

# Wood Quality...

## Impact on Product Yields, Grades and Value

---

W O R K B O O K



Canada

CANADA – BRITISH COLUMBIA  
PARTNERSHIP AGREEMENT ON  
FOREST RESOURCE DEVELOPMENT:  
FRDA II





# Big or Small Trees, Fast or Slow Growing Trees?



Canada  
CANADA-BRITISH COLUMBIA  
PARTNERSHIP AGREEMENT ON  
FOREST RESOURCE DEVELOPMENT  
PRED 11



Wood Quality... Impact on Product Yields, Grades and Value  
INTRODUCTION, HISTORICAL TRENDS 1.0



## Then & Now



Wood Quality... Impact on Product Yields, Grades and Value  
INTRODUCTION, HISTORICAL TRENDS 1.2

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---



---

---

---

---

---

---

---

---



---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

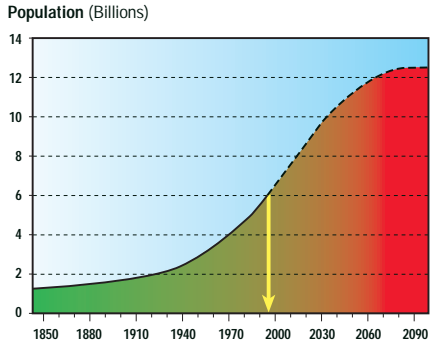
---

---

---

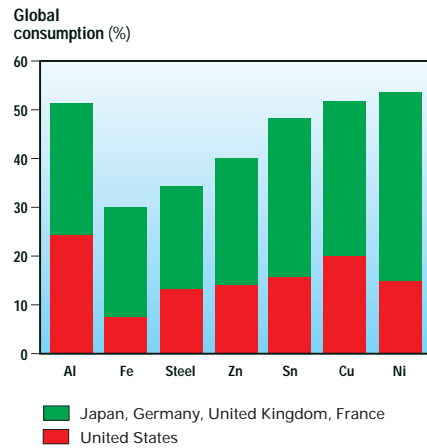
---

### World Population 1850 to 2100



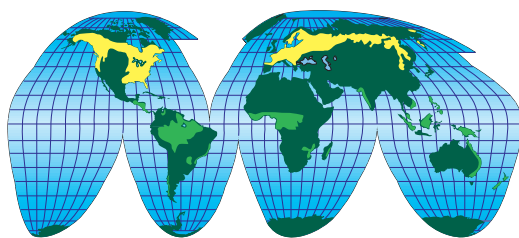
Wood Quality... Impact on Product Yields, Grades and Value GLOBAL TRENDS 5.9

### Global Consumption of Raw Materials by 10.3% of Global Population



Wood Quality... Impact on Product Yields, Grades and Value GLOBAL TRENDS 6.0

### Our Forests



- Temperate coniferous and mixed forests
- Tropical rain forests

Wood Quality... Impact on Product Yields, Grades and Value GLOBAL TRENDS 7.0

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---



Wink Sutton holds "The Wedge"; a 1.8 litre piece of wood that represents the average amount of wood used each day by each person on earth.

(Based on FAO figures:  $\frac{\text{total wood harvested}}{\text{population of earth}}$ )

Wood Quality... Impact on Product Yields, Grades and Value GLOBAL TRENDS 8.0

## Annual World Consumption of Wood

Industrial Roundwood 1.7 billion m<sup>3</sup>  
Fuelwood 1.8 billion m<sup>3</sup>



Wood Quality... Impact on Product Yields, Grades and Value GLOBAL TRENDS 8.0

---

---

---

---

---

---

---

---

---

---

---

---

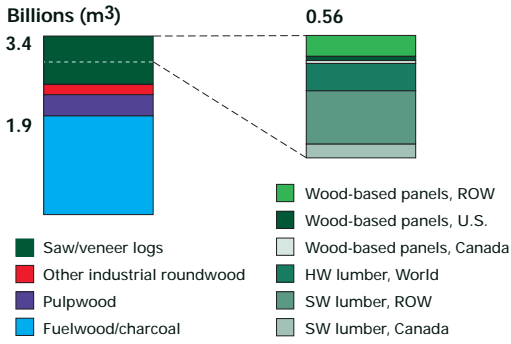
---

---

---

---

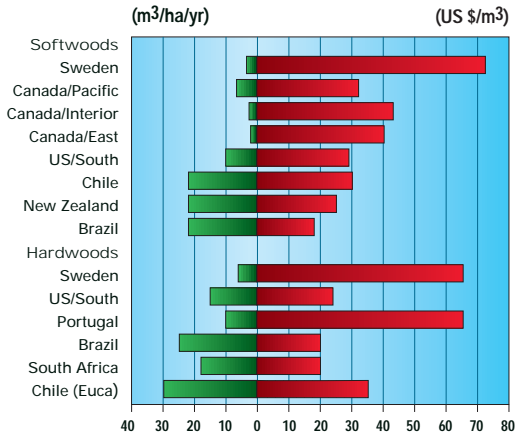
### Global Production of Fibre



Source: FAO

Wood Quality... Impact on Product Yields, Grades and Value GLOBAL TRENDS 10.0

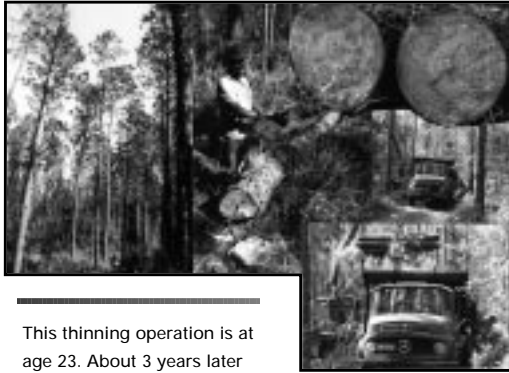
Growth and Mill Delivered Cost of Pulpwood – 1/91



Wood Quality... Impact on Product Yields, Grades and Value  
GLOBAL TRENDS 11.9



Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 12.0



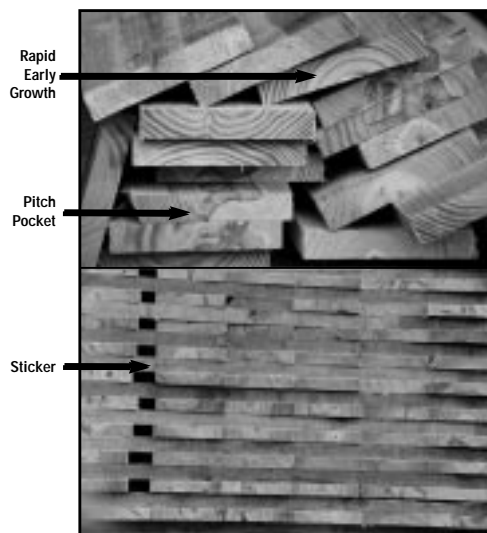
This thinning operation is at age 23. About 3 years later this stand will be clearcut and replanted.

Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 130



26-year-old Caribbean pine hybrid.

Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 140



Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 150



---



---



---



---



---



Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 170



Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 160

---



---



---



---



---



---



---



---



---



---



---



---



---



---

Properties and Uses of  
**New Zealand Radiata Pine**

VOLUME ONE - WOOD PROPERTIES  
Edited by J.A. Kininmonth & L.J. Whitehouse



Wood Quality... Impact on Product Yields, Grades and Value  
BRAZIL AND NEW ZEALAND 180

---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



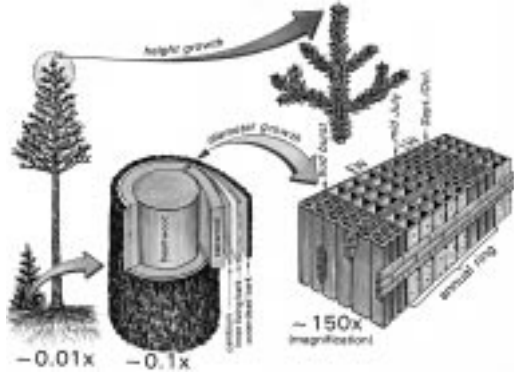
---



---

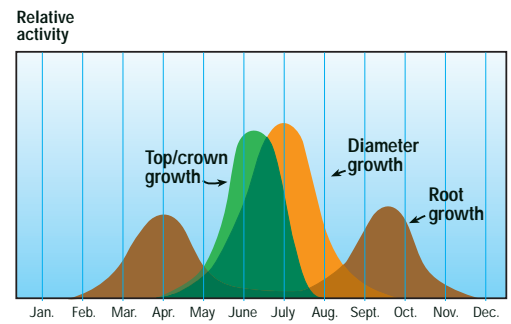


---



Wood Quality... Impact on Product Yields, Grades and Value. TREE GROWTH AND TREE PHYSIOLOGY 190

### Phenology of Tree Growth



Wood Quality... Impact on Product Yields, Grades and Value. TREE GROWTH AND TREE PHYSIOLOGY 200

---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



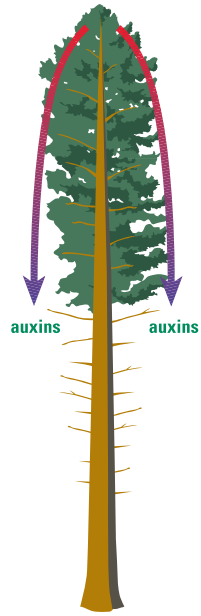
---



---



---



- Terminal shoot and vigorous last formed portions of the crown foliage produce growth regulating hormones (auxins) and photosynthate.
- Lateral and downward translocation of auxins to reach lower stem.
- In spring radial growth begins first at the top of the tree and proceeds gradually downward = more EW and wider rings in upper crown region near pith.
- Less EW and smaller rings at the base where rings are far from pith.
- Transition to LW occurs first near the base, farthest from the source of auxin supply and proceeds upward.
- The destiny (and density) of an individual fibre is thus determined by its relative position; its distance from the active live crown region and the time of its formation (season).

Wood Quality... Impact on Product Yields, Grades and Value  
TREE GROWTH AND TREE PHYSIOLOGY 210

---



---



---



---



---



---



---



---



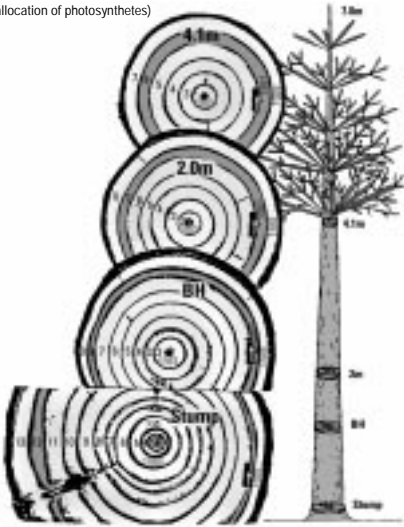
---



---

**Allometry**

(allocation of photosynthetes)



Wood Quality... Impact on Product Yields, Grades and Value  
TREE GROWTH AND TREE PHYSIOLOGY 220

---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



---



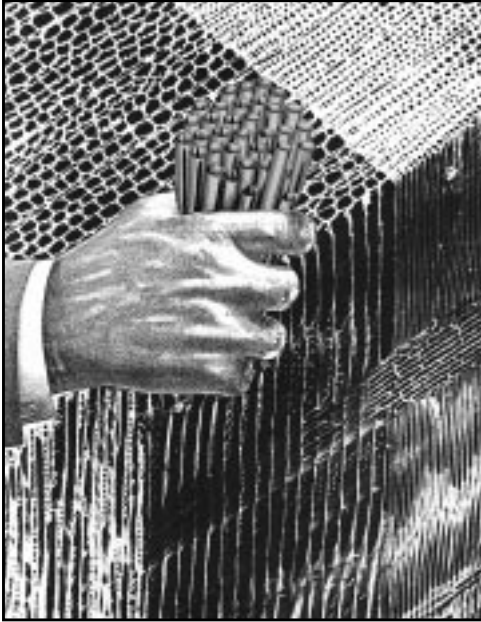
---



---



---



Wood Quality... Impact on Product Yields, Grades and Value. WOOD STRUCTURE AND WOOD ANATOMY 239

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

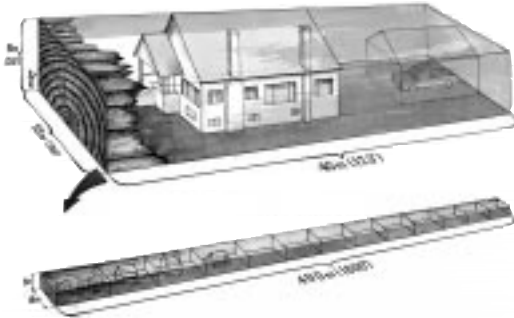
---

---

---

---

---



Wood Quality... Impact on Product Yields, Grades and Value. WOOD STRUCTURE AND WOOD ANATOMY 240

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

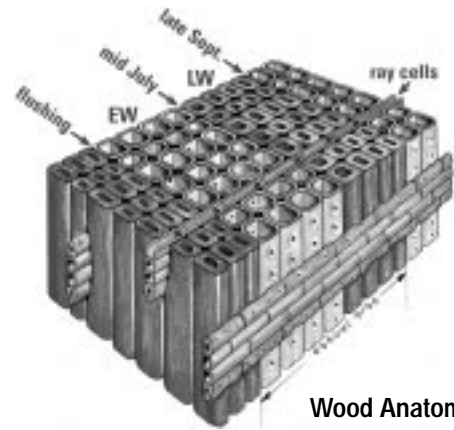
---

---

---

---

---



Wood Anatomy

Wood Quality... Impact on Product Yields, Grades and Value. WOOD STRUCTURE AND WOOD ANATOMY 200

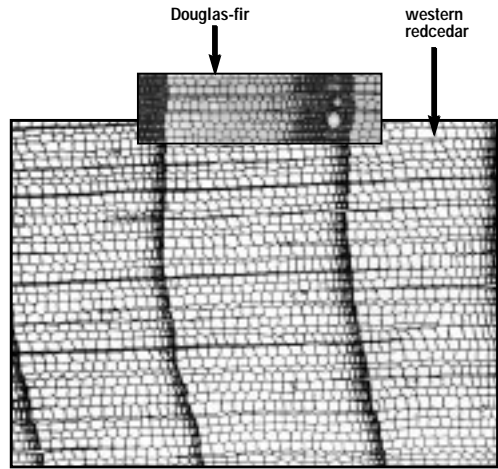
Earlywood



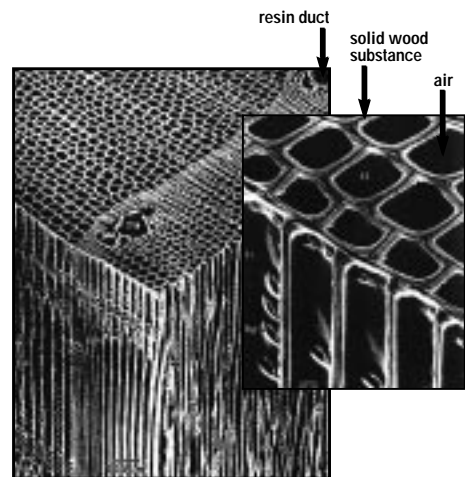
Latewood

Wood Quality... Impact on Product Yields, Grades and Value. WOOD STRUCTURE AND WOOD ANATOMY 200

