Wood Quality… Impact on Product Yields, Grades and Values

Forest Practices Branch
Ministry of Forests

Canada

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

BC

Forintek
Canada
Corp.

Big or Small Trees, Fast or Slow Growing Trees?

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Introduction and Historical Trends

The official title of this workshop is **WOOD QUALITY...IMPACT ON PRODUCT YIELDS, GRADES AND VALUE.** If we were forced to condense the theme of this workshop into a brief "grandmother's-executive- summary", the following would be good one: what would you rather grow, **BIG OR SMALL TREES?...FAST OR SLOW GROWING TREES?**

Funding for developing this workshop was provided by the Canada-British Columbia Partnership Agreement on Forest Resource Development: FRDA II – a five-year (1991–96) $2000 million program, cost-shared equally by the federal and provincial governments.

I would like to thank my friends and colleagues not only for the financial support, but also for their help and suggestions in putting together this workshop: Mr. Dean Mills, Canadian Forest Service, Victoria, BC, Messrs. Frank Barber and Ralph Winter, Forest Practices Branch, BC Ministry of Forests, Victoria, BC.

We are grateful to Ms. April Anderson, BC Forestry Continuing Studies Network, for the logistics of arranging four sessions.

The presentation material consists of **Instructor's Notes** and a **Student's Workbook**. This text is part of the Instructor's Notes; accompanying each overhead, these are the key points to be made in a verbal presentation. The Student's Workbook contains reduced black-and-white reproductions of each overhead (two to a page) for note taking, and a selection of technical reports and publications.

This one-day workshop grew out of Forintek's resource evaluation research, showing that wood quality attributes important to primary and secondary manufacturers are determined to a large extent by the circumstances in which trees grow. This means there is an important role for foresters in linking stand management practices to end-product requirements.

Although the course was designed for personnel involved in planning, prescribing or implementing silvicultural activities in the field, others would benefit as well (foresters, forest educators, mill managers, marketing experts, etc.). The course is structured around the following headings:

- Introduction and historical trends
- Global wood supply and wood demand trends
- Brazil and New Zealand
- Tree growth and tree physiology
- Wood structure and fibre morphology
- Relative density of wood
- Juvenile wood, crown-formed wood
- Compression wood
- Shrinkage of wood
- The concept of “free” and “bound” water
- Douglas-fir Task Force
- Lodgepole Pine Task Force
- Machine Stress Rated (MSR) lumber
- Lodgepole pine confirmation study
- Western hemlock basic wood properties
- Composite products, summary and conclusions

Then & Now

Overhead 2

Historical Perspective – Then & Now

Some things change, some things don't...

Large old-growth logs are no longer the staple for British Columbia's forest products industry. Instead, the industry had to learn to adapt to the processing of smaller stems, and increasingly to the processing of young and small second-growth logs.

For example, 40 years ago, coastal utilization standards were shocking; logs smaller than 40 cm (16 in.) small-end diameter could be left behind in the woods (in other words wasted) without penalty. This went on to the late 1960s when close utilization standards were introduced with the stroke of a pen; the small-end diameter was reduced to 10 cm (4in.).

This was the advent of the Interior sawmilling industry, and more importantly the "rehabilitation" of lodgepole pine. With the "fall-down effect" and fibre shortages, industry had no choice but adopt a broad range of new technologies. This included computerized controllers, electronic and optical scanning devices, thin-kerfed saws, lumber drying, finger jointing, edge-gluing, composite products, etc.

(Before one gets into a self-righteous frame of mind, one must remember that if one were in the logging/sawmilling business of that time, one would have had to do exactly the same to stay in business.). On the other hand, reliance on the internal combustion engine, as the primary means of log transport, has changed very little (except for safety and efficiency).

Overhead 3

This overhead illustrates "then & now" as well, with one major wood quality attribute often overlooked; this Douglas-fir tree was 2.5 m diameter at breast height, it was about 850 years old, and it was sound to the pith. The lower 30 m portion of the stem was free of branches. The tree was so well balanced that the loggers had to use a hydraulic jack to push it over at the time of felling. Bark was up to 25 cm thick, which the loggers stripped from the bottom log for firewood (outer dead bark of Douglas-fir burns with a glowing intensity for a long time, sometimes melting the iron grill that is used in fireplaces).

They could not make lumber from these logs, they could not peel them for veneer........they were chipped for pulp because of excessive **spiral grain.** Why is spiral grain so bad? From the solid wood products perspective, excessive spiral grain in logs results in excessive slope of grain in lumber, hence weak lumber. In panel products, raised grain is impossible to finish through planing or sanding.

Each overhead shown has a main message to deliver (as stated above). In addition, there must be a number of qualifications the instructor should be prepared to make, as follows in this example:

A common spiral-grain pattern in our conifers is one in which grain in the first annual ring is parallel to the pith, but in immediately following rings a left-hand spiral (S) develops. This increases to a maximum, then diminishes to zero, and finally becomes increasingly right-handed (Z) with great age, as shown in this illustration.

What causes spiral grain? According to a morphogenetic explanation "the arrangement and orientation of cambial cells very largely predetermines the relative position and arrangement of the various xylem derivatives, and hence the grain angles in wood". Environmental and silvicultural conditions are not well studied and documented, however, the author has observed extensive spiral grain in very old trees (>500 years), and in upper-elevation timberline environments while hiking in the mountains.

Some facts:

- Northern trees do not reverse their spirals when grown in the southern hemisphere. Note left- hand spiral in the young radiata pine on the RH side of this overhead (this tree is about 10 years of age and the spiral grain is close to 30 degrees).
- Spiral grain in lodgepole pine utility poles contributes to sapwood rot because water gets trapped from rain more readily than in straight (vertical) grained poles.
- Twisting of utility poles in service is definitely correlated with spiral grain. Because of internal grain structure, poles with RH spiral were more stable than straight-grained poles.
- In a study of western larch, researchers found a correlation between the ratio of live-crown length and spiral grain; trees in open stands had LH spirals (with long crowns), while trees from dense stands (with short crowns) had RH spirals. These observations were made on stem surface only (difficult to do).

