Who talks about wood?

...just foresters, civil engineers, conservationists, environmentalists, climatologists, museologists, wood scientists, industry, designers, architects, artists, linguists, lawyers and many others...

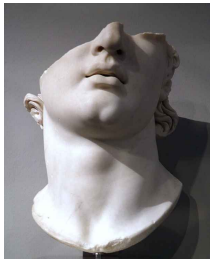
Václav Sebera

„We may use wood with intelligence only if we understand wood“ (F. L. Wright)

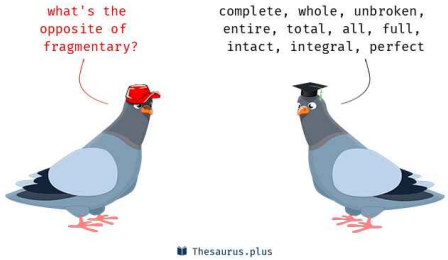
Praying Wood, Krištof Kintera, 2014

Mendelova univerzita v Brně
MENDELU Faculty of Forestry and Wood Technology

Fragmentary approach



From the Pergamon Gymnasium, Hellenistic period, 2nd century BCE (Pergamon Museum, Berlin)



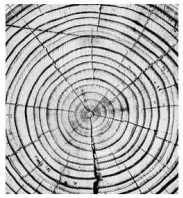
SHATIS22 *7. – 9. 9. 2022, Prague*

SHATIS22
MENDELU Faculty of Forestry and Wood Technology

I. Wood *vs.* Tree *vs.* Forest/Woods

Material vs. **single living organisms** vs. **society of organisms**

***widhu-** (PIE), meaning “*wood*”, “*tree*” and “forest”, then ***widhu** --> ***widu** (Old High German & Old English --> **wudu** (Old English) --> **wood**



SHATIS22
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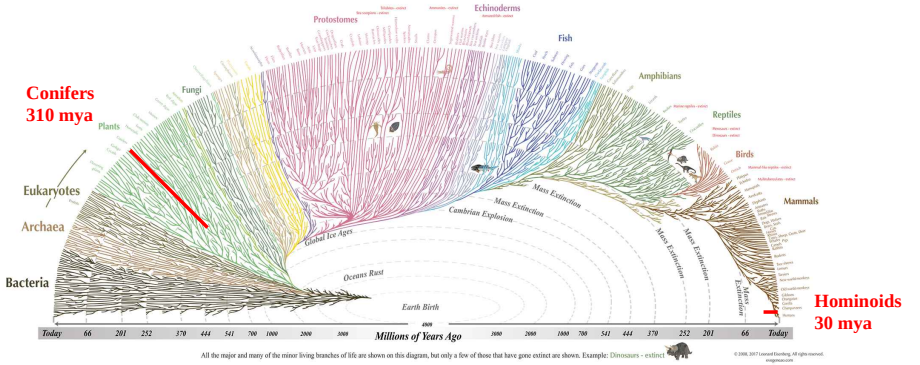
I. Evolution of Trees via “*Tree of life*”



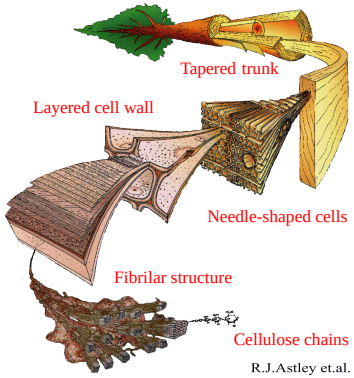
https://www.evogeneao.com/en

I. What can wood be?

I. Wood as structure

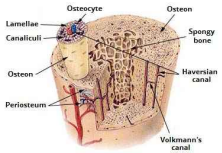
Natural **hierarchical** bio-**composite** on a **polymeric** basis
Anisotropic heterogeneous material
Highly **hygroscopic**
Material with a **high aesthetic** and **social** value
Traditional and **modern** material in most cultures
Important structural and industrial material coming from "**renewable**" resources
Carbon-based material (~ 50 % p. w.)
...and many others

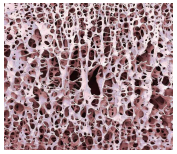
+ Wood structure changes dramatically with time
...with respect to surrounding conditions



