



HAL
open science

Wood anatomical characters: Are they good climatic markers?

Anais A Boura

► **To cite this version:**

Anais A Boura. Wood anatomical characters: Are they good climatic markers?. Congrès Paléobotanique et Evolution du monde végétal: quelques problèmes d'actualité, May 2007, Paris, France. hal-03665589

HAL Id: hal-03665589

<https://hal.science/hal-03665589>

Submitted on 5 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

WOOD ANATOMICAL CHARACTERS: ARE THEY GOOD CLIMATIC MARKERS?

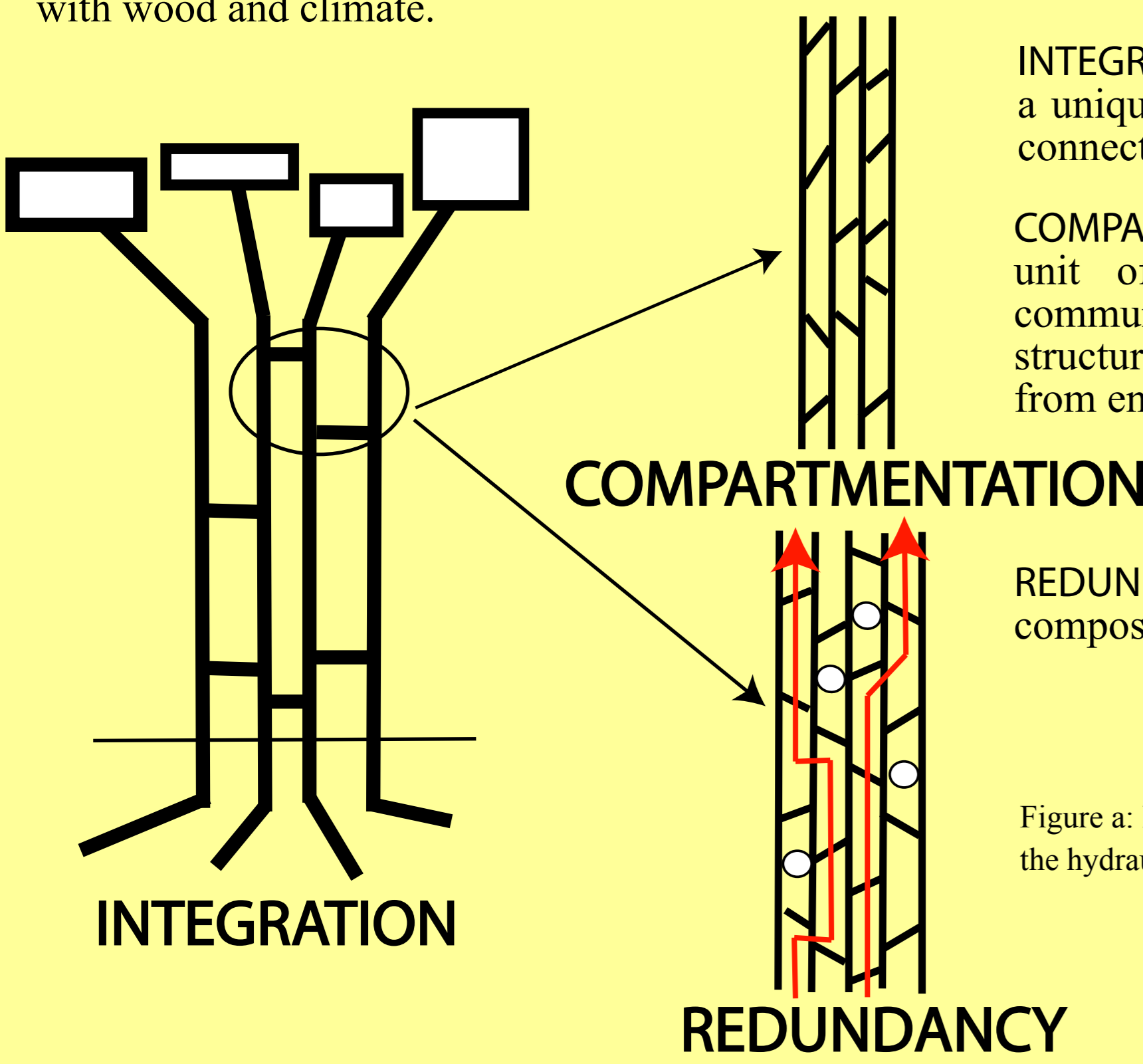
BOURA Anaïs
UMR-CNRS-MNHN n°5143, 8 rue Buffon MNHN, CP 38, 75005 Paris, France. Email: boura@mnhn.fr