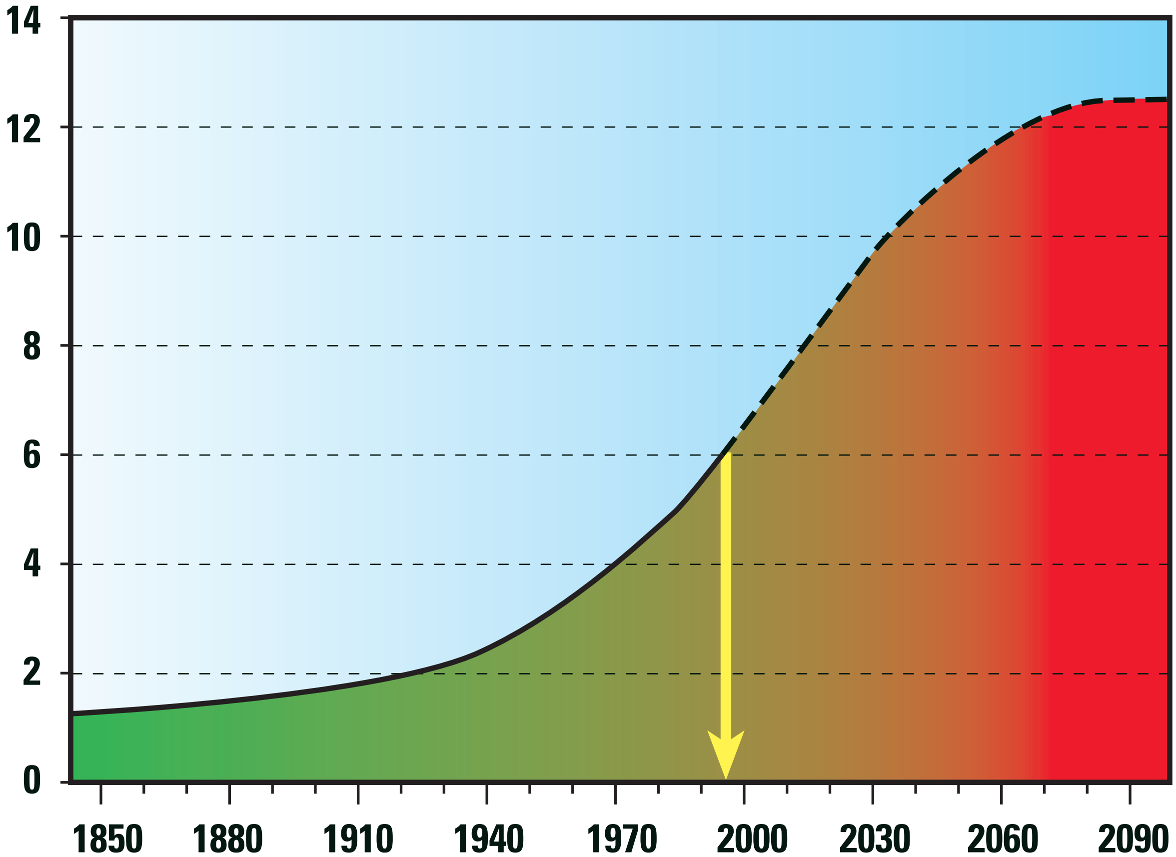
Where will they come from

Wood and other raw materials for the 21st Century

GLOBAL TRENDS

World Population 1850 to 2100

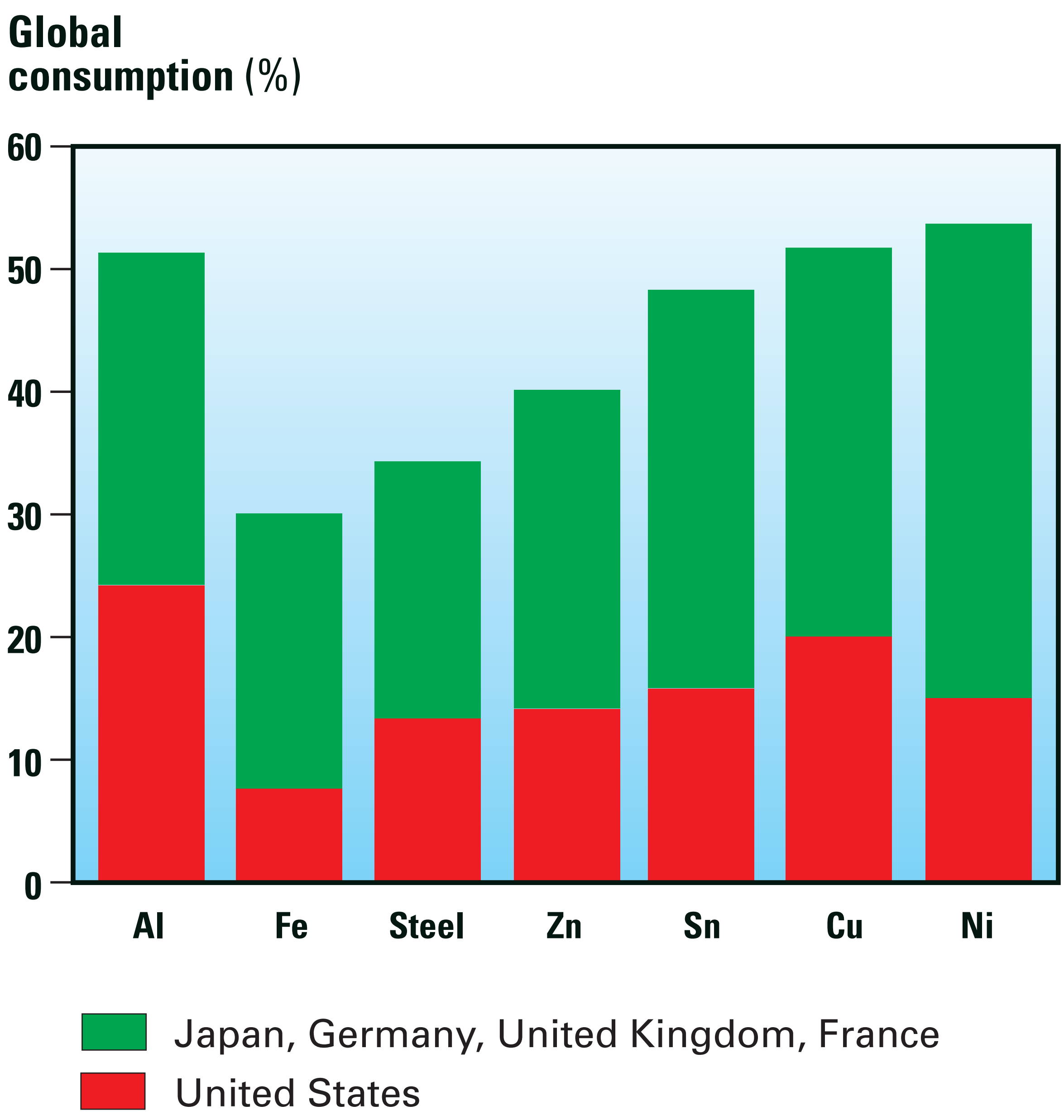
Population (Billions)



Overhead 5

The greatest threat to global well-being is the unprecedented population explosion. Currently, the net population gain is 3 people per second. This means that in one minute from now there will be 180 more people on Earth. By the time we take a coffee-break, in one hour, there will be 10 800 more people... in 24 hours 259 200...by the end of the month 7 776 000...and by the end of the year 93 600 000!!!!!!!!!!!!!!!!.....They will need food, clean water, clothing, and shelter.

Global Consumption of Raw Materials by 10.3% of Global Population



Overhead 6

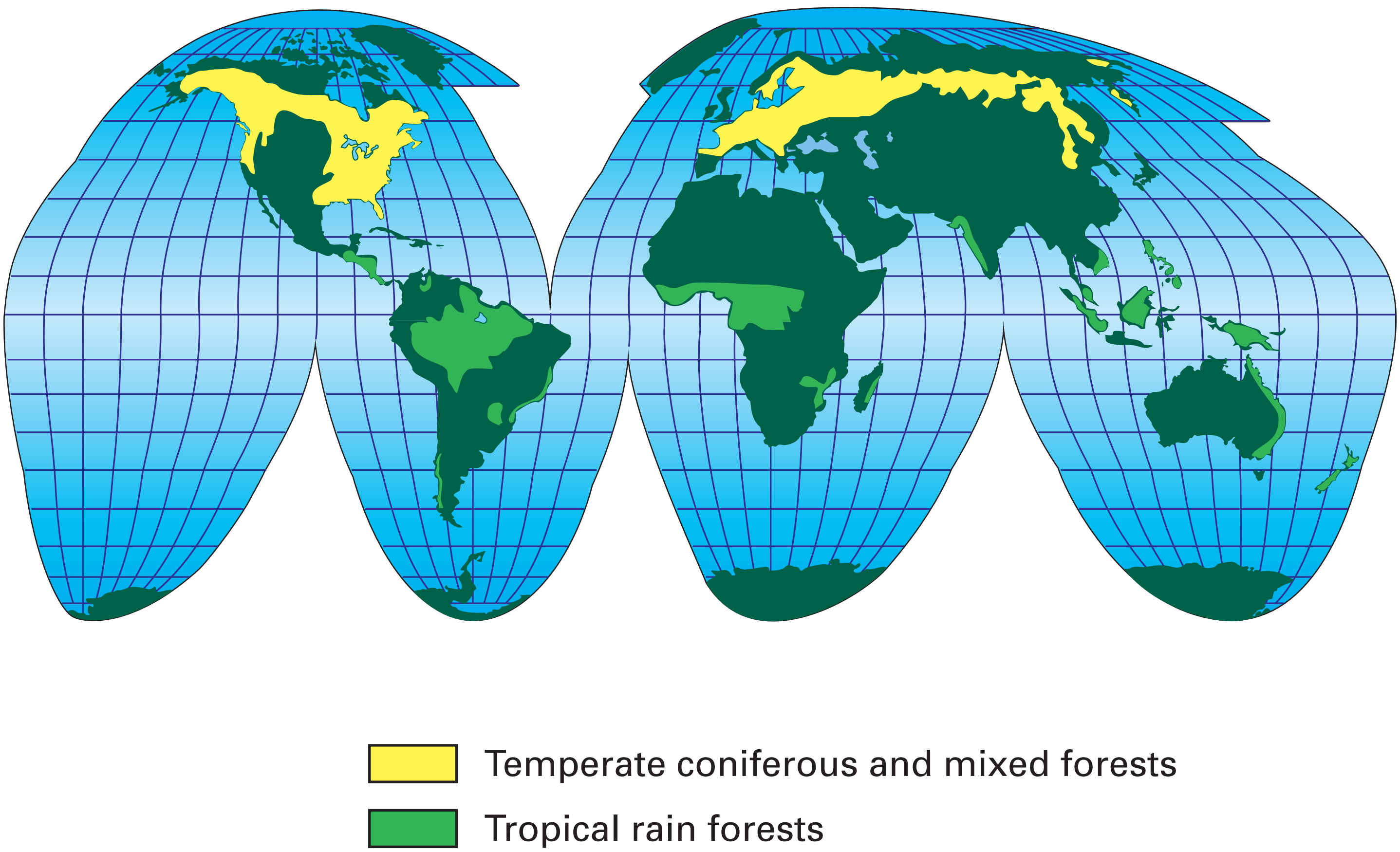
Twenty-two percent of the world's population lives in the **developed nations,** who use more than half of all global resources and energy. If all the inhabitants of planet earth enjoyed our high standard of living, we would need another 4 planet earths to sustain us!