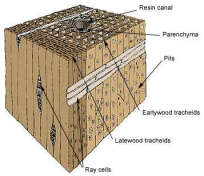
I. Anisotropic elasticity: Wood *vs.* Bone

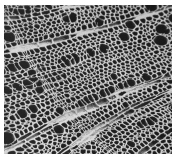
Bones





Wood





Human femural bone at 4 positions

A_C = {0.6-3.2} %

A_S = {0.6-4.7} %

4 spruce species, resonant wood

A_C = {48-65} %

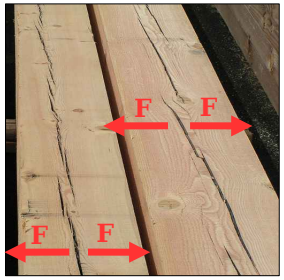
A_S = {71-87} %

* Compression anisotropy factor (A_C)
* Shear anisotropy factor (A_S)

Katz and Meunier (1990) A generalized method for characterizing elastic anisotropy in solid living tissues

I. Wood & its imperfections

Wood = ***material of perfect imperfections*** (knots, pithrays, drying cracks, spiral grain, density variations in wood cell, tree ring, tree diameter, creep etc.)
Reduce stiffness, strength etc.



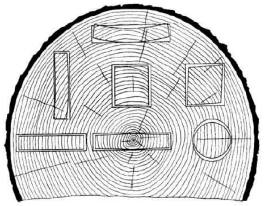


Figure 4–3. Characteristic shrinkage and distortion of flat, square, and round pieces as affected by direction of growth rings. Tangential shrinkage is about twice as great as radial.

Wood Handbook 2010, FPL USDA.

I. Wood & its imperfections

Wood = ***material of perfect imperfections*** (knots, pithrays, drying cracks, spiral grain, density variations in wood cell, tree ring, tree diameter, creep etc.)
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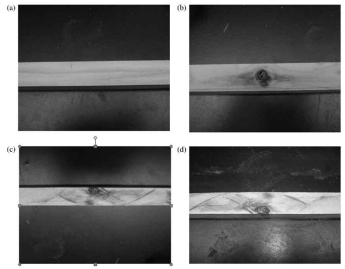
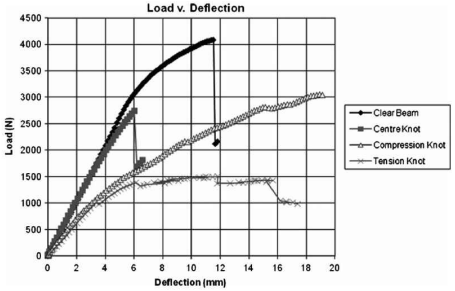




Betts SC et al. (2010) Location of the neutral axis in wood beams: A preliminary study, Wood Material Science & Engineering

I. Wood & its durability

Wood = ***material full of tasty things*** (especially sugars from cellulose and hemicelluloses)
INSECT: min. moisture content 10 % (optimal 15-60 %), optimal T = 18-25 °C
FUNGI: min. MC about 18 %, optimal T = 20-35 °C

Photo taken from Botanical garden in Lyon

I. Wood & its durability

Wood = ***material full of tasty things*** (especially sugars from cellulose and hemicelluloses)
INSECT: min. moisture content 10 % (optimal 15-60 %), optimal T = 18-25 °C
FUNGI: min. MC about 18 %, optimal T = 20-35 °C
Abiotic factors modify wood significantly too

1 – B. Locust
2 – Pine
3 – Oak
4 – Douglas
5 – Maple
6 – Larch
7 – Alder
8 – Spruce
9 – Poplar

Oberhofnerová et al. (2017) Maderas. Ciencia y tecnología 19(2): 173 – 184.

I. Fungal wood protection

Self-healing facade using fungi (not wood destroying one)
Automatic regrowth, ..and when hungry, needs to add linseed oil

https://www.fungiforce.com/

I. Extending limitations of wood

- a.k.a. **Wood modification** (big field within Wood Science)
- Many techniques to improve physical (water related), mechanical props., and durability
- Provides improvement of certain properties for the sake of others **(purpose-oriented modification)**
- Thermowood, Acoya etc.