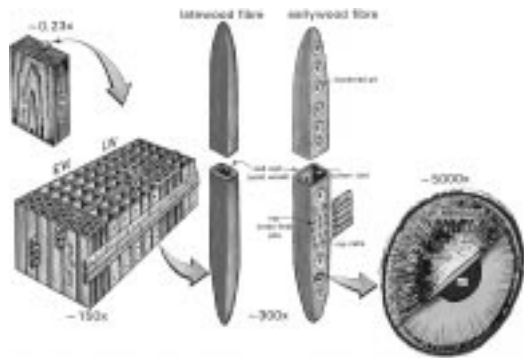




Wood Quality... Impact on Product Yields, Grades and Value.  
WOOD STRUCTURE AND WOOD ANATOMY 29.0



Wood Quality... Impact on Product Yields, Grades and Value.  
WOOD STRUCTURE AND WOOD ANATOMY 30.0



Wood Quality... Impact on Product Yields, Grades and Value. WOOD STRUCTURE AND WOOD ANATOMY 319

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

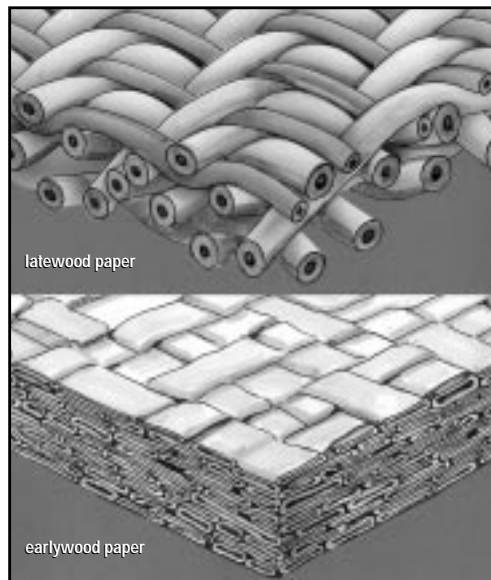
---

---

---

---

---



Wood Quality... Impact on Product Yields, Grades and Value. WOOD STRUCTURE AND WOOD ANATOMY 320

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

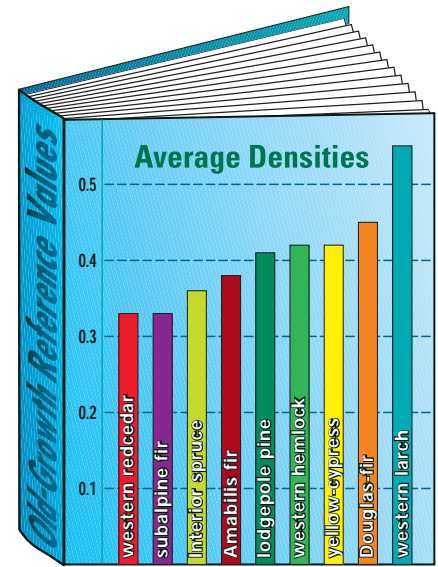
---

---

---

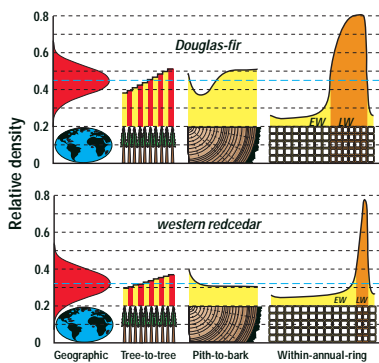
---





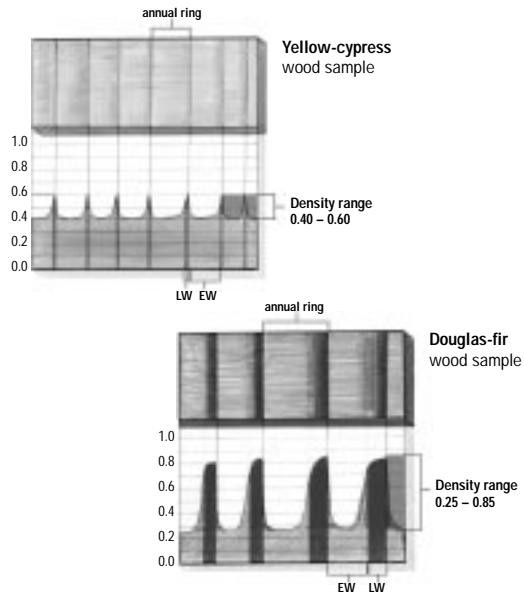
Wood Quality... Impact on Product Yields, Grades and Value. RELATIVE DENSITY OF WOOD 33.0

Global to Microscopic View of Density Distribution in BC Tree Species



Wood Quality... Impact on Product Yields, Grades and Value. RELATIVE DENSITY OF WOOD 34.0

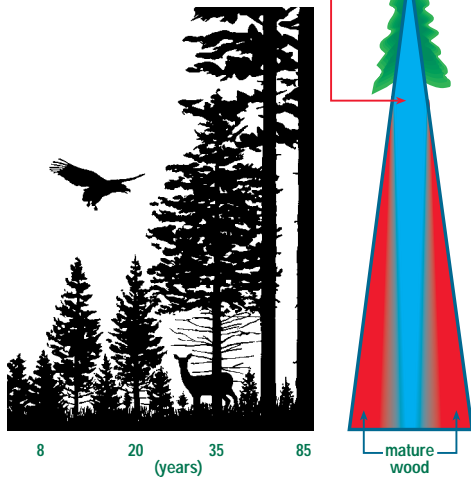
Wood Density Variation within Growth Rings



Wood Quality... Impact on Product Yields, Grades and Value. RELATIVE DENSITY OF WOOD 35.0

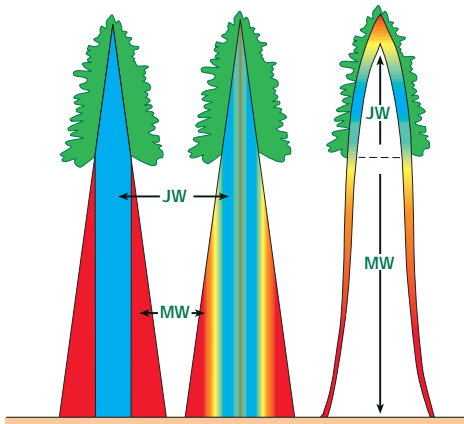
## Juvenile Wood

(wood that is formed in the live crown)



Wood Quality... Impact on Product Yields, Grades and Value  
JUVENILE WOOD, CROWN FORMED WOOD 26.0

## Juvenile Wood (JW) and Mature Wood (MW)

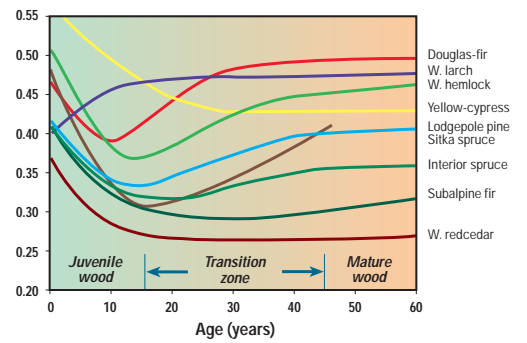


Wood Quality... Impact on Product Yields, Grades and Value  
JUVENILE WOOD, CROWN FORMED WOOD 27.0

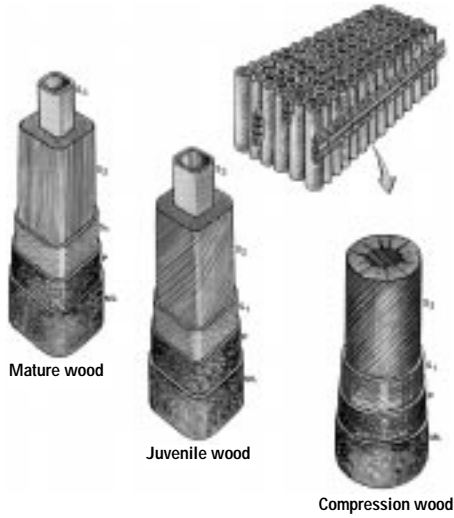


Wood Quality... Impact on Product Yields, Grades and Value. JUVENILE WOOD, CROWN-FORMED WOOD 33.0