Since a long time, it has been admitted that climate has an effect on wood anatomical characteristics. Some wood blemishes happen after a very cold winter. What is more, it is not rare to see on a wood sample, two consecutive tree-rings with very different sizes. It then exists, for one tree, "good years", during which wood production is very important and "bad years" in which, on the contrary, this production drop. These characteristics regarding wood production are usually used in studies dealing with wood and climate.

The main function of wood is sap conduction; water ascends plants in a stable state of tension at negative pressure. Water is a limiting factor in several habitats (cold and dry areas), and a lack of water can lead to a gaseous embolism of the hydraulic system of the tree. Embolism or cavitation is the abrupt change from liquid water under tension to vapour. Several properties of the hydraulic system allow the tree to recover to embolism; integration, compartmentation and redundancy (Figure a).

Summer embolism (water stress-induced embolism or "air seeding" hypothesis): is due to the difference of pressure between an empty vessel and the adjacent functional vessel. The gas bubble will be trapped at the pit membrane until the pressure difference between the vessels becomes great enough for a small bubble to be drawn through a pore into a functional vessel where it may nucleate a new cavitation (Figure b).

Winter embolism (freeze-thaw embolism): is due to gases that are less soluble in ice than in the liquid sap. Freezing of the sap forces gases out of solution to form bubbles in the ice. On thawing, these bubbles can either dissolve back into the sieve or they can grow to obstruct the entire xylem conduit. Size of bubbles increases with vessel diameter (Figure c).



INTEGRATION: The hydraulic system of the tree forms a unique network in which any root is more or less connected to any branch.

COMPARTMENTATION: Each vascular element is a unit of the hydraulic system of the tree in communication with other element by special structure, the pits. Pits protect the conductive system from entrance of air.

REDUNDANCY: The hydraulic system of the tree is composed of several pipes in parallel

Figure a: Illustration of the three main qualitative characteristics of the hydraulic architecture of a tree. From Cruiziat *et al.* (2002).

