DOUGLAS FIR

Pseudotsuga menziesii (Mirb.) Franco

Characteristics and potential

Dr. Udo Hans Sauter

TABLE OF CONTENT

Photo on page 1.: M. Mößnang, www.waldwissen.net

INTRODUCTION

- Pseudotsuga menziesii originating from the west coast of North America has extended geographically in many temperate regions and is expected to continue its spreading in the next decades due to the climate change

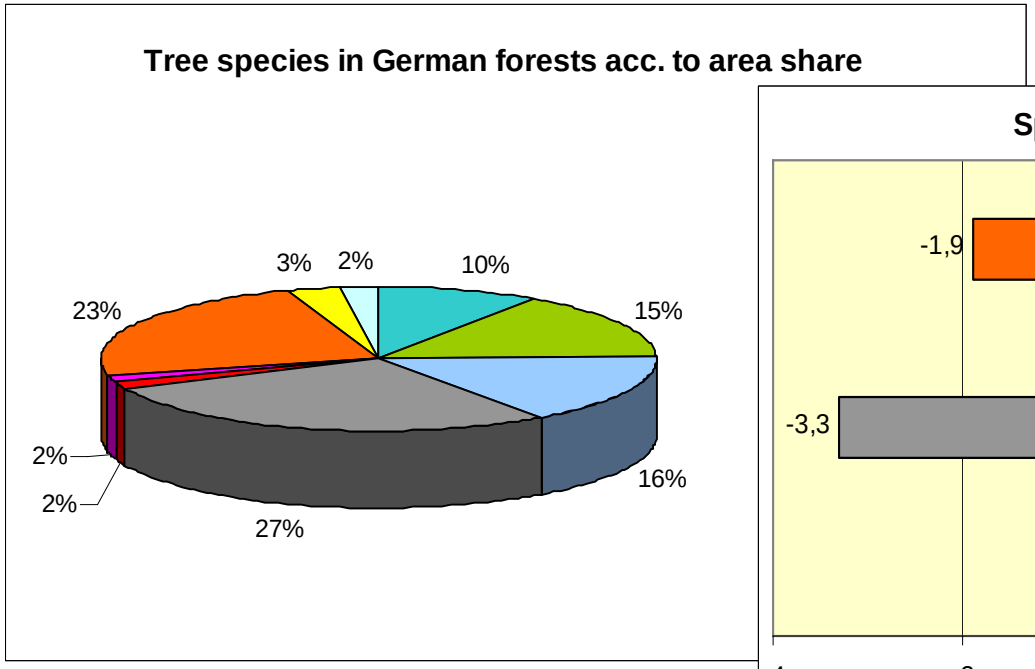
- 1880, the species was introduced in the north of Germany to enrich the tree composition of German forests with foreign species

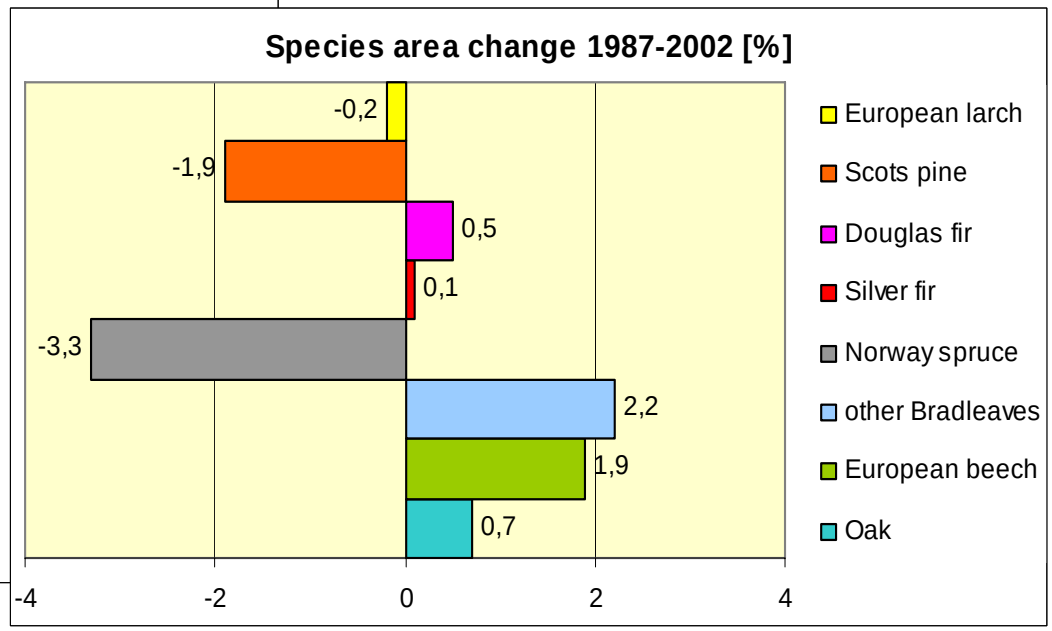
- In Baden-Württemberg the provenience “viridis” imported from the Pacific NW coast has been very successful and was recommended for local breeding already in 1922

DOUGLAS FIR IN GERMANY

FOREST AREA

- Current state: 179 607 ha = 2 % of the forest area
  - 73 % in only 4 western German Federal States (Baden-Württemberg, Rheinland-Pfalz, Hessen und Niedersachsen)
- Area change (1987-2002): + 0,5 %



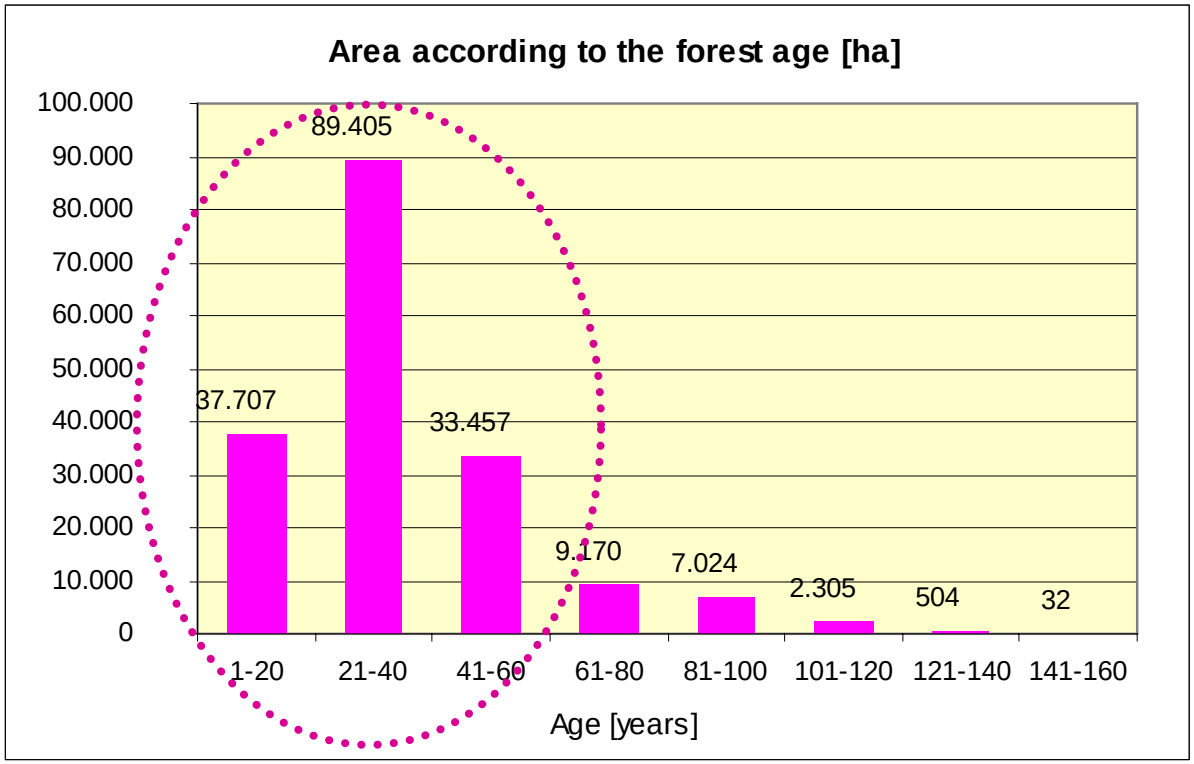


Source: German National Forest Inventory 2001-2002 (BWI ²)

