

5.2 Variation circadienne de la structure foliaire

variation circadienne de l'épaisseur de la feuille

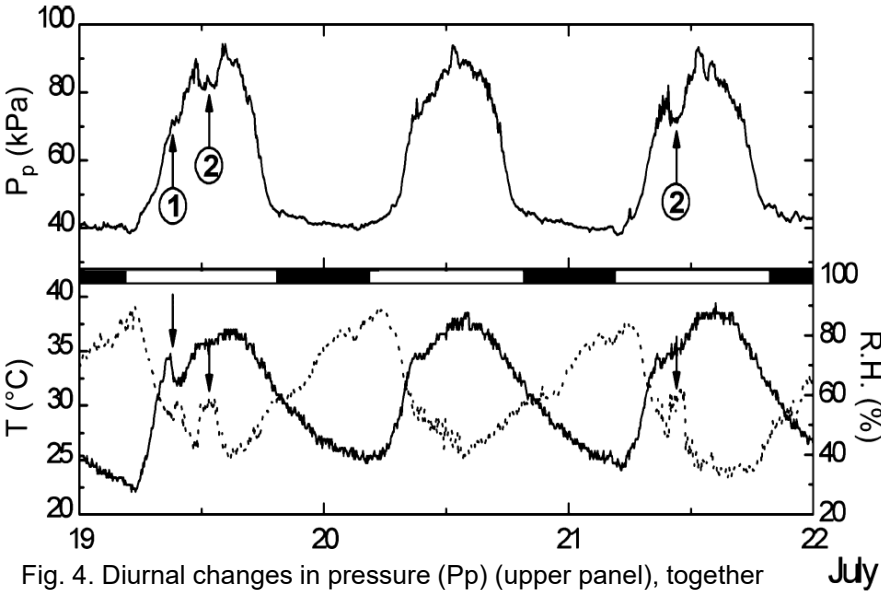
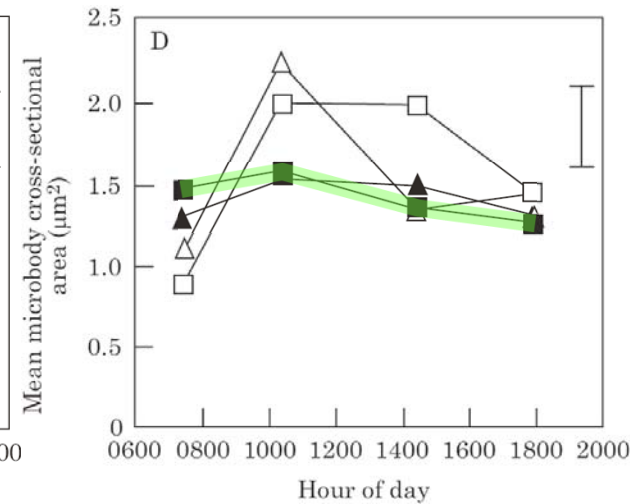
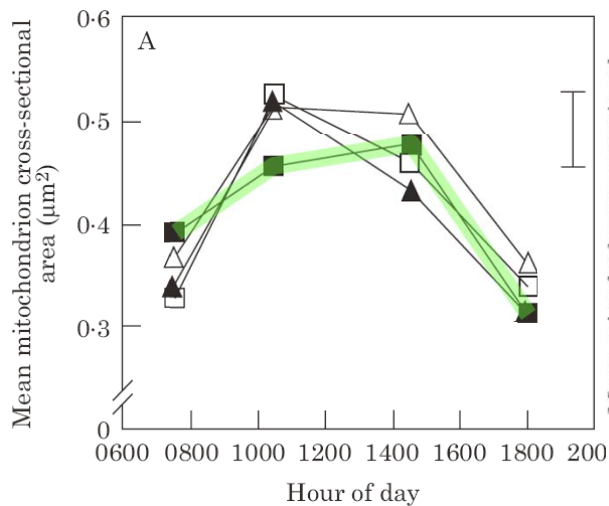
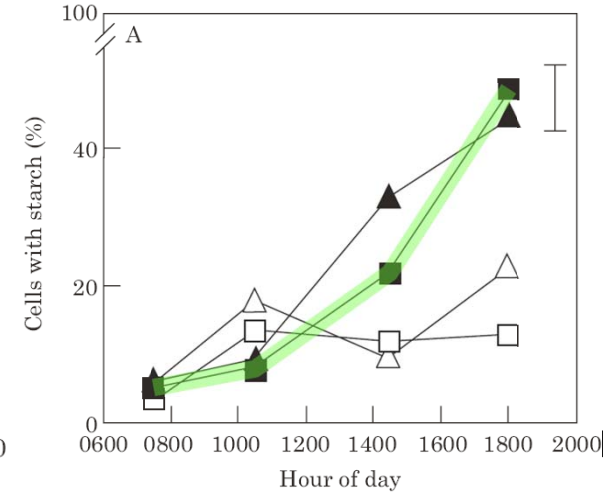
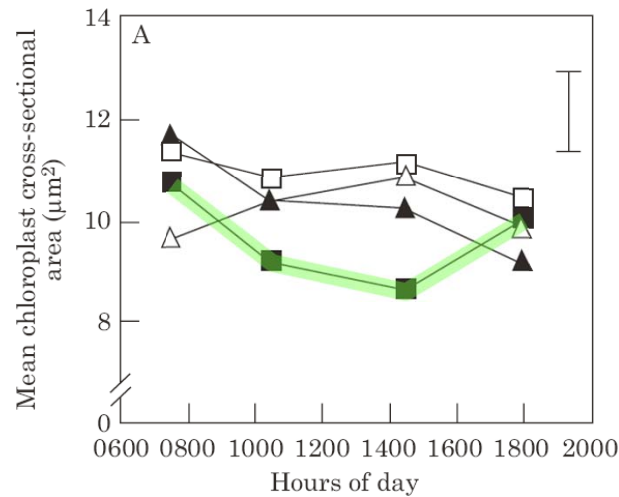


Fig. 4. Diurnal changes in pressure (P_p) (upper panel), together with corresponding changes in ambient temperature (T , solid line, lower panel) and relative humidity (RH, dotted line, lower panel) recorded on a mostly sun-exposed leaf of a Banane plant (*Musa acuminata*) growing close to the edge of the Ma'agan plantation (height 1.3 m). The days from 19 to 21 July 2008 were relatively windless (on average $2.23 \pm 1.20 \text{ m s}^{-1}$, $n = 144$). Note that the relatively rapid small increases and decreases in T associated with opposite changes in RH during the morning hours (08:01–09:26 h) led only to a weak P_p response (arrow 1), whereas the continuous increase in RH observed on 19 July between 11:36 and 13:46 h and on 21 July between 09:50 and 11:31 h (arrows 2) at constant T resulted in a pronounced decrease of P_p .