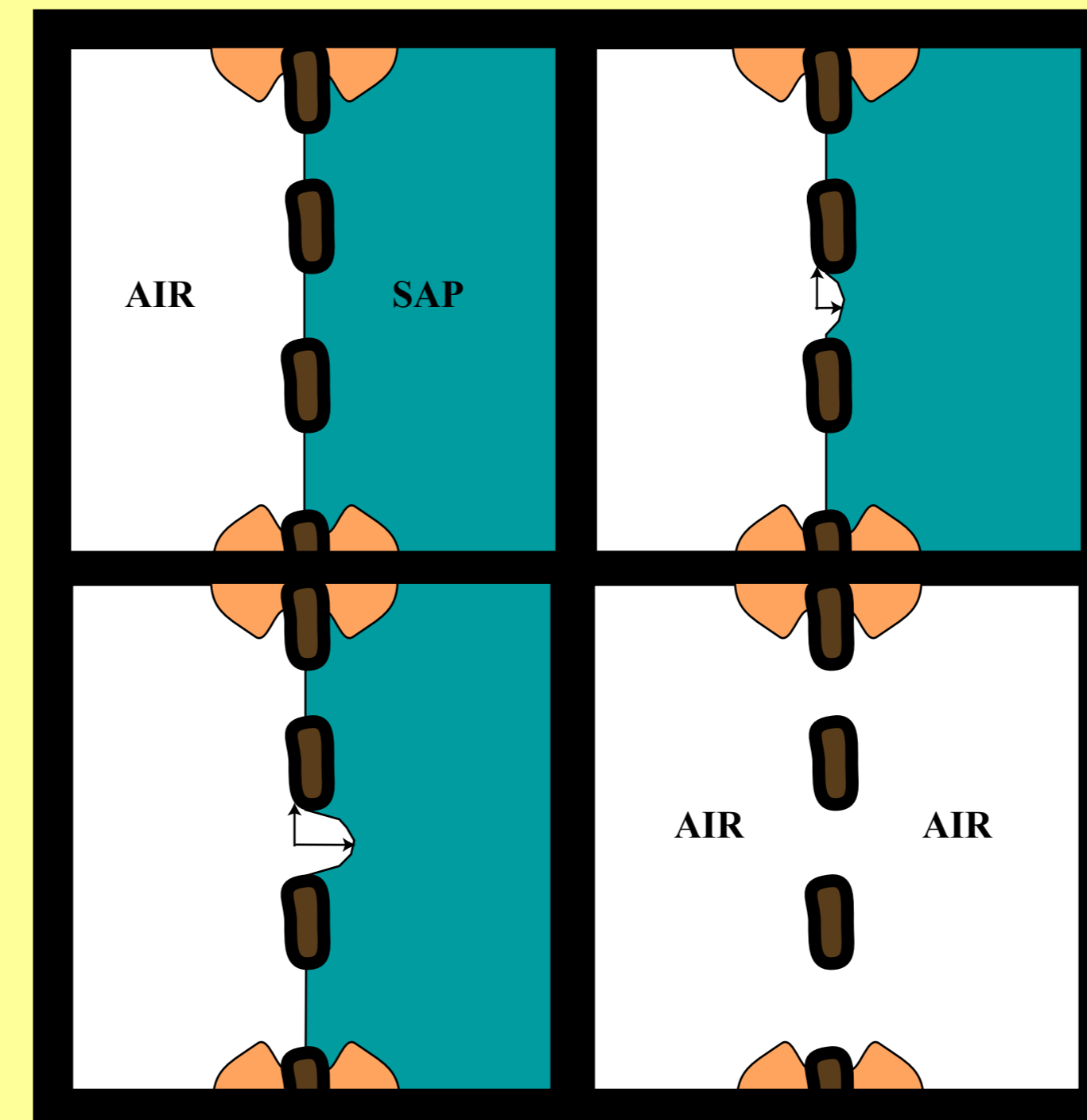


Figure b: Water stress-induced embolism. Adapted from Cruiziat *et al.* (2002).