DOUGLAS FIR IN GERMANY

FOREST AGE

- Average of 29 a/tree and 39 a/ha
- Big production potential



Source: BWI ²

DOUGLAS FIR IN GERMANY

GENERAL CHARACTERISTICS

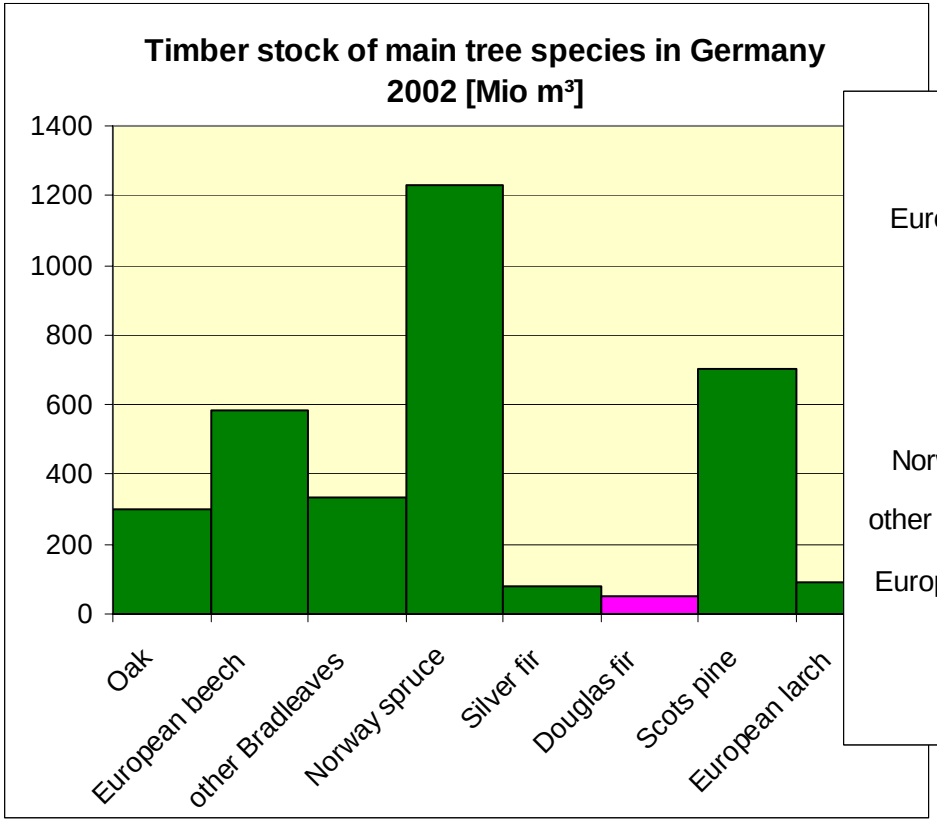
- Typical species of mountainous temperate oceanic climate
- Performs better than other softwoods on a wide range of sites, and **outperforms** them in the advantageous conditions

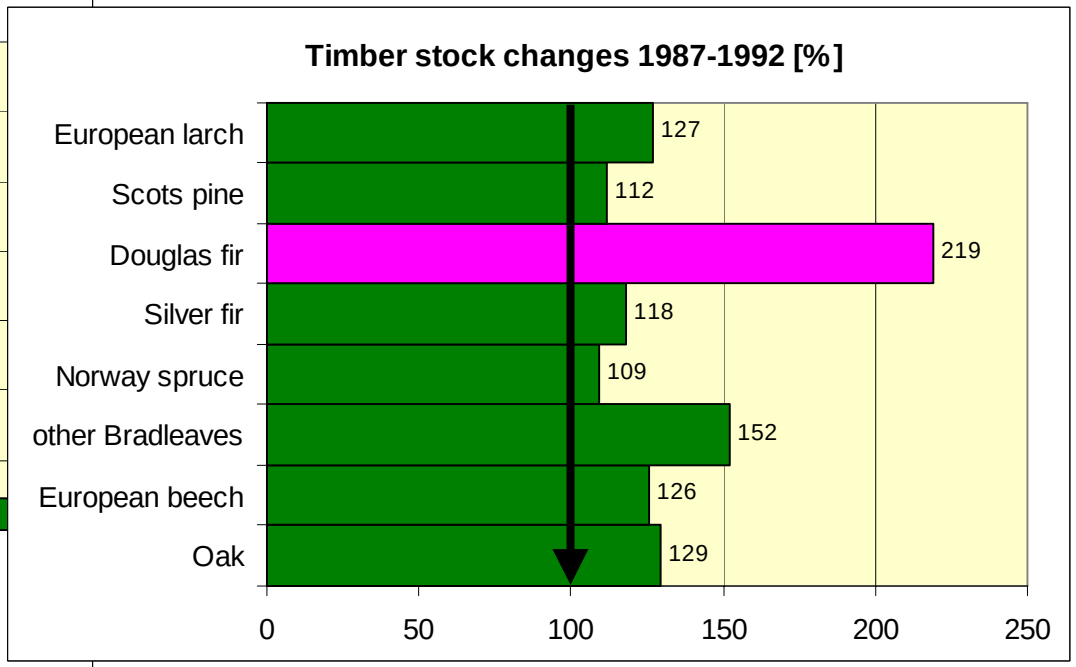
Main characteristics	All softwoods all DBH classes (BWI²)	Douglas fir all DBH classes (BWI²)	Douglas fir (N=47) (Sauter 1997)
Tree age [a]	47	29	92 (80 - 106)
Tree height [m]	17	16	44 (35 - 55)
DBH [cm]	20	20	64 (43 – 81)
Tree volume [m³]	0,42	0,37	-
Total volume production [m³/ha]	348	274	-
Volume increment [m³/ha/a]	14,24	19,41	-

DOUGLAS FIR IN GERMANY

TIMBER STOCK

- Current timber stock: 49 863 877 m^3 (BWI^2)
- Stock changes (1987-2002): 219 %