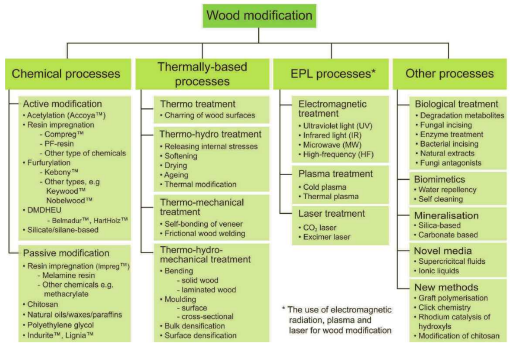
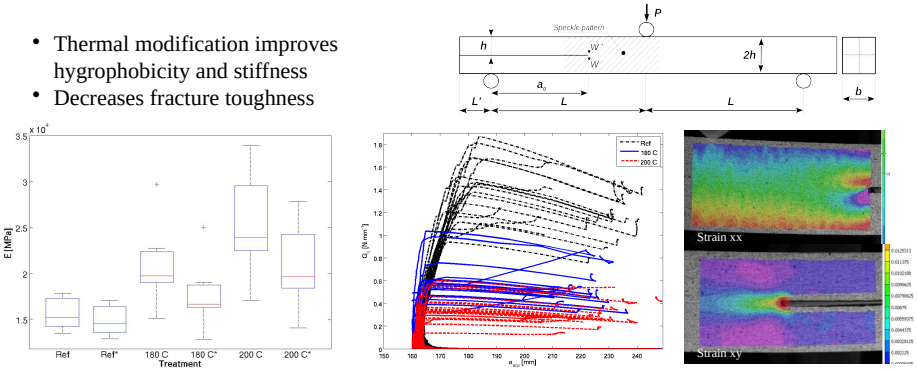


Figure 1.2 Classification of wood modification processes.
Sandberg et al., Wood modification technologies, principles, sustainability and need for innovation, 2021

I. Thermally modified wood

- Thermal modification improves hygrophobicity and stiffness
- Decreases fracture toughness

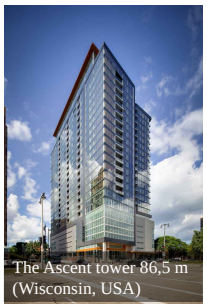


Sebera et al. 2019 Thermally modified (TM) beech wood: compression properties, fracture toughness and cohesive law in mode II obtained from the the three-point end-notched flexure (3ENF) test. Holzforschung 73.

II. Tree as a timber structure

Culture (CLT, GLT) *vs. Nature* (cylindrical system + roots)
Nature "*builds*" higher timber structures than people


Hyperion – 116 m (Sequoia sempervirens)


The Ascent tower 86,5 m (Wisconsin, USA)

Wikipedia Commons

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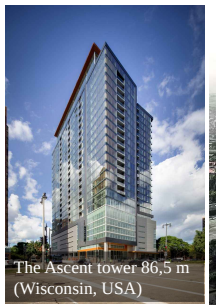
The Ascent tower 86,5 m (Wisconsin, USA)


The Dutch Mountains, 100 & 130 m, Eindhoven

Wikipedia Commons

https://www.thedutchmountains.nl/

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II. Tree as a timber structure

Culture (CLT, GLT) *vs. Nature* (cylindrical system + roots)
Nature "*builds*" higher timber structures than people

6-10x (up to 100x) more efficient as a conventional micropile system in developing tensile capacity on a per volume basis.

Matthew Burrall et al. 2020. Bioinspir. Biomim. 16 016009

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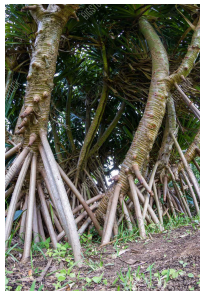
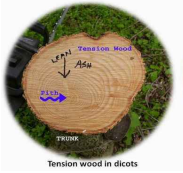
II. Tree as a timber structure

Adaptive structure *(morphology, structure)*
Trees survive what animals/people would not





Tension wood in dicots

Strength
Spruce ||

~ 40 MPa

~ 80 MPa

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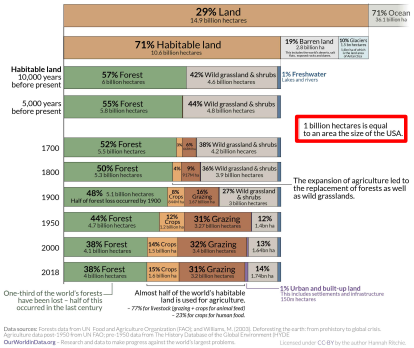
II. Forest as a society