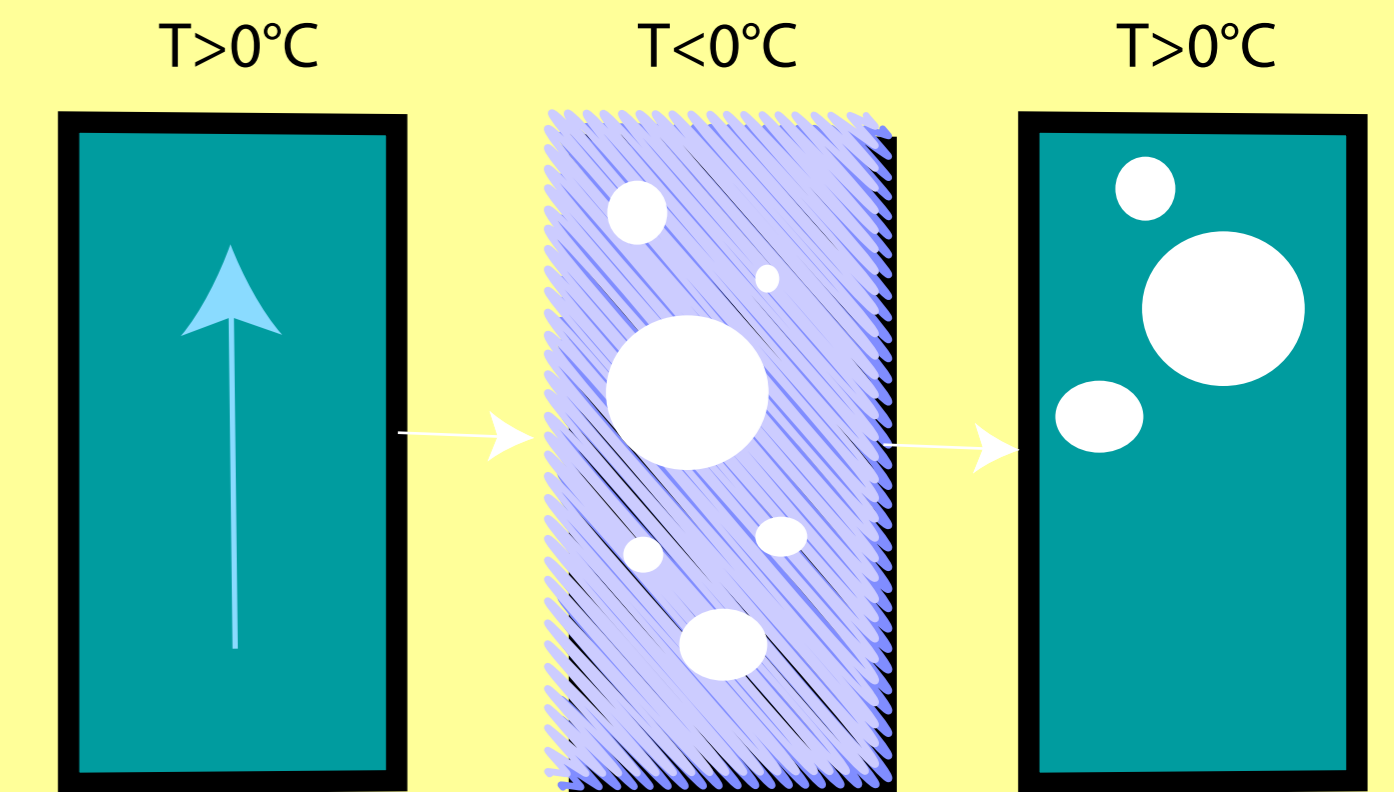
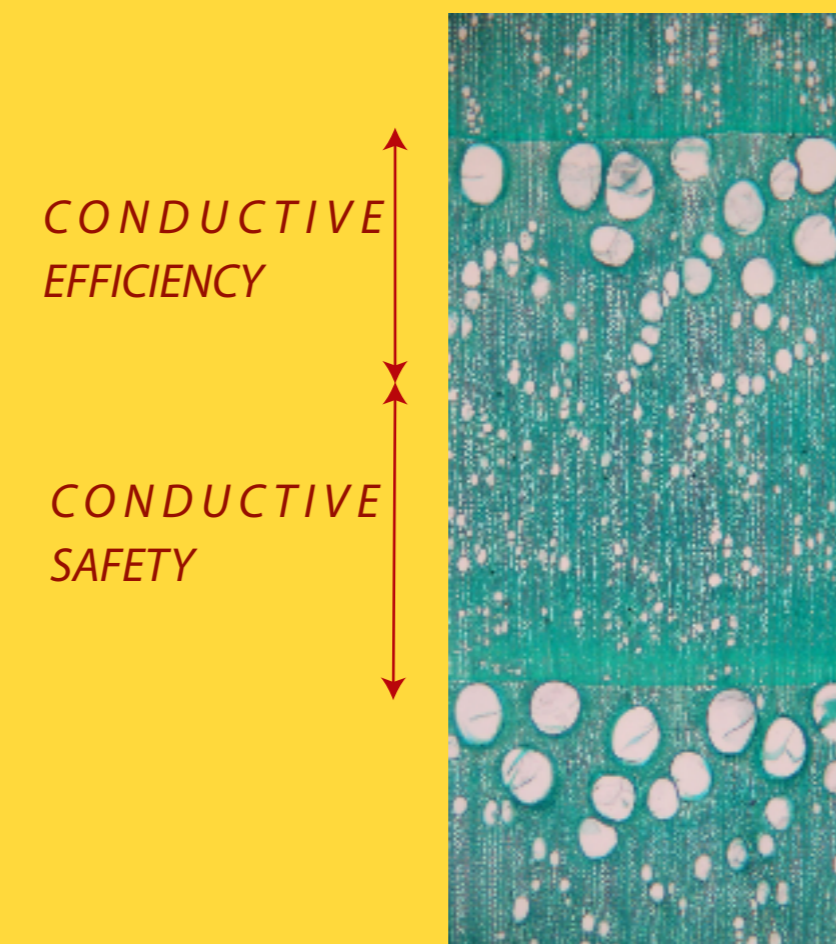


Figure c: Freeze-thaw embolism. Adapted from Cruiziat *et al.* (2002).

This work is a bibliographic summary, which presents wood anatomical adaptation of characters related to vessels and fibres to climatic constraints threatening the tree hydraulic efficiency.

GROWTH-RING: Ring porosity provide the reversibility of vessel diameter and vessel density in a single season; initial wood provide conductive efficiency, final wood conductive safety (Figure 1).