Relative Density at BH of Rapidly Grown B.C. Woods

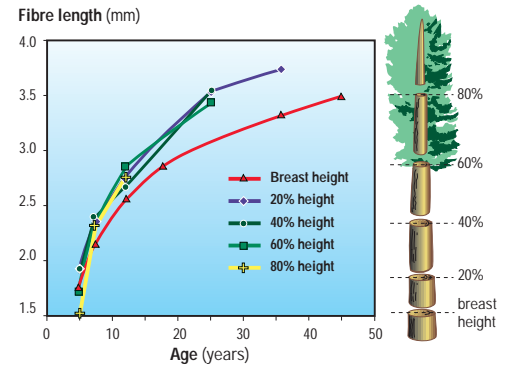


Wood Quality... Impact on Product Yields, Grades and Value. JUVENILE WOOD, CROWN-FORMED WOOD 33.0



Wood Quality... Impact on Product Yields, Grades and Value  
 JUVENILE WOOD, CROWN-FORMED WOOD 40.0

### Second Growth Douglas-fir



Wood Quality... Impact on Product Yields, Grades and Value  
 JUVENILE WOOD, CROWN-FORMED WOOD 41.0

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

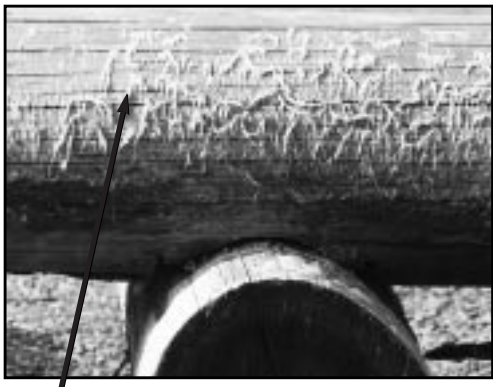
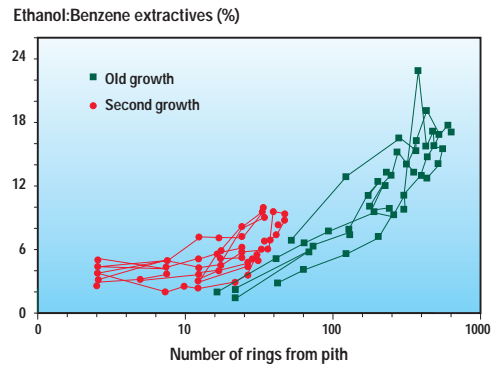
---

---

---

---

### Western Redcedar



Wood fibres from U.V. (ultraviolet) exposure damage from sunlight.

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---

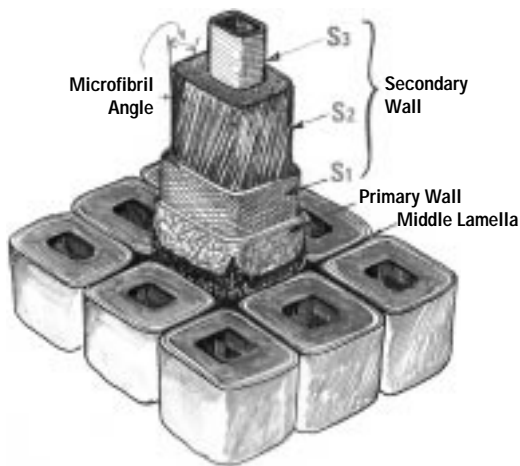
---

---



71-year-old open-grown lodgepole pine.

Wood Quality... Impact on Product Yields, Grades and Value  
JUVENILE WOOD, CROWN-FORMED WOOD 44.0



Wood Quality... Impact on Product Yields, Grades and Value  
JUVENILE WOOD, CROWN-FORMED WOOD 45.0

## Compression Wood



Wood Quality... Impact on Product Yields, Grades and Value  
COMPRESSION WOOD 46.0

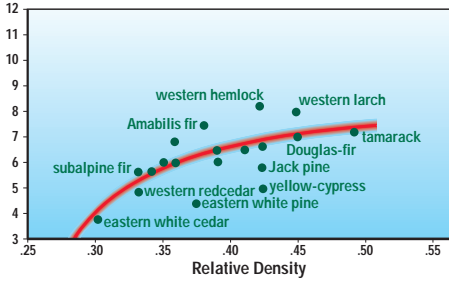
## Typical Shrinkage Values for "Normal" Wood



Wood Quality... Impact on Product Yields, Grades and Value  
SHRINKAGE OF WOOD 47.0



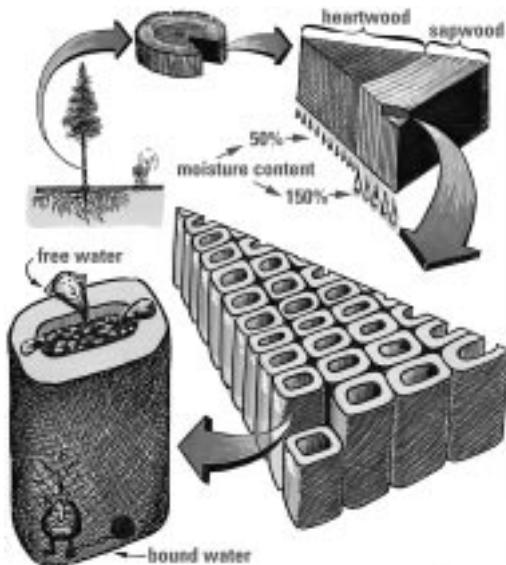
% Volumetric Shrinkage at 12% MC



Wood Quality... Impact on Product Yields, Grades and Value  
SHRINKAGE OF WOOD 49.0



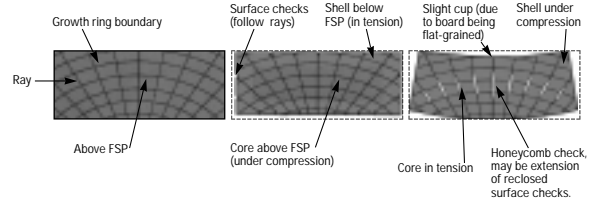
Wood Quality... Impact on Product Yields, Grades and Value  
SHRINKAGE OF WOOD 49.0



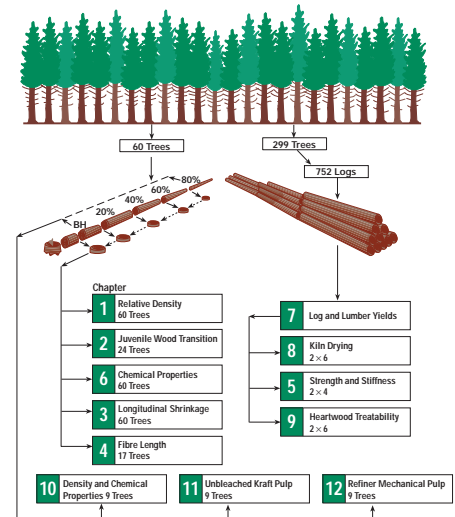
Wood Quality... Impact on Product Yields, Grades and Value  
CONTENT OF FREE AND BOUND WATER 50.0

## The Process of Wood Drying

Drying Stage:	I	II	III
Moisture Condition:	Above fibre saturation point (FSP) throughout: Drying begins with loss of free water from surfaces.	Shell now below FSP, core still above FSP. Core moisture migrates outward to shell.	Below FSP throughout, eventually reaches uniformly low EMC.
Stress Condition:	Stress-free	Shell tries to shrink, creates tension across surfaces, squeezes the core into compression. Drying sets shell in oversized condition.	Core now trying to shrink away from oversized shell. Core develops tension, pulls shell into compression.
Defects:	Defect-free	Surface may check; core may collapse.	Surface is casehardened; core may honeycomb.