Competitive and cooperative society of
Flora & Fauna (*Evolution pressure*)



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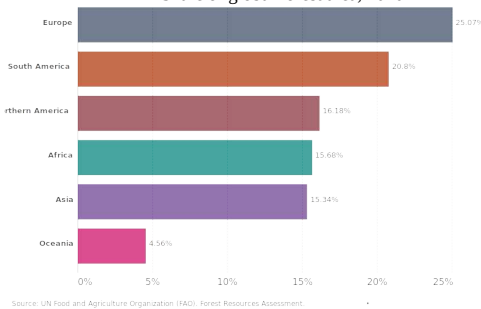
II. Forest as a society

Competitive and cooperative society of
Flora & Fauna (*Evolution pressure*)
Trying to reach equilibrium, but can't...

Wikipedia Commons

Share of global forest area, 2020



Source: UN Food and Agriculture Organization (FAO). Forest Resources Assessment

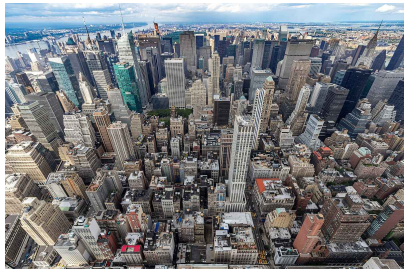
III. Extractivism

Extractivism = **extracting** and **processing natural resources from the Earth**
it is also seeing resource over the thing itself (ie. one sees stone mine over the beautiful land, wood over the beautiful forest etc.)


Wikipedia Commons

III. Extractivism

Extractivism = **extracting** and **processing natural resources from the Earth**
it is also seeing resource over the thing itself (ie. one sees stone mine over the beautiful land, wood over the beautiful forest etc.)
*we **would not have any material** without this process – **we are dependent on it!***




Wikipedia Commons

III. Extractivism

Wood has beed extracted a lot since 10 000 year ago
It transports material globally (market & oceanic drifts too)

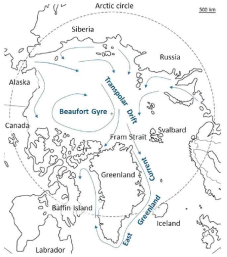


Wikipedia Commons

III. Extractivism

Wood has beed extracted a lot since 10 000 year ago
It transports material globally (market & oceanic drifts too)

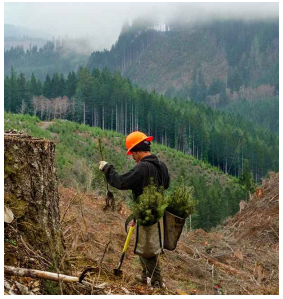




Wikipedia Commons

III. Extractivism

Wood has beed extracted a lot since 10 000 year ago
Wood can be extracted with "**an ease"** (+ it regrows)



https://oregonforests.org/reforestation

III. Deforestation of Central Europe

Forest land in Central Europe – **900 AD** vs. **1900 AD**

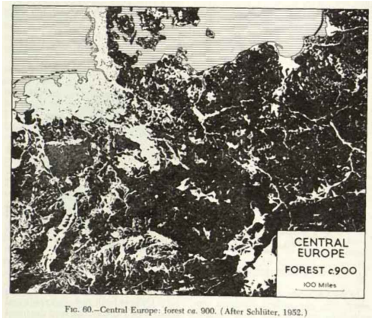


Fig. 60.—Central Europe: forest ca. 900. (After Schlüter, 1952.)

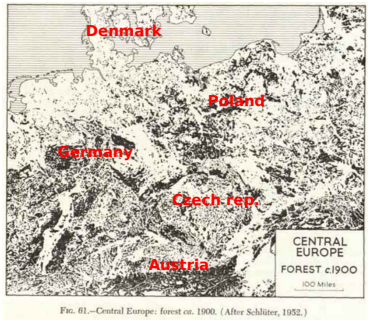
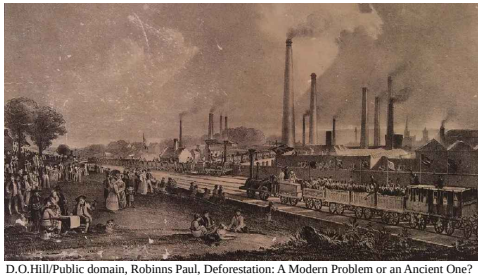


Fig. 61.—Central Europe: forest ca. 1900. (After Schlüter, 1952.)

