



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Tento projekt je spolufinancován Evropským sociálním fondem a Státním rozpočtem ČR InoBio – CZ.1.07/2.2.00/28.0018

Silviculture

#2



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Laboratory of Ecological Physiology of Plants



evropský
sociální
fond v ČR



EVROPSKA UNIE

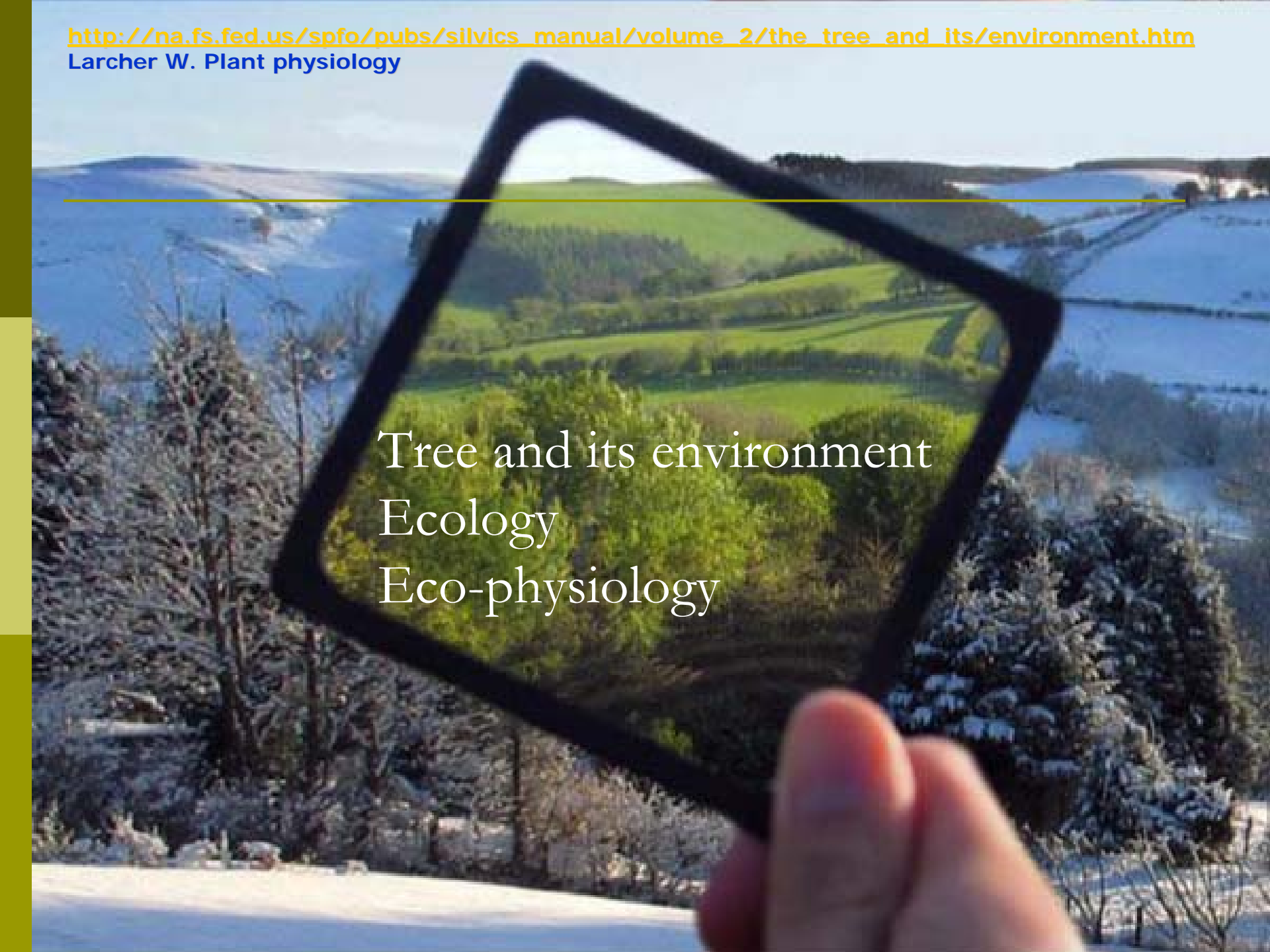


MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY



OP Vzdělávání
pro konkurenceschopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ