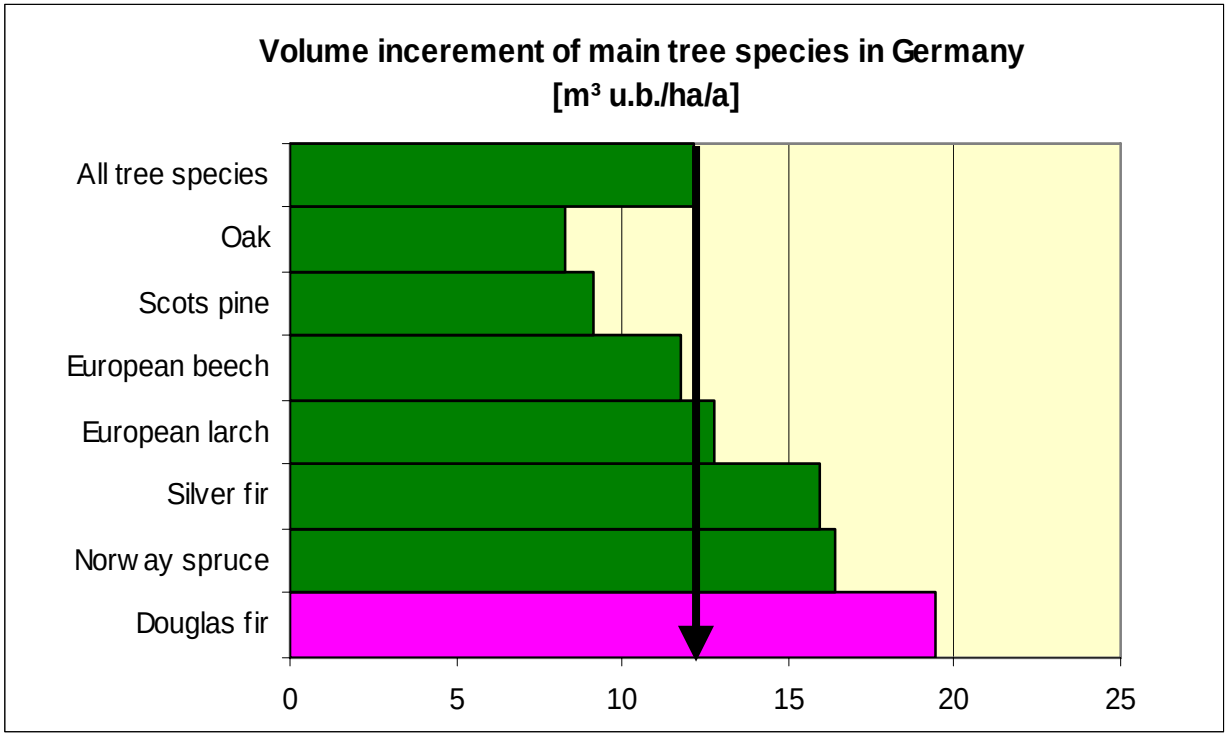




Source: BWI ²

DOUGLAS FIR IN GERMANY

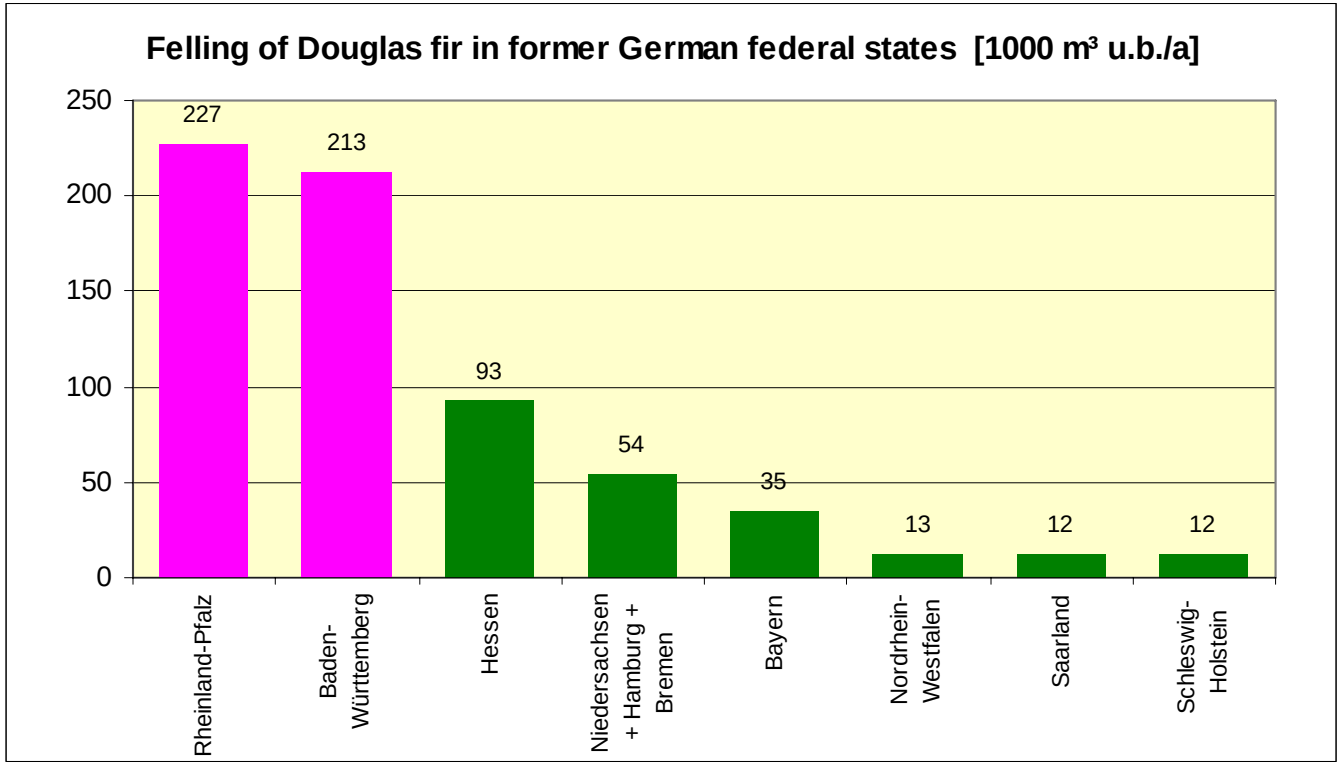
- Volume increment
  - Mean of 19,4 m^3/ha/a
  - Volume increment of Douglas fir significantly higher than by other main German tree species



DOUGLAS FIR IN GERMANY

PRODUCTION

- Significant dominance of SW Germany ~ average 220 000 m^3 u.b./a

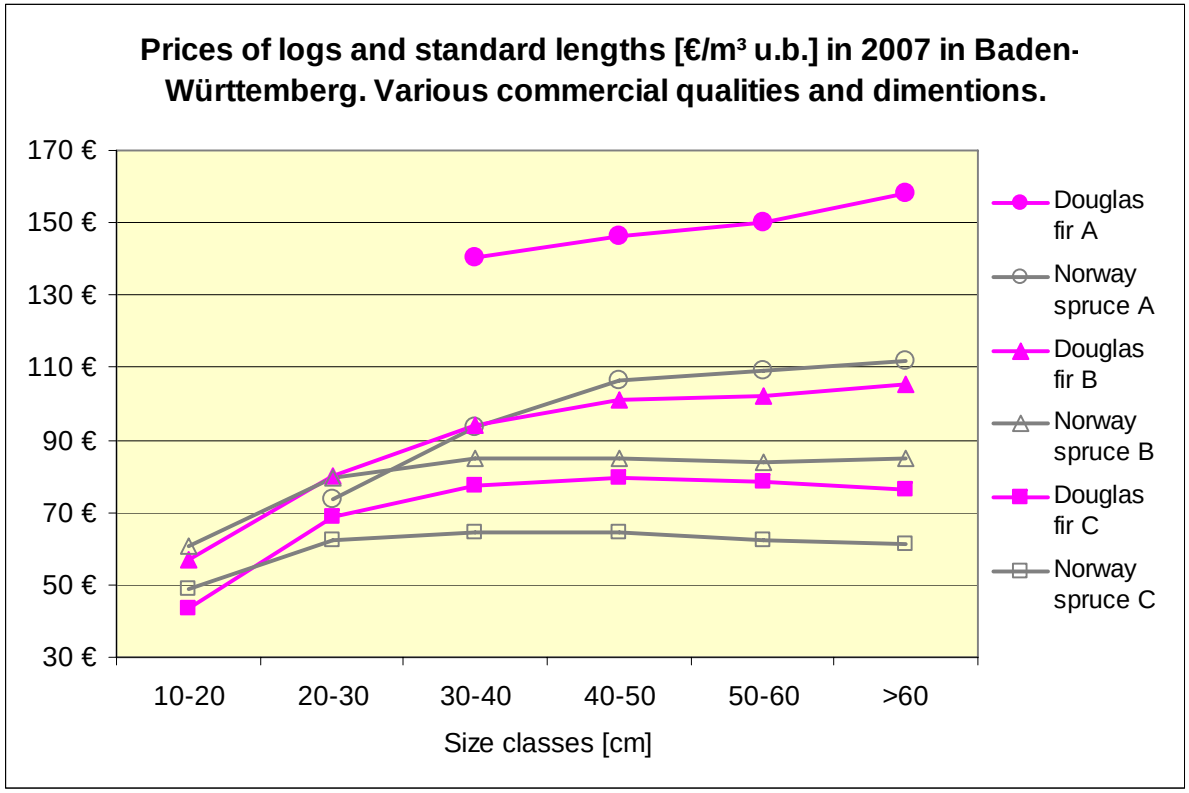


Source: BWI ²

DOUGLAS FIR IN GERMANY

PRICES

- In general better prices for Douglas fir than for other softwoods
- Production of high quality timber very profitable



Source: FOFIS B-W April 2008

DOUGLAS FIR WORLDWIDE

- Characterised by great adaptation capability Douglas fir performs much better than Norway spruce grown on similar sites:
  - High growth and CO_2 consumption rates
  - Good storm resistance
  - Favourable wood mechanical properties

- **Can Pseudotsuga menziesii be an alternative to the local tree species in the times of climate change?**

YES?

HOW TO MANAGE THE FOREST?

HOW TO PRODUCE HIGH QUALITY TIMBER?

HOW TO MARKET THE WOOD PRODUCTS?

FOREST MANAGEMENT

- Production of the valuable timber with a wide range of utilisation possibilities demands a TARGETED FOREST MANAGEMENT
- Wood characteristics of Douglas fir strongly determine the production goal and can be influenced by:
  - Genetics
  - Site
  - Silvicultural treatment

SEED SELECTION

- Choice of adequate proveniences is important
- Provenience (origin unknown) planted in Freiburg turned out to be more productive than others and nowadays it is even exported back to the US

SITE

- After a sensible youth phase, Douglas fir usually grows very well on a wide variety of sites
- In favourable site conditions there are very high chances for extraordinary good tree performance and production benefits

Stocking control

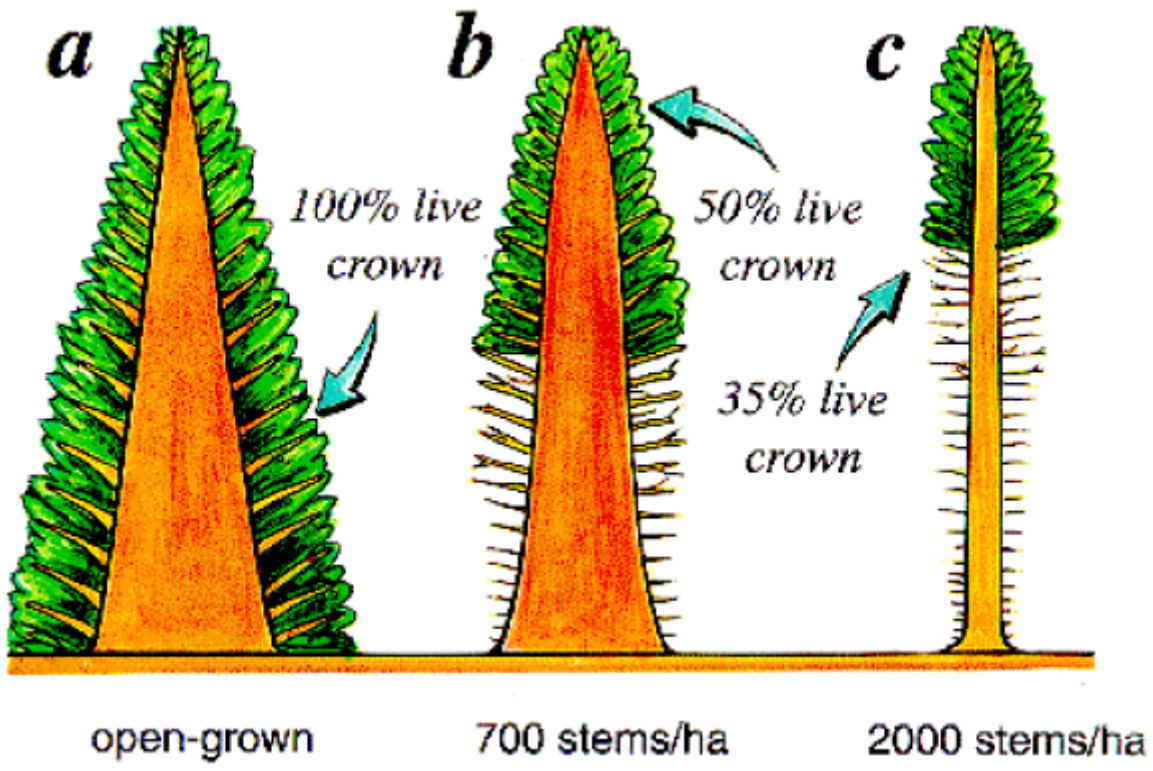


Fig. Effect of stocking density on crown development.