Exemple d'un capteur de pression, mesurant les variations d'épaisseur d'une feuille de chêne

variation circadienne de la micro-morphologie cellulaire

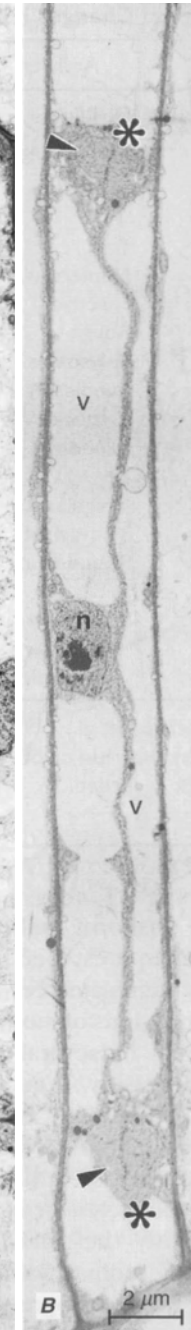
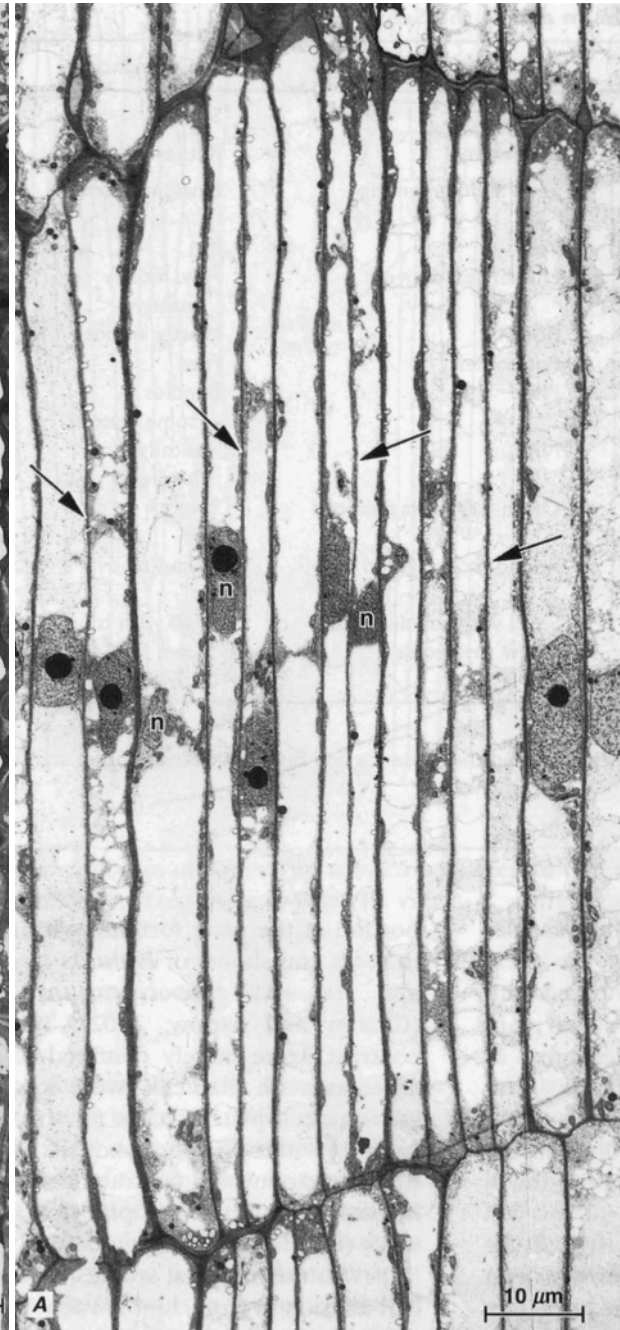
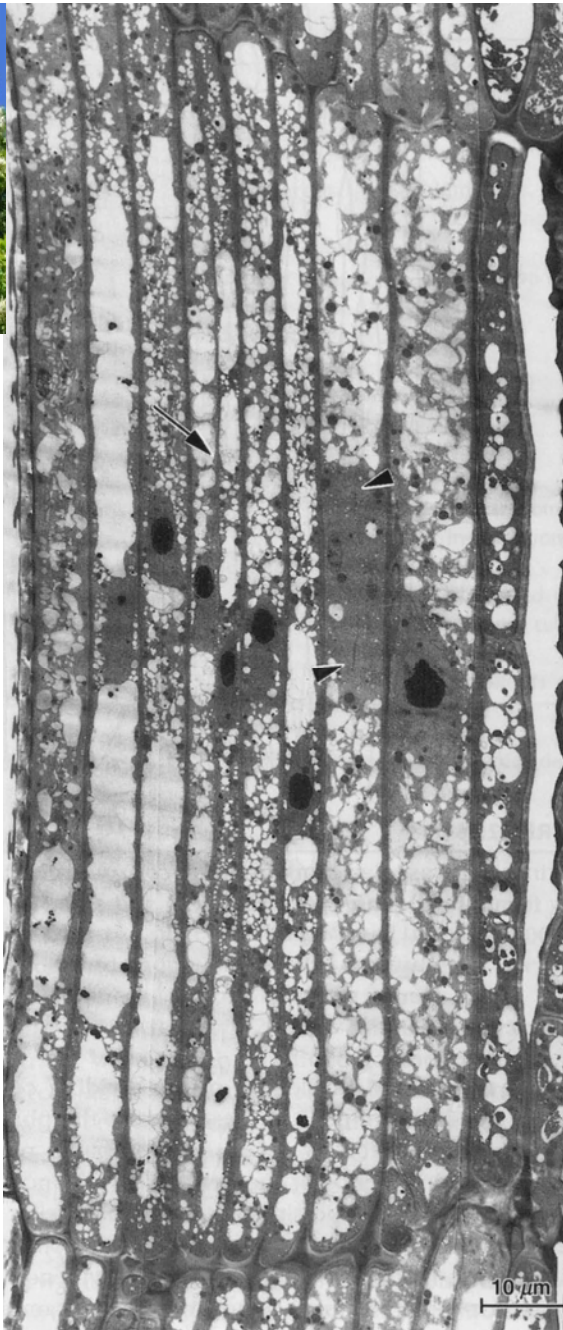


Daily changes in several subcellular structures size and abundance in Norway spruce (*Picea abies* (L.) Karst.) needles(...) Spruce saplings were exposed to charcoal-filtered air, (□■) or non-filtered air + added ozone, (△▲) and kept well-watered, (■▲) or drought-stressed, (□△).
 : control treatment.

référence:

- Zimmermann et al. (2009). Effects of environmental parameters and irrigation on the turgor pressure of banana plants measured using the non-invasive, online monitoring leaf patch clamp pressure probe. *Plant Biology* 12, 424-436.
- Kivimäenpää et al. (2001). Diurnal changes in microscopic structures of mesophyll cells of Norway spruce, *Picea abies* (L.) Karst., and the effects of ozone and drought. *Annals of Botany* 88, 119-130.

5.2 Variation saisonnière de la structure des initiales fusiformes



élimination par écorçage annulaire au printemps de voisins concurrents dans un perchis de chênes. L'écorce très hydratée se détache alors aisément. L'arbre écorcé, en séchant lentement, contribue longtemps encore à l'obtention de tiges de qualité peu branchues chez les arbres de place sélectionnés (arrière-plan). Bettens/VD, juin 2019.

FIGURE 12.15 Radial views of fusiform cells in the active cambium of black locust (*Robinia pseudoacacia*). A, view of cambial zone showing highly vacuolate, uniuucleate fusiform cells. Arrows point to recently formed tangential walls. B, view of phragmoplast (arrowheads) and developing cell plate in dividing fusiform cell. The phragmosome is represented by the region of cytoplasm just in advance of the phragmoplast (asterisk). Other details: n, nucleus; v, vacuole. (From Farrar and Evert, 1997).

