COST Action E42
Growing Valuable
Broadleaved Tree Species
Thessaloniki – Greece – 17–21 May 2005

Utilisation of walnut (Juglans), robinia (Robinia pseudoacacia) and ash (Fraxinus) on the basis of Hungarian experiences

by

Róbert Németh & Sándor Molnár
University of West-Hungary, Sopron

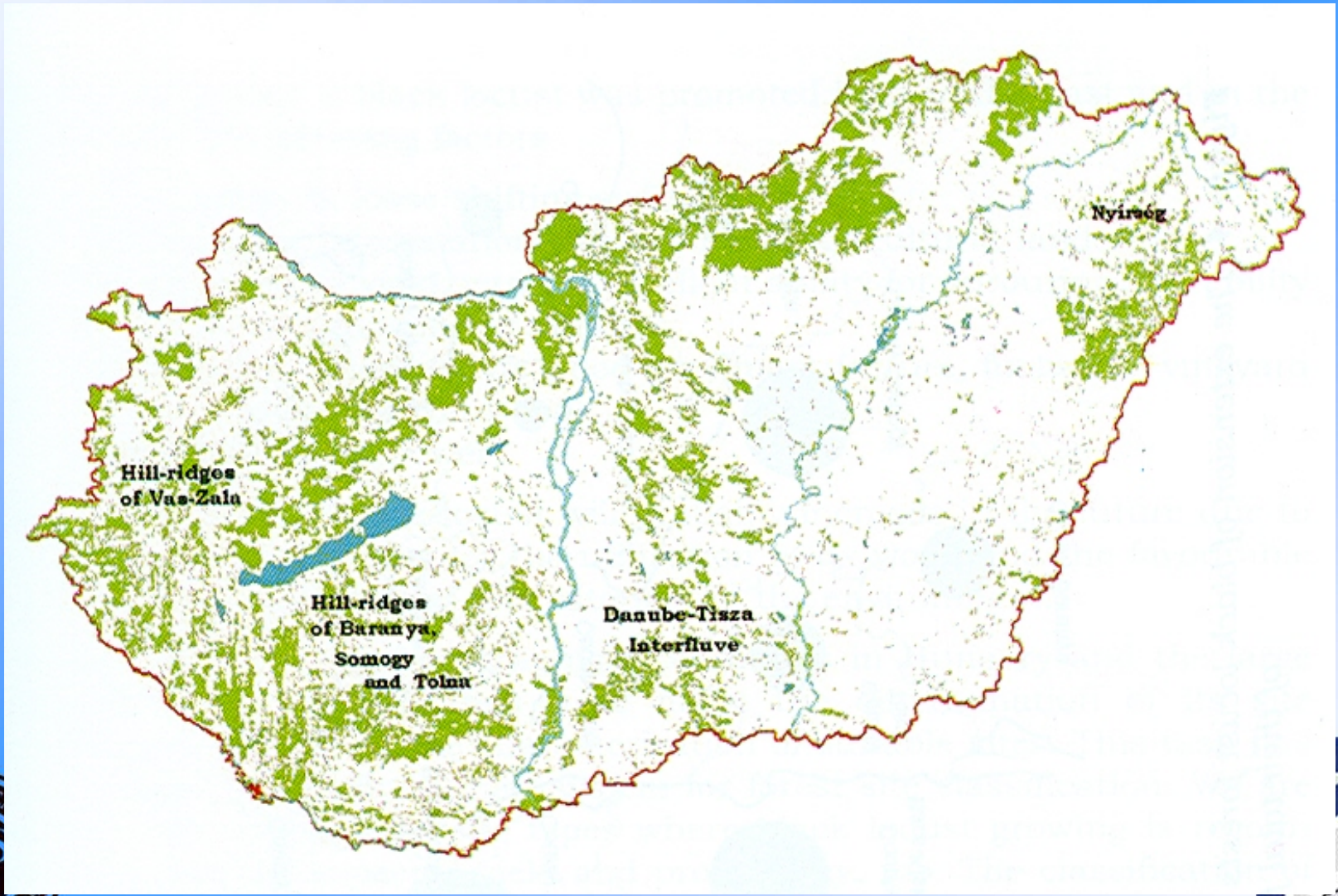
Contents

- Basic characteristics of the Hungarian forestry
- Importance of robinia, walnut and ash plantations (stands) in Hungary
- Morphological characteristics
- Microscopic and macroscopic characteristics
- Defects, damages, durability
- Physical and mechanical properties of robinia, walnut and ash
- Main characteristics of the tending and yield of robinia plantations
- Utilization of robinia, walnut and ash robinia in Hungary and workability
- Conclusions

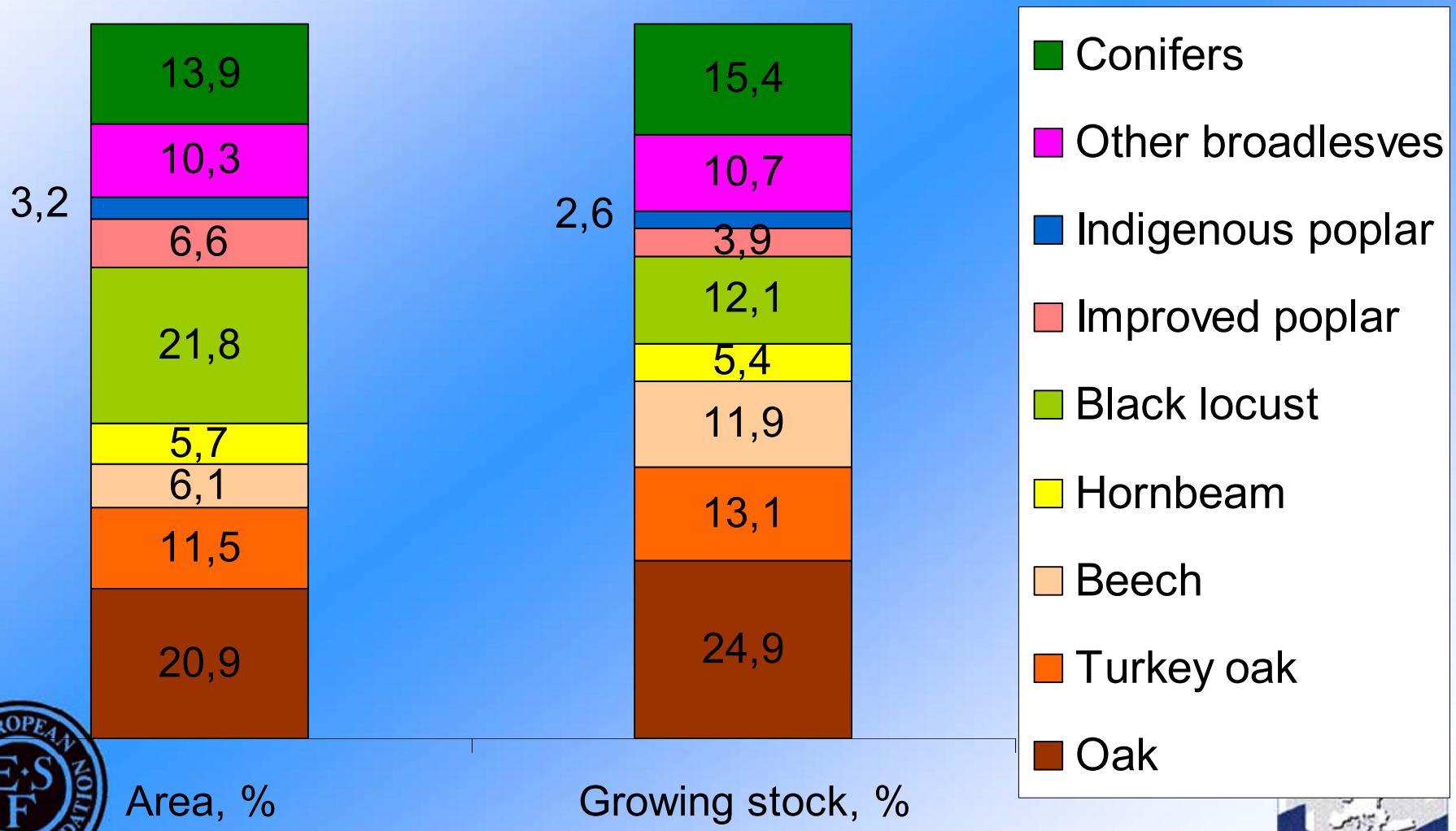
Basic characteristics of the Hungarian forestry /KSH 2003

Total area of the country	in 1,000 hectare	9,303.0
Population	capita in millions	10.14
Forest area	in 1,000 hectare	1,843.9
Forest ratio	%	19.6
Forests for 1,000 habitants	ha/1,000 capita	180
Lands assigned for forestry use	in 1,000 hectare	1,955.2
Growing stock	in millions gross m^3	330.9
Gross annual increment	in million m^3/year	12.3
Total fellings	in millions gross m^3	7.0
Final cut, volume	in millions gross m^3	5.0
Final cut, area equivalence	in 1,000 hectare	21.0
Regeneration (initial stand establishment)	in 1,000 hectare	22.3
Afforestation (initial stand establishment	in 1,000 hectare	14.8
Rate of forest treated on management plans	%	100