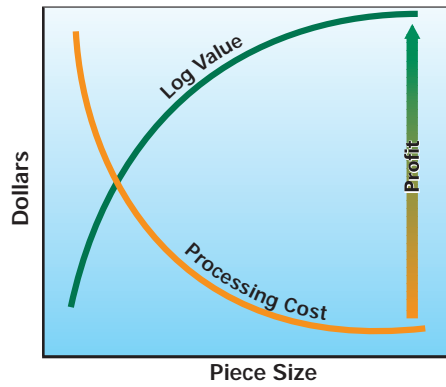
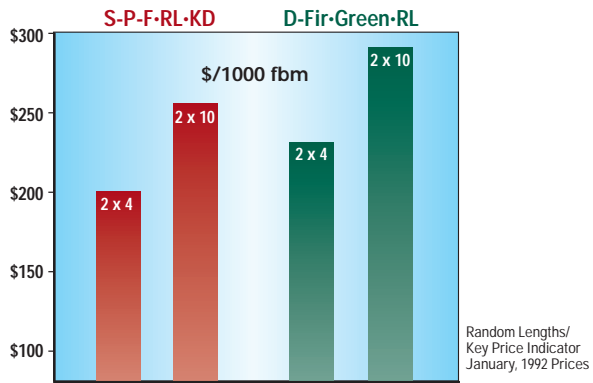


## Second Growth Douglas-fir Resource

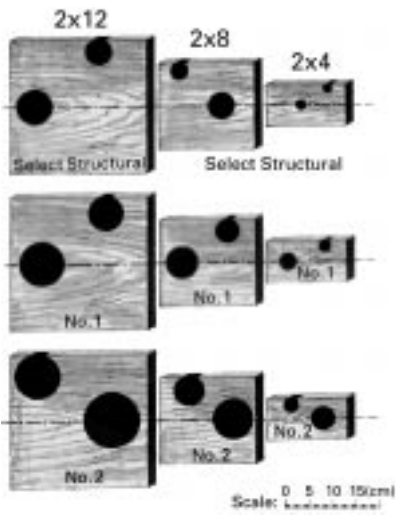




### Size Premium

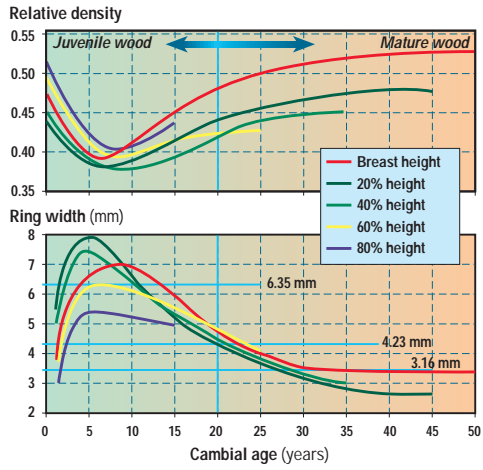


Wood Quality... Impact on Product Yields, Grades and Value  
DOUGLAS-FIR TASK FORCE 56.0



Wood Quality... Impact on Product Yields, Grades and Value.  
DOUGLAS FIR TIMBER 579

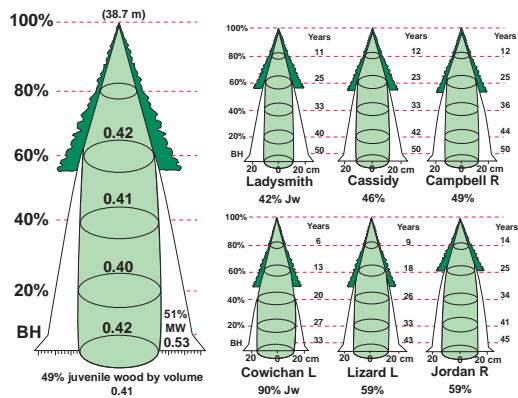
### 50-year-old Douglas-fir



Wood Quality... Impact on Product Yields, Grades and Value  
DOUGLAS-FIR TREE FORM 58.0

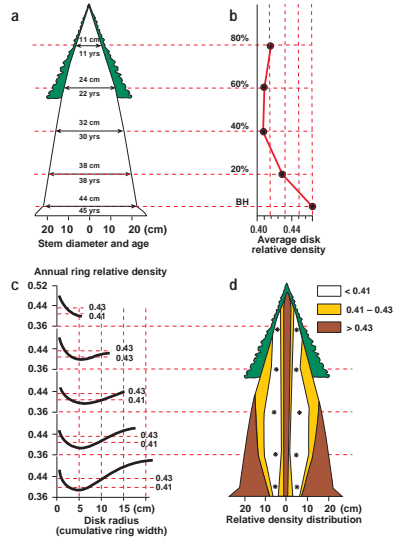
### Juvenile Wood Cylinder

First 20 Years of Growth in 50-year-old Douglas-fir



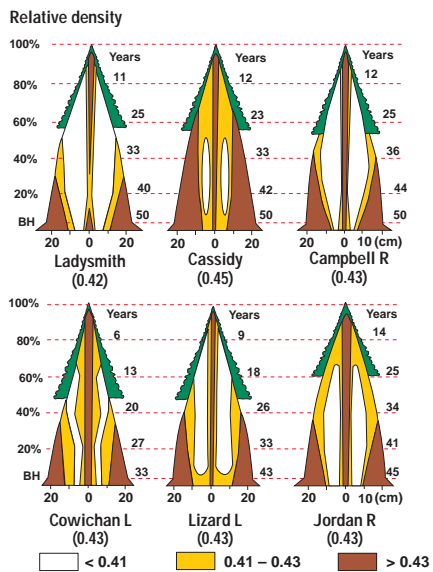
Wood Quality... Impact on Product Yields, Grades and Value  
DOUGLAS-FIR TREE FORM 59.0

### Diameter, Taper and Density Distribution in Douglas-fir



Wood Quality... Impact on Product Yields, Grades and Value. DOUGLAS-FIR TASK FORCE 60.0

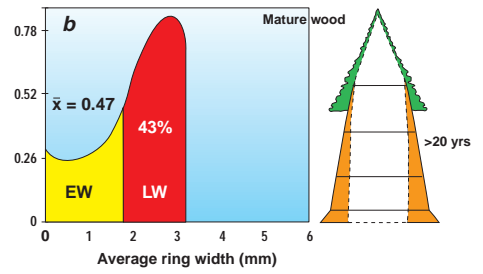
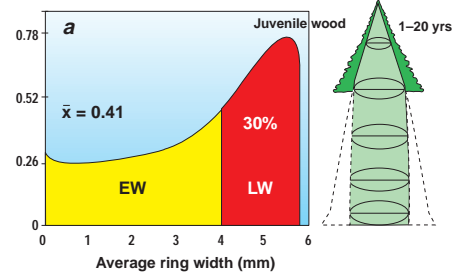
### Relative Density Zones in Douglas-fir



Wood Quality... Impact on Product Yields, Grades and Value. DOUGLAS-FIR TASK FORCE 61.0

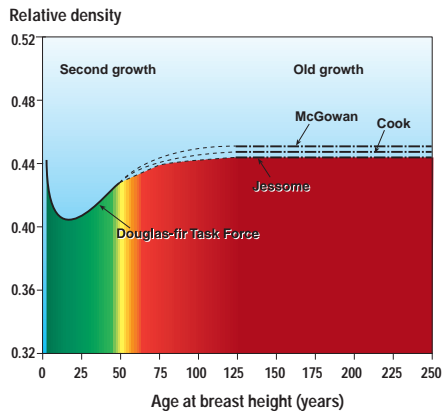
### Juvenile/Mature Wood Ring Profiles

Relative density



Wood Quality... Impact on Product Yields, Grades and Value  
DOUGLAS-FIR TASK FORCE 62.0