Just consider the global consumption of **aluminum, iron, steel, zinc, tin, copper,** and **nickel**;.......about 50% is being consumed by only 10.3% of globe's population (please note the USA share of the pie!).

It is noteworthy that we will never exactly run out of our **limited global resources**, instead, we will have to go farther, deeper, and higher to get our raw materials. For example, if we look at the average global copper ore today, we have to mine 8 times more ore than we did in the late 1800s, to get the same amount of copper. Of course this adds to air pollution (not only in mining and transport, but also in smelting) and to the greenhouse gases.

In the future we definitely have to do more with less!!!!!!!!!!!

Our Forests



Temperate coniferous and mixed forests
Tropical rain forests

Overhead 7

When we look at the global forest cover map, a number of shocking realities emerge:

First, there is a lot of land area that is not forested.

Second, there is about a 50–50 split between the northern (Boreal) forest and the equatorial rain forest.

Third, all of the Boreal Forest cover is north of the 49th parallel, the USA–Canada border.

Fourth, there is no Boreal Forest equivalent in the southern hemisphere. In fact, arable land mass, south of the 49th parallel in the southern hemisphere, is less than the size of BC.

Not so obvious is that only one half of the very dominant green forest cover in Canada is capable of sustaining commercial forestry.

If we look in our own backyard, there is very little commercial forestry north of the BC–Yukon border (the 60th parallel). This dividing line dips even further south in the vicinity of Hudson Bay and James Bay.

Anticipated changes in the global fibre supply in the next 10–20 years:

Increases— USA NE (abandoned farmlands have some poor quality oaks), Chile, Europe, Scandinavia, and New Zealand.

Decreases—Pacific NW, USA SE (hottest housing starts), all of the equatorial rain forests (because of environmental pressures), Baltic states (overharvested in the recent past because of the hunger for currency).

Wildcards—Siberia and Japan. Siberia is large and has very harsh climate and very poor infrastructure. Japan has a lot of forests, but it is cheaper for them to buy our wood. In addition to their very high wages, logging and sawmilling is seen by their young as the "four-D job": Dark, Dirty, Dangerous, and probably Demeaning.

Unfortunately, there are no hidden forest treasures out there. We are it! The Pacific Northwest is the best timber growing environment on the planet, particularly when we consider both quantity and quality.

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: $\dfrac{\text{total wood harvested}}{\text{population of earth}}$)

Overhead 8

According to the Food Agriculture Organization (FAO), every person uses 1.8 litres of wood per day, as Dr. Wink Sutton reminded us so eloquently, not long ago. Of this daily allotment, 80% is used for cooking and heating in the underdeveloped nations (about 78% of the world's population). Only 20% is used industrially for building houses, making furniture, producing paper products, etc. In the developed nations, 75% of the wood is used industrially, and 25% is used for heating and cooking.

A number of factors must be considered to put these numbers in the proper perspective. Although in the developed nations the per capita wood use is about 3–5 times more than the global average, the **net population gain** is near zero in these countries. Poor nations don't have the ability to buy/pay for our wood.

There are two extreme views; "the Chicken Little, the sky is falling" and "the technology will solve any problem, there is plenty of fibre". Most likely the truth lies somewhere in the middle.

A Contrary View....

- Population growth is in developing countries
- Fuelwood needs will not increase
- Less developed countries do not favour wood construction
- Engineered wood, wood preservation treatments
- Technology is improving yield from raw material
- Substitution effect
- Plantation effect

Overhead 8A

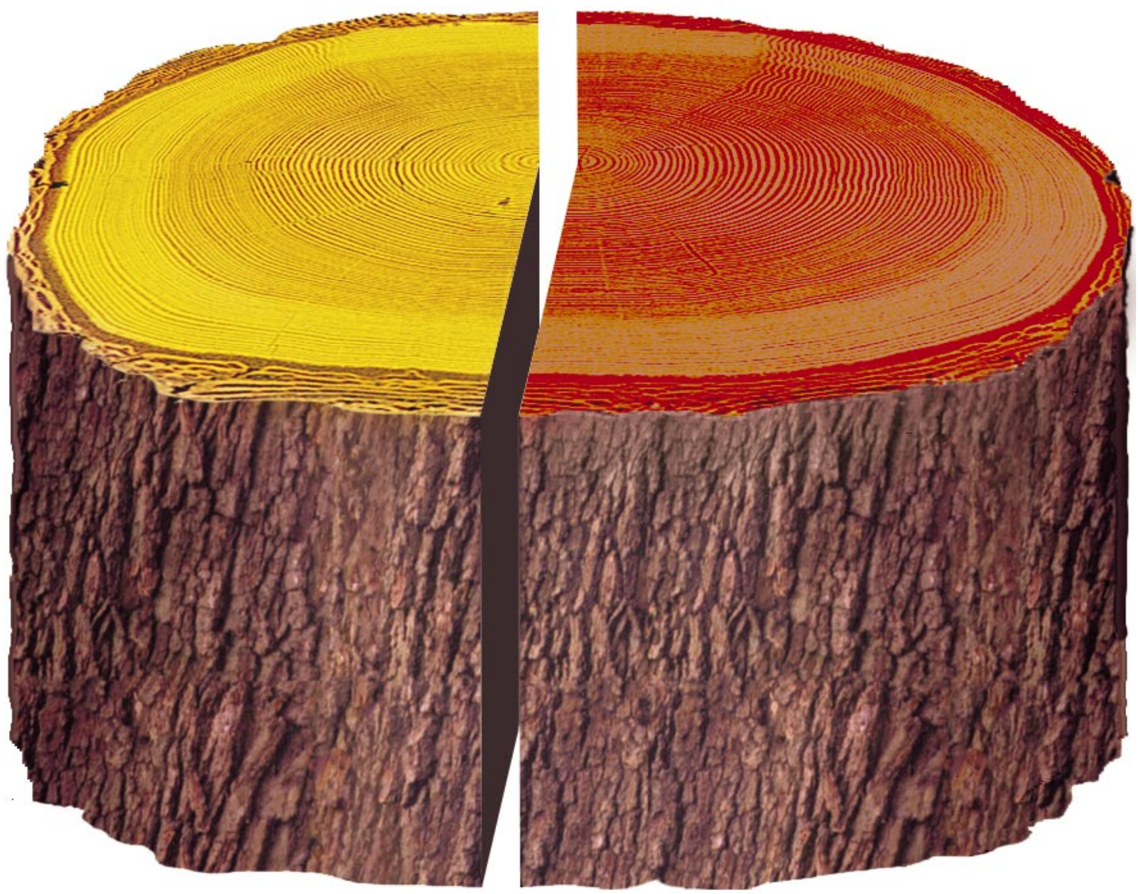
A Contrary View................