FIGURE 12.17 Radial view of fusiform cells in cambial zone of black locust (*Robinia pseudoacacia*). Cell division has just recently begun in this cambium, whose cells still contain numerous small vacuoles and abundant lipid droplets, both of which are characteristic of the dormant cambium. Arrow points to recently formed cell wall and arrowheads to a phragmoplast in a fusiform cell in the process of dividing. (From Farrar and Evert, 1997).

5.2 Saisonnalité de l'activité cambiale, de la réactivation de la conduction de la sève et de la production de nouveaux éléments conducteurs

TABLE 12.4 ■ Cambial Activity and Times of Initiation of New Phloem (P) and Xylem (X) Production and Differentiation in Several Temperate-Zone Conifers

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
<i>Abies balsamea</i>				+P	X							
<i>Larix laricina</i>				+P	X							
<i>Picea mariana</i>				+P	X							
<i>Pinus spp</i> ^a			+P		X							

a *Pinus banksiana*, *P. resinosa*, *P. strobus*

+ Phloem mother cells on outer margin of cambial zone begin to differentiate

■ Some mature sieve elements present year-round

Note: In these species some of the last-formed sieve cells remain functional through winter until new sieve elements differentiate in spring. The first new sieve elements in spring arise from phloem mother cells that overwinter on the outer margin of the cambial zone. The times of cessation of phloem and xylem production and differentiation are not indicated.

chêne

frêne

hêtre



Débourrement tardif versus précoce chez les espèces à zone poreuse (chêne, frêne) versus porosité diffuse (hêtre). Bonstetten, le 02 mai 2016

référence: Evert (2006). Esau's plant anatomy. Wiley, Hoboken.



P. Vollenweider
AEF-Cours 5, page 5/84

TABLE 12.3 ■ Cambial Activity and Times of Initiation of New Phloem (P) and Xylem (X) Production in Temperate-Zone Woody Angiosperms

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
<i>Pyrus communis</i>			*	P	X							
<i>Malus sylvestris</i>				*P	X							
<i>Populus tremuloides</i>			*	P	X							
<i>Parthenocissus inserta</i>				*P	X							
<i>Rhus glabra</i> ^a				*PX								
<i>Robinia pseudoacacia</i> ^a				*PX								
<i>Celastrus scandens</i> ^a					P X							
<i>Acer negundo</i>				P	X							
<i>Tilia americana</i>				R	P X							
<i>Vitis riparia</i>				R		PX						
<i>Quercus spp</i> ^a				P X								
<i>Ulmus americana</i> ^a				P X								

a Ring-porous species

* First functional sieve elements arise from phloem mother cells that overwinter on outer margin of cambial zone

