

The areas, planted on the Napa Valley floor, receive approximately 36 inches of rainfall per year, most of which occurs between November and March. We selected six tree species for growth comparisons.

Management varies at the two locations. Tree spacing is 2.4 by 2.4 meters, or 8 by 8 feet (1,680 trees per hectare), at the Grant Street location, and 1.5 by 1.5 meters, or 5 by 5 feet (4,300 trees per hectare), at the Bale Lane location. The Grant Street location was irrigated during the first two years after seedling establishment with no further irrigation applied since then. The Bale Lane location has had consistent, frequent irrigation throughout the entire growth cycle. Both areas have received chemical weed control annually.

Tree data

The two species of *Eucalyptus* were the fastest growing of the five tree species evaluated at Grant Street (table 1). Manna gum, *Eucalyptus viminalis*, although about a year younger, is significantly taller than river red gum, *Eucalyptus camaldulensis*, at this location. Coast redwood, *Sequoia sempervirens* and Paradox walnut, *Juglans regia* × *hindsii* are not adapted to this site. The five separate clones of Monterey pine, *Pinus radiata*, at Grant Street are not significantly different at this time.

Table 1 gives average measurements, but there is a great deal of variability within species planted as seedlings. The clones of Monterey pine had much lower variability than the seedling species. Current work in the Department of Environmental Horticulture at UC Davis on cloning *Eucalyptus* may reduce this variation and lead to greater, more consistent growth (*California Agriculture* May-June 1983).

Wood yields

At both planting sites, at least 10 percent of the trees of each *Eucalyptus* species were measured to develop wood volume formulas. Outside bark diameters were measured at several different heights on these sample trees to determine tree volume. Table 2 shows the general form of the equations used to estimate the cubic volume for individual trees to a 5-centimeter small-end diameter. These volume equations are specific to species and location. Analysis of these equations showed the manna gum had a more extreme taper than the river red gum at Grant Street. This is apparently a genetic trait, since the two species were exposed to identical conditions.

From these volume equations, we calculated wood volume per block of trees for each species. The growth rate (mean annual increment in cubic meters per hectare per year) increased for all *Eucalyptus* species between 1981 and 1983 (table 3). The best growth was achieved by river red gum at Bale Lane, under irrigation and in a spacing of 1.5 by 1.5 meters: 26.7 cubic meters per hectare per year, which is approximately 4.5 cords per acre per year.

The difference in growth rate between the river red gum at the Grant Street and Bale Lane locations cannot be explained by differences in irrigation and tree spacing. The river red gum at the two sites came from seed collected from different seed sources, demonstrating the importance of evaluating seed source as well as species when planting *Eucalyptus*.

Conclusions

The calculated annual growth rates show that eucalyptus trees were growing more rapidly in 1983 than in 1981. Eucalyptus still outperforms Monterey pine and other species planted for comparison. For a landowner wishing to maximize wood volume production, it would have been worth letting the stands grow the additional two years. Future measurements will indicate when growth rates reach a maximum at these two locations.

Comparisons between border trees in a block and trees inside the block were statistically evaluated. Significant tree size differences occurred at the 1.5-meter spacing: inside trees were significantly smaller as a result of competition at this spacing. However, tree size is not yet significantly different between inside and outside trees at the 2.4-meter spacing, indicating that individual trees have not yet fully used the available growing area at that spacing.

We will continue to monitor the growth of these trees to determine the growth patterns of these species. Future plans also include a sampling of wood properties to determine specific gravity, moisture content, and actual energy yield.

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Eucalyptus trees planted in the Napa Valley in 1977 were growing faster in 1983 than in 1981 and far out-performed other species. Photo at left was taken in 1981. The same tree is shown in the photo at right, taken in February 1984.