(Source: Jozsa, L.A.; Middleton, G.R. 1994)

Thinning & pruning

- Influencing the knotiness and annual ring width
- Controlling of wood density and juvenile wood
- Better timber quality
- Higher profits!

or

Photos: www.waldwissen.net

Importance of the SILVICULTURAL TREATMENT

Management measures (Research plot)	**Not managed** (Dgl 98)	**Heavily thinned** (Dgl 120/3)
Number of trees	>3.000 Dgl/ha	1.200 Dgl/ha
Age / Height	47 a / 32,5 m	47 a / 33,2 m
Total volume production (Growing stock / Yield)	817 m^3 u.b./ha (678 / 139 m^3 u.b./ha)	819 m^3 u.b./ha (438 / 381 m^3 u.b./ha)
Stand density	905 Dgl/ha	263 Dgl/ha
DBH_{100}	39,8 cm	48,4 cm
Felling return, netto (Stand + intermediate return)	13.900 €/ha	19.900 €/ha

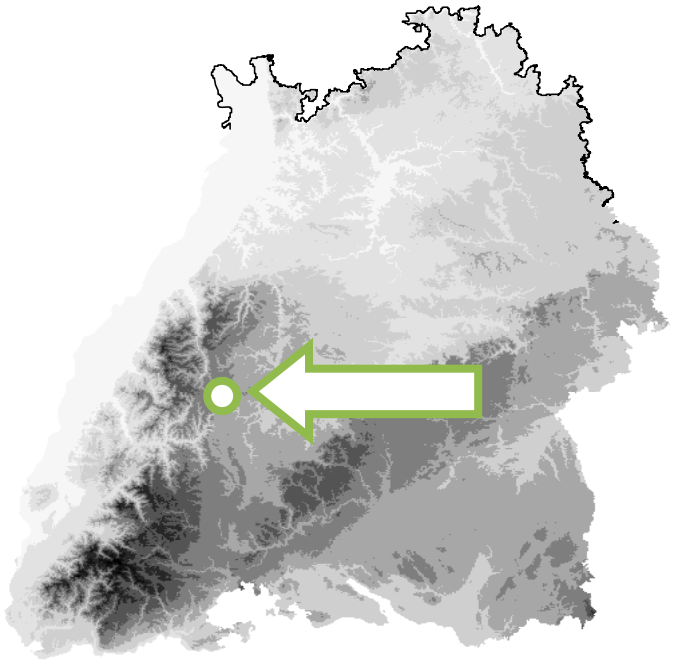
FOREST MANAGEMENT

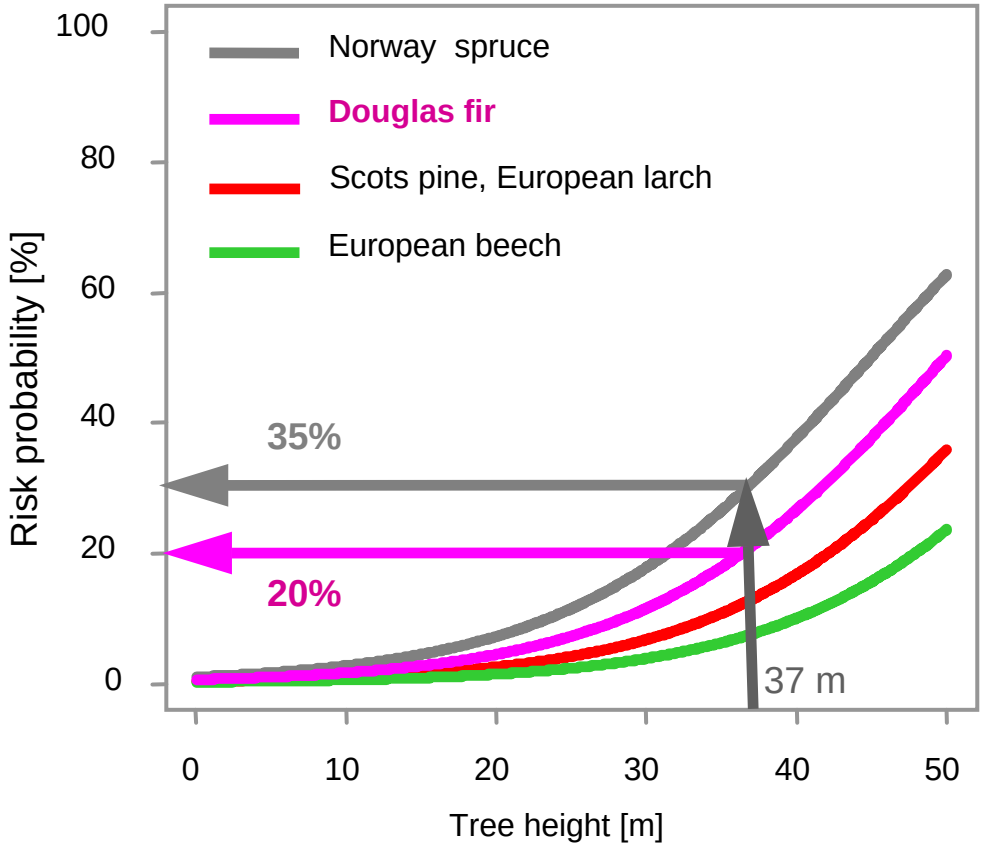
- Acc. to Hapla & Sauter (1987) the best results can be achieved by:

  - Close-to-nature forestry with mixed stands
  - Minor thinning after first 40 years (fine annual rings and small knots)
  - Sustainable transition to more intensive thinning later on to avoid abrupt annual rings width decline

Photo: T. Bosch, www.waldwissen.net

- Minor biological and mechanical RISK THREAT
  - Low rot tendency
  - Robust bark
  - Good storm resistance





Source: Kohnle, 2008

BASIC WOOD QUALITIES

- Most important WOOD CHARACTERISTICS influencing the quality of Douglas fir timber include:
  - Annual ring width
  - Wood density
  - Juvenile wood
  - Knottiness

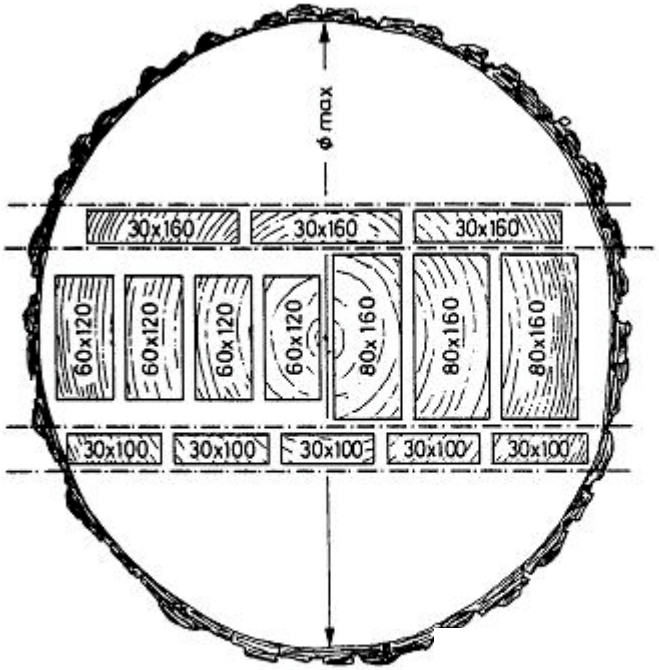


Fig. Cutting scheme for wood testing on 47 Douglas fir trees cut to 900 studs and beams and lamellas (Sauter, U.H. 1992)