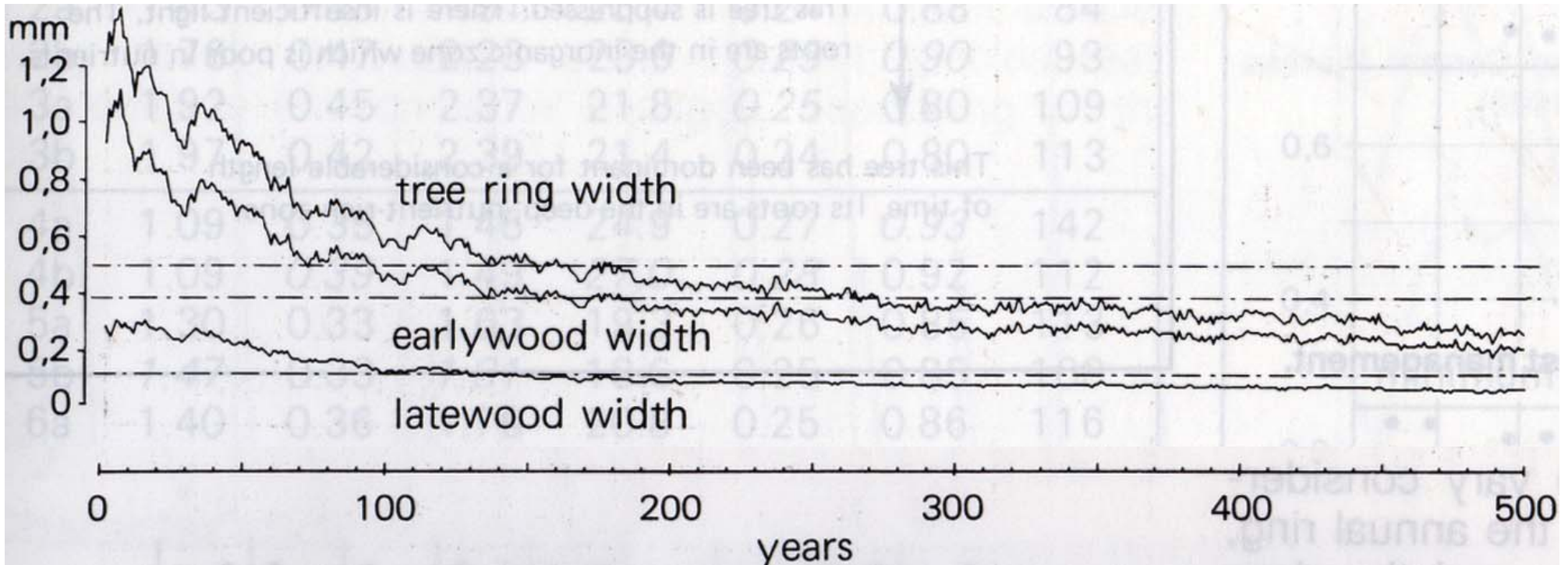
R Reactivation

■ No overwintering mature sieve elements

■ Some mature sieve elements present year-round

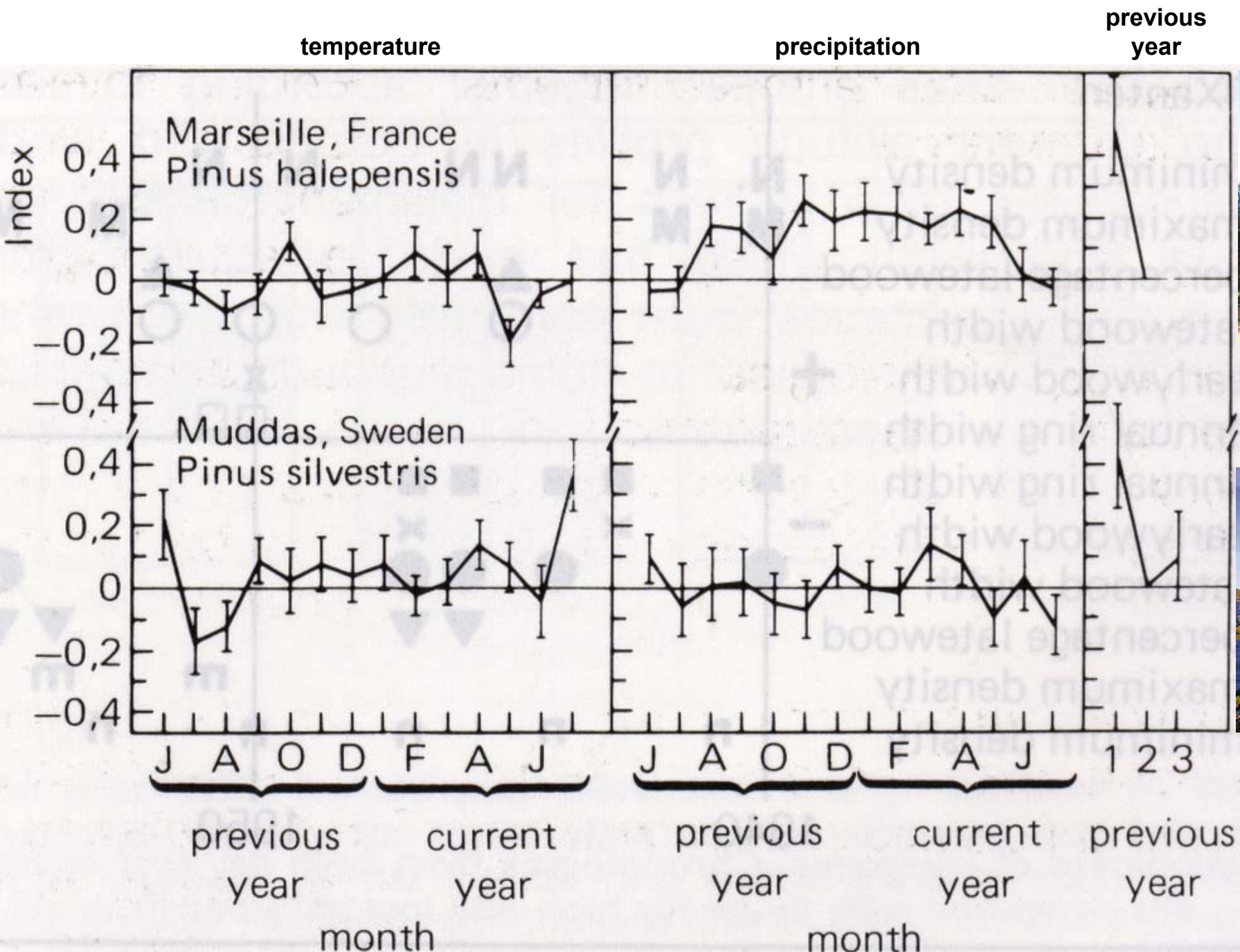
Note: In species with no overwintering mature sieve elements, the first functional sieve elements in spring originate from phloem mother cells that overwinter on the outer margin of the cambial zone. In two of the species (*Tilia americana* and *Vitis riparia*), with some mature sieve elements present year-round, the sieve elements that overwinter develop dormancy callose at their sieve plates and lateral sieve areas in late fall; the dormant sieve elements are reactivated in spring before the renewal of cambial activity. The times of cessation of phloem and xylem production and differentiation are not indicated. To the exception of *Pyrus communis* (Davis, California) and *Malus domestica* (from Bozeman, Montana), trees grew within a 5 km radius of the University of Wisconsin-Madison campus.

5.2 Accroissement radial (I): déterminisme de l'âge physiologique



mélèze (*Larix decidua*); provenance: Grächen/VS

5.2 Accroissement radial (II): déterminisme du climat



5.2 Accroissement radial (II): annexe: modélisation

Modelling (response functions)

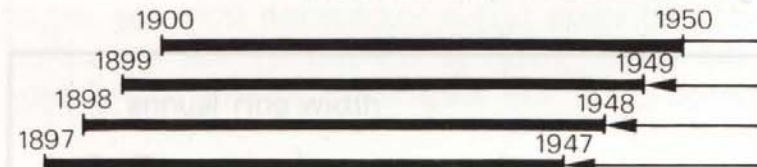
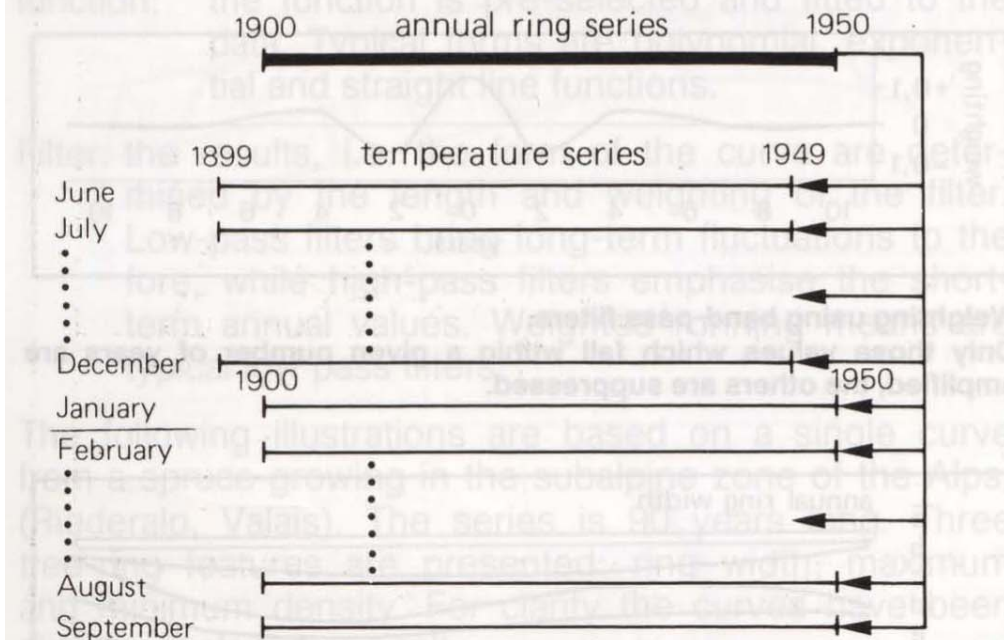
Response functions are used to identify the relationship between climate and tree rings. A number of different statistical procedures, e.g. sign tests, correlations, multiple regression with or without the identification of the principal components of the population, can be used to identify and plot the relationships between climate and

tree rings.

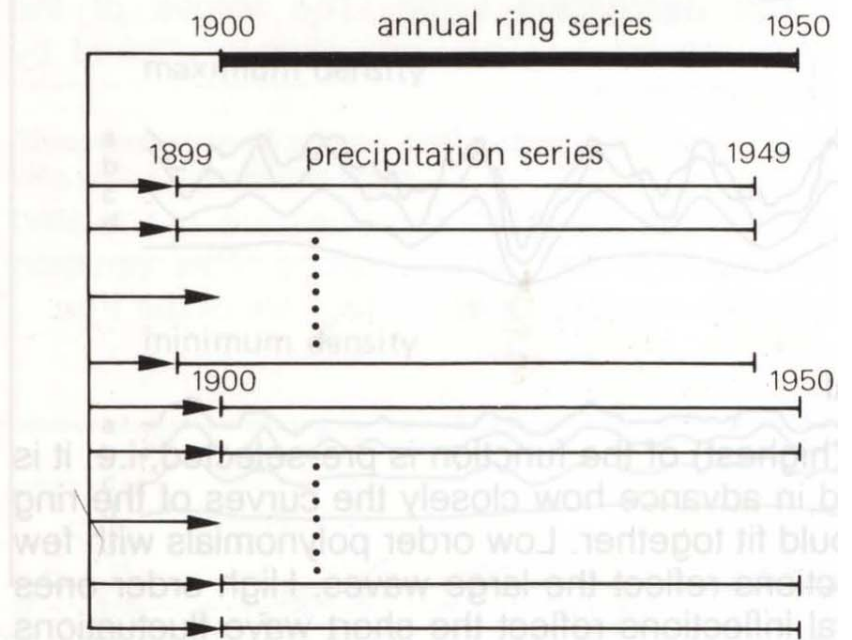
Fritts (1976) and Fritts and Wu (1986) described these methods, which are by no means always straightforward. A response function diagram may contain a number of different comparisons. The diagram below compares a ring series covering 50 years with a number of factors.