- Population growth is in the developing world, where per capita consumption is small.
- Fuelwood needs will not increase because fossil fuels are cheap and abundant.
- Less developed countries (LDC) do not favour wood construction (equated to peasant status). When incomes increase, brick and concrete is preferred (e.g., Koreans did historically live in wooden houses, war and the devastation of their own forests resulted in the conversion to concrete as the basic building material. Until not long ago, a Korean house had to double as a bomb shelter as well.
- Engineered wood, wood preservation treatments, etc. are reducing world demand for construction (by using less wood on one hand, and having a much longer service life on the other).
- Technology is improving yields from raw material
  - greater lumber recovery/log
  - residues are being used in boards and panel products
  - high-yield pulps (TMP, CTMP, etc.)
- Substitution effect
  - electronic for printed page
  - non-wood (kenaf, corn, straw, hemp, etc.) for fibre
  - non-wood (steel, vinyl, etc.) for house/industrial construction
- Plantation effect
  - industrial wood needs have increased by 100 million m^3/decade between 1960–1990
  - planting 250 000 ha. of new Eucalyptus each year would meet this demand (with 40 m^3/ha/year)

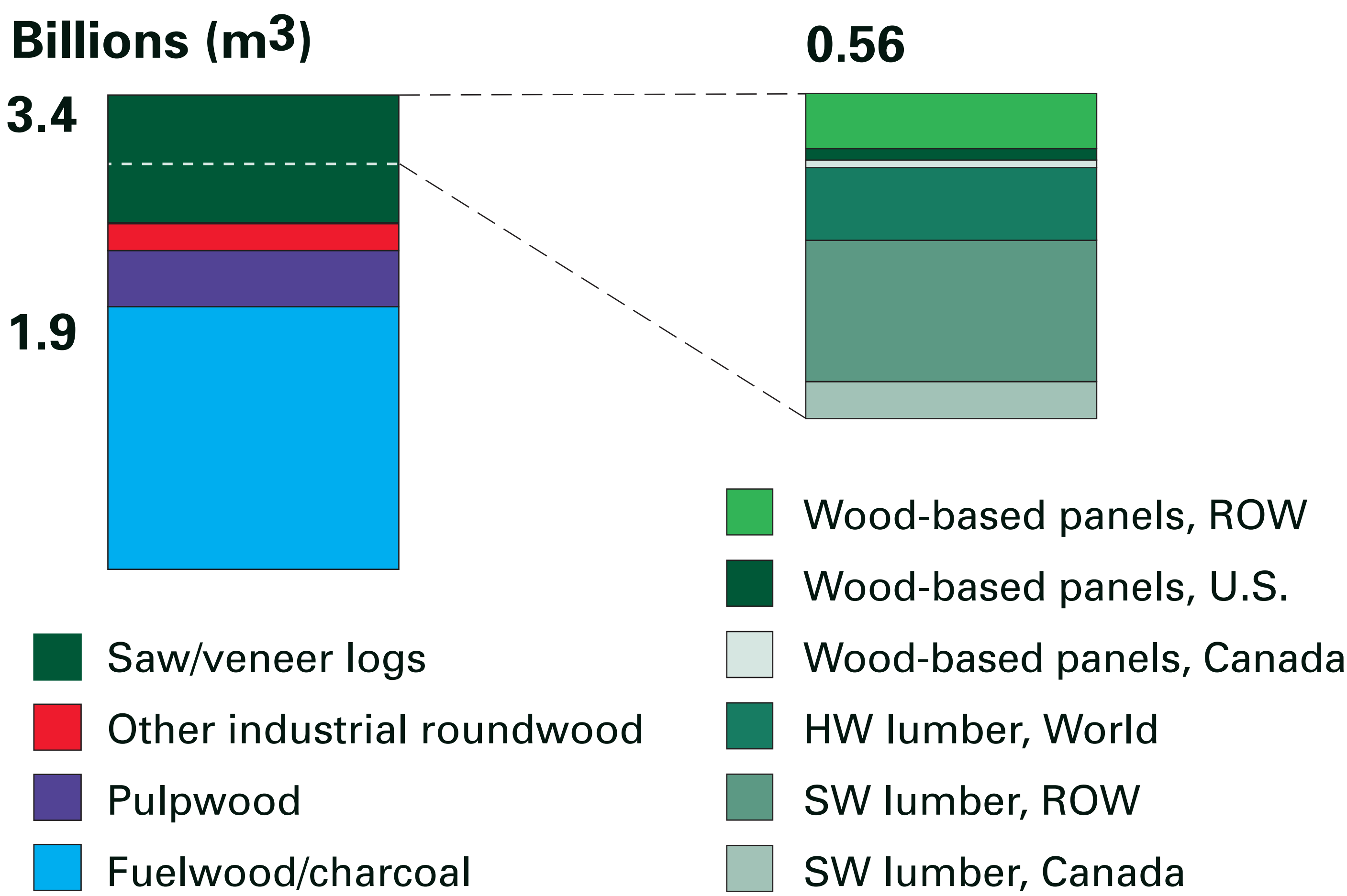
Annual World Consumption of Wood

Industrial Roundwood 1.7 billion m^3

Fuelwood 1.8 billion m^3

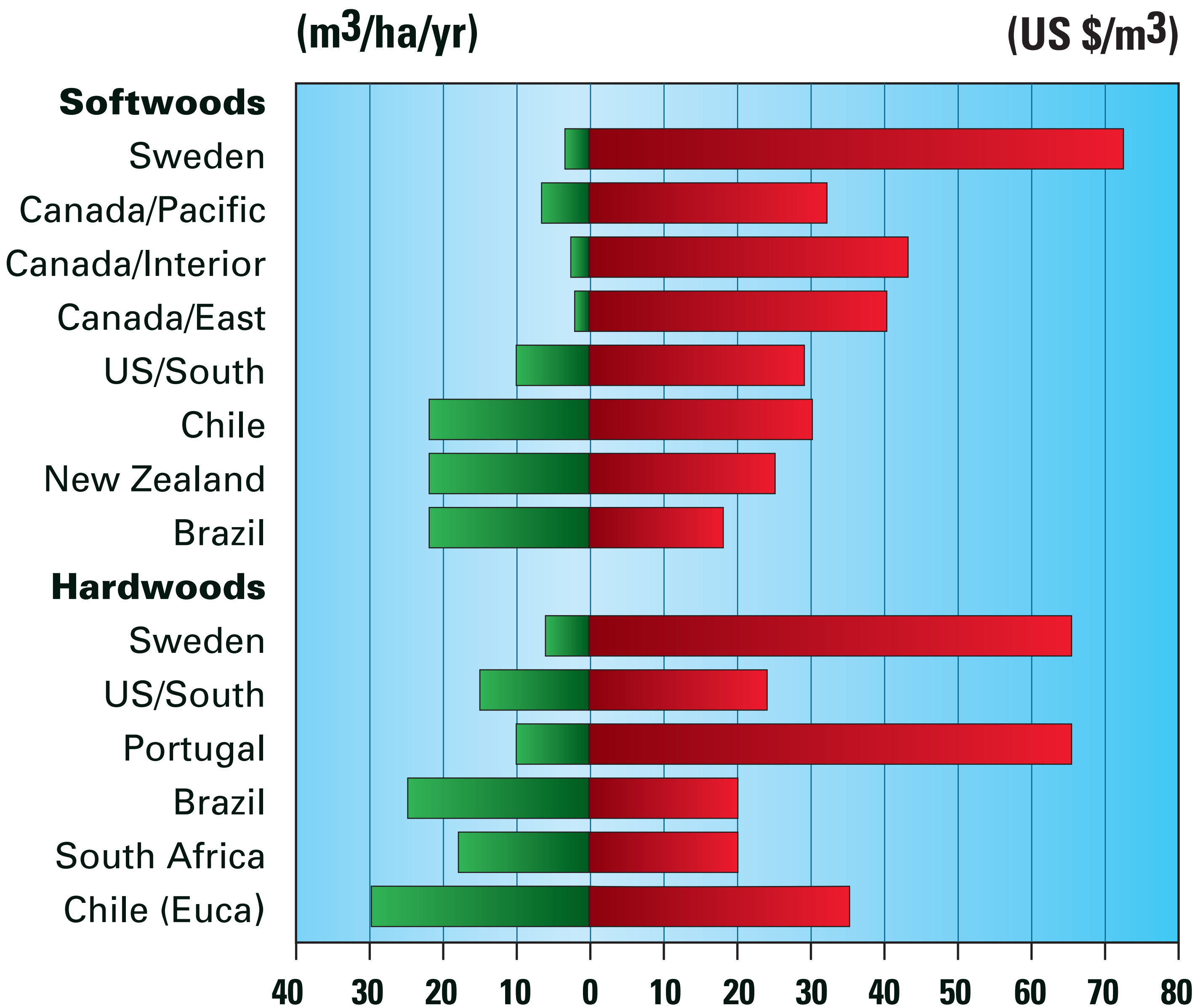


Global Production of Fibre



Source: FAO

Growth and Mill Delivered Cost of Pulpwood – 1/91