Figure 1: Transverse section. *Castanea sativa*. Scale bar = 1 mm



VESEL DIAMETER: Small diameter vessels are less vulnerable to freeze-thaw embolism (Figure 2 & Figure 3).

Figure 2: Transverse section. 1-*Corylus avellana*. 2-*Dombeya pilosa*. Scale bar = 1 mm.

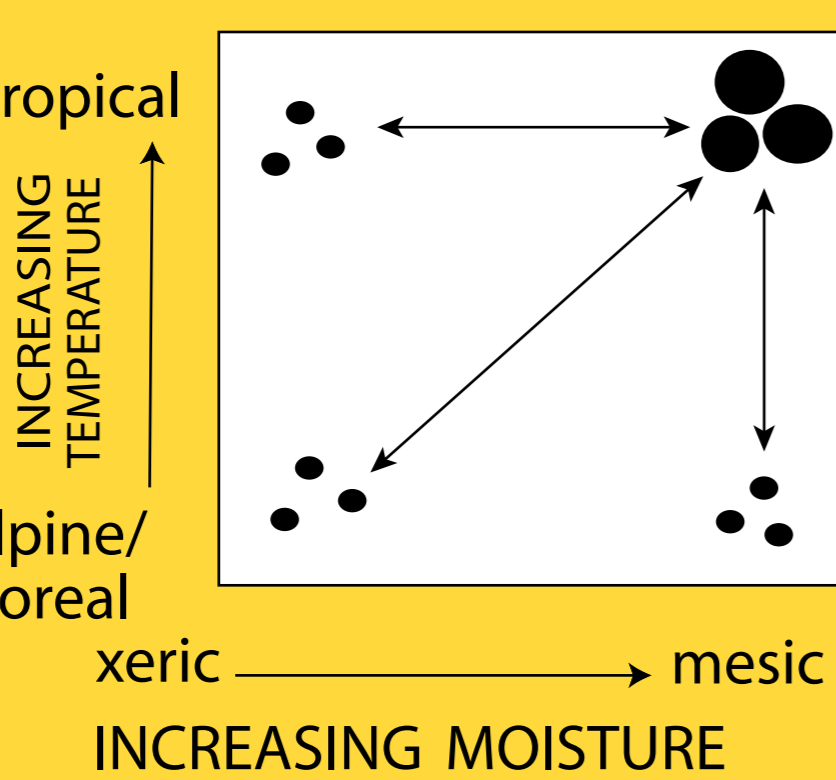
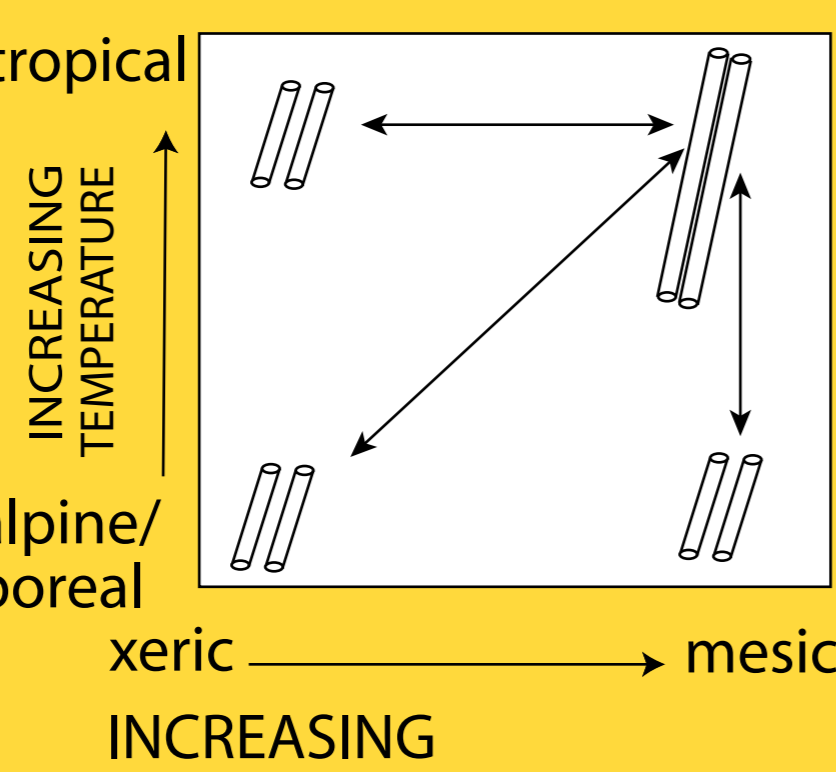


Figure 3: Size of vessels related to habitat. Adapted from Lindorf (1994).