a) with itself, but in serial correlation (time displacement).
This shows how strongly the previous year, which determines the physiological condition of the tree, influences growth in the current year.

b) with the monthly mean temperatures



c) with the total monthly precipitation



5.2 Accroissement radial (I): déterminisme des facteurs édaphiques

Effet de la fertilisation sur l'accroissement et la structure des cernes chez l'épicéa et interaction avec les facteurs climatiques

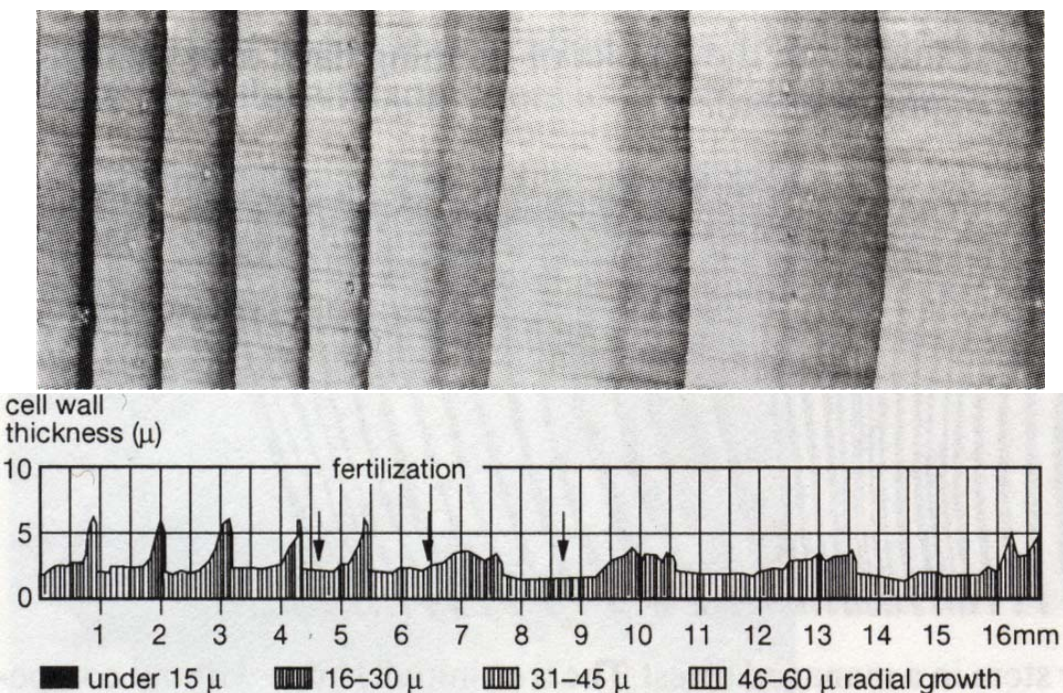


Fig.18.6. Tree rings of a 63-year-old spruce from a nutrient poor site in the Black Forest, Germany. When the nutrient supply is poor, tree-ring widths are narrow and latewood densities are high (thick-cell walls). After fertilization, tree-ring widths increase along with the amount of latewood but the latewood density decreases. According to SPIECKER (1987), the 1954 fertilization was particularly effective because it was followed by a series of years with heavy precipitation in the vegetation period (VON PECHMANN 1960).

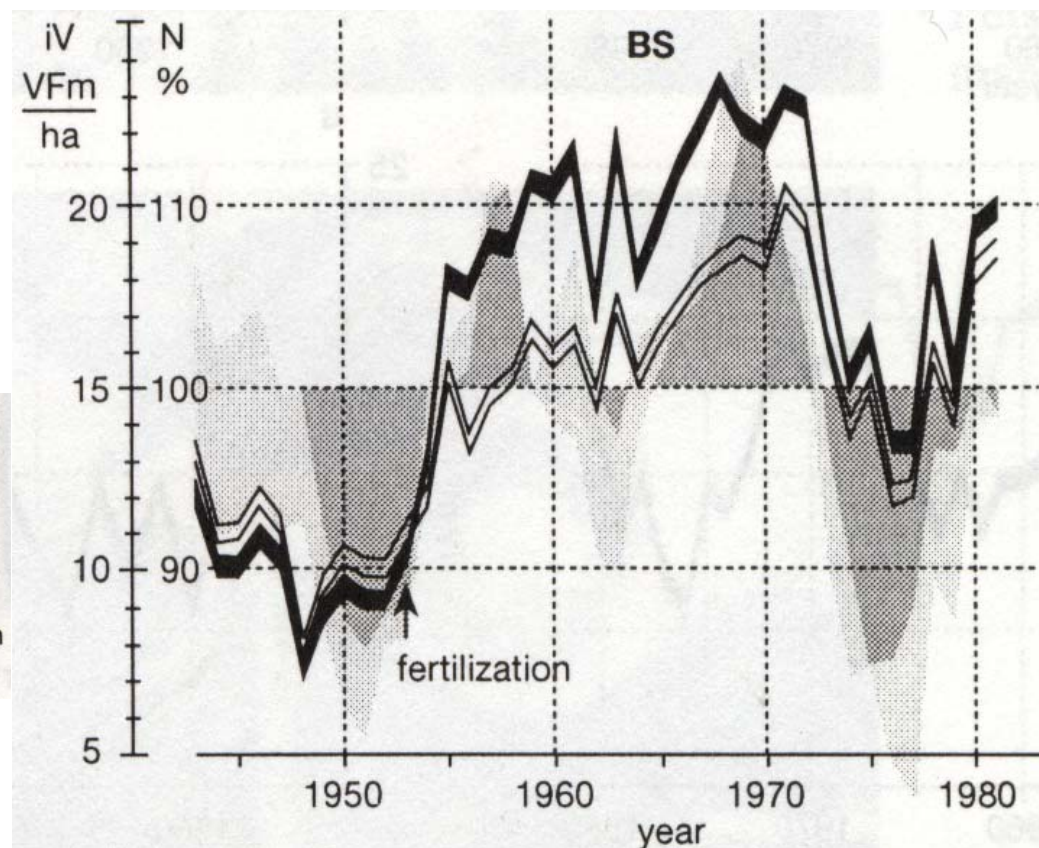


Fig. 18.5. Relationship between the 1953 fertilization (arrow), precipitation during the vegetative period (shaded area), and tree growth in the fertilized (dark curve) and unfertilized (light curve) areas on nutrient poor soil in the Black Forest, Germany.

N = precipitation from May to September, smoothed mean of the five previous years in percentage of the mean for 1950-1980 from two data stations (light and darkly shaded).
iV = (usable stem wood) per hectare.