Overhead 11

When we look at productivity rates (m^3/ha/yr) and the cost of mill-delivered wood, it is hard to imagine that Sweden and Canada can compete with countries like Brazil, New Zealand, and Chile.

Global Competitiveness is possible through a fine balance of biology, technology, and political stability.

Biogeoclimatic reality is something we cannot escape, it is a bit like our genetic code. The genetic potential of our tree species, soil/site quality, and climate actually provides us with an excellent quality resource; what we lack in quantity we make up in quality.

Technology implies a trained work force, the ability to use the most current, efficient, and environmentally friendly processes, and lastly, an efficient infrastructure.

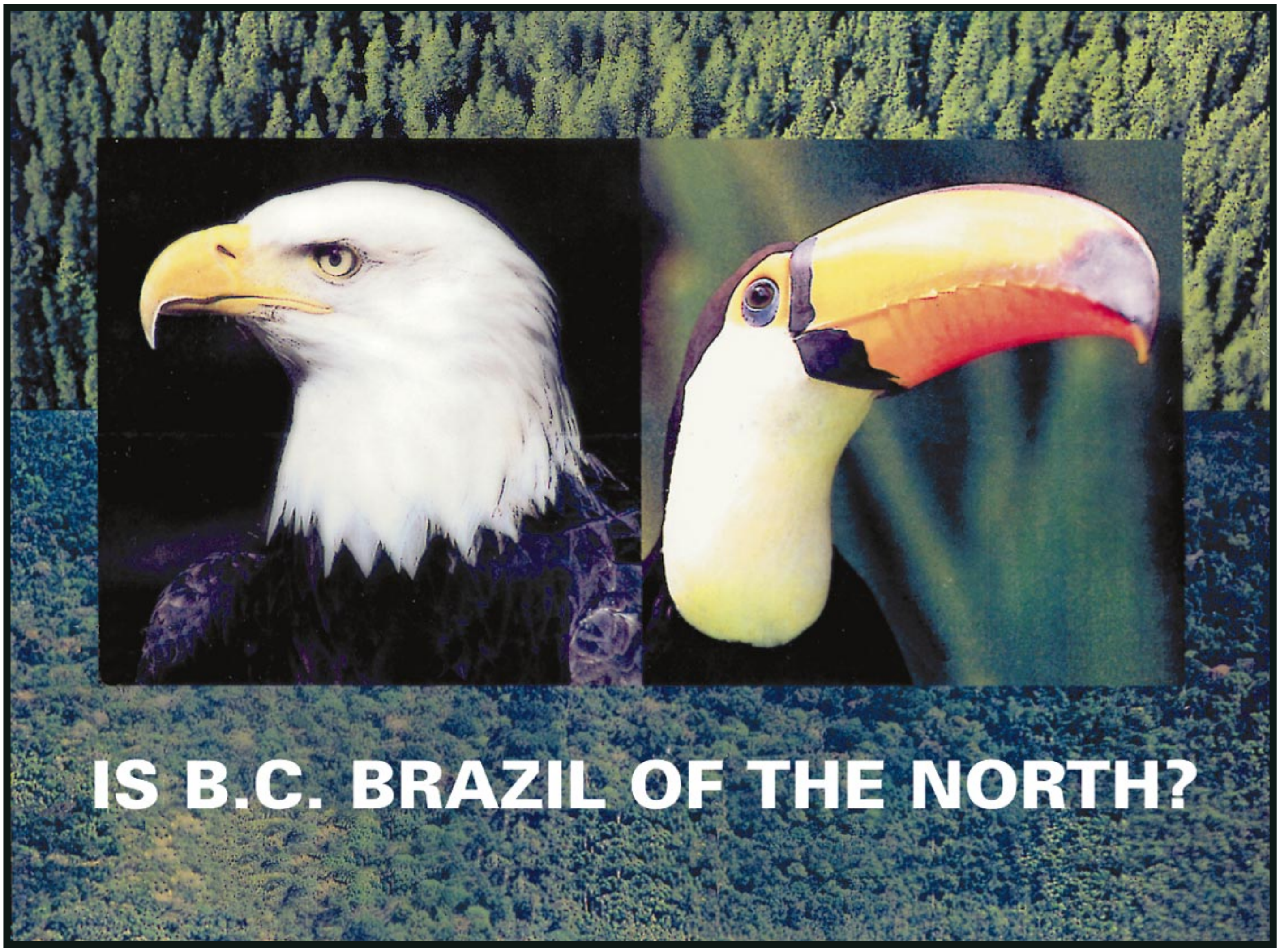
Political stability is self evident. Investors need confidence in recouping their capital investment over a long period of time.

No other nation, country, state, or province is as dependent on the forest products industry as British Columbia; out of every $1 revenue, 65% of our trade balance comes from forestry... in the next closest countries (like Sweden and New Zealand) this figure is at 35% or less.

For a leading economy to remain in the lead, it needs the following:

1. Avoid complacency
2. Innovate, Innovate, Innovate (hence the need for R&D).

The East Asian Miracle in the last 20 years was based on: **hard work, openness and competitiveness, a passion to learn, a willingness to change, and an optimistic attitude.**


IS B.C. BRAZIL OF THE NORTH?