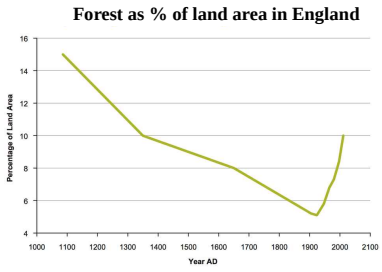
Darby, The clearing of woodland in Europe, in Man's Role in Changing the Face of the Earth, 1956

III. De/Re-forestation in England

Pasturing and heat source in middle ages
Fundamental material in industrial era
Not that needed in postindustrial society



D.O.Hill/Public domain, Robinns Paul, Deforestation: A Modern Problem or an Ancient One? 2022



Wikipedia - Forestry in the United Kingdom

III. De/Re-forestation in Adriatic area

First deforestation during Iron Age
Massive deforestation during Greeks and Romans (ships, baths, metallurgy, charcoal)
Bans of transhumance (Vienna act 1771), ban of goat breeding (1848-1890)
Last 100 years, massive replanting (policies)

Andrej Kranjc (2012) Dinaric Karst - An Example of Deforestation and Desertification of Limestone Terrain, Deforestation Around the World, Dr. Paulo Moutinho (Ed.)

III. Reducing extractivism

People try **to reduce extraction of materials and its consequences**

Reuse, recycle, repurpose, repair, degrowth, sustainability, circularity = *"environment friendly"*

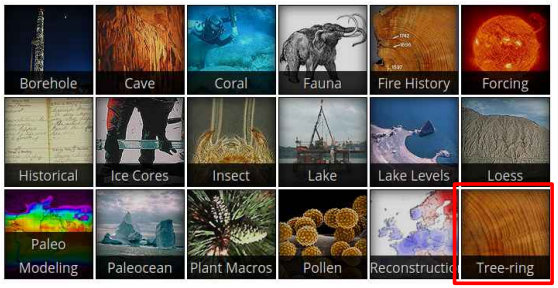
...impossible without individual and corporate responsibility

III. Reducing extractivism

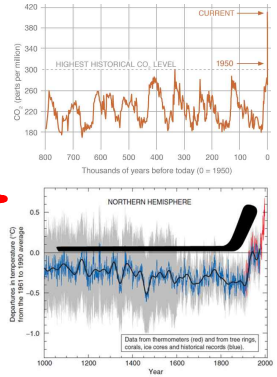
Repair & retrofitting of old constructions is "**sustainable act**"

IV. Wood & Climate

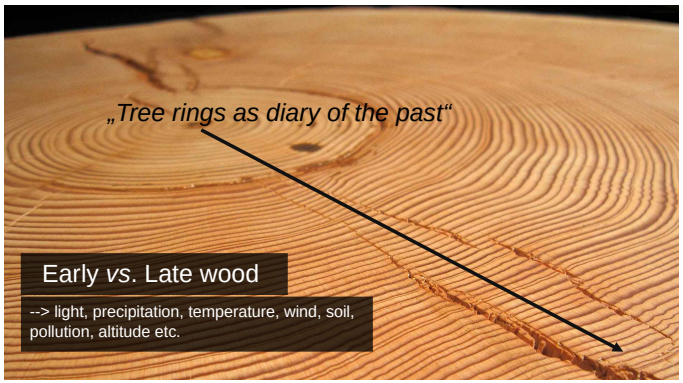
Wood is one of the pillars of climate reconstruction

