

# Wood properties of *Sequoia sempervirens* grown in New Zealand and California

## A Comparison

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### Abstract

The properties of two sample groups of wood specimens, one from New Zealand and the other from California were compared. The properties of, appearance, density, shrinkage, static bending strength – Modulus of Rupture (MoR), and static bending stiffness – Modulus of Elasticity (MoE) were measured. The results are limited by the small sample sizes of specimens. However, based on these results it is concluded that there was no significant difference in the wood properties of the coastal redwood grown in New Zealand and the coastal redwood grown in California and that the wood properties were similar to those previously reported for California-grown, young-growth coastal redwood.

### Introduction

Coastal redwoods (*Sequoia sempervirens*), native to California, were first planted in New Zealand in the mid to late 19th century, first reported in about 1860 [3, 5]. Since that time various trials were planted in different regions of both the North Island and South Island of New Zealand with varying degrees of success. Of the more than 5000 hectares (about 12,400 acres) of coast redwoods planted in New Zealand it was estimated that only about 250 hectares remained in 1961 [5]. Recent reports on New Zealand-grown coastal redwood are showing promise [4] but questions remain about consumer acceptance in a market dominated by California-grown redwood. In this study we present data from previous studies and compare with results from tests conducted by the authors on samples from New Zealand and California.



Figure 1: Baldwin 60,000 Universal Testing Machine

**Density and Specific Gravity** Density and specific gravity were measured from 50 mm long specimens following the standard

test methods of ASTM D2395-14 [1] after the bending test. Specimens were equalized in a controlled 12 percent moisture content environment and were measured at the time of the bending tests.

**Shrinkage** Each specimen was measured in length, thickness, and volume at three moisture content conditions: time of test, fully saturated, and oven-dry. Volumetric dimensional change (shrinkage) was calculated for each specimen.

**Bending Strength and Stiffness** The standard [2] bending test was used to calculate the strength MoR and stiffness MoE of each 25 x 25 x 410 mm test specimen using Baldwin 60,000 pound capacity universal testing machine (Figure 1). Failure over a span of 400 mm; stress and strain (deflection) were measured.

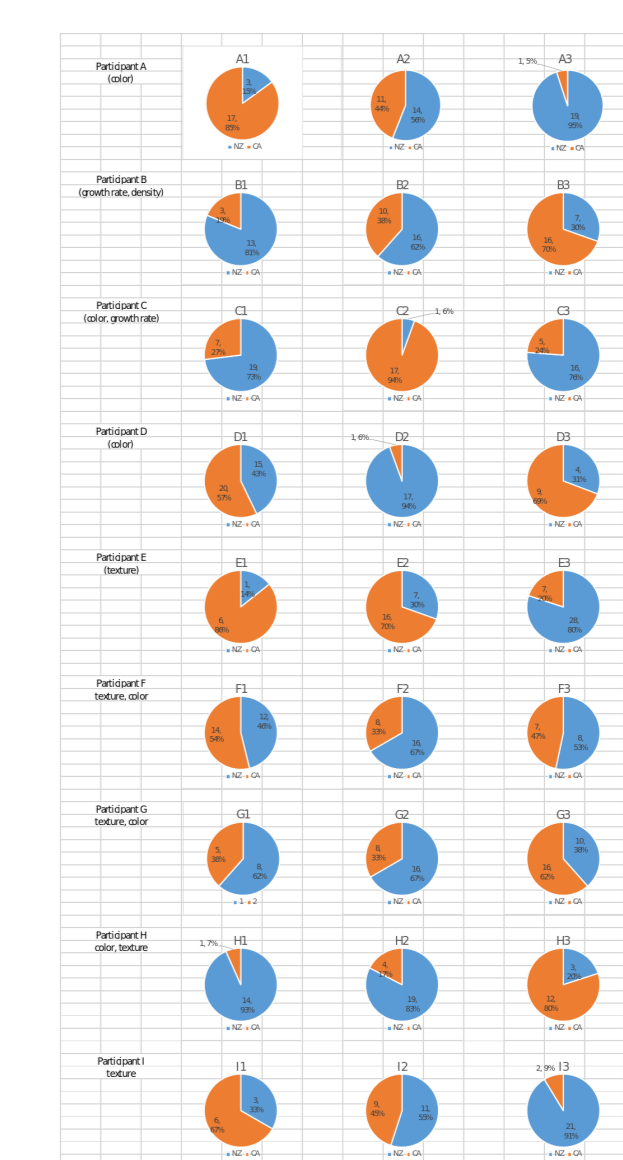


Figure 2: Appearance grouping results of each participant; Blue represents NZ specimens, Orange represents CA specimens

### Results

**Appearance** Figure 2 indicates that discernible differences exist in the appearance characteristics of New Zealand-grown and California-grown coastal redwood but this cannot be considered a definitive result.