TABLE 1. Summary of tree diameter at breast height (DBH) and height data, Napa County field plots, 1981 and 1983

Location and species	Age 1981	Age 1983	Survival 1983	Avg. height 1981	Avg. height 1983	Avg. DBH 1981	Avg. DBH 1983
	months		%	*m*	*m*	*cm*	*cm*
Bale Lane							
E. camaldulensis	27	51	87	4.9	9.9	5.1	8.2
E. dalrympleana	27	51	72	3.8	7.8	3.6	6.9
Grant Street							
E. viminalis	39	63	80	8.3	12.0	7.9	12.5
E. camaldulensis	50	74	89	6.7	10.0	7.9	12.1
Pinus radiata clones:	39	63					
Z6			93	4.4	7.5	5.2	7.6
Z3			87	4.3	7.8	5.1	8.6
MM13			67	3.8	7.0	5.0	8.7
MM6			93	3.4	6.3	4.0	7.2
Z6			80	3.0	6.0	2.9	5.9
Juglans regia x hindsii	50	74	97	2.2	2.2	2.1	2.4
Sequoia sempervirens	39	63	68	1.5	2.4	—	2.5

NOTE: Means not connected by bars are significantly different at the 0.05 level.

TABLE 2. Coefficients for cubic meter volume equations to a 5-centimeter small-end diameter*

Location and species	Coefficients a_0	a_1	a_2	R^2
Bale lane				
E. camaldulensis	-11.968	2.062	1.594	.97
E. dalrympleana	-10.234	2.142	.785	.97
Grant Street				
E. viminalis	-13.571	1.939	2.212	.99
E. camaldulensis	-10.529	1.763	1.320	.93

* Generalized equation used: $\ln(\text{volume [meter}^3\text{]}) = a_0 + a_1 \ln(\text{DBH[cm.]}) + a_2 \ln(\text{tot. ht.[m.]})$

TABLE 3. Calculated volumes for field-planted *Eucalyptus*, Napa County, 1981 and 1983

Species and location*	Trees per hectare	Irrigation	Age	Average volume yield† Total	Average volume yield† Mean annual increments
E. camaldulensis			*months*	*cu m/ha*	*cu m/ha/yr*
Grant Street	1680	No	50	24.7 (25.4%)	5.9
			74	86.1 (10.1%)	12.0
Bale Lane	4300	Yes	27	11.3 (83.6%)	5.0
			51	113.6 (57.1%)	26.7
E. dalrympleana					
Bale Lane	4300	Yes	27	3.5 (22.3%)	1.6
			51	60.0 (25.2%)	14.1
E. viminalis					
Grant Street	1680	No	39	18.9 (31.5%)	5.8
			63	109.6 (22.9%)	20.9

* Seed sources: Grant Street — *E. camaldulensis* from San Diego County, 0-500 ft.; *E. viminalis* from Ventura County, 0-500 ft. Bale Lane — *E. camaldulensis* from Spain; *E. dalrympleana* from Wiharesa, Australia, 300 ft.

† To convert to cords per acre, multiply times 0.168; figures in parentheses are the coefficient of variation, expressed as the standard deviation divided by the mean and multiplied by 100.

Redwood clone BLOCK 1	Redwood seedling BLOCK 1	Red gum BLOCK 1	Manna gum BLOCK 2	Paradox walnut BLOCK 2	Red gum BLOCK 4	Redwood seedling BLOCK 3
Redwood clone BLOCK 2	Z3 Monterey MM13 pine Z6 clones Z5 MM6 BLOCK 1	Paradox walnut BLOCK 3	Redwood seedling BLOCK 2	Red gum BLOCK 2	Manna gum BLOCK 3	Paradox walnut BLOCK 1
Redwood clone BLOCK 3	Manna gum BLOCK 1	Paradox walnut BLOCK 4	Z6 Monterey MM13 pine Z3 clones MM6 BLOCK 2 Z5	Red gum BLOCK 3	Z6 Monterey Z3 pine MM13 clones Z5 MM6 BLOCK 3	

Experimental block design at the Grant Street biomass field planting.