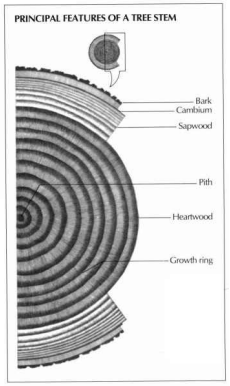


Source: NOAA



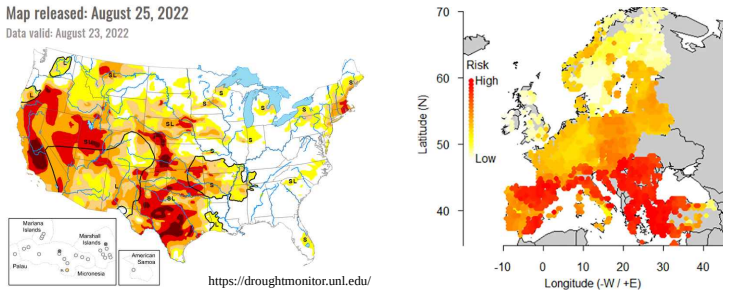
IV. Wood & Climate





IV. Forest & Climate

Climate models predict an increase in the intensity and frequency of droughts in the N. Hemisph.
Tree mortality increases with combination of heat waves & droughts & insect



Gazol and Camarero (2022) Compound climate events increase tree drought mortality across European forests, Science of The Total Environment 816.
Andrus et al (2021) Increasing rates of subalpine tree mortality linked to warmer and drier summersJ. Ecol., 109

IV. Forest & Climate

Diverse forest stand cope better with pests, but what about droughts? **...not a scientific consensus!**
Managing forest ecosystems for high tree species diversity does not necessarily assure improved adaptability to the more severe and frequent drought events predicted for the future.

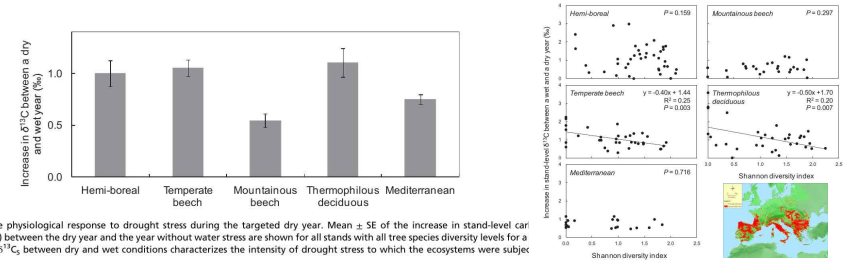
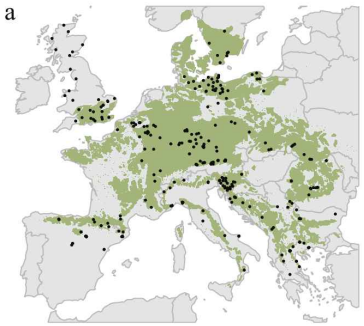


Fig. 1. Intensity of the physiological response to drought stress during the targeted dry year. Mean ± SE of the increase in stand-level car composition ($\Delta\delta^{13}C_s$, ‰) between the dry year and the year without water stress are shown for all stands with all tree species diversity levels for a type. The increase in $\Delta\delta^{13}C_s$ between dry and wet conditions characterizes the intensity of drought stress to which the ecosystems were subjec

Grossiord et al. (2014). Tree diversity does not always improve resistance of forest ecosystems to drought. PNAS, 111(41), 14812–14815. doi:10.1073/pnas.1411970111

IV. Forest & Climate

324 study plot of European beech (*Fagus Sylvatica* L.) around Europe



Climate-change-driven growth decline of European beech forests, COMMUNICATIONS BIOLOGY | (2022) 5:163 | https://doi.org/10.1038/s42003-022-03107-3

IV. Forest & Climate

324 study plot of European beech (*Fagus Sylvatica* L.) around Europe
Severe future growth declines ranging from **−20% to more than −50% by 2090**, depending on the region and climate change scenario
Mostly in persisting atmospheric high-pressure systems
Except Denmark, Norway and Sweden, all will decline

- **So should we plant Beech trees at all?**
- **...or what should we plant?**

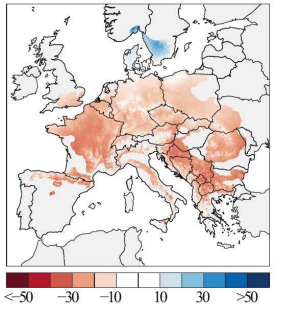


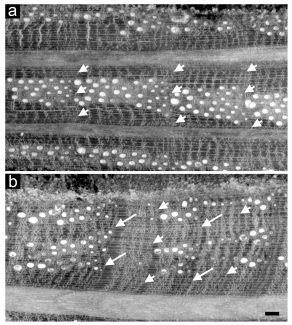
Fig. 3 The spatial pattern of beech growth changes across Europe. Tree growth changes are expressed in percent BAI change from 1986 to 2016 relative to the 1955–1985 period mean.