BASIC WOOD QUALITIES

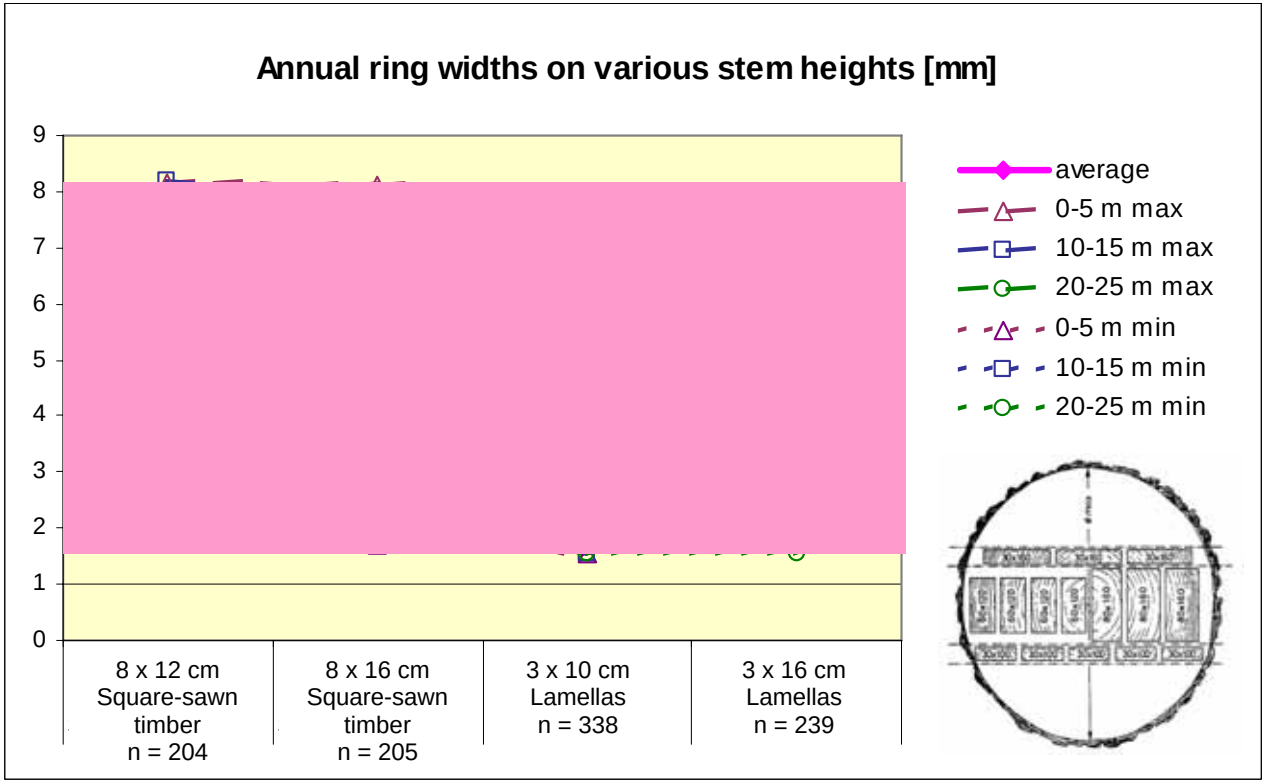
ANNUAL RING WIDTH

- Very high variability (1,5 - 8,2 mm) with average ~ 4 mm

→ **wood quality differences**

Δ Ring width

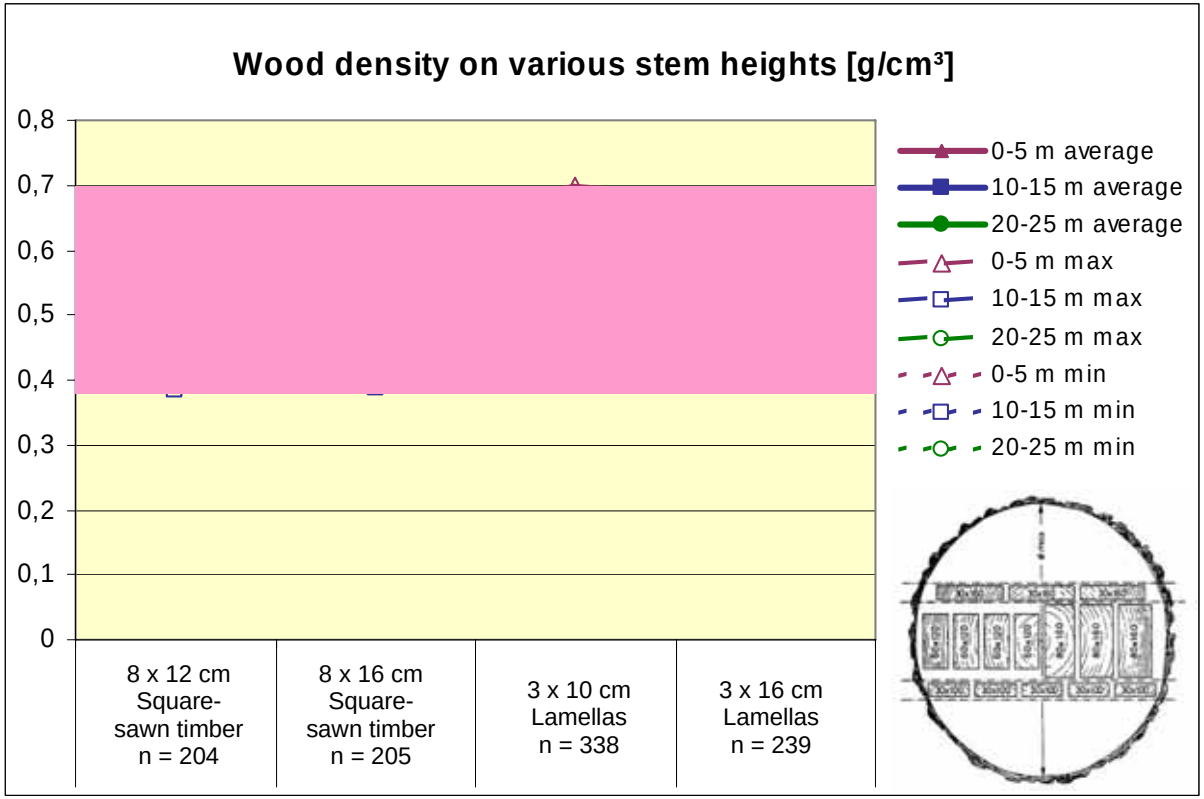
6,7 mm



WOOD DENSITY

- Considerable differences in wood density

Δ density 0,32 g/cm³



BASIC WOOD QUALITIES

WOOD DENSITY

- Significantly higher than in other conifers

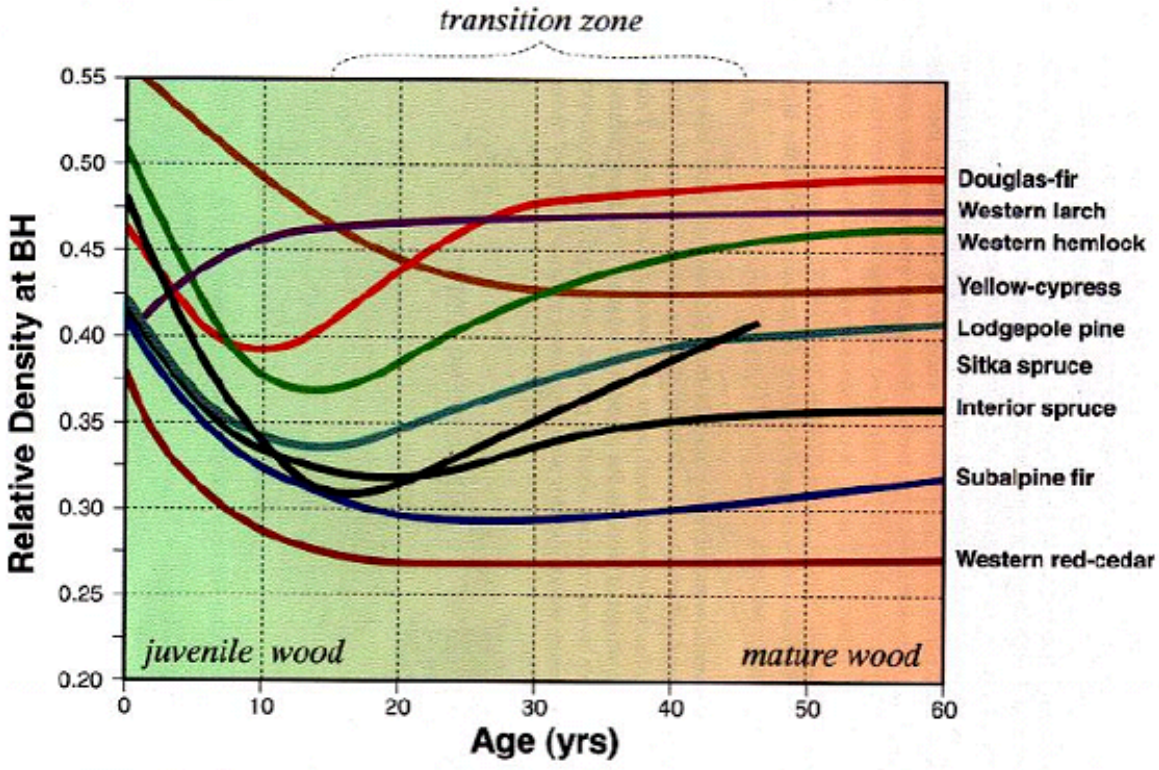


Fig. Average ring density trend from pith-to-bark in some second-growth woods

Source: Jozsa, L.A.; Middleton, G.R.; 1994

N.B.: Average trend lines are based on examinations and summaries of various numbers of trees as follows: Douglas-fir - 60 trees; Lodgepole pine - 60 trees; Sitka spruce - 20 trees; Subalpine fir - 15 trees; Western hemlock - 26 trees; Western larch - 15 trees; Western red cedar - 10 trees; White/Engelmann spruce - 20 trees.