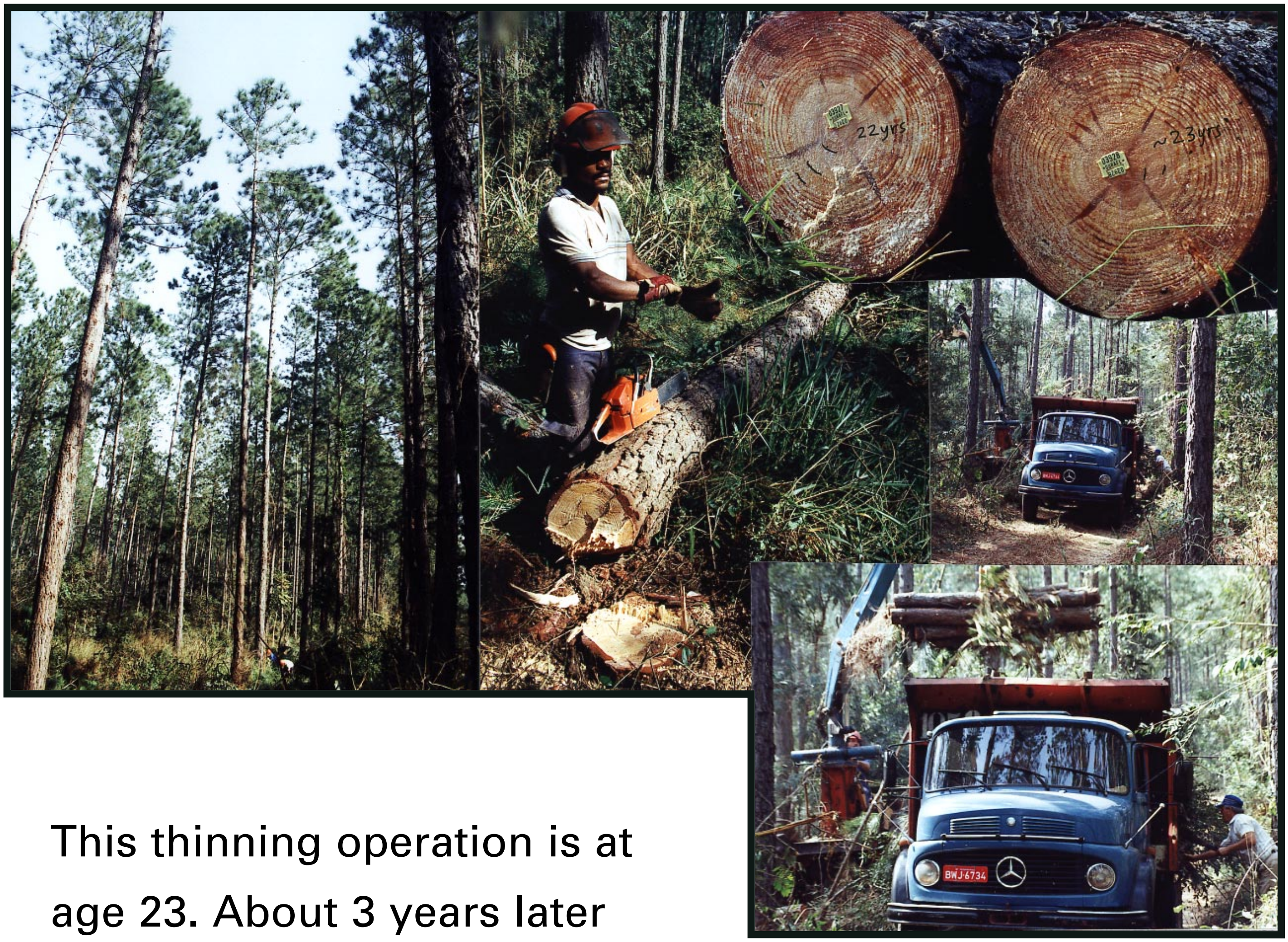
OVERHEAD 12

Are we Brazil of the North?... of course, we are not. The environmentalists coined this very catchy phrase, in criticizing BC logging practices of a decade or so ago.

If we looked at climate and natural riches alone, Brazil would be one of the richest countries in the world. As we know from the nightly news, it is not!

Brazil is only 15% smaller than Canada (8.5 compared to 10 million km^2), but it has at least six times the population (150 compared with 26.3 million), GDP/capita in USA $1 980 vs $21 813.

Brazil harvested 90 million m^3 of wood last year for industrial purposes, and harvested another 190 million m^3 of wood for heating, cooking and for making charcoal.



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

Overhead 13

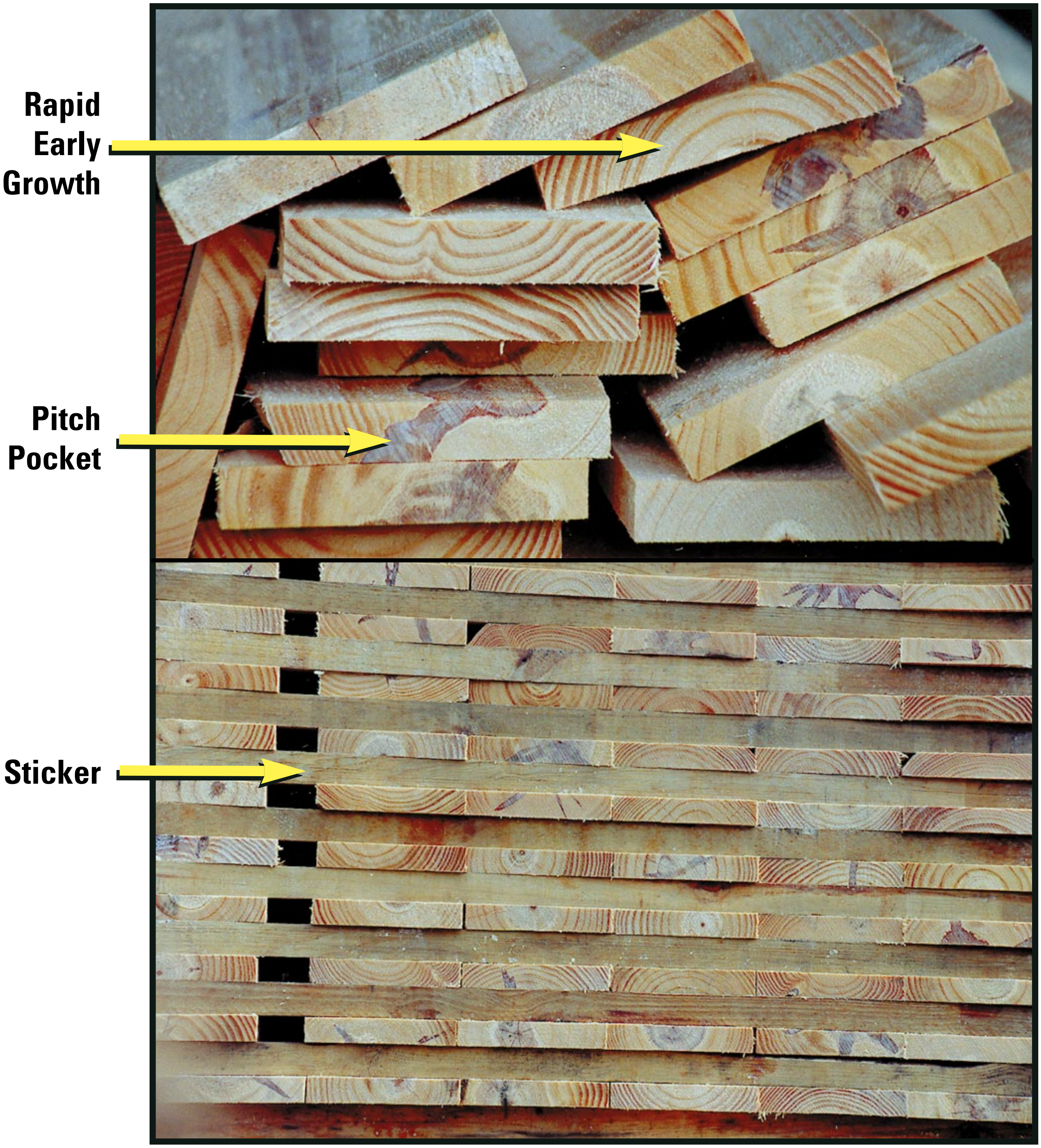
Hybrid Caribbean pines are grown south of 23 degree latitude. Any closer to the equator is too hot for pine. They plant 2500 stems per hectare, prune every tree at age four, and they return to thin every three years. By the time of harvest, at age 26, they end up with 500 stems/ha. In 26 years they will have entered the stand eight times. The pine plantation at Duratex was 40 000 ha (about 100 Stanley Parks). All forest roads were in place to the sawmill and hardboard plant; the longest hauling distance was 15 km.