**Density and Specific Gravity** analysis of the density data reveals a tendency for slightly lower values but less variation in the New Zealand sample than in the California sample.

**Shrinkage** Volumetric shrinkage is greater for the New Zealand (7.4%) sample than percent for the California sample (6.4%), but the range of averages is similar for both the New Zealand and the California sample. No statistical difference between the two samples was noted.

**Bending Strength and Stiffness** The statistical analysis revealed that the MOE value of 7,150 MPa for the New Zealand sample is not significantly different from the MOE value of 7,490 MPa for the California sample. Similarly the New Zealand MOR of 59 MPa is not significantly different from the MOR of 63 MPa for the California sample.

### Conclusions

Sample Group	Basic Density (g/cm <sup>3</sup> )	MOE (MPa)	MOR (MPa)	Volumetric Shrinkage
New Zealand – all specimens	0.33	7,150	59	7.4
New Zealand - North Island	0.32	8,145	62	8.2
New Zealand - South Island	0.33	6,154	55	6.4
New Zealand – literature review	0.33	nr	nr	6.3
California – all specimens	0.36	7,490	63	6.4
California - north range	0.35	6,984	60	6.6
California – south range	0.36	7,996	66	6
California, old growth - Wood Handbook	0.38	9,200	69	6.8
California, young growth - Wood Handbook	0.34	7,600	54	7
California, old growth – literature review	0.37	8,917	64	6.6
California young growth – literature review	0.35	7,377	53	7.3

Table 3: Comparison of mean values of New Zealand-grown and California-grown coast redwood test specimens to the values reported in the literature

Based on the results of this study it is concluded that there was no significant difference in the wood properties of a sample of coastal redwood grown in New Zealand and a sample of coastal redwood grown in California and that the wood properties are similar to those previously reported for California-grown, young growth coastal redwood. The summary of mean values of the New Zealand and California samples and how they compare to the commonly cited values (Wood Handbook) for California-grown, young growth is presented in Table 8. The sample sizes are insufficient to parse regional differences but the mean values are presented as they show hints of possible trends.

### References

- [1] ASTM International. ASTM D2395-14e1 Standard Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials, 2014.
- [2] ASTM International. D143 Standard Test Methods for Small Clear Specimens of Timber, 2014.
- [3] Tom Gaman. California's coast redwood in New Zealand. In Theodore J. Standiford, Richard B. Weller, Douglas D. Piirto, and John D. Stuart, editors, *Proc. coast Redw. For. a Chang. Calif. A Symp. Sci. Manag.*, pages 611–615. Albany, CA, 2012. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.
- [4] Trevor G. Jones, Charlie B. Low, Diahanna R O'Callahan, and Colleen M. Chittenden. Variation in the wood properties of coast redwood trees in New Zealand. *New Zeal. J. For. Sci.*, 44(1):11, dec 2014.
- [5] F B Knowles and J T Miller. *Introduced forest trees in New Zealand: recognition, role and seed source*. 13. *The redwoods: Sequoia sempervirens (D. Don) Endl., coast redwood, Sequoiadendron giganteum (Lindley) J. Buchholz, giant sequoia and the related ornamental genera Taxodium and. New Zealand Forest Research Institute Rotorua, N.Z.*, 1993.

Note that references in Table are not shown in the references section due to space limitations. Please contact the authors for the full bibliography.