VESEL FREQUENCY: The numerous vessels induce the integration of the hydraulic system of the tree (Figure 4).

Figure 4: Vessel density related to habitat. Adapted from Lindorf (1994).



VESEL ELEMENT LENGTH: Small length vessel elements confine bubbles (Figure 5).

Figure 5: Length of vessels related to habitat. Adapted from Lindorf (1994).

VESEL ARRANGMENT: Grouped vessels induce the redundancy of the tree hydraulic system. If one of a group of adjacent vessels cavitates, the others of the group maintain the water column pathways (Figure 6).

Figure 6: Grouped vessels in *Corylus avellana*. Scale bar = 0.2 mm.

	Temperate and xeric area	Tropical and mesic area
Growth-ring <i>Figure 1</i>	Present, tendency to ring porosity	Not present or little marked
Vessel diameter <i>Figure 2 & 3</i>	Narrow	Wide
Vessel density <i>Figure 2 & 4</i>	High density	Low density
Vessel element length <i>Figure 5</i>	Short	Elongated
Vessel arrangement <i>Figure 6</i>	Grouped vessels	Solitary vessels
Spiral thickening <i>Figure 7</i>	Frequent occurrence	Not frequent
Perforation plate <i>Figure 8 & 9</i>	Simple	Scalariform
Pit <i>Figure 10 & 11</i>	Vestured pit	Simple pit
Tracheid fibre	Very frequent	Not very frequent

PIT:

Vestured pits reduce water stress-induced embolism. Vestures prevent pit membrane rupture by providing a mechanical support of the pit membrane (Figure 10 & Figure 11).

Figure 11: Vestured pits in *Castanea sativa*. Scale bar = 0.025 mm.

TRACHEID FIBRE:

Tracheid fibres induce the integration and redundancy of the tree hydraulic system. If a very high proportion of vessels were blocked by embolism, tracheids would represent a supplementary conductive system.



SPIRAL THICKENING:

Refilling of the embolized vessels is aided by the helical sculpture (Figure 7).