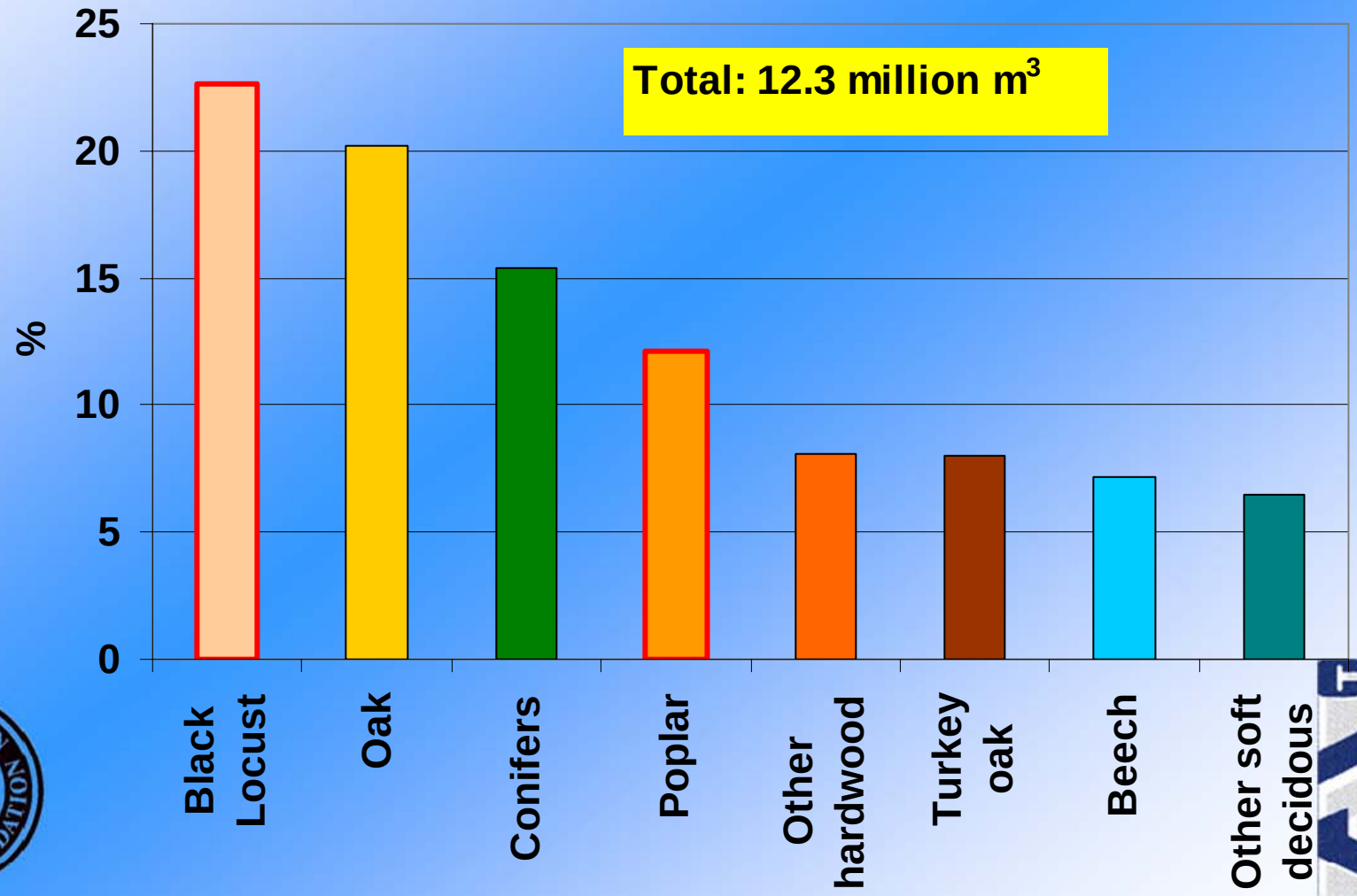
Forest map of Hungary



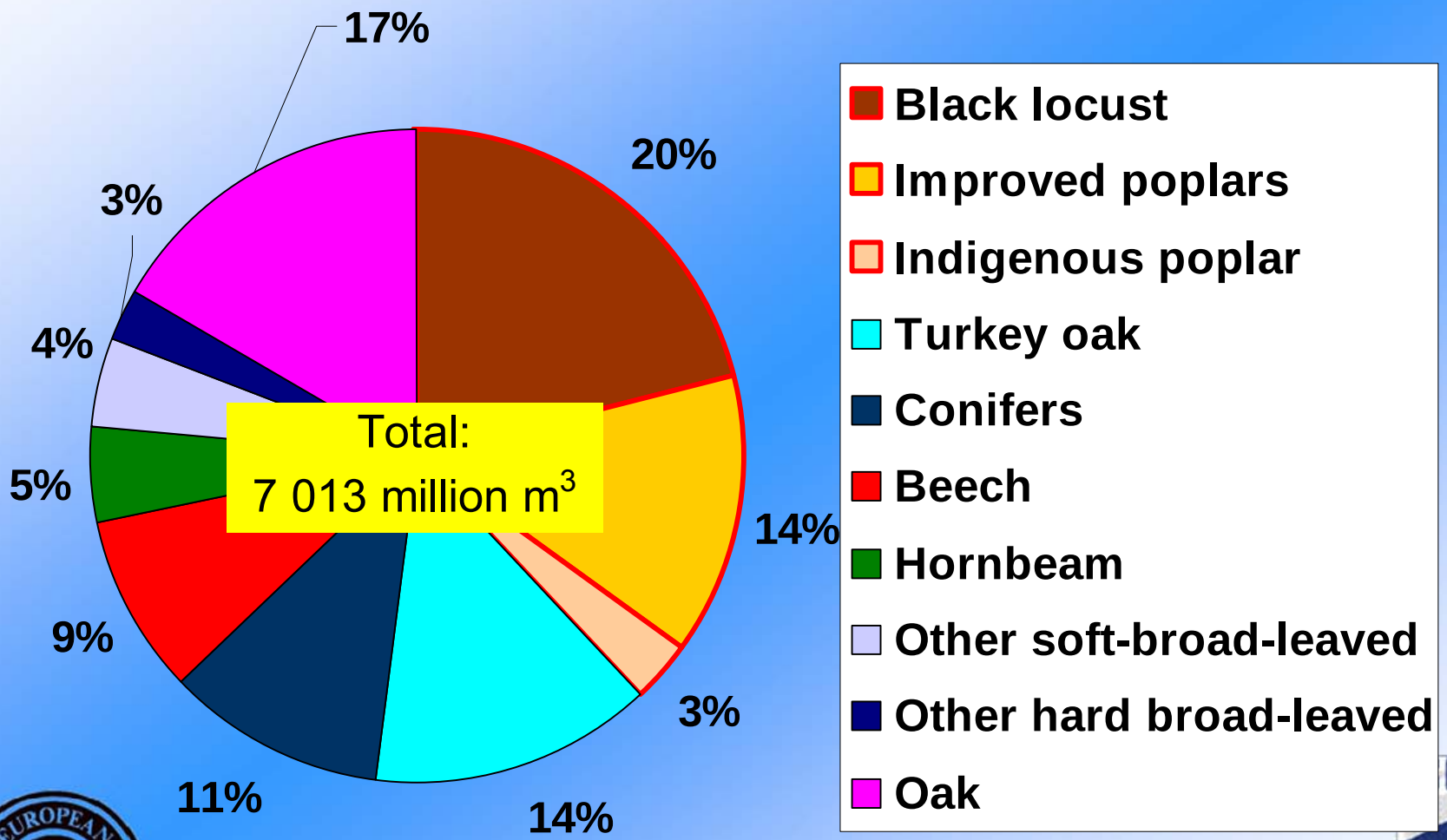
Tree species distribution *(ÁESz, 2002)*