### Acknowledgements

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New Zealand											California												
Location (County)	Tree Age	Ring Per Inch	Specific Density Range *	Specific Density Average *	Rad. Shr. **	Tang. Shr. **	Vol. Shr. **	MOR +	MOE +	Reference	Location (County)	Tree Age	Ring Per Inch	Specific Density Range *	Specific Density Average *	Rad. Shr. **	Tang. Shr. **	Vol. Shr. **	MOR +	MOE +	Reference		
nr	70	nr	260-500	nr	nr	nr	nr	nr	nr	Cown, 1970	Mendocino	>100	29	nr	390	2.4	4	6.8	52	8136	Newlen and Wilson, 1917		
Tauranga, Bay of Plenty, NI	45	nr	282-388	353	2.8	5.4	8.22	nr	nr	Colbert and McConchie, 1983; Young, 1983	Humboldt and Mendocino	>100	>20	299-438	374	2.8	4.6	6.7	70	9308	Luxford and Markwardt, 1932		
nr	28-69	nr	0	332	nr	nr	nr	nr	nr	Young, 1983	Humboldt and Mendocino	<50	<20	288-459	337	3	5.2	7.4	51	6481	Luxford and Markwardt, 1932		
nr	50	nr	0	335	nr	nr	nr	nr	nr	Knowles, 1993	Humboldt and Mendocino	>100	29	261-338	380	2.7	4.4	6.8	71	9308	Markwardt and Wilson, 1935		
Rotoehu Forest, NI	22	nr	237-444	321	nr	nr	nr	nr	nr	Vincent, 2001	Humboldt and Mendocino	<50	5	272-347	305	2.4	5	7	53	6826	Markwardt and Wilson, 1935		
nr	42655	nr	290-375	330	0	0	0	0	0	Cown, 2008	Mendocino	66	5	nr	340	nr	nr	nr	53	8618	Fritz, 1950		
Hawkes Bay, Gisborne, NI	38	nr	262-280	323	1.3	3.1	4.44	nr	nr	McIntyre, 2009	nr	>100	28	nr	3923	2.1	4	6.2	nr	nr	Schniewind, 1963		
Kinleith, Waikato, NI	71	nr	285-378	336	nr	nr	nr	nr	nr	Jones et al., 2014	nr	<50	4	nr	3443	2.2	5.2	7.5	0	0	Schniewind, 1963		
Mangatu, Gisborne, NI	38	nr	274-420	329	nr	nr	nr	nr	nr	Jones et al., 2014	Humboldt and Mendocino	40+	6	nr	350	2.2	4.9	7.3	54	7584	Bendtsen, 1966		
Rotoehu, Bay of Plenty, NI	22	nr	264-444	316	nr	nr	nr	nr	nr	Jones et al., 2014	Humboldt	>500	17	230-530	320	nr	nr	nr	nr	nr	nr	Resch and Arganbright, 1968	
											Mendocino	<50	11	270-550	400	0	0	0	0	0	0	0	Resch and Arganbright, 1968
											nr	>100	nr	nr	380	2.6	4.4	6.8	69	9200	Wood Handbook, 2010		
											nr	<100	0	0	340	2.2	4.9	7	54	7600	Wood Handbook, 2010		
Averages NI				330							Averages Humboldt Mendocino			356	2.6	4.6	6.9	65	8,733				
SI											Overall			357	2.5	4.7	7	58	8,037				
Overall				331	2.1	4.3	6.3				<100			346	2.5	5.1	7.3	53	7377				
											>100			371	2.5	4.3	6.6	64	8,917				

Table 1: Properties of redwood collected from literature. \* kg/m<sup>3</sup> \*\* Percentage, + MPa

### Materials and Methods

The experimental design compared wood properties between two samples of coast redwood, a New Zealand-grown sample and a California-grown sample. Specimen locations are listed in Table 2. Sample size was restricted by time and budget and the small sample size reduces the strength of the conclusions but provides reliable evidence differentiating wood from New Zealand and California. All material was collected from young-growth trees (estimated to be less than 50 years old).

Origin	Location	Site	Site n*	Location n**
California	Northern half of range	Humboldt County	5	14
		Mendocino County (north)	4	
California	Southern half of range	Mendocino County (south)	3	15
		Santa Cruz County	3	
New Zealand	North Island	Mangatu Forest	5	21
		Otorohanga	1	
		Unknown	1	
New Zealand	South Island	Nelson	2	15
		Golden Downs	2	
		Ashley Gorge	1	

Table 2: Source of samples tested. \* Number of NZ Trees or CA Boards. \*\* Total Number of Specimens from Location

All samples were collected in 2013 and sent to the University of California forest products laboratory for specimen preparation and testing. The following were tested:

**Appearance** A subjective test using nine participants categorized all samples into three groups based on color, grain pattern, weight, and a combination two or more characteristics.