Climate-change-driven growth decline of European beech forests, COMMUNICATIONS BIOLOGY | (2022) 5:163 | https://doi.org/10.1038/s42003-022-03107-3

IV. Wood & Climate

tree species have different strategies to deal with stress at different sites conditions → different wood formation (**xylogenesis)**
Ring porous species such Oak modifies its **Intra-annual density fluctuations (IADF)** when exposed to drought
- **--> Impact on mechanical behavior**!

Strategies differs in **pure** and **mixed stands** and should be reflected in **forest management**



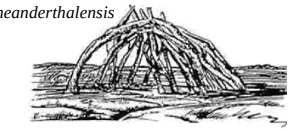
Light microscopy views of cross sections of tree rings of *Quercus ilex* without (a) and with IADFs (b). Arrowheads point the boundaries of tree rings; arrows point to the IADF. Bar: 100 µm.

Front. Plant Sci., 2019, Sec. Functional Plant Ecology, https://doi.org/10.3389/fpls.2019.00397

V. Timber structures

Used since very long time (to height and big spans)
Easy to produce, thermal insulation, mechanical properties

120 000 – 40 000 BCE
Homo neanderthalensis



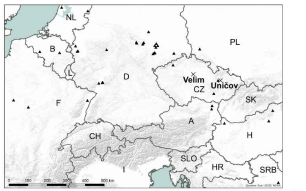
4500 – 1500 BCE
Longhouse

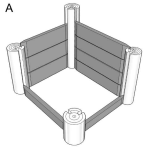
Kuklík P. (2005) Dřevěné konstrukce; Handbook 1 – Timber Structure

https://www.thebalancesmb.com/what-is-glulam-applications-and-advantages-of-glulam-845106

V. Timber structures

The oldest wooden and dated structure found (**5256 BCE**)
Stone Age water well
Sophisticated carpentry wooden joints were found
Discovery of wooden structure has huge impact on historiography (**it changes history textbooks**)

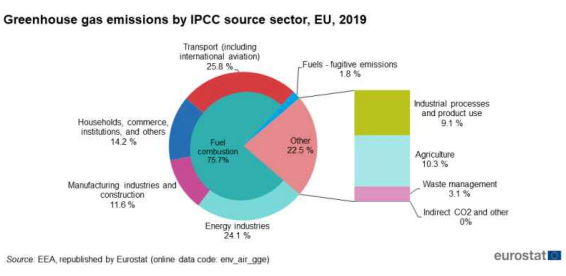


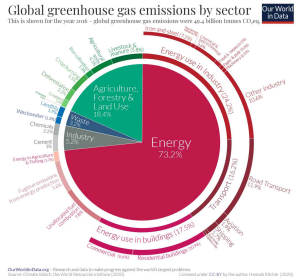


Rybníček et al. (2018) New dendroarchaeological evidence of water well constructions reveals advanced Early Neolithic craftsman skills. Dendrochronologia, 50, 98–104.
Rybníček et al. (2020) World's oldest dendrochronologically dated archaeological wood construction. Journal of Archaeological Science 115 (2020) 105082

V. Timber structures & Climate

Construction sector **15-30 % of GHG emissions (depends on methodology)**
What carbon footprint have structures from different materials?





Construction sector = manufacturing + transportation + energy use + others

V. Timber structures & Climate

Construction sector **20-30 % of GHG emissions**

What carbon footprint have structures from different materials?

LCA of 5storey building
- timber
- hybrid
- concrete

EN 15978:2011; Sustainability of Construction Works—Assessment of Environmental Performance of Buildings-Calculation

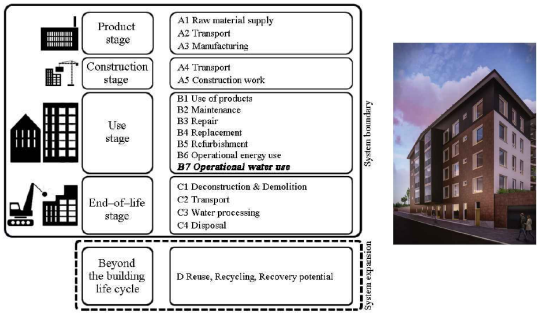


Figure 9. Assessment system boundary based on EN 15978. (The bold and italics stage was not included in this analysis).