Distribution of the gross annual increment by tree species *(ÁESz, 2003)*



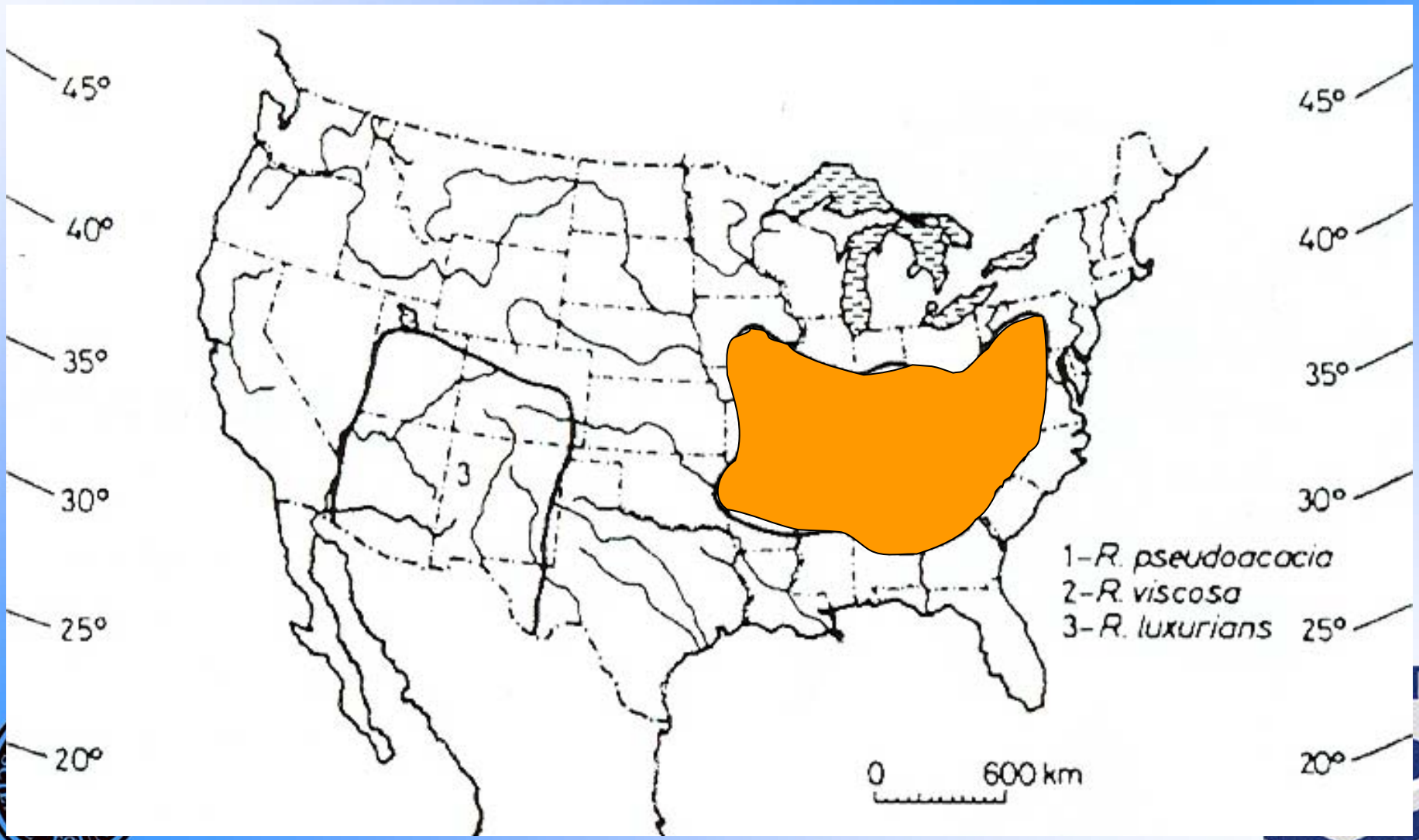
Fellings by groups of tree species



Robinia – history, distribution, facts

- Together with many other plants, robinia has been introduced to Europe from North America by J. Robin, the royal chief gardener of Paris in 1601.
- Today, 20% our forests is made up of robinia, and no other European country has as much of it as Hungary does (345,000 ha). Thus, it is no wonder that robinia is considered to be a Hungarian species in the folklore.
- It prefers warm climates and nutrient-rich sandy soils (its climatic requirements are close to those of grapes).
- Romania, Italy, France, Serbia, Bulgaria, Slovakia and the Ukraine also have large stands of robinia. Presently, robinia forest areas shows fast expansion in China and South Korea.

Natural range of robinia in the USA



Robinia – morphological characteristics

- Robinia grows 20-25 m tall with a 30-60 cm breast height diameter.
- The growth slows down after 25 years, and so it is customarily harvested at the age of 25-40 years.
- Its thick, greyish-brown bark has net-like crevices. Robinia develops relatively straight, cylindrical trunks in closed stands.
- The cultivation of special strains, like the straight "ship mast robinia" variety, increasingly get greater attention.

Robinia – the tree

Robinia - macroscopic charactersitics/1

- Robinia is a ring-porous deciduous tree species.
- The thin sapwood (about 2-6 annual rings) is bright yellow, the colour of the heartwood varies from yellowish-brown to greenish-grey.
- The heartwood formation: heart wood forming substances get deposited on the one hand, and tyloses penetrate into the vessels and clog them on the other.
- The most important of these substances are tannins, resins, pigments, gum and robinetins. Above all, tannins and robinetins are essential for the durability of robinia heartwood. Sapwood contains much moisture and many simple organic compounds, and so fungi and insects are attracted.
- According to our measurements, the ratio of latewood in trees from a 30-35 year old robinia stand amounts to 77%, and the average annual ring width is 3.0-3.5 mm.

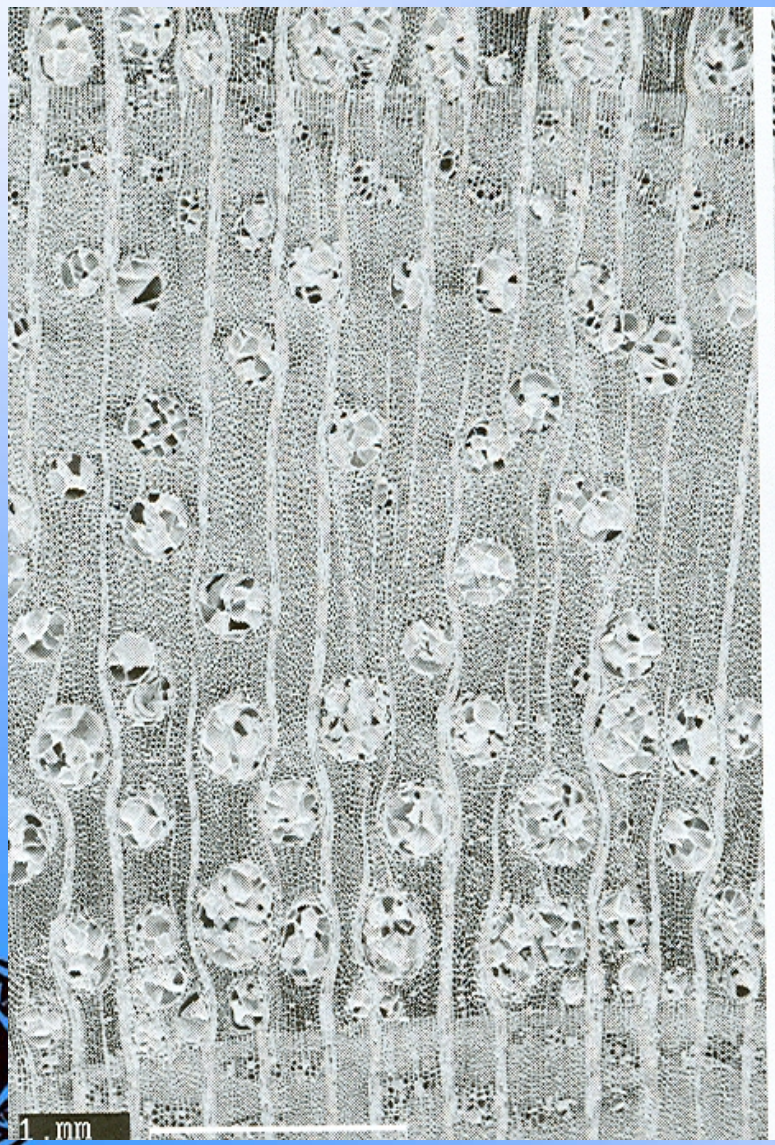
Robinia

macroscopic charactersitics/2

Robinia - microscopic charactersitics/1

- The bulk of the xylem is made up of thick-walled libriform fibres. Their proportion is 58% with an average length of 1 mm.
- The wide earlywood vessels (150-220 μm) are arranged in a 2-3 vessels thick ring. They are heavily clogged by tyloses. Latewood vessels have smaller diameters (70-140 μm). The ratio of vessels in the tissue is about 15%.
- Rays amount to approx. 21%, and they are narrow (1-3 cells).
- The longitudinal parenchyma is paratracheally arranged along the vessels and often assembled in longitudinal rows. Their share is only 6% section.
- The longitudinal and the ray parenchyma often contain crystalline deposits.
- Because of various clogging substances and tylosis, robinia is impermeable to liquids in all directions. Quarter-sawing is not a requirement for robinia staves.

Robinia - microscopic charactersitics/2



Robinia – defects damages, durability/1

- The following defects require greater attention in robinia: uneven annual ring width, eccentric growth, false growth rings, in-grown bark and, last but not least, knots.
- Due to its special tissue structure and chemical composition, robinia withstands attacks of biological agents well. The single most important fungus, harming living trees, is *Fomes fraxineus* Cooke, causing butt rot. Powder post beetle (*Lyctus linearis*) damage is frequent in the sapwood of stored or built-in wood.
- According to our observations, excessive taper (above 1.5 cm/m) occurs in 20-24% of robinia sawlogs.
- About 15-20% of the logs processed in the sawmills are bent in one direction. The butt taper in robinia is not very extensive, usually less than 50 cm. Since buttresses and pith-rot are often present, this log part shall preferably be removed.
- The sawdust of robinia may cause allergic reactions upon skin contact.