Bs = the locality red sandstone, Black Forest, Germany

Fertilization had a strong impact in the wet years following the 1954 fertilization: the trees grew a maximum of 5 m³ more wood per year. In the dry years (1973, 1979) the impact declined: there was a maximum of only 1-2 m³ more wood per hectare. Short-term changes in impact are also attributed to variations in climate. For example, the fertilized area had an increase of 4.5 m³/ha in the wet year 1961, and only 2.3 m³ in the following dry year. SPIECKER (1987)

fertilisation de stations forestières sur sols pauvres et acides avec, principalement, des carbonates de calcium (100-300 t/ha) et des phosphates (50-100 t/ha). Autres fertilisants: K, N, S, sous différentes formes chimiques.

5. Références

Principaux ouvrages et articles de référence utilisés:

Chapitre 5.1

Choat, B., Jansen, S., Brodribb, T.J., Cochard, H., Delzon, S., Bhaskar, R., Bucci, S.J., Feild, T.S., Gleason, S.M., Hacke, U.G., Jacobsen, A.L., Lens, F., Maherali, H., Martínez-Vilalta, J., Mayr, S., Mencuccini, M., Mitchell, P.J., Nardini, A., Pittermann, J., Pratt, R.B., Sperry, J.S., Westoby, M., Wright, I.J., Zanne, A.E. 2012. Global convergence in the vulnerability of forests to drought. *Nature* 491, 752-755.

Cruziat, P., Cochard, H., Améglio, Th., 2002. Hydraulic architecture of trees: main concepts and results. *Ann. For. Sci.* 59, 723-752.

Cruziat, P., Tyree, M.T., 1990. La montée de la sève dans les arbres. *La Recherche* 21, 406-414.

Ellenberg, H., 1986. *Vegetation Mitteleuropas mit den Alpen in ökologischer Sicht*. 4. verb. Aufl. Ulmer, Stuttgart.

Eschrich, W., 1995. *Funktionelle Pflanzenanatomie*. Springer, Berlin.

Evert, R.E., 2006. *Esau's plant anatomy*. Wiley, Hoboken.

Heil, G.W., Hansen, K., Muys, B., Van Orshoven, J., 2007. Introduction: demand for afforestation management in North-Western Europe. Extrait de: Heil, G.W., Muys, B., Hansen, K., (éds.). *Environmental effects of afforestation in North-Western Europe*. Springer, Dordrecht.

Schweingruber, F.H., 1982. *Anatomie microscopique du bois*. Deuxième édition, EAFV, Birmensdorf.

Tyree, M.T., Ewers, F.W., 1991. The hydraulic architecture of trees and other woody plants. *New Phytol.* 119, 345-360.

Vollenweider P., 1995. Influence de l'état physiologique et des conditions de croissance chez le Hêtre (*Fagus sylvatica* L.), sur la structure de la zone cambiale et du phloème conducteur. Thèse, Université de Lausanne.

Chapitre 5.2

Evert, R.E., 2006. *Esau's plant anatomy*. Wiley, Hoboken.

Kivimäenpää M., Sutinen, S., Medin, E.-L., Karlsson, P.E., Sellden, G., 2001. Diurnal changes in microscopic structures of mesophyll cells of Norway spruce, *Picea abies* (L.) Karst., and the effects of ozone and drought. *Annals of Botany* 88, 119-130.

Schweingruber, F.H., 1989. *Tree rings. Basics and applications of dendrochronology*. Kluwer, Dordrecht.

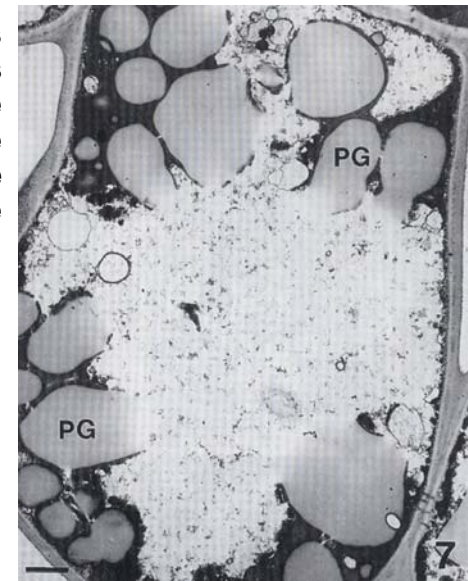
Schweingruber, F.H., 1996. *Tree rings and environment dendroecology*. WSL (ed.). Haupt, Bern.

Zimmermann, U., Rüger, S., Westhoff, M., Reuss, R., Geßner, P., Zimmermann, G., Israeli, Y., Zhou, A., Schwartz, A., Bamberg, E., Zimmermann, D., 2009. Effects of environmental parameters and irrigation on the turgor pressure of banana plants measured using the non-invasive, online monitoring leaf patch clamp pressure probe. *Plant Biology* 12, 424-436.



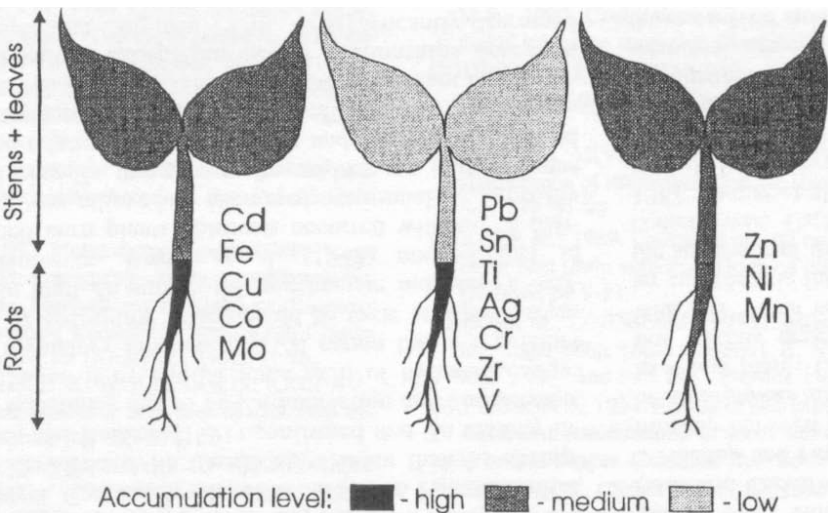
Symptômes visibles caractéristiques d'un champignon pathogène (*Cladosporium* sp.) sur une feuille de peuplier

Dégénérescence des organelles cellulaires dans le limbe d'une feuille de hêtre durant la sénescence automnale