### Stem-wood Relative Density



Wood Quality... Impact on Product Yields, Grades and Value  
DOUGLAS-FIR TASK FORCE 63.0



**Conclusions:**

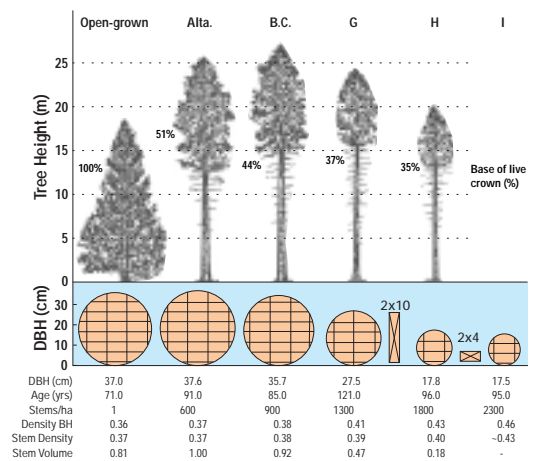
- ➔ These 50-year-old Douglas-fir trees, growing at 530 stems/ha, contained 50% juvenile wood and 50% mature wood.
- ➔ At all height levels, the first 20 years of growth "defaulted" to juvenile wood because of wood density, fibre length, and longitudinal shrinkage.
- ➔ Juvenile wood is not useless wood.
- ➔ Larger knots permitted in wider widths.
- ➔ Challenge: find optimum between tree size and branch size at rotation age to maximize value, keeping future trends in mind.

**\$/ha/yr** commercial forestry has to be profitable

- Other non-woody pressures on the land base – social forestry

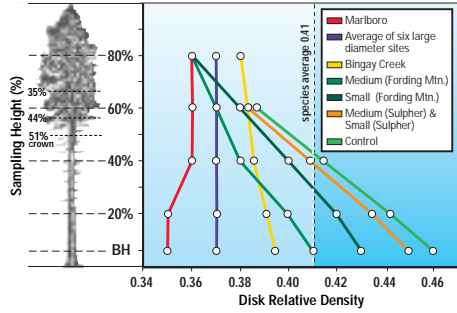
Wood Quality... Impact on Product Yields, Grades and Value  
DOUGLAS-FIR TASK FORCE 459

**Average Dimensions of Small, Medium and Large Diameter Lodgepole Pine Task Force Trees**

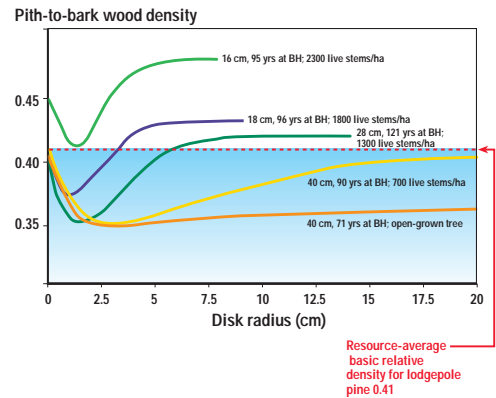


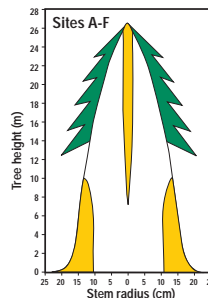
Wood Quality... Impact on Product Yields, Grades and Value  
LOGEPOLE PINE TASK FORCE 450

### Average Disk Density at Five Sampling Heights

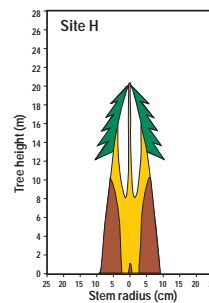
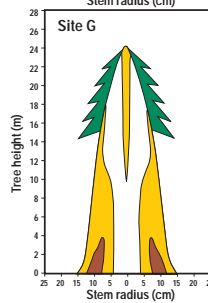


### Pith-to-bark Wood Density and Tree-size Trends as a Function of Stand Density



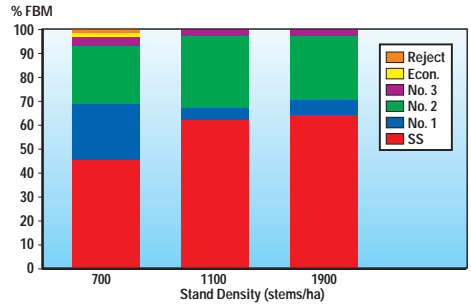


### Second Growth Lodgepole Pine Density Distribution



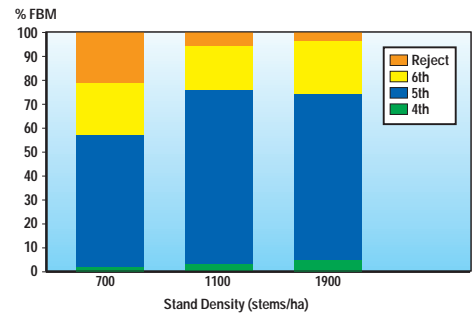


### Structural Lumber Yields by Visual Grading



Wood Quality... Impact on Product Yields, Grades and Value. LODGEPOLE PINE TASK FORCE 0710

### Door, Window and Furniture-Grade Lumber Yields by Visual Grading



Wood Quality... Impact on Product Yields, Grades and Value. LODGEPOLE PINE TASK FORCE 0720

**MSR Summary**

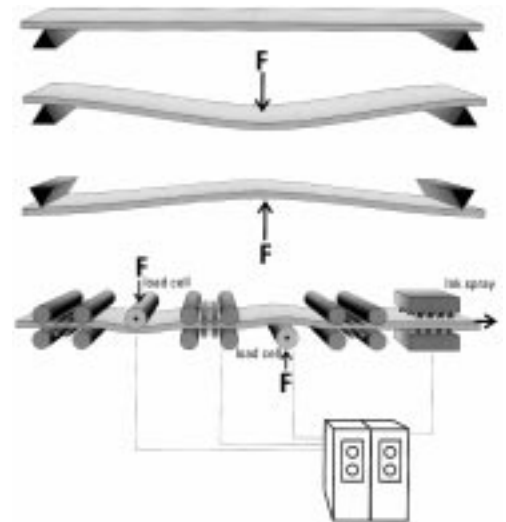
**Uses of MSR Lumber**

- ➔ Primarily for roof trusses, I-joists, laminating stock for glulam
- ➔ Parallel chord floor trusses – new market (ease of handling, longer spans, ready openings for wiring, plumbing and ductwork)

**Advantages of MSR Lumber**

- better consistency because of E rating (more uniform “links”)
- quality control in the plant – none with visually graded
- lumber can be cut from small logs (no need for very wide widths)
- reduced variability = reliability and exactness
- reduced waste (2% vs 10%)
- uniformity across “species boundaries” (fewer grades)
- **Profit** (marketability)

**MSR Grading System**



Wood Quality – Impact on Product Yields, Grades and Value MACHINE STRESS RATED (MSR) LUMBER 74.0

**Strength of wood**

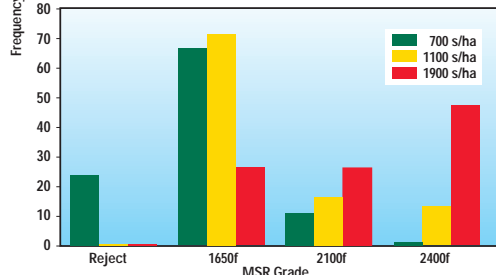
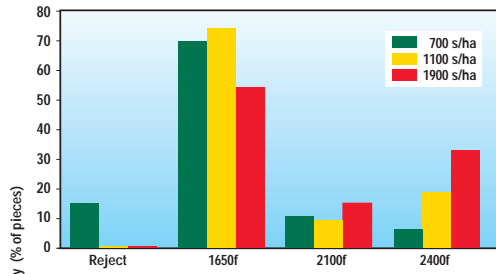
is the resistance to forces deforming it.