Robinia – defects damages, durability/2

- According to EN 350-2, robinia is the only European species that can be put into the durability class 1-2. Because it does not require chemical treatment for outdoor applications, robinia can be considered a very environment-friendly material.
- During a series of focussed investigations, the fungus-resistance of robinia was verified. Natural wood proved to be completely resistant: the weight loss was 0.1-0.6%. Conversely, steamed robinia has lost some of its resistance in contact with *Grifola sulphurea* and *Irpex lactea* (the weight losses were 2.1 and 4.4%, respectively). Accordingly, the steamed, and thus brown-coloured, robinia sawnwood is not recommended for outdoor use or where it is exposed to possible fungal infection.
- According to Hungarian and foreign experience, the service life of robinia is estimated to be:
  - outdoors, in soil contact 25-40 years
  - outdoors, without soil contact 80-100 years
  - in dry conditions and under water more than 500 years

Robinia – physical properties/1

Density (kg/m^3)	
oven-dry	540-740-870
air-dry (12% MC)	580-770-900
Shrinkage (%)	
longitudinal	0.1
tangential	5.4-7.2
radial	3.2-4.6
volumetric	11.4-12.2
Porosity (%):	52
Thermal properties	
Burning rate (structures)	0.5 mm/min
Calorific value	bark-free wood: 17,777 kJ/kg

Robinia – physical properties/2

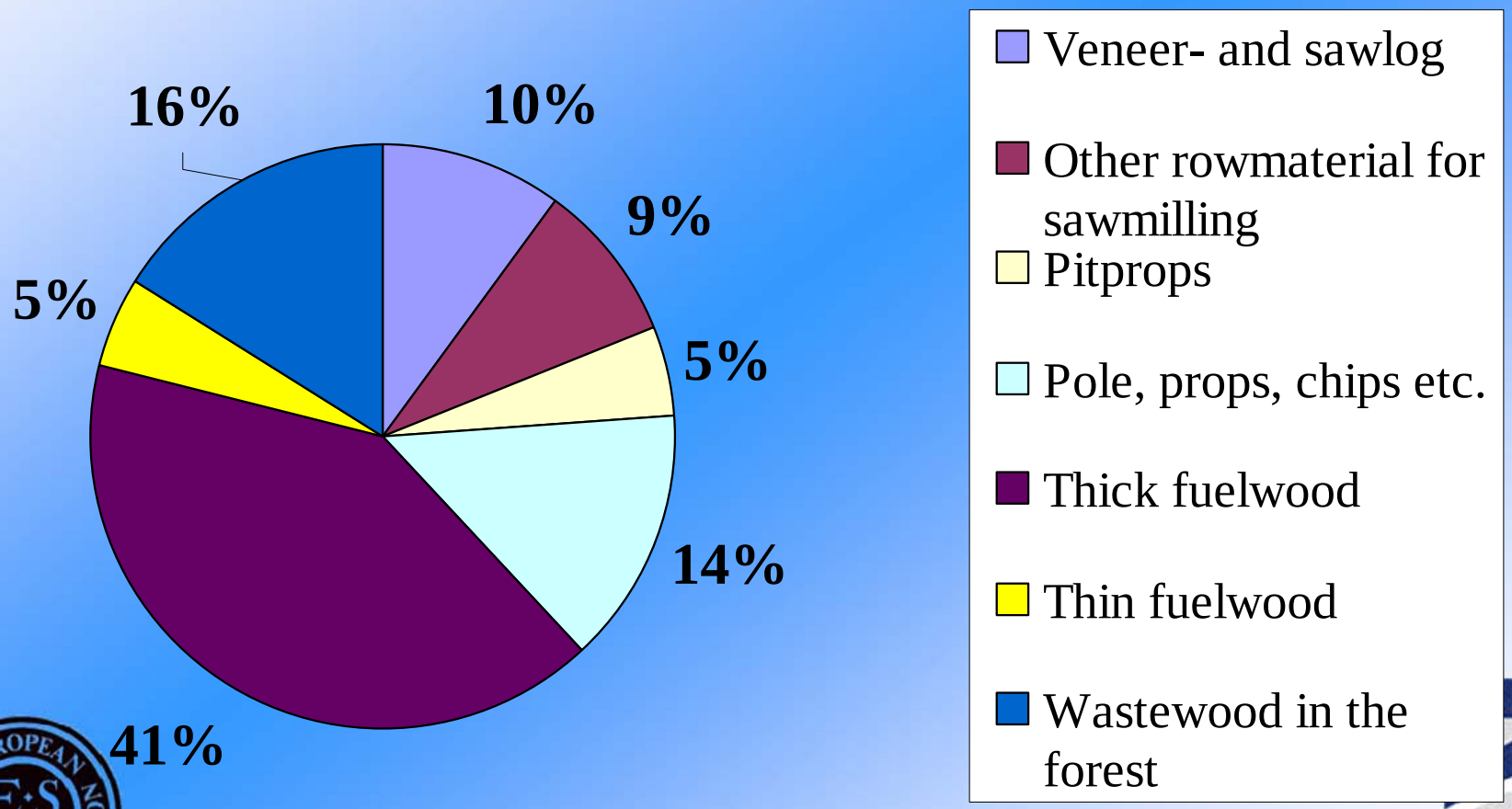
- Freshly felled robinia contains only 35-45% of water, therefore it burns well even without drying.
- The fibre saturation point of robinia was determined by various studies to be at 21.8-22.5%.
- The ratio of the tangential and radial shrinkage (shrinkage anisotropy) is rather favourable in robinia. However, significant internal stresses were observed in robinia. They might have been introduced by the fast growth, the inhomogeneous growth ring structure, the high proportion of juvenile wood and the frequently occurring eccentric growth. The internal forces often cause various deformations and splits.
- Assuming a density of 700 kg/m^3 (bark included), the volumetric calorific value is 12,633 MJ/m^3, i.e., 2.5 tons (or 3.5 m^3) of air-dry robinia wood would replace 1 ton heating oil.

Robinia – mechanical properties/1 (MPa)

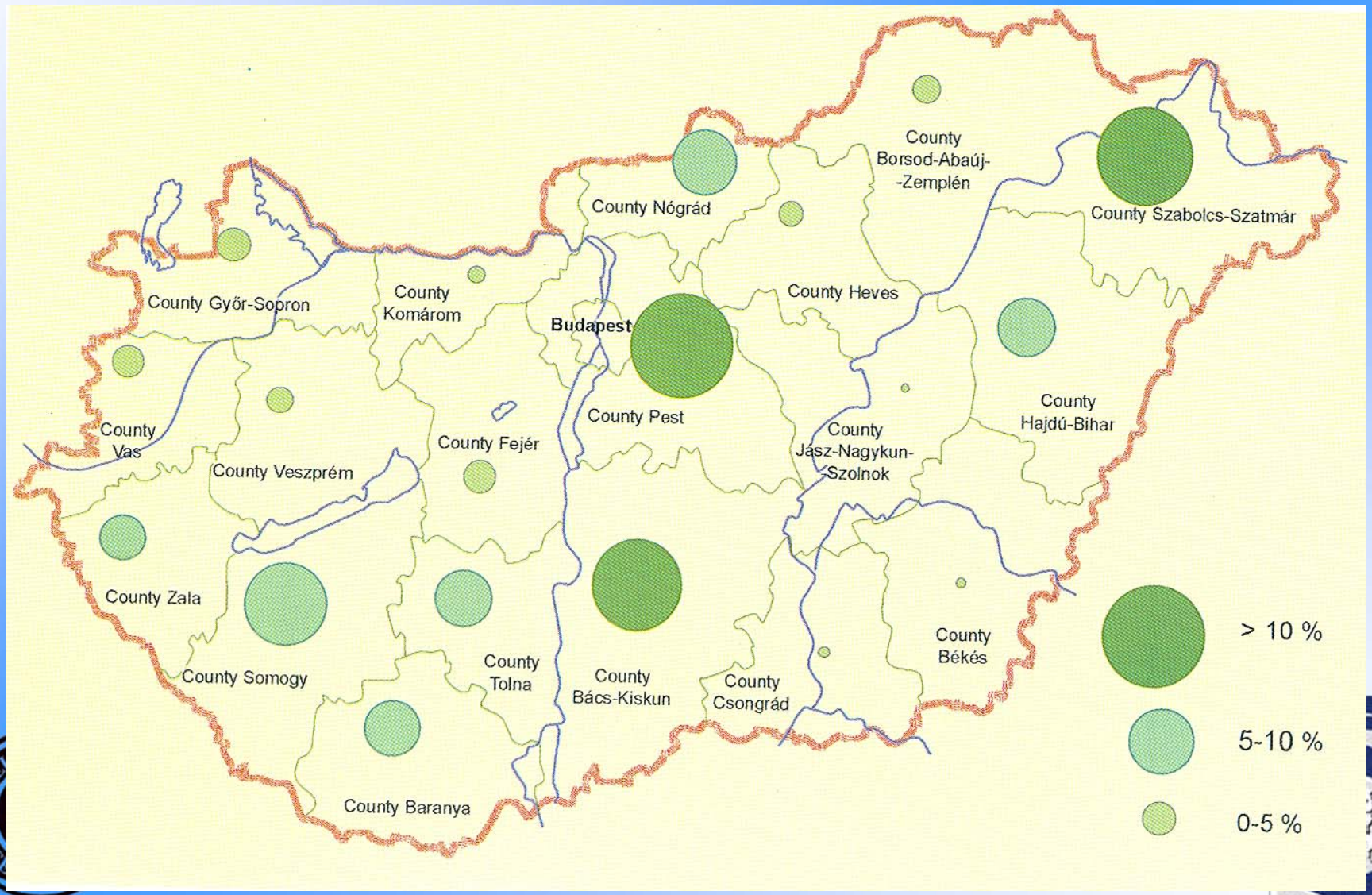
Compr. Str. longitudinally	62-72-81
across the gr.	18.5
Tensile strength	166.8
Bending strength	103-136-169
Shear strength (tang.)	11-13-16
Cleavage radial:	1.12
tangential:	0.6-1.1
Hardness (Brinell), end	67-78-88
side	39
MOE	9,000-11,300-13,600
Impact-bending str. (J/cm^2)	12-14-18
Robinia's wear resistance is unique among the European tree species.	robinia 0.37; beech 1.00; ash 1.53; oak 1.56.