BASIC WOOD QUALITIES

JUVENILE WOOD

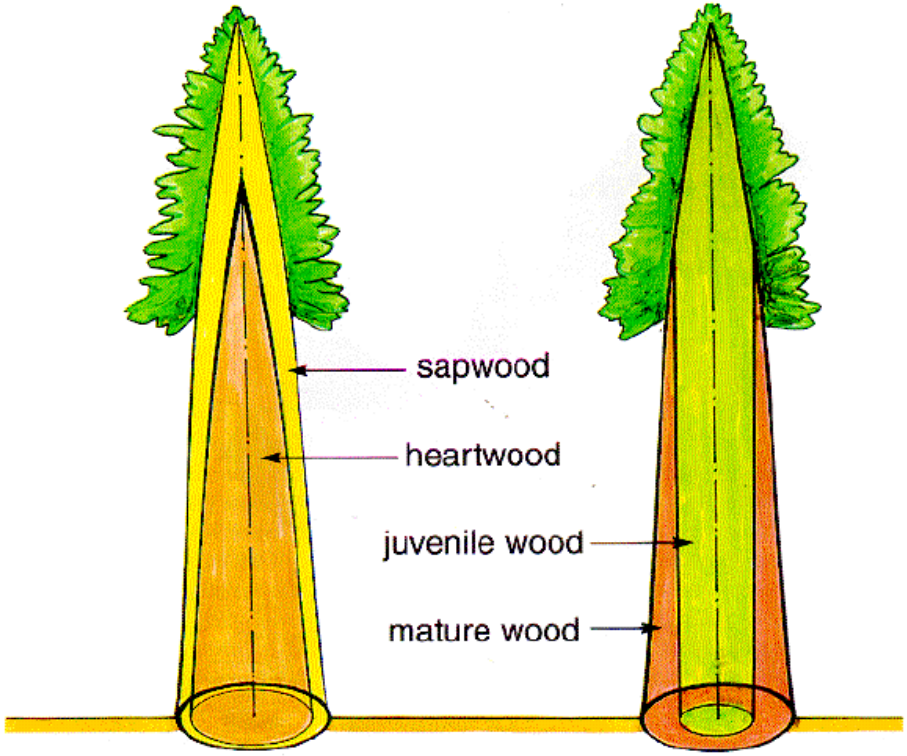


Fig. Stem juvenile-/ mature-wood distribution

Figures: Jozsa, L.A.; Middleton, G.R.; 1994

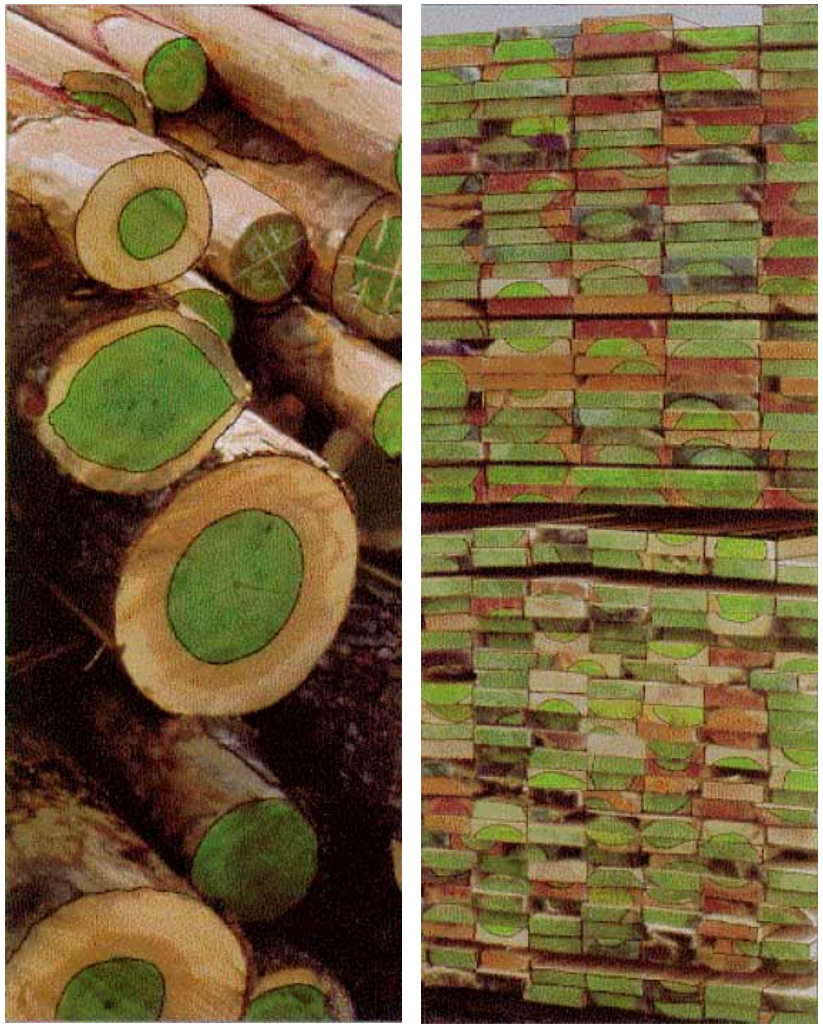
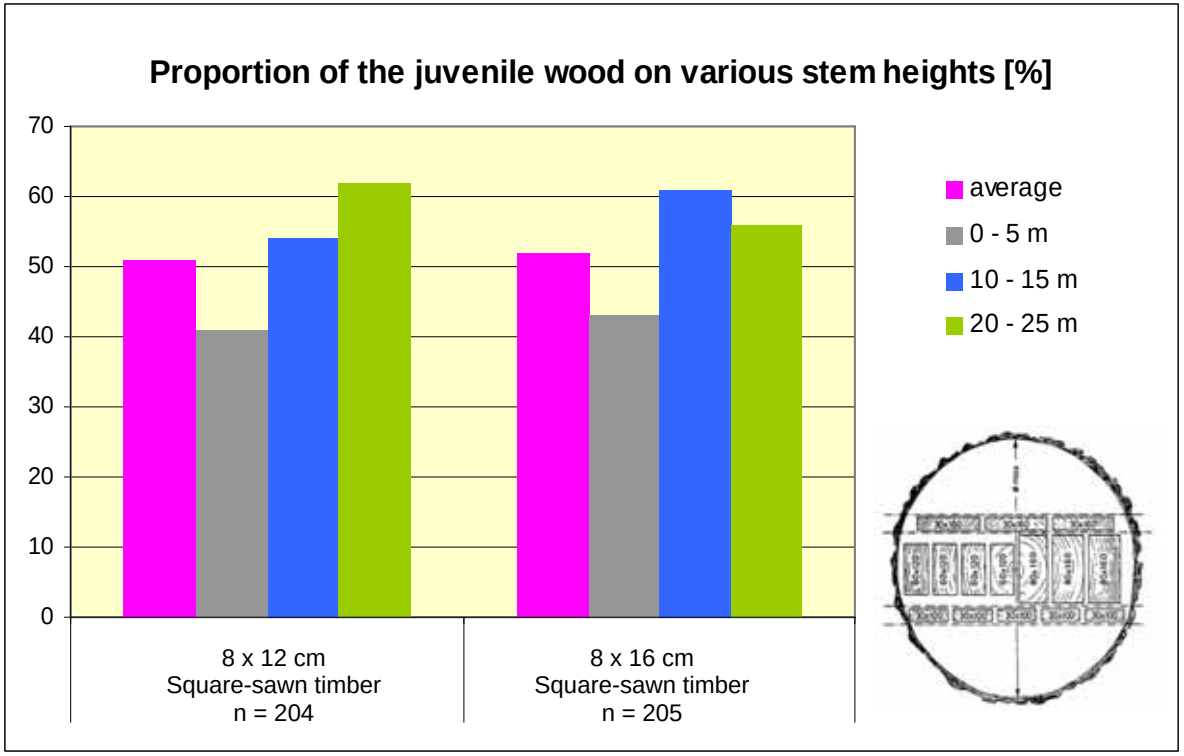


Fig. Juvenile wood (first 20 years of growth) marked on 50 year-old Douglas fir log and lumber ends

BASIC WOOD QUALITIES

- JUVENILE WOOD core extent depends on:
  - Tree age
  - Extent and vigour of the living crown



BASIC WOOD QUALITIES

- JUVENILE WOOD / MATURE WOOD

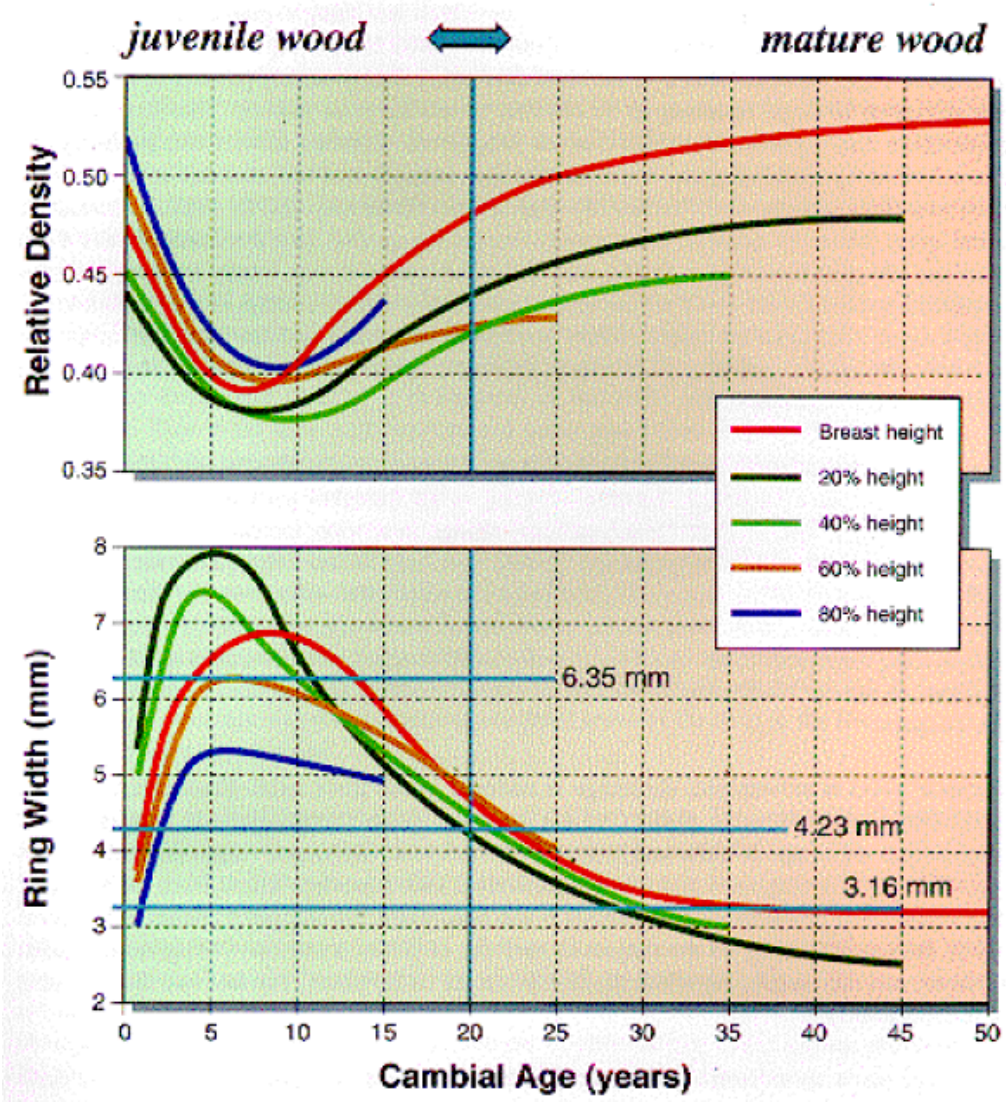


Fig. Average ring density and ring width versus rings from the pith by sampling height for 60 Douglas fir trees.