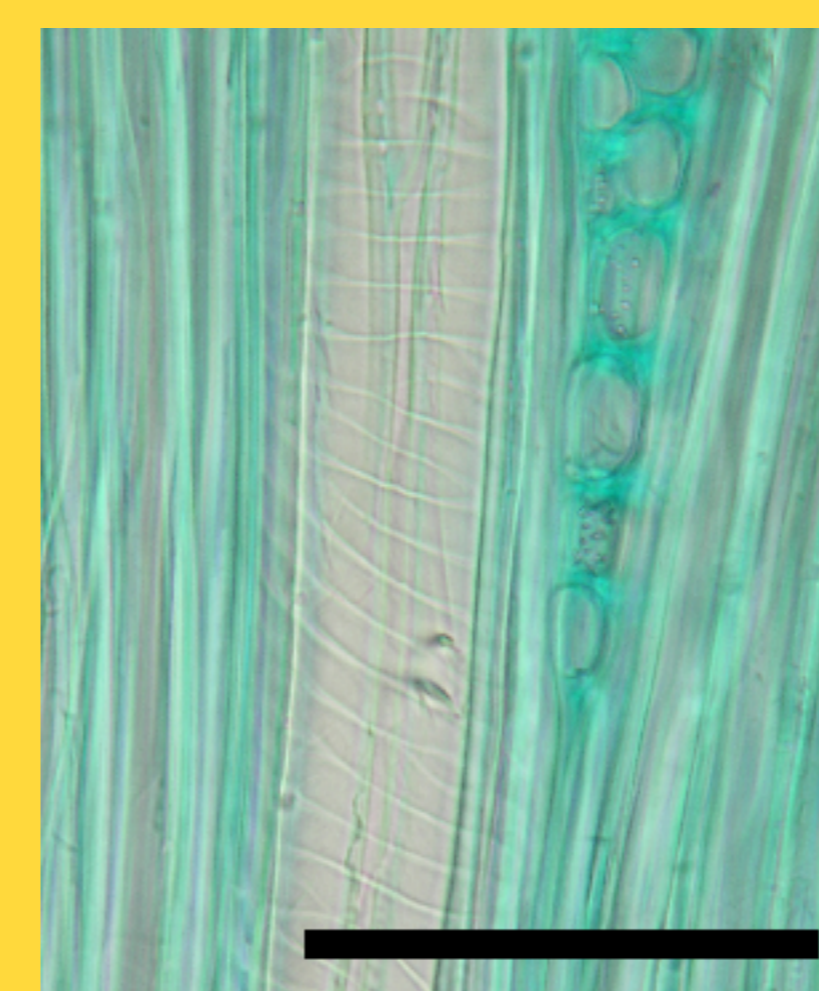


Figure 7: Spiral thickenings in *Prunus avium*. Scale bar = 0.1 mm.

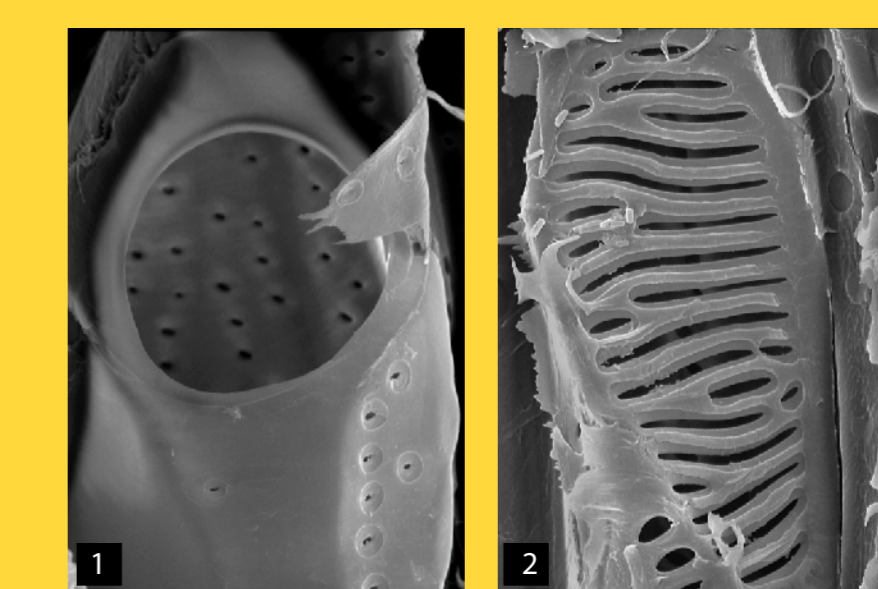


Figure 8: 1- Simple perforation in *Castanea sativa*. 2- Scalariform perforation in *Fagus sylvatica*. SEM.

PERFORATION PLATE:

Simple perforations allow to increase hydraulic efficiency of vessels. They constitute an adaptative mechanism for species living in high seasonality area to compensate a lack of water during a part of the year (Figure 8 & Figure 9).