Even a seemingly ideal "textbook" operation is not so. In case of both pine and eucalyptus plantations, other crops are more lucrative to grow (e.g., sugar cane, citrus fruits, coffee.

26-year-old Caribbean
pine hybrid.

Overhead 14

Caribbean pine logs, after debarking. Note heavy pitch oozing from the log ends. Butt logs are about 40 cm (16 in.) in diameter, and 26 years of age. These logs contain 100% sapwood, with >200% moisture content (this means that for every unit weight of bone-dry wood there are two unit weights of water.


Rapid Early Growth
Pitch Pocket
Sticker

Overhead 15

1.5 inch thick boards of Caribbean pine, after kiln drying.

Please note:

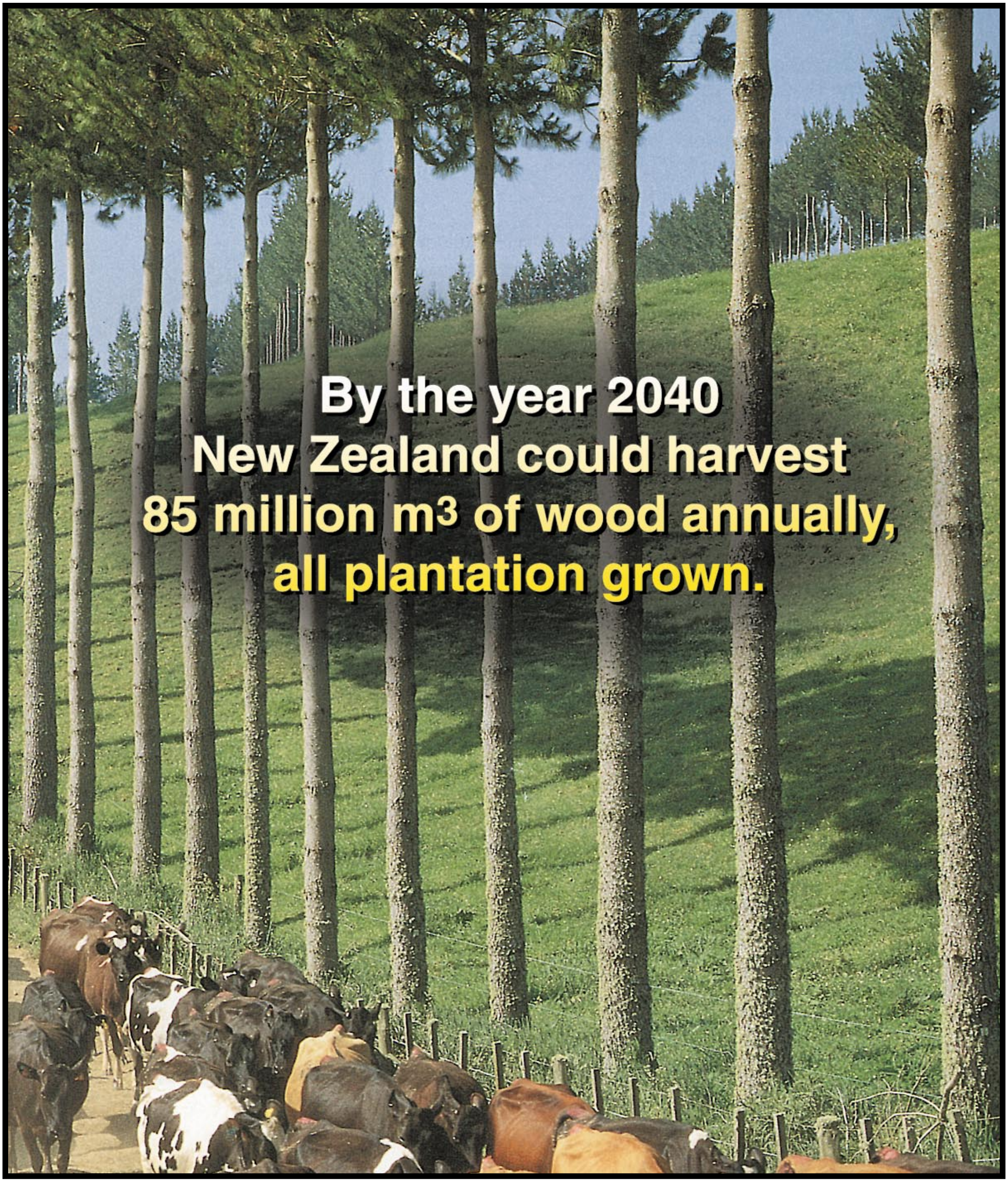
- about 35% of the boards have pitch-soaked wood
- extremely rapid growth rate next to pith, first 3–4 years
- varying amounts of dark latewood
- distinct annual rings
- 1.5 in. thick stickers to facilitate efficient airflow during lumber drying.

Overhead 16

Eucalyptus grandis hybrid clonal plantation, where different clones are being evaluated under identical site conditions.

Please note: excellent self-pruning, small crowns (a lot of sky is evident in the overhead shot), at age six these trees were the same size as the average lodgepole pine tree harvested in BC in 1994........

19 cm DBH and 26 m tall, but 125 years of age.