Rinne et al (2022) Comparative Study on Life-Cycle Assessment and Carbon Footprint of Hybrid, Concrete and Timber Apartment Buildings in Finland. Int. J. Environ. Res. Public Health 2022, 19, 774.

V. Timber structures & Climate

Overall, 1st Timber, 2nd Concrete, 3rd Hybrid
Timber is "**bad**" in stages **B1-B5** and **C1-C4**
Incl. D --> Hybrid is better option than pure concrete (sagging, acoustics)

[kg CO_2e]

Module	Hybrid	Concrete	Timber
A1–A3 Product stage	403,951	409,932 (+1.5%)	292,901 (–27.5%)
A4 Transport	11,529	13,736 (+19.1%)	5140 (–55.4%)
A5 Construction work	37,103	37,103	37,103
B1–B5 Use of products and Refurbishment	51,457	51,341 (–0.2%)	62,261 (+21.0%)
B6 Operational energy use	761,472	752,501 (–1.2%)	773,006 (+1.5%)
C1–C4 End-of-life stage	35,061	28,732 (–18.1%)	44,627 (+27.3%)
In total	1,300,573	1,293,345 (–0.6%)	1,215,038 (−6.6%)
D Beyond the building life cycle	–167,572	–121,058 (–27.8%)	–245,590 (+47.2%)

Rinne et al (2022) Comparative Study on Life-Cycle Assessment and Carbon Footprint of Hybrid, Concrete and Timber Apartment Buildings in Finland. Int. J. Environ. Res. Public Health 2022, 19, 774.

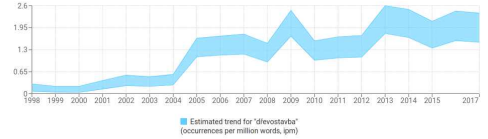
VI. Timber structures in Czech language

New timber family houses – **2000: 1,4 %**, **2020: 15,6 %**
Language as a mirror ("*reflects what people wish or do*")

VI. Timber structures in Czech language

New timber family houses – **2000: 1,4 %**, **2020: 15,6 %**
Language as a mirror ("*reflects what people wish or do*")
"***Timber structure***" frequency rises in 20 years

Frequency of using "***Timber structure***" in Czech language

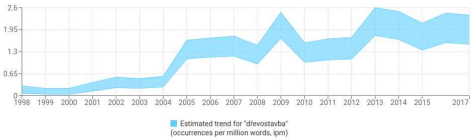


Source: syn_v7 / nationwide press, more detailed information: výsledky v SYN verze 7 (KonText)

VI. Timber structures in Czech language

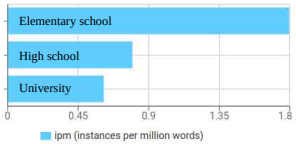
New timber family houses – **2000: 1,4 %**, **2020: 15,6 %**
Language as a mirror (“*reflects what people wish or do*”)
“***Timber structure***” frequency rises in 20 years
Mostly people without university degree talk about it
Men talk about it more than Women

Frequency of using “***Timber structure***” in Czech language

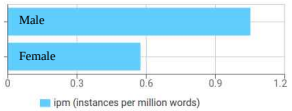


Source: syn_v7 / nationwide press, more detailed information: výsledky v SYN verze 7 (KonText)

Education



Birth sex



Source: oral_v1, more detailed information: frekv. distribuce v KonTextu

VII. Tree/forest & law

Tree/forest as **client of lawyer** suing human kind

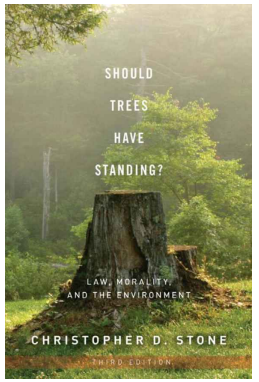
Different species (humans) are interfering, poisoning and destroying its **habitat** and **right** for **decent life**

Can **natural objects** have **rights**?

Is it **moral**, **legitimate** and **legal** case?

How would „***Natural court***“ decide?

...some answers in the book



Stone, Christopher D. Should trees have standing? Law, morality, and the environment. 3rd ed. Oxford University press, Inc.. 2010

Thank you for attention & Questions?

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