Robinia - Rate of assortments within the removal

The popularity of robinia firewood significantly influences the assortment composition. Logs and firewood are often the only assortments because of the great market demand.



The extension of robinia forests in Hungary within counties expressed in % of their total forest covered area



Tending regime for robinia stands

(Yield table: Rédei 1984)

Operation	Age (year)	Height (m)	Basal area (m^2/ha)	DBH (cm)	Density (stems/ha)	Growing Space (m^2)	Volume cut (m^3/ha)
			Yield class I				
Cleaning	5	8	7	6	2500	2.1	6
Cleaning	9	13	13	10	1700	2.6	20
Selective thinning	12	16	12	13	900	3.6	30
Selective thinning	18	20	17	19	600	4.4	35
Increment thinning	25	24	18	24	400	5.4	50
Harvest cutting	**40**	27	32	**32**	400	5.4	**425**
			(Yield Class II…..IV)……**Yield Class V**				
Cleaning	9	7	7	5.5	3000	1.8	4
Cleaning	15	10	9	9	1500	2.8	20
Harvest cutting	**25**	14	20	**13**	1500	2.8	**155**

Robinia – workability/1

- Due to the relatively small diameter of the industrially used timber (on average 23-24 cm), the knot-free portion is rather small. The mean distance between larger knots is 60-70 cm, and rotten knots are quite frequent.
- Robinia is not easy to saw due to its hardness and strength characteristics; the cutting resistance (power requirement) is 20-30% greater than of oak and so the tool wear.
- Timber does not require any special protection (e.g., spraying) on the log yard.
- In the past few years, about 150 to 220 thousand m^3 of robinia timber was annually converted to lumber in Hungary.

Robinia – workability/2

- If properly steamed, the wood loses its unpleasant greenish-yellowish colour and gradually browns. After steaming, robinia wood can be machined more easily then before, and there will be less grain tear and splits.
- Robinia is easy to dry (the schedules are similar to those of beech). The inherently low initial moisture content of timber is of great advantage.
- Steam-softened wood bends well for furniture parts.
- Robinia can be properly bonded with the usual glues and bonding techniques. However, the specific features of robinia (e.g., clogged pores) have to be taken into consideration when choosing bonding parameters.

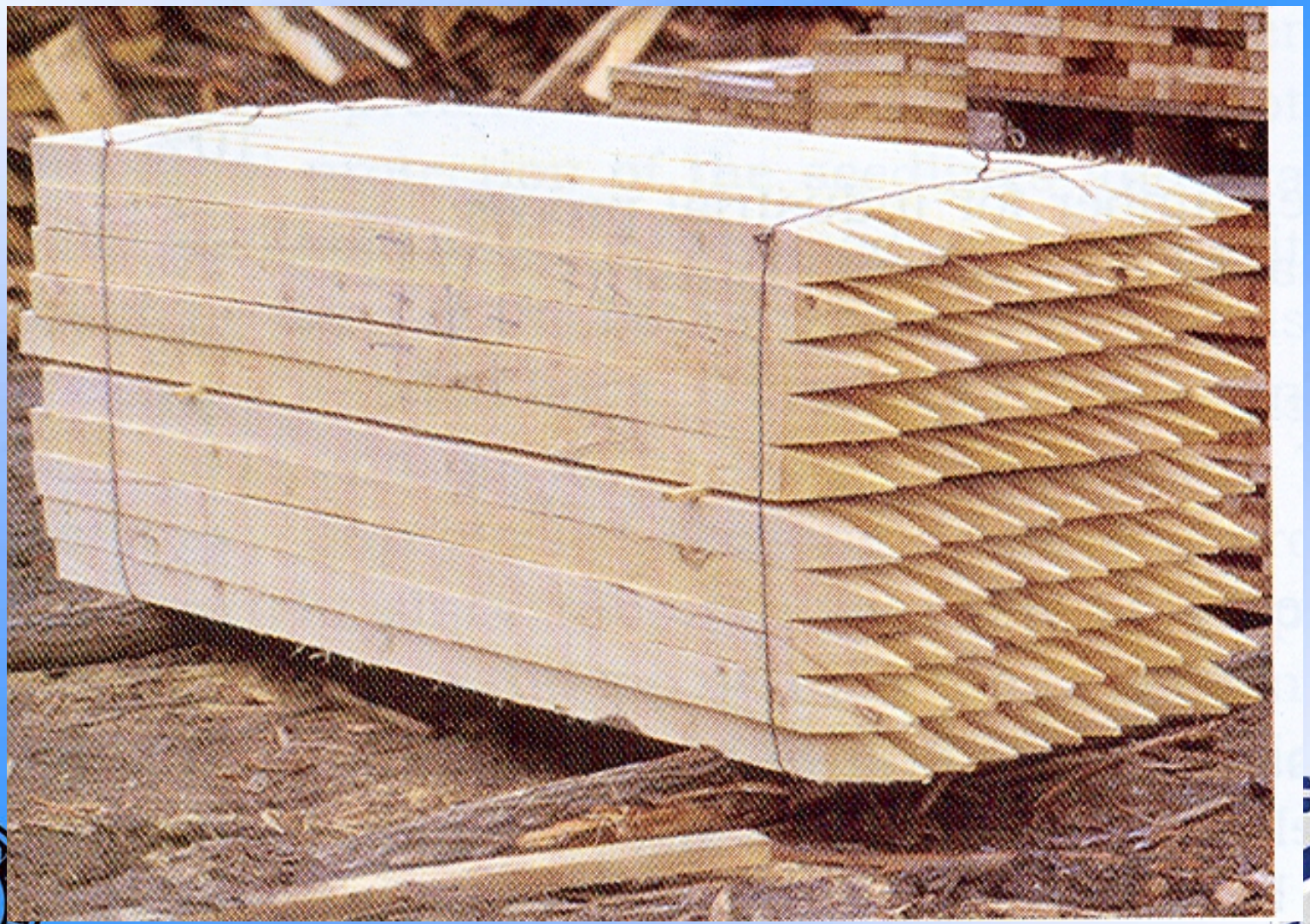
Robinia – utilization/1

- Robinia can be used as a supplementary species in manufacturing particle boards.
- Hidden structural components (e.g., the framework of upholstered furniture, clothes-hanger rods, etc.).
- Robinia kitchen chairs (petite seats) and desk frames. living room chairs and tables.
- Owing to its durability, robinia is currently the most important raw material for outdoor furniture.
- Significant quantities of hardwood flooring, staircase and railings are also made of it in Hungary.
- It plays an important part in structural applications, gluelam beams, residential housing, tool-sheds, fence components and panelling.
- In addition to solid wood flooring, laminated floors are also manufactured where the surface layer exposed to wear is made of robinia.

Robinia – utilization/2

- Cartwright traditionally makes use of robinia.
- Tool handles are produced in large amounts of it.
- Attempts seem to be successful to manufacture large glued-laminated railway ties for switches.
- Robinia turned out to be an excellent resource for tight barrels. The wood is impermeable to liquids, regardless of sawing direction, and robinia staves rarely break during bending.
- Currently, 600 to 700 thousand m^3 of robinia firewood is used in Hungary annually. Also, promising experiments are conducted into establishing short-rotation energy wood plantations.