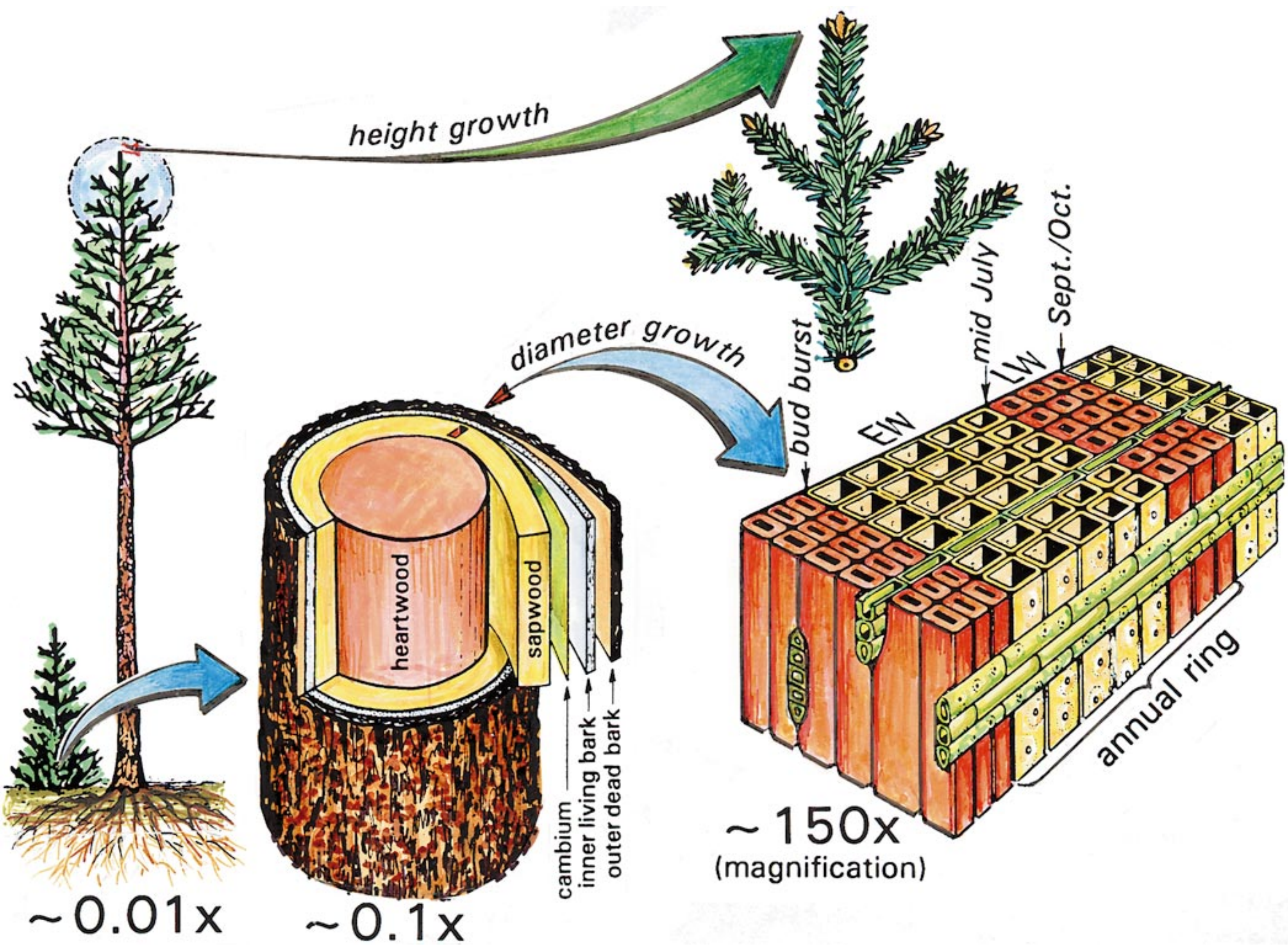

By the year 2040
New Zealand could harvest
85 million m3 of wood annually,
all plantation grown.

Overhead 17

We can take a lead from the New Zealanders in terms of promoting our commercial tree species. They have published a number of books that describe the properties and uses of NZ radiata pine, covering the whole spectrum from seedling to the machining properties of the wood. They have already introduced clear radiata pine wood into the USA Pacific Northwest for window manufacturing.

Most serious problems with radiata pine wood include coarse grain (wide rings), prominent resin canals, and **excessive spiral grain** in the first 10 years of growth.

Advantages include good workability, and excellent permeability (in pressure treating with preservatives, the wood gets treated throughout the piece in minutes, even with thick pieces.


height growth
diameter growth
bud burst
mid July
Sept./Oct.
EW
LW
heartwood
sapwood
cambium
inner living bark
outer dead bark
annual ring
~0.01x
~0.1x
~150x
(magnification)

Overhead 19

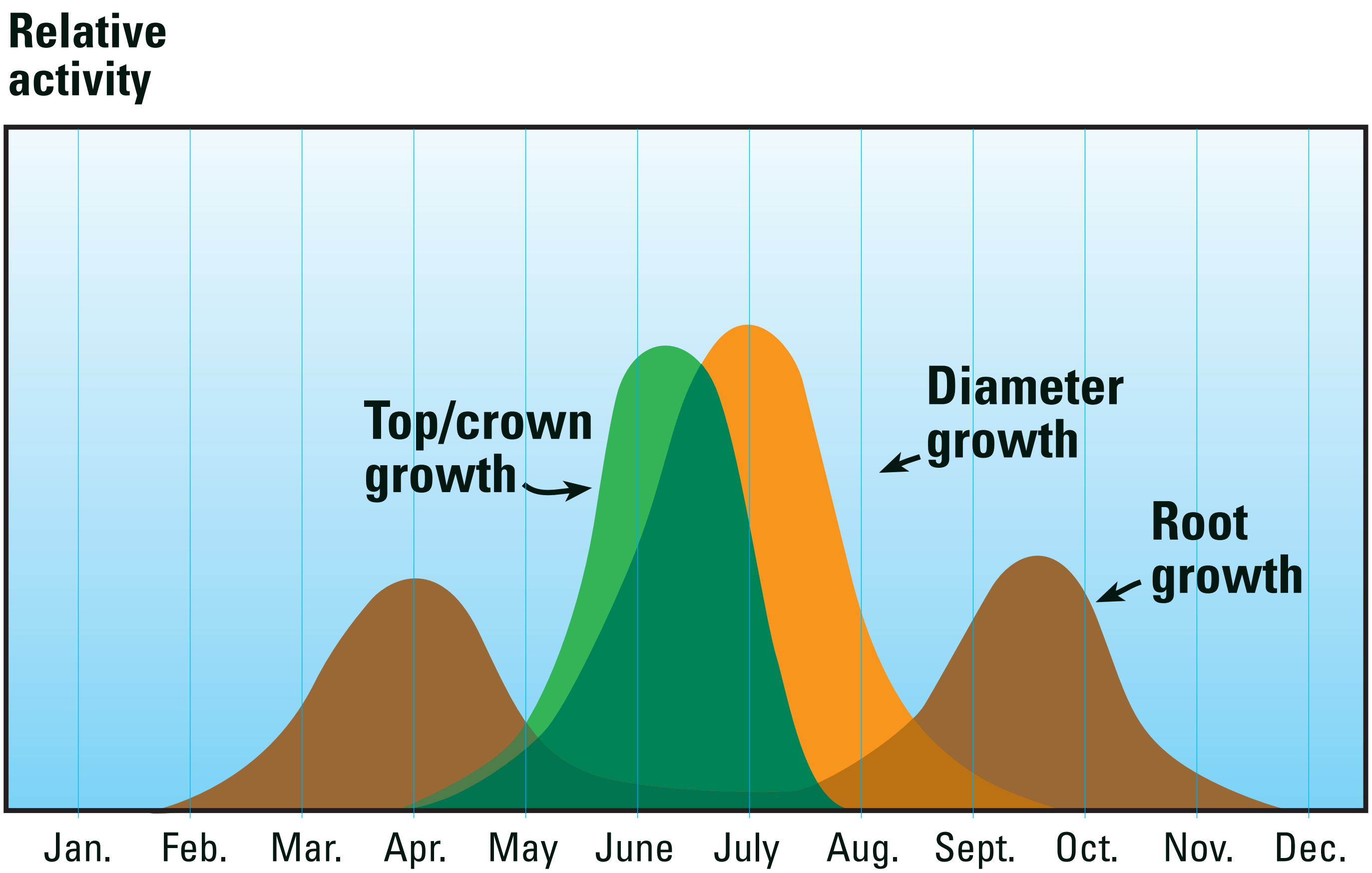
Describe different tissue types and their respective roles in a living tree. Spend some time on the important transport corridors in the living bark and sapwood. Arrive at the important sapwood/heartwood differences in terms of permeability, moisture content, extractives content, and natural durability of some of our woods.

Question and "tease" about that invisible barrier that separates the dry heartwood (50% M.C.) from the wet sapwood (150% M.C.). This wood quality attribute is extremely important in pressure treating telephone poles (western redcedar poles must have at least 1.5 in. sapwood on the outside), in lumber drying (sapwood dries faster and easier), in chemical pulping (in terms of liquor penetration).

In terms of silviculture, explain how ringing the tree (cutting off the inner bark) interferes with photosynthate translocation, and fine root-hairs can not grow (for lack of food) and the "tree starves to death". This knowledge is being utilized to control unwanted vegetation in newly established stands where herbicides can not be used.

For example, what is one to do if red alder becomes an aggressive colonizer in a newly established Douglas-fir plantation? Cutting the alder trees simply does not work because 20–25 new suckers shoot up from the stump, making a bad situation worse. Ringing the trees does work, provided there is no inner bark tissue left behind in the ringed portion (the author has observed that trees have a tremendous capacity to repair themselves).

Phenology of Tree Growth



Overhead 20

Describe the phenology of root, crown and stem growth. Contrast determinate and indeterminate tree species in terms of height growth, earlywood/latewood formation.

This discussion is extremely important in the context of the window of opportunity for latewood formation (on average, from mid-July to the end of September) and the lack of moisture in some parts of the province. Refer to the low-density Douglas-fir in the Rocky Mountain Trench and the high-density lodgepole pine in the ICH (more research is needed to prove the hypothesis).

Corollary discussion should include the amount of energy that goes into producing fine root-hairs, and the preferred times of transplanting trees with high success ratio. High rate of physiological activity in June and July makes trees vulnerable and doing pruning at this time could result in excessive mechanical injury.