- ➔ There are still other things besides relative density that affect the strength of wood.
- ➔ These include knots, slope of grain, compression wood, the relative amounts of earlywood and latewood, moisture content, temperature (above 65°C), and fibril angle (the part of the tree, near the pith, or farther out from which the piece was cut).
- ➔ A few basic terms in wood mechanics:
  - force: push, pull and shear
  - stress: force per unit area (psi)
  - strain: unit deformation
  - stiffness (elasticity): stress/strain
  - creep: continuously stressed in bending, “flow”, “sag”
  - fatigue: loss in wood property due to repeated force application (bending back and forth, 1/3 max. stress, 30,000,000 times)

Wood Quality – Impact on Product Yields, Grades and Value MACHINE STRESS RATED (MSR) LUMBER 75.0

### Machine-stress rated lumber yields

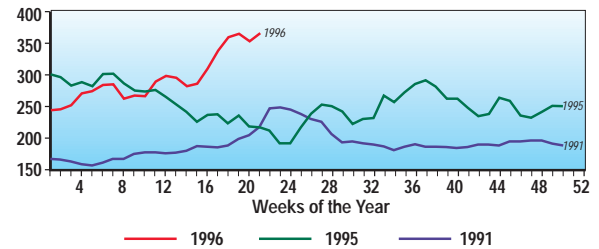
Distribution of MSR Grades for 2x4's by Stand Density



Distribution of MSR Grades for 2x6's by Stand Density

### Western SPF KD Std&Btr Random Lengths – 2x4

US Funds –  
FOB Mill



As reported by Madison's Canadian Lumber Reporter – May 24, 1996

### MSR Lumber—Kiln Dried—8'/20'

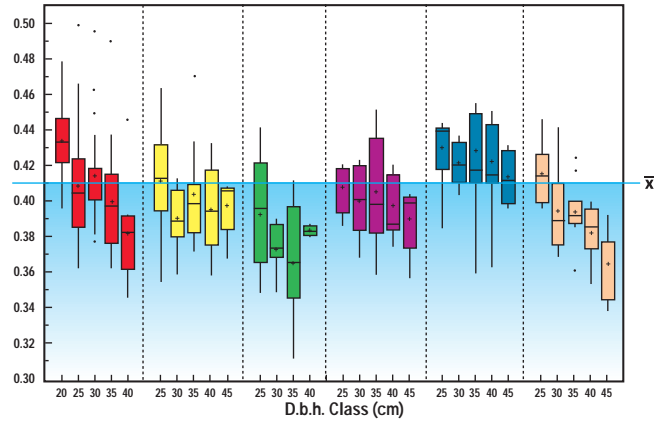
	2x4 SPF		2x6 SPF	
1650f	\$490	{450}	\$440	{400}
1800f	495	{455}	n/a	n/a
2100f	495	{460}	465	{425}
2400f	520	{480}	480	{440}

\*Prices are in U.S. funds, F.O.B. Chicago  
Prices in () are f.o.b. Vancouver

As reported by Madison's Canadian Lumber Reporter

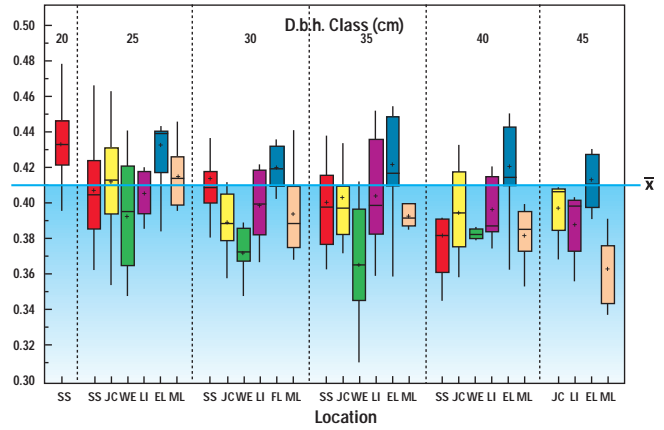


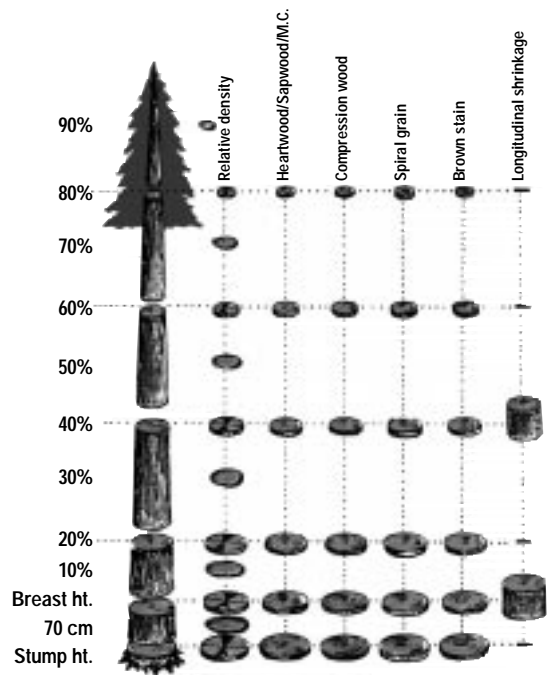
Breast Height Relative Density



Legend for Locations:

- Sulphur Springs (MS) = SS
- Jamieson Creek (MS) = JC
- Wells (ESSF) = WE
- Likely (IDF) = LI
- Elbow Lake (ICH) = EL
- Modeste Lake (SBS) = ML

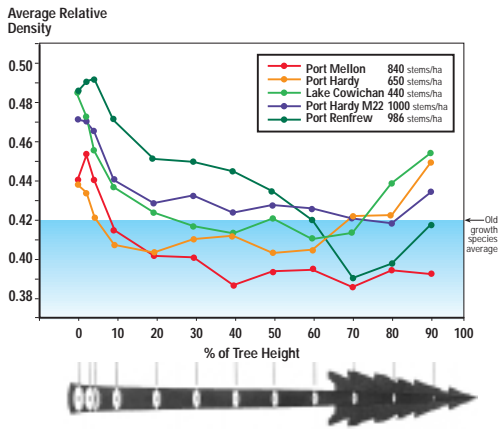




Sampling plan for basic wood properties characterization of second-growth western hemlock.

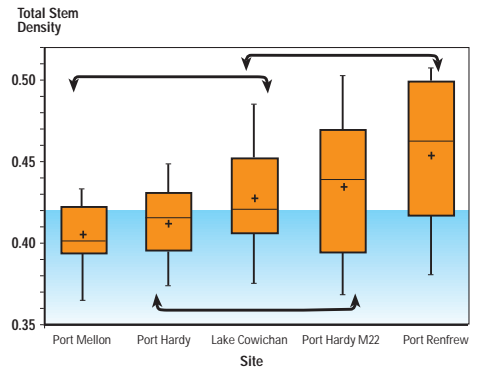
### Second-growth Western Hemlock

Disk Densities at 12 Heights for Five Sites



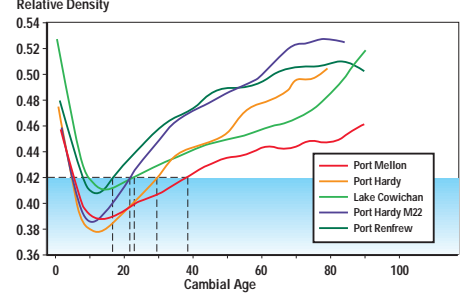
Wood Quality... Impact on Product Yields, Grades and Value... WESTERN HEMLOCK BASIC WOOD PROPERTIES 80.0