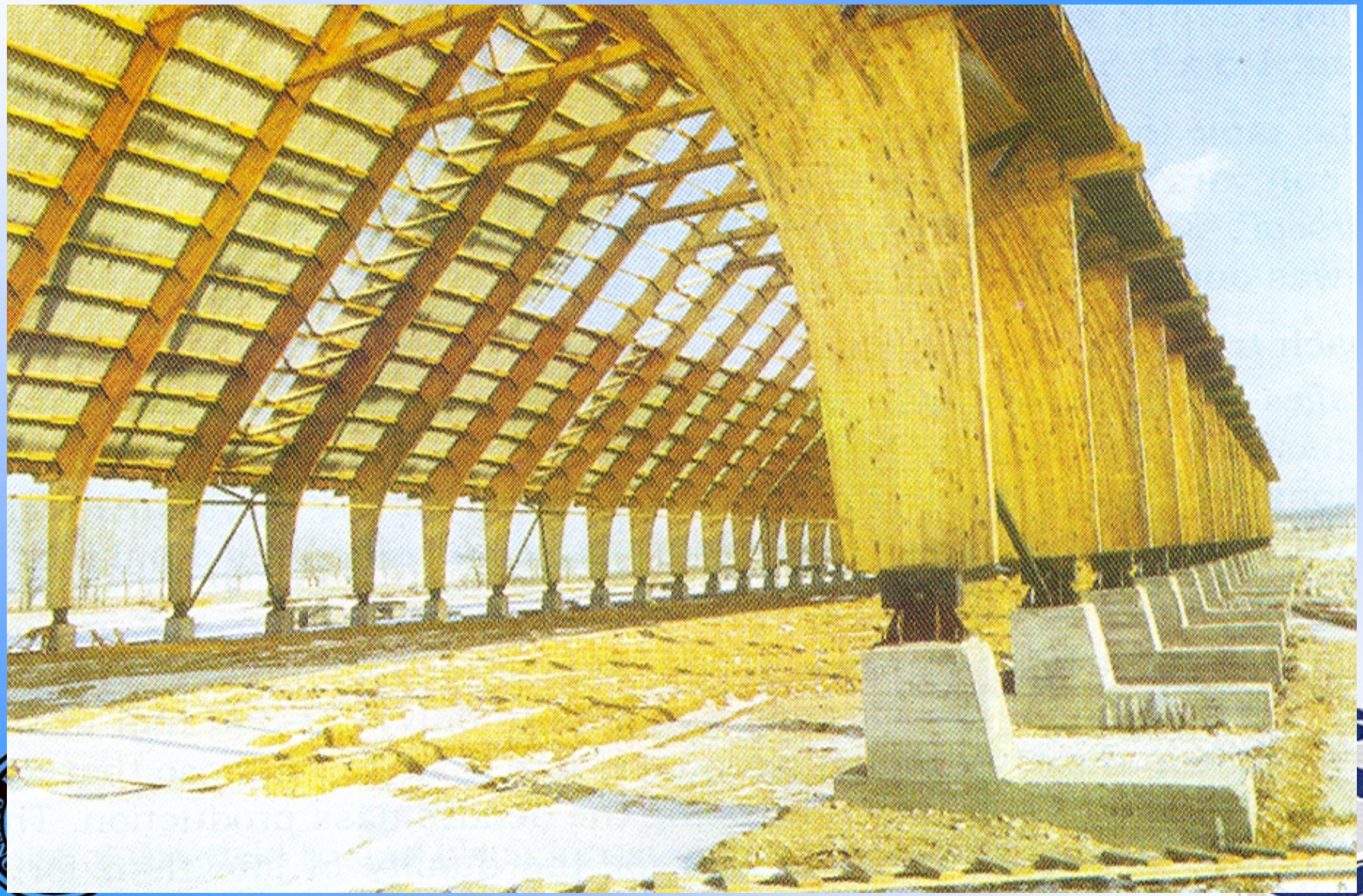
Props of robinia wood Photo: Molnar, L.



Robinia assortments of sawn wood Photo: Erdős, L.

Robinia outdoor furniture Photo: Erdős, L.

Glue-lam structure from robinia wood Photo: Erdős, L.



Walnut – distribution, facts

- The *Juglans* genus encompasses 15 species. **Two of these are relevant to the industry in Hungary: common walnut (*Juglans regia* L.) and black walnut (*Juglans nigra* L.).** From the ecological point of view, common walnut is one of the most precious tree species of the world, both its wood and fruit have ever been high in demand.
- Common walnut is native to the Balkan Peninsula and Asia Minor, and it has spread over the Northern Hemisphere everywhere in the temperate zone, from the plains to the mountains of medium height. It thrives on deep, nutrient-rich soil. Primarily, walnut is planted for horticultural purposes in Hungary, yet, the largest orchards are found in France and California. The Hungarian Forest Research Institute (Budapest) has obtained promising experimental results as far as the establishment of **dual-purpose plantations** (fruit and timber) is concerned. Accordingly, walnut is recommended to be planted on a larger scale as yet in Hungary.

Walnut – morphological characteristics

- Usually, walnut grows 12-15 m tall, but 25-30 m tall giant specimens exist, too.
- The average trunk diameter is 0.4-0.5 m, and it may reach 0.8-1.0 m.
- The trunk forks at a low height, therefore, logs are seldom longer than 2.0-2.5 m.
- The tree develops a large, wide crown.
- The bark is hard, ash-grey, mostly smooth, but cracked at older trees.

Walnut – the tree

Walnut - macroscopic charactersitics/1

- The wide sapwood is light yellowish-grey, the heartwood dark grey with a brownish tinge.
- The irregular annual rings often stand out in the heartwood as dark lines. Earlywood and latewood within the annual ring are more or less distinct, the latter showing smaller vessels.
- Walnut is a semi-ringporous tree species.
- The longitudinal section displays characteristic, noticeable, irregular grooves (traces of the large vessels). The radial section is striped, the tangential section presents a rather decorative texture.