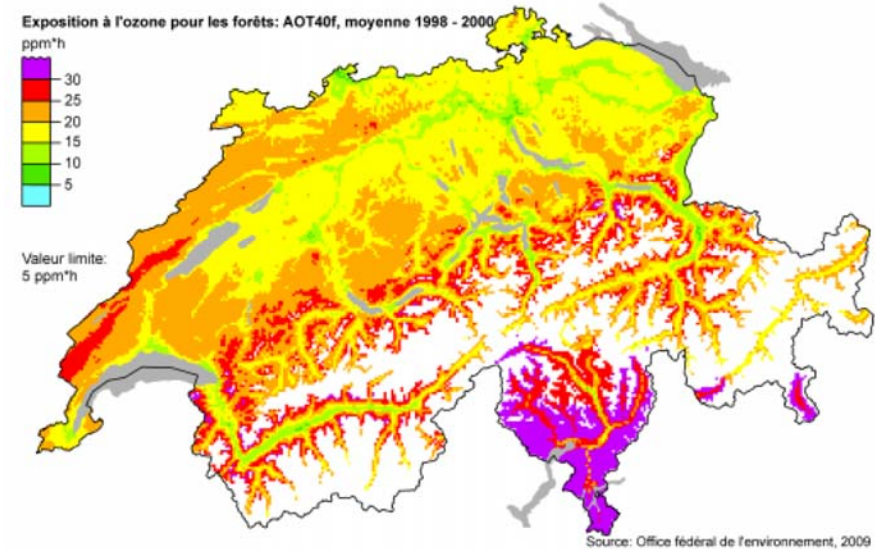


6. STRESS ENVIRONNEMENTAL ET RÉACTIONS STRUCTURALES:
6.1 Les symptômes visibles: des changements structuraux détectables à l'œil nu
6.2 La sénescence et ses conséquences au niveau structural
6.3 Bioindication de facteurs de stress biotique et abiotique avec des marqueurs structuraux

Translocation des métaux dans les plantes



Exposition à l'ozone pour les forêts: AOT40f



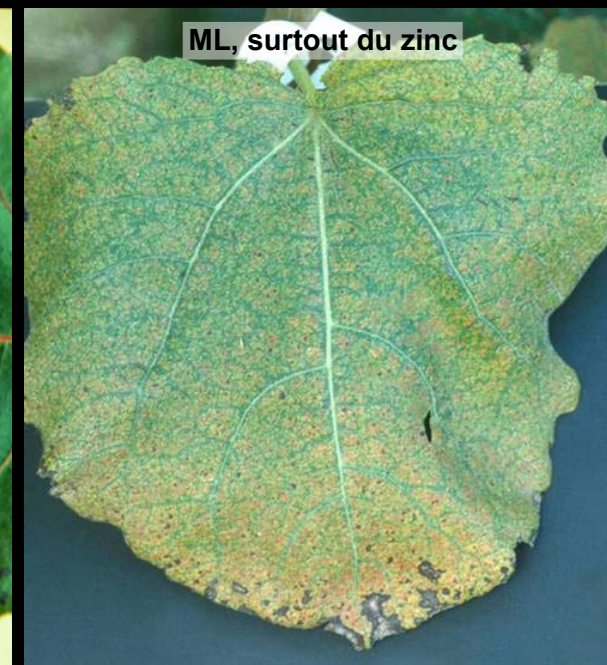
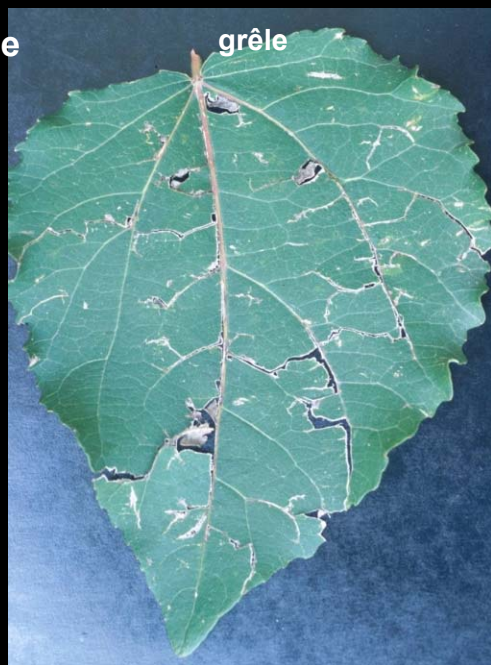
6.1 Diversité des symptômes visibles causés par les facteurs de stress biotique et abiotique chez le peuplier

facteurs de stress

biotique



abiotique



6.1 Organigramme des symptômes visibles en vue du diagnostic des facteurs de stress biotique et abiotique

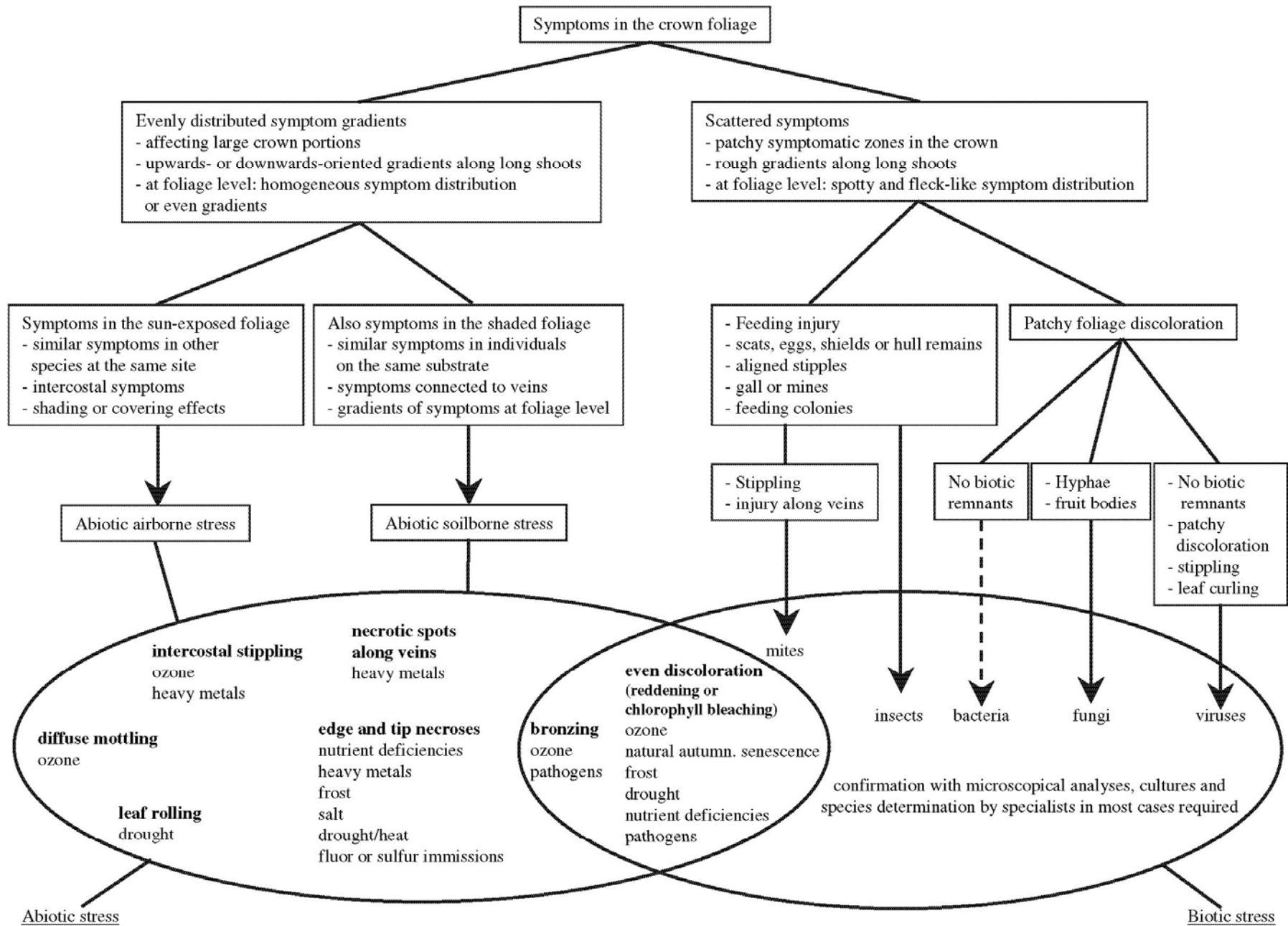
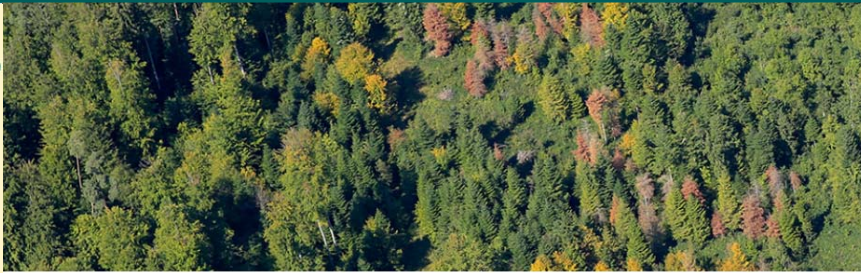
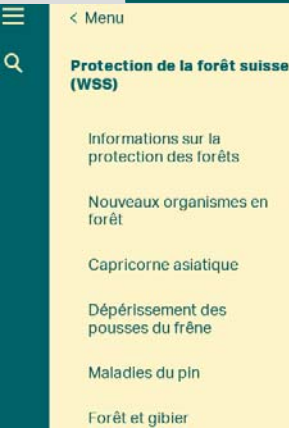