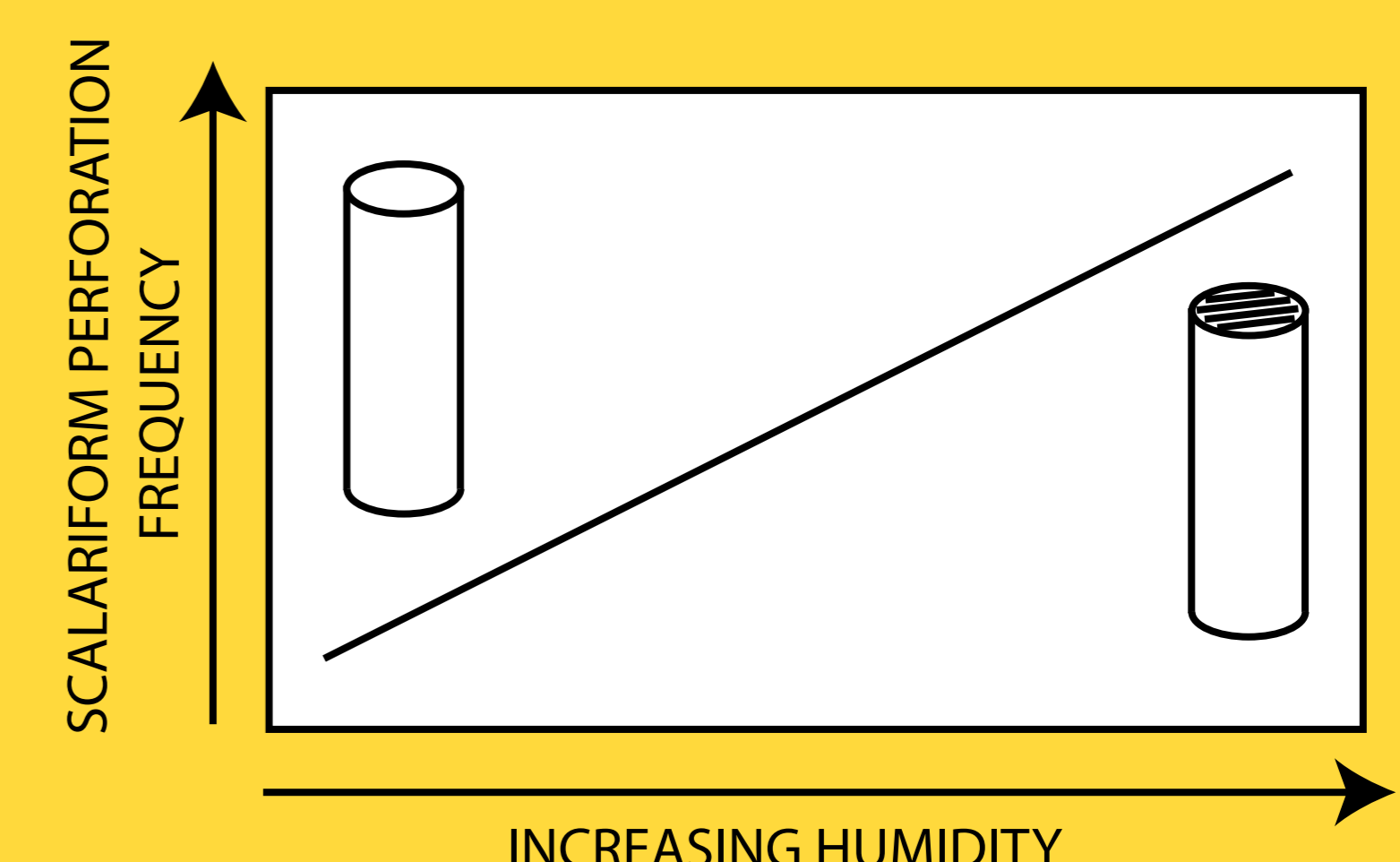


Figure 9: Scalariform perforation frequency related to humidity. Adapted from Jansen *et al.* (2004).

Looking at the obtained results, it is judicious to consider the wood as an excellent paleoenvironmental marker; anatomical variables exhibit a high degree of climatic sensitivity in their spatial occurrence. The use of fossil wood in the reconstruction of palaeoclimate, as it has been done since a long time, is for the same reasons very relevant. Studies are now being conducted in order to refine these results and to find new climatic intra and inter-specific markers.

BIBLIOGRAPHY:

Baas, P., Werker, E., Fahne, A. (1983) Some ecological trends in vessel characters. IAWA Bulletin n. s. 4(2-3):141-159.

Carlquist, S. (1977) Ecological factors in wood evolution: a floristic approach. American Journal of Botany. 64(7): 887-896.

Carlquist, S. (2001) Comparative wood anatomy, systematic ecological, and evolutionary aspects of Dicotyledon wood. Springer series in wood science second edition, Springer ed. Berlin, X + 448 p.

Cruiziat, P., Cochard, H., Améglio, T. (2002) Hydraulic architecture of trees: main concepts and results. Annals of Forest Sciences. 59:723-752.

Jansen, S., Baas, P., Gasson, P., Lens, F., Smets, E. (2004) Variation in xylem structure from tropics to tundra: Evidence for vestured pits. Proceedings of the National Academy of Sciences of the United States of America. 101(23): 8833-8837.

Lindorf, H. (1994) Eco-anatomical wood features of species from a very dry tropical forest. IAWA Journal. 15(4): 361-374.

Woodcock, D.W., Ignas, C.M. (1994) Prevalence of wood characters in Eastern North America: what characters are most promising for interpreting climates from fossil wood? American Journal of Botany. 81(10): 1243-1251.