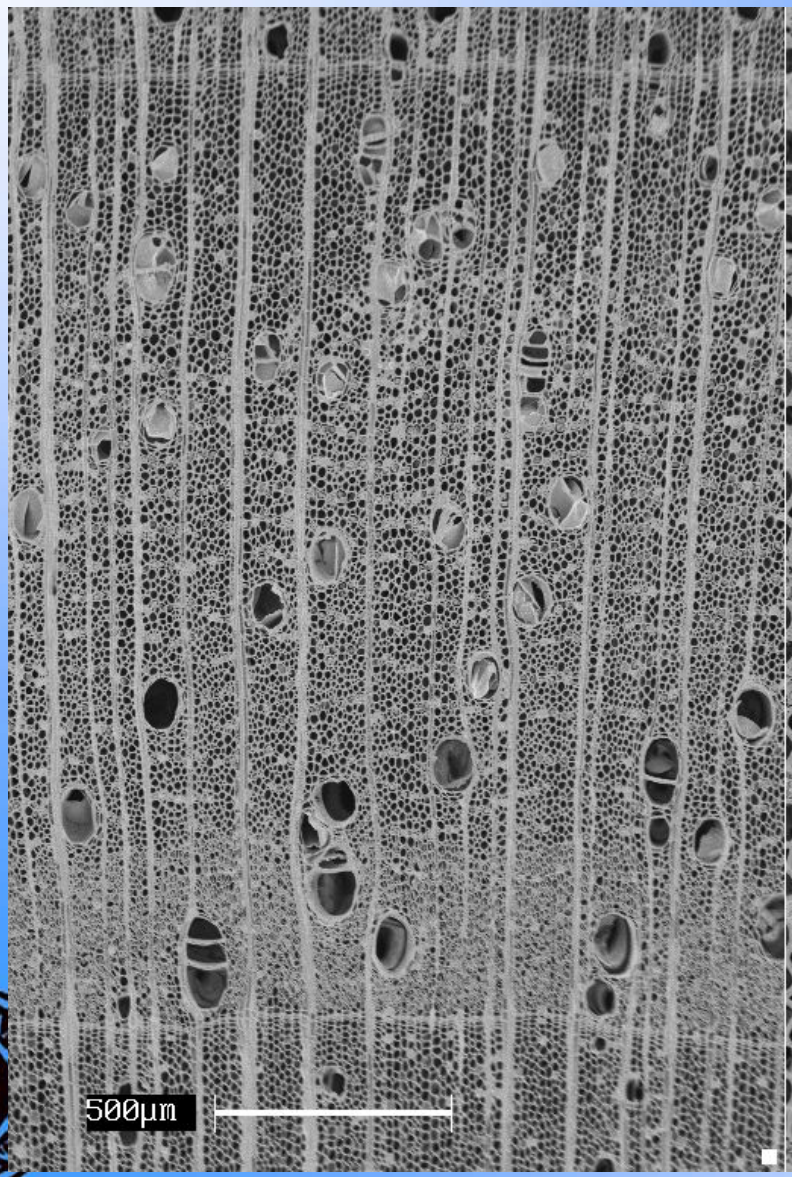
Walnut

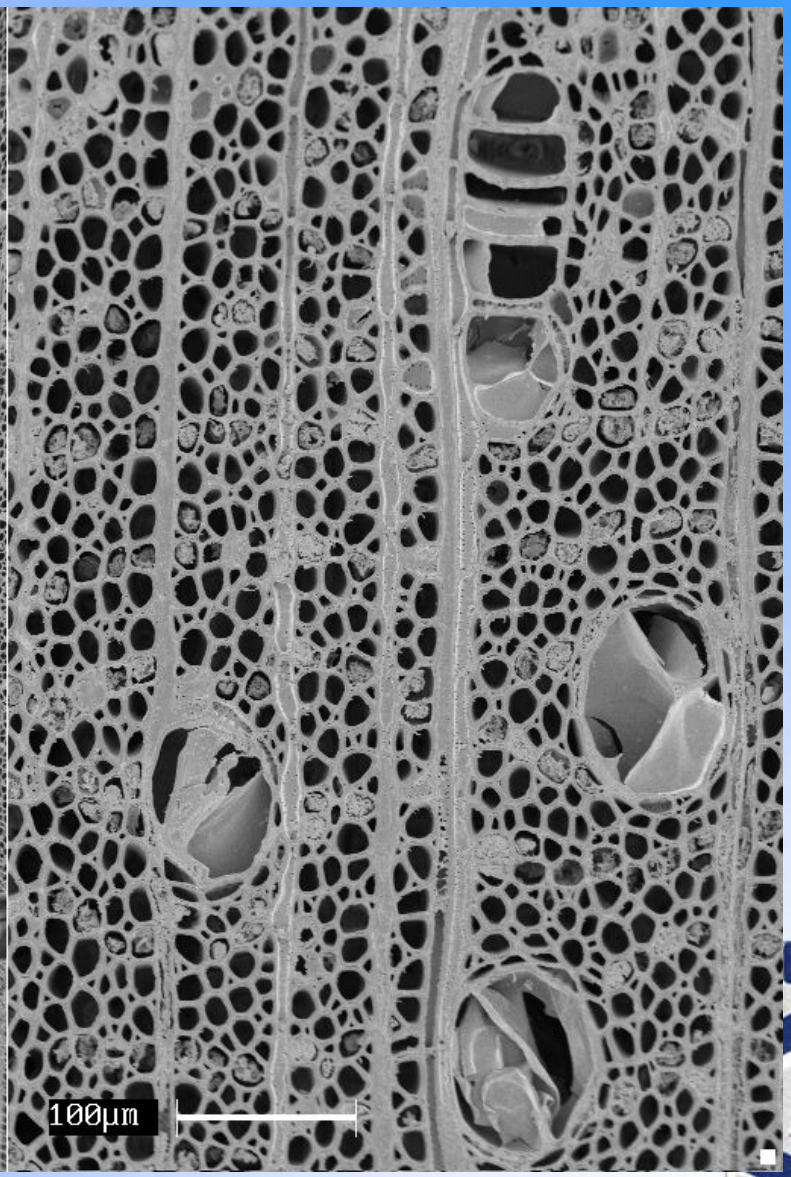
macroscopic charactersitics/2

Walnut - microscopic charactersitics/1

- Vessels are wide in the earlywood (200 μm) and well visible even in the latewood where they are arranged in short radial rows.
- Rays are only 1-5 cells wide and often heterogeneous in the composition.
- Longitudinal parenchyma forms tangential bands in the latewood, occasionally, touching the vessels.
- The bulk of the substance consists of fibre tracheids in the first place.

Walnut - microscopic charactersitics/2





Walnut – defects, damages, durability

- The trunk is often crooked, buttressed and twisted.
- Frost ribs occur.
- Living trees are likely to be infected by *Polyporus* and *Fomes* fungi, and the wood is often attacked by Goat moth (*Cossus cossus*).
- Walnut is not weather-resistant, and so it is classified as little durable. The wide sapwood is particularly susceptible to fungi and insect damage.

Walnut – physical properties

Density (kg/m^3)	
oven-dry	450-640-750
air-dry (12% MC)	570-680-810
Shrinkage (%)	
longitudinal	0.5
tangential	7.5
radial	5.4
volumetric	11.4-12.2
Porosity (%):	57

Walnut – mechanical properties (MPa)

Compr. Str. longitudinally	47-72-89
Tensile strength	99-100-125
Bending strength	99-147-178
Shear strength (tang.)	7.0-9.0
Cleavage	0.6-0.9
Hardness (Brinell), end	70
side	52
MOE	12,500-13,000
Impact-bending str. (J/cm^2)	9.5-19.0

According to the figures, walnut is hard with a medium density, firm, tough, resilient, exerts medium shrinkage values, and splits easily.

Walnut – workability

- Walnut is easy to machine, carve, split, nail and glue.
- Surface treatment is not problematic either.
- It requires careful kiln schedules due to its inhomogeneous structure.
- The timber is often sawn live and stacked in boules.
- Solid wood blanks are easy to bend upon steaming.

Walnut - assortments

- The precious walnut trees are often harvested with the method of stump extraction.
- The stump provides veneer logs for slicing with a beautiful texture ("root veneer").
- Walnut yields the following assortments:
  - sawlogs,
  - veneer logs,
  - short and low quality logs,
  - other industrial wood and
  - firewood.

Walnut – utilization

This noble-looking, hard, tenacious wood can be utilised in many ways

- If possible, roundwood is converted into sliced face veneer and sawn wood.
- Furniture industry applies it for the production of classy furniture as solid wood as well as veneer.
- In buildings, it is requested for decorative panelling and flooring.
- Also musical instruments and weapons (rifle butts) are made of walnut.
- Machine parts and airplane propellers used to be manufactured from it, yet, it has been always a material high in demand at turning, carving, engraving and for making statues.

Ash – distribution, facts

- There are about 65 species in the *Fraxinus* genus. Most of them are native to North America and East Asia.
- Three species are indigenous in Hungary: Common ash (*Fraxinus excelsior*), Flowering ash (*Fraxinus ornus*) and Pannonian ash (*Fraxinus angustifolia ssp. pannonica*). The latter is actually a sub-species of the Pannonian ash, and the forestry and wood industry do not distinguish it from common ash.
- Common ash is a typical European tree species. In Hungary, it grows mainly in hills and mountains, but it is present on the Great Plain (Alföld) as well. It prefers moist, loose, deep soils, but tolerates drier sites as well. In the wood working practice, it is not distinguished from the morphologically fairly similar Pannonian ash. Their joint proportion of the total forest area is about 1.6-1.7%. Ash is frequently planted in parks and alleys.
- Regarding the wood, there is no significant difference between the various ash species, thus in the following, we will discuss only common ash, our most widespread species.

Ash – morphological characteristics

- Ash grows 20-35 m tall. Its longitudinal growth slows down after 40 years but continues until about 80.
- The breast height diameter is 0.3-0.6 m at harvesting age (80-100 years), but can reach 1.0 m as well.
- The trunk is usually regular, straight, cylindrical. The branch-free bole may be as long as 15 m.
- The bark remains smooth for a long time, later with greyish-brown, diamond-shaped cracks. The oddly pinnate, spear-shaped leaflets grow in sets of 9-15.

Ash – the tree

Ash - macroscopic characteristics

- Sapwood and heartwood have the same yellowish-white colour until about the age of 60. Thereafter, the heartwood becomes darker, light brown, often striped.
- It is a ring-porous species. The large vessels in the earlywood (250 μm) are arranged in concentric rings. Latewood vessels are narrower (50 μm), as tiny light dots still visible to the naked eye.
- Ray flecks dot the radial section.
- Because of the marked difference between the anatomical structure of earlywood and latewood, the radial section is rather striped, and the tangential section shows a pleasing texture.