Source: Jozsa, L.A.; Middleton, G.R.; 1994

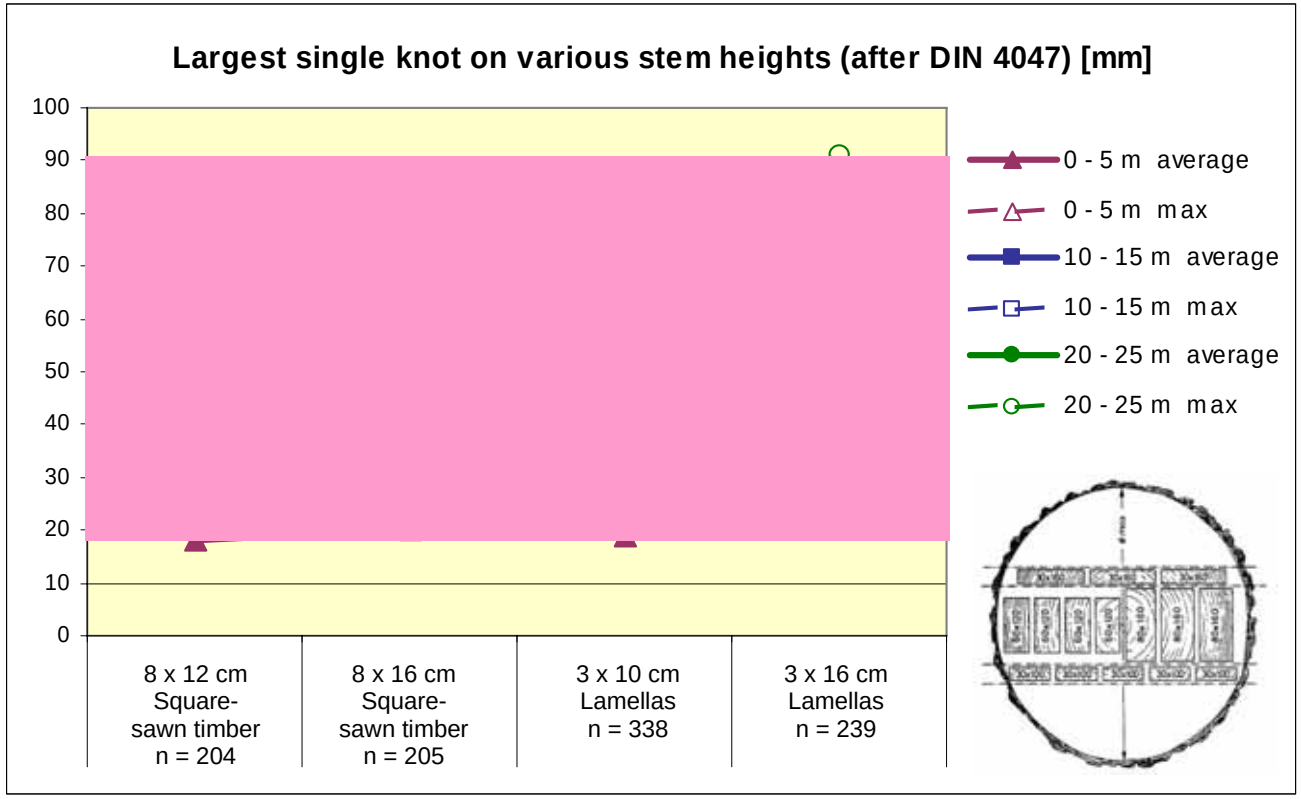
BASIC WOOD QUALITIES

KNOTTINESS

- Largest single knot reaching up to 90 mm

Δ knot size

70 mm



MECHANICAL PROPERTIES

- Most decisive MECHANICAL WOOD PROPERTIES:
  - Static and dynamic modulus of elasticity (MOE)
  - Tensile strength
  - Bending strength

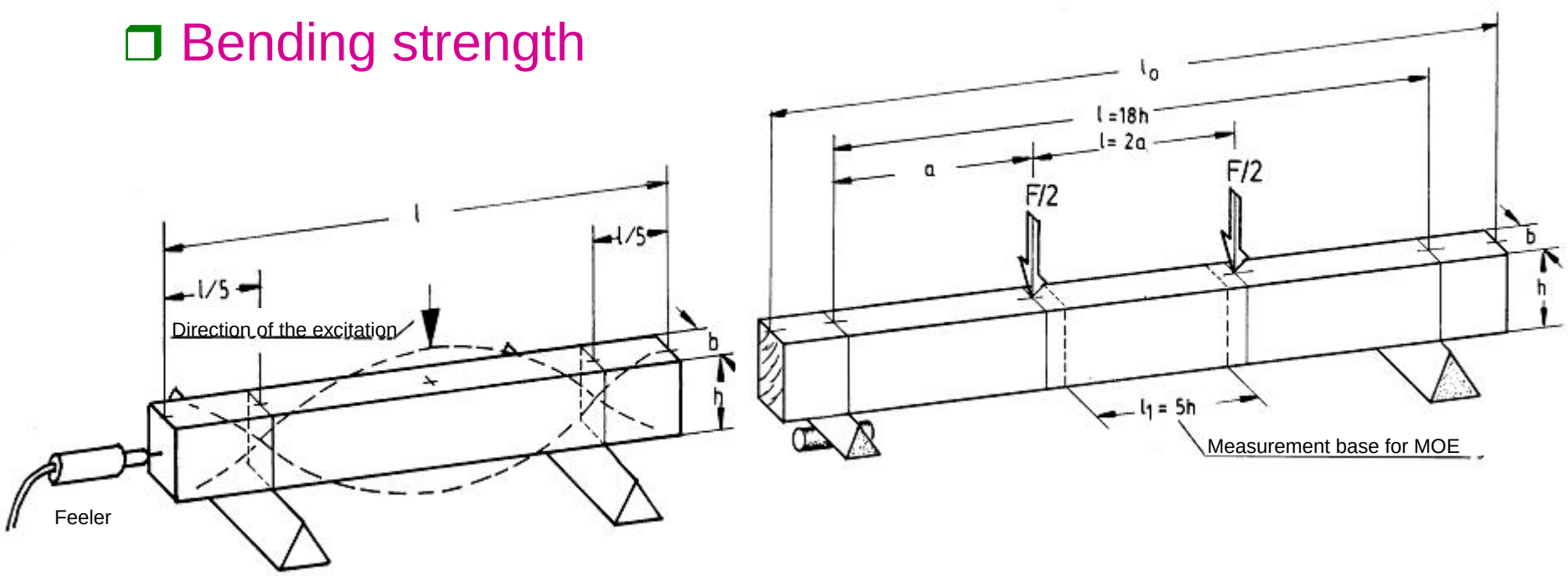


Fig. Examples of tests for MOE_{stat} , MOE_{dyn} and strength for ca. 900 sqare-sawn lumber and lamellas from 47 Douglas fir trees from 10 forest sites in Baden-Württemberg (Sauter, 1992).