### Second Growth Hemlock – Total Stemwood Density Distribution

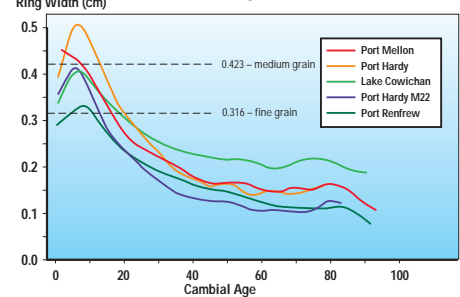


Wood Quality... Impact on Product Yields, Grades and Value... WESTERN HEMLOCK BASIC WOOD PROPERTIES 81.0

Average Pith-to-Bark Density Profiles

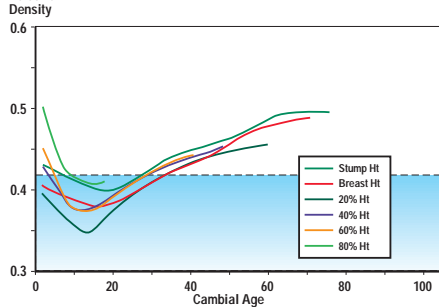
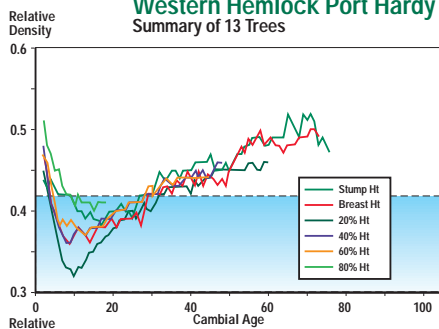


Ring Width (cm) Pith-to-Bark Ring Width Profiles



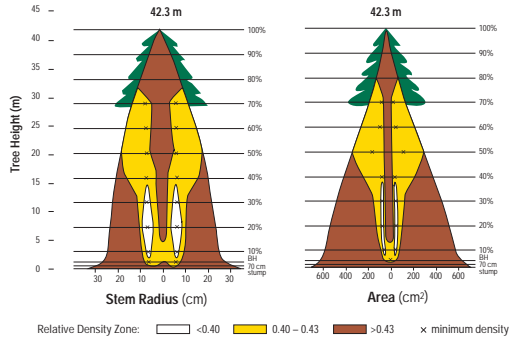
Wood Quality... Impact on Product Yields, Grades and Value  
WESTERN HEMLOCK BASIC WOOD PROPERTIES 82.0

Western Hemlock Port Hardy  
Summary of 13 Trees



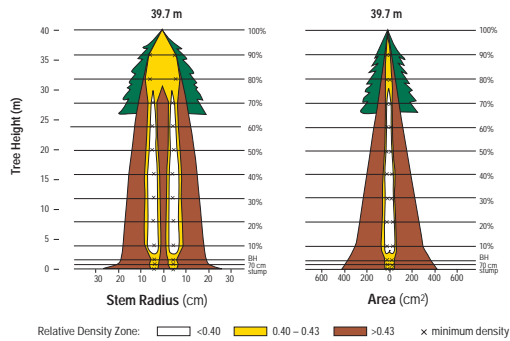
Wood Quality... Impact on Product Yields, Grades and Value  
WESTERN HEMLOCK BASIC WOOD PROPERTIES 83.0

**Lake Cowichan**  
Summary of 13 trees (450 stems/ha)



Wood Quality... Impact on Product Yields, Grades and Value... WESTERN HEMLOCK BASIC WOOD PROPERTIES 84.0

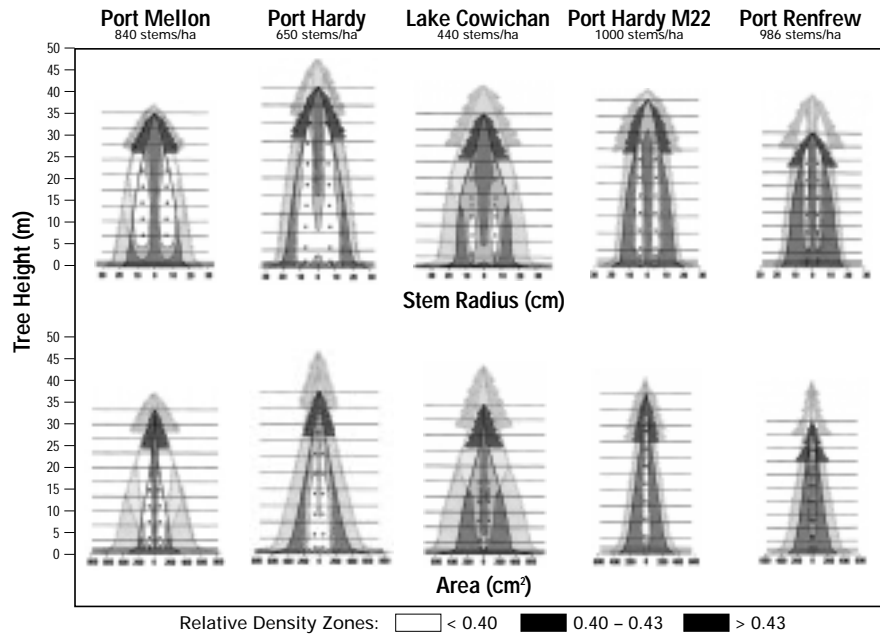
**Port Hardy M22**  
Summary of 13 trees (1000 stems/ha)



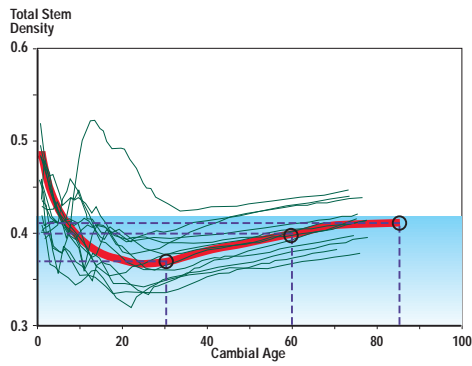
Wood Quality... Impact on Product Yields, Grades and Value... WESTERN HEMLOCK BASIC WOOD PROPERTIES 85.0

## Average Tree Stem Profiles and Density Distributions

(summary of 13 trees per site at age 60 superimposed onto 90 year old trees)

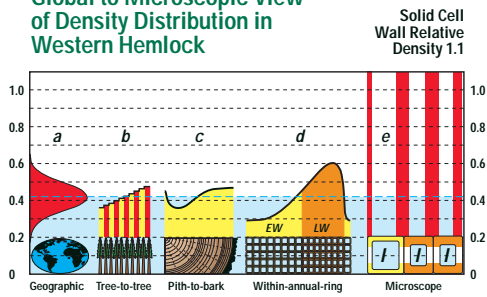


### Western Hemlock Port Hardy



Wood Quality... Impact on Product Yields, Grades and Value. WESTERN HEMLOCK BASIC WOOD PROPERTIES 870

Global to Microscopic View of Density Distribution in Western Hemlock



Wood Quality... Impact on Product Yields, Grades and Value. WESTERN HEMLOCK BASIC WOOD PROPERTIES 88-9

Western Hemlock

Log Grade	Old-growth	Second-growth
small Ø D log length	\$ 10,000	\$ 4,000
12 – 36 in. H 16 – 24'	12,000	8,000
15 – 36 in. I 12 – 14'	12,000	15,000
4 – 11 in. J 16 – 24'	5,000	20,000
4 – 14 in. X 8 – 14'	6,000	4,000
15 – 36 in. X 8 – 10'	6,000	4,000
4 – 36 in. Y < 8'	5,000	4,000
<b>Total</b>	<b>\$ 50,000</b>	<b>\$ 55,000</b>

- Stand volume in second-growth 150 – 200m<sup>3</sup> higher than in old-growth

WFPL – North Vancouver Island





### Global to Microscopic View of Density Distribution in BC Tree Species