Fig. 1. Diagnosis flow chart for the identification of visible symptom types in the foliage. Application range: deciduous bush and tree species from central Europe, but also usable for conifers in the same temperate zone. The arrows in the model indicate the class of stress factors causing the visible symptoms, on the basis of the symptom morphology in the foliage and the symptom distribution and frequency at the foliage, branch and crown level.

référence:

Vollenweider and Günthardt-Goerg (2006). Diagnosis of abiotic and biotic stress factors using the visible symptoms in the foliage. *Env. Poll.* 140, 562-571.

6.1 Encart no. 27: diagnostique des symptômes visibles: une adresse et une référence utiles



Vallorbe, Jura vaudois (2023)



Protection de la forêt suisse (WSS)

Nous disposons à tout moment d'une vue d'ensemble de la situation phytosanitaire dans les forêts suisses.

<https://waldschutz.wsl.ch/fr/index.html>

Protection de la forêt suisse (WSS)

Service spécialisé en matière de protection des forêts

...**informe** les services forestiers, les propriétaires de forêt, les milieux intéressés et le public de l'actualité en matière de protection des forêts.

...**relève**, avec les services forestiers cantonaux, la présence et l'ampleur des atteintes à la forêt par les agents abiotiques et les organismes pris en compte par la protection forestière (insectes, champignons, gibier)

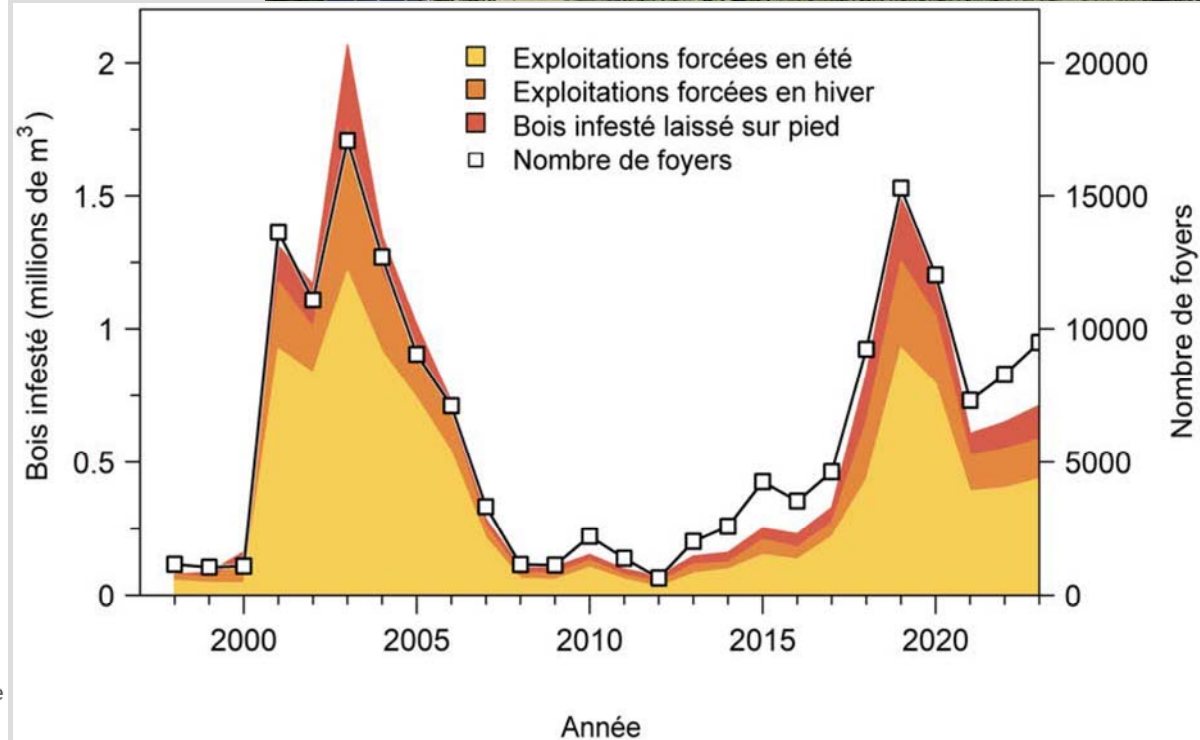
...**s'engage** dans la formation continue destinée aux services forestiers, aux étudiants d'Universités ou de Hautes Ecoles spécialisées, dans le domaine de la protection des forêts et de la santé des arbres, et ce, au moyen de conférences, de cours et d'exposés.

...**conseille** les services forestiers, les propriétaires de forêt, les administrations et les milieux intéressés en réponse à leurs questions sur la protection des forêts.

...**veille** à l'échange d'informations avec les autres professionnels de Suisse et de l'étranger.

Notre offre

- Informations et conseils au sujet des effets produits sur la santé des arbres et de la forêt par les insectes, les bostryches, la faune sauvage, les maladies cryptogamiques, les bactéries, les facteurs climatiques et abiotiques.
- Analyses scientifiques des causes, prévision de l'évolution probable, mesures curatives possibles, renseignements sur la présence et la propagation de ravageurs ou de maladies dans la forêt suisse. Documentation, tels que diapositives, photos digitales, notices pour le praticien, posters ou autres.
- Le WSL offre ces services à titre gracieux aux services et propriétaires forestiers, aux autorités et aux services administratifs. Les propriétaires de jardin et les amis des arbres obtiennent gratuitement une brève consultation orale; un rapport écrit leur sera facturé au prix correspondant au travail qu'il en aura coûté.



Atlas illustré des dégâts d'origine biotique et abiotique chez les arbres:

Hartmann et al. (2007) Farbatlas Waldschäden.
Eugen Ulmer KG, Stuttgart.