MECHANICAL PROPERTIES

- All properties show wide ranges of test values, mainly caused by large variety of wood density and knottiness

Source	Wood density (Moisture = 12%) kg/m³	Static MOE N/mm²	Bending strength N/mm²	Tensile strength (Lamellas) N/mm²
FISCHER 1994 (N = 415)	471	10.603	27,1	-
GLOS et al. 1995 [10] (N = 165)	501	-	-	-
GLOS et al. 1995 (N = 268)	488	16.357	36,9	-
SAUTER 1992 (N = 393)	506	12.576	24,7	42,3 (N = 129, s = 25,5)
PELZ et al. 1998 (N=115)	438 (s = 33)	9.158 (s = 2.824)	18,1 (s = 7,4)	22,9 (N = 116, s = 10,03)

Source: Pelz, S.; Sauter, U.H. 1998

MECHANICAL PROPERTIES

- Douglas fir timber is generally characterised by very good mechanical properties
  - Suitability for construction purposes

- Despite of usually relatively high knottiness Douglas fir lumber reach the required bearing capacity of the higher sorting class

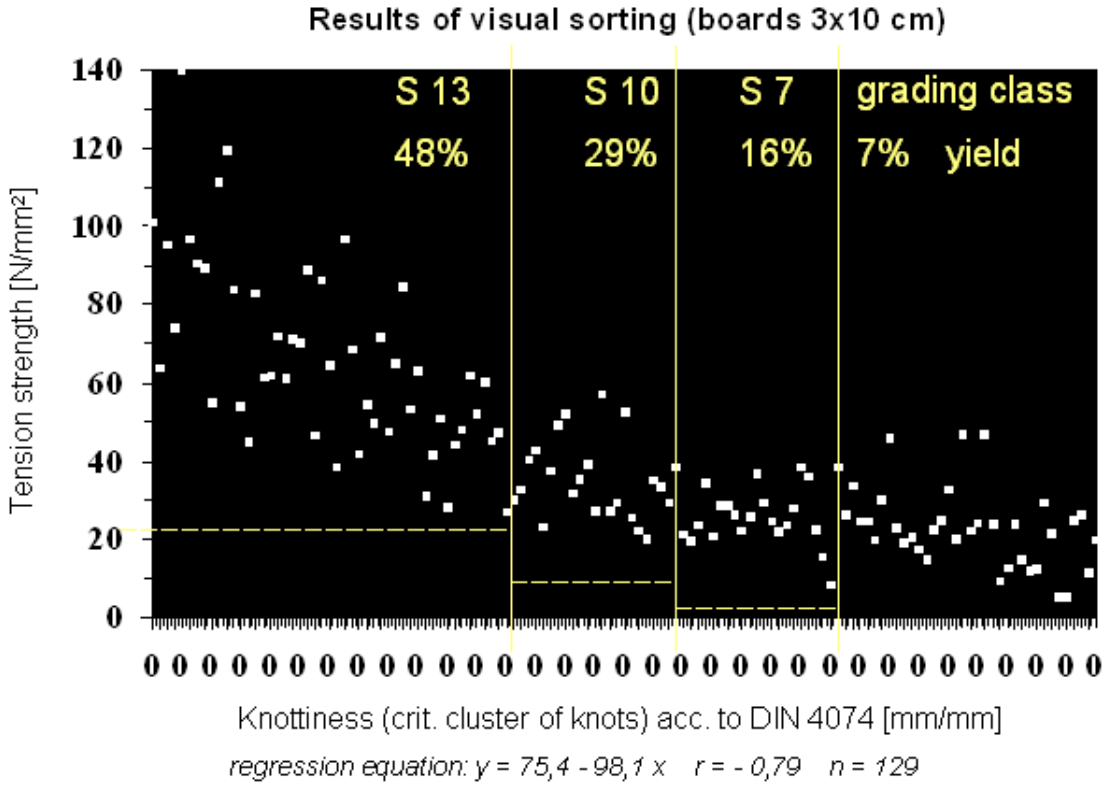
- However… also the correlations of negative qualities (high proportion of juvenile wood and low wood density) are possible which causes downgrading even with the low knottiness

WOOD GRADING

- GERMAN VISUAL SORTING STANDARDS (DIN 4074) developed initially for Norway spruce inappropriate for grading of Douglas fir.

- S10 and S13 classes unrestricted suitable for the constructive purposes!

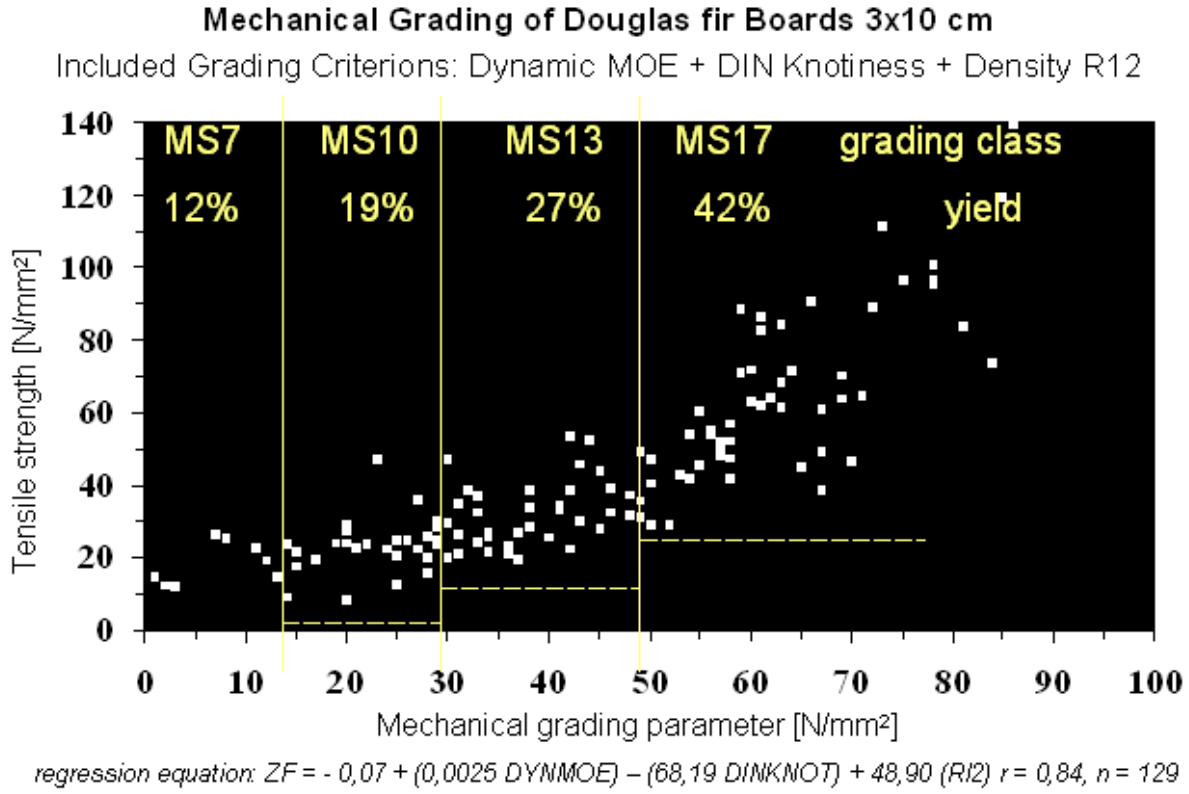
- Existing strength potential not fully utilised due to not adapted thresholds



WOOD GRADING

- Effective measuring of Douglas fir wood can be realised by MECHANICAL TIMBER GRADING – a combination of:

  - automatic measurements:
    - wood density
    - dynamic MOE
    - knottiness



WOOD GRADING

- Visual sorting of Douglas fir does not reach the two highest sorting classes of EN 338
- Mechanical grading is more precise and enables better pricing of timber

Assignment of strength classes und minimal values according to EN 338					
Strength class According to EN 338	C 40	C 35	C 30	C 24	C 16
Mechanical sorting class According to DIN 4074	MS 17	MS 13	-	MS 10	MS 7
Visual sorting class According to DIN 4074	Not applicable	Not applicable	S 13	S 10	S 7
Required characteristic **Tensile strength [N/mm²]**	24	21	18	14	10
Required characteristic **Wood density [g/cm³]**	0,42	0,40	0,38	0,35	0,31
Required characteristic **Modulus of elasticity [N/mm²]**	14.000	13.000	12.000	11.000	8.000

UTILISATION

Delivering generally stronger and bearable timber than local softwoods, Douglas fir is especially predestined for:

- Construction timber of all dimensions
  - Other tree species discriminated already due to the insufficient size
- Construction timber not treated with wood preservatives
- Timber for optical uses

Photo: www.waldwissen.net

UTILISATION





Wide range of possible usage:

- Untrimmed boards
- Floor boards
- Sawn timber
- Visual construction timber
- Windows / joinery
- Balconies / pergola
- Complete houses
- External formwork
- Glued wooden cladding
- Particle boards
- Outdoor / garden products
- Poles and piles



Photos: www.rettenmeier.com

UTILISATION

Main reasons mentioned against utilisation of Douglas fir *(from the point of view of the saw mill managers)* :

- Limited supply in raw material
- High prices
- Lacking demand for final products
- Hardness (screws necessary)
- Reduced lifetime of saw blades and profiler knives
- Problems with segregation of wood residues - mixing of wood chips

Apart from the hardness –

NO TECHNOLOGICAL DISADVANTAGES!

Other problems can be solved by adequate management

CONCLUSIONS

- Long positive experiences lead to a firm opinion that Douglas fir can be a high-performance alternative to the local tree species in the times of climate change

POTENTIAL AVAILABLE

↓

PRODUCT ORIENTED MANAGEMENT NEEDED!

- **Targeted silviculture treatments** for reduction of undesired wood qualities
  - Site and provenience choice
  - Stocking control, thinning and pruning

CONCLUSIONS

- **Separate marketing** of Douglas fir from other softwoods including:
  - in depth knowledge of **customers demand**
  - revision of **marketing and logistics strategies**
- Establishing of **customer / product oriented timber supply chains**
- **Rigorous sorting** according to quality and tree dimensions for optimal timber use, planning security and better pricing
- **Saw mills specialisation** in the species specific processing of Douglas fir to achieve the highest market value of the timber products

THANK YOU FOR YOUR ATTENTION

Thanks to

Katarzyna Zielewska

for preparing the presentation.

Dr. Udo Hans Sauter
Department of Forest Utilisation
Forest Research Institute Baden-Württemberg
www.fva-bw.de