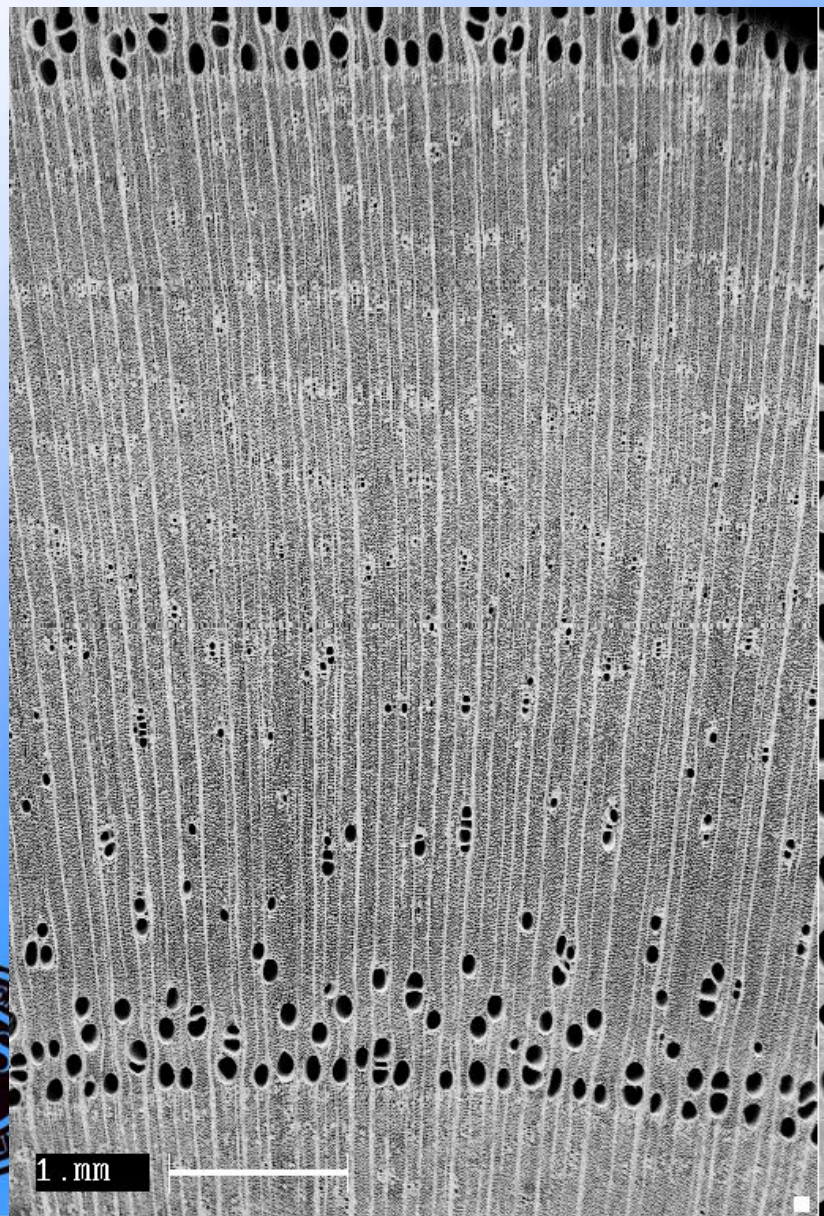
Ash

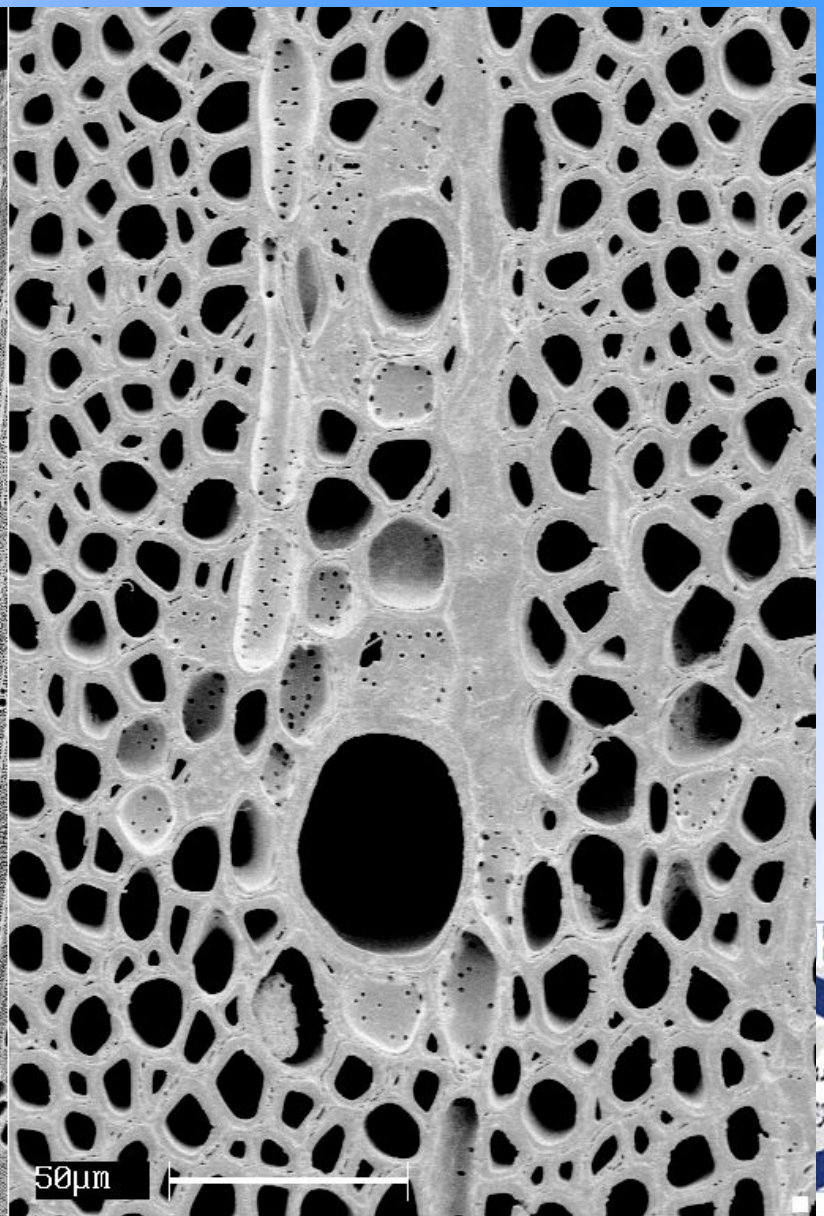
macroscopic charactersitics/2

Ash - microscopic charactersitics/1

- The proportion of vessels is about 12%. Tyloses forms mainly in older trees. The thick-walled vessels of the latewood are scattered, sometimes arranged into short radial rows.
- There is a relatively high amount of longitudinal parenchyma (10.6%), ordered partly paratracheally around the vessels, and partly marginally along the annual ring boundaries. Rays are narrow (1-3 cells) but relatively high (8-12 cells), and amount to 15% of the tissue. The fibres, that furnish the timber with strength, have relatively thin walls but a high volume proportion (62.4%).

Ash - microscopic charactersitics/2





Ash – defects, damages, durability

- Sweep, forking and twisted grain are frequent problems.
- Frost cracks and false heartwood occur, too.
- As far as wood quality is concerned, red deer causes probably the most serious damage to living trees (bark stripping and chewing).
- Built-in wood is often attacked by fungi and insects.
- Because the wood is not weather resistant, it is recommended essentially for indoor use at dry places.

Ash – physical properties

Density (kg/m^3)	
oven-dry	410-650-820
air-dry (12% MC)	450-690-860
Shrinkage (%)	
longitudinal	0.2
tangential	8.0-8.4
radial	4.6-5.0
volumetric	12.8-13.6
Porosity (%):	57

Ash – mechanical properties (MPa)

Compr. Str. longitudinally	23-52-80
Tensile strength	70-165-293
Bending strength	58-105-210
Shear strength (tang.)	9.0-12.0-14.6
Cleavage	0.7
Hardness (Brinell), end	36-65-100
side	41-74-115
MOE	4,400-13,400-18,100
Impact-bending str. (J/cm^2)	6.8

Ash – workability

- Right following felling, the ends of valuable ash logs should be protected.
- Trunks with narrow annual rings are especially suitable for veneer production. Hydrothermal treatment (steaming) is necessary before slicing.
- Band sawing is the recommended way of processing. Usually, the machining of wood is without problems.
- It is easier to dry than oak, but still requires proper skill. Darkening of lumber may be prevented by using vacuum dryers.
- Upon steaming, it is uncomplicated to bend.
- Glue may seep through the large vessels in thin veneers.
- In order to avoid discoloration, cleanliness is a prerequisite at surface treatment. Open-pore surface treatment methods are customary, producing a better aesthetic effect.

Ash - assortments

- Logs for (sliced) veneer
- Sawlogs
- Short and low quality logs
- Other industrial wood
- Firewood

Ash – utilization

- Because of its decorative texture, ash is widely applied in the furniture industry and in interior finishing (veneered furniture fronts, chairs etc.).
- Trunks with wide annual rings are best for manufacturing sporting gadgets and tool handles.
- Boats, ship components and ornaments can also be made of ash.
- In the past, it used to be an important species for cartwrights as well.
- Ash is a standard material for particleboard and fibreboard production, and an excellent firewood.

Conclusions

- The forest area in Hungary will increase in the next decade up to 800,000 ha (robinia & walnut plantations could have a considerable share).
- Robinia and walnut are fast-growing, with high dry matter production, suitable for energy plantations as well.
- High quality products from high quality roundwood from plantations are possible, such as parquets, indoor and outdoor furniture from robinia, walnut and ash.
- Plantations have high social impact in rural areas (short rotation time - workplaces, fuelwood, bee-forage-robinia)

References

- S. Molnar, M. Bariska, 2002:
  Wood Species of Hungary, Szaktudás Kiadóház, Bp.
- Growing Robinia, Hungarian Forest Res. Inst, 2000.
- www.cost-e44.be/
  WOOD PROCESSING STRATEGY