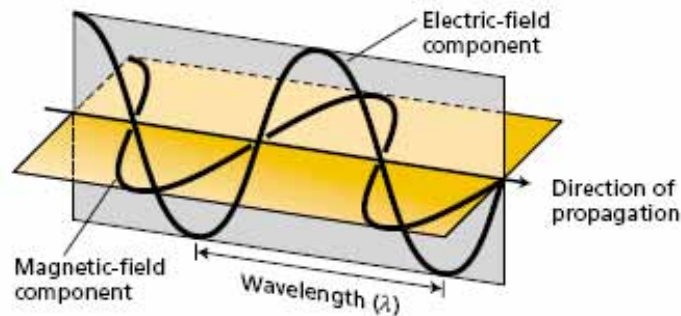
Tree and its environment
Ecology
Eco-physiology

Tree and its environment

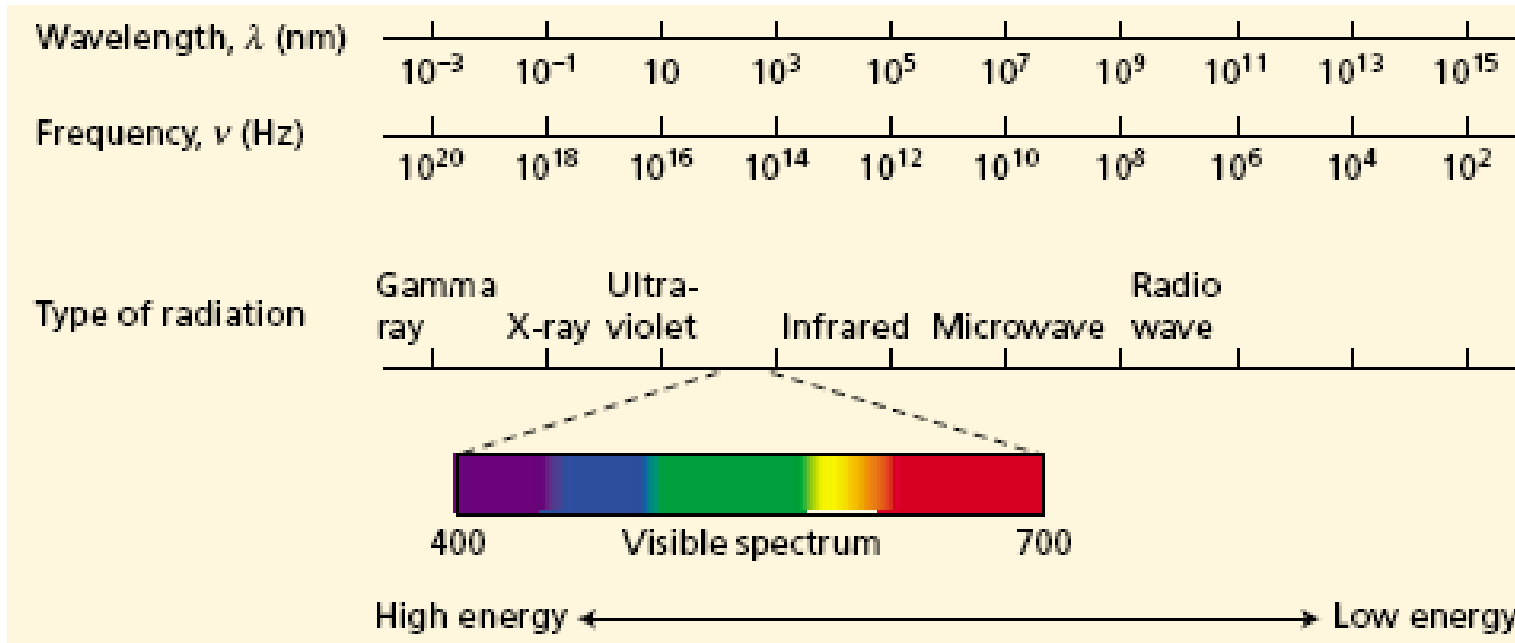
- ❑ The total environment of a tree is a complex integration of physical and biological elements.
- ❑ The **physical elements** are related to climate and soil, include radiation, precipitation, and the movement and composition of air; as well as the texture of the soil and its structure, depth, moisture capacity, drainage, nutrient content, and topographic position.
- ❑ **Biological elements** are the plant associates; the larger animals that use the forest as a source of food and shelter; the many small animals, insects, and insectlike animals; the fungi to which the trees are hosts; and the microorganisms in the soil.

#Complete and exact quantification of the environment is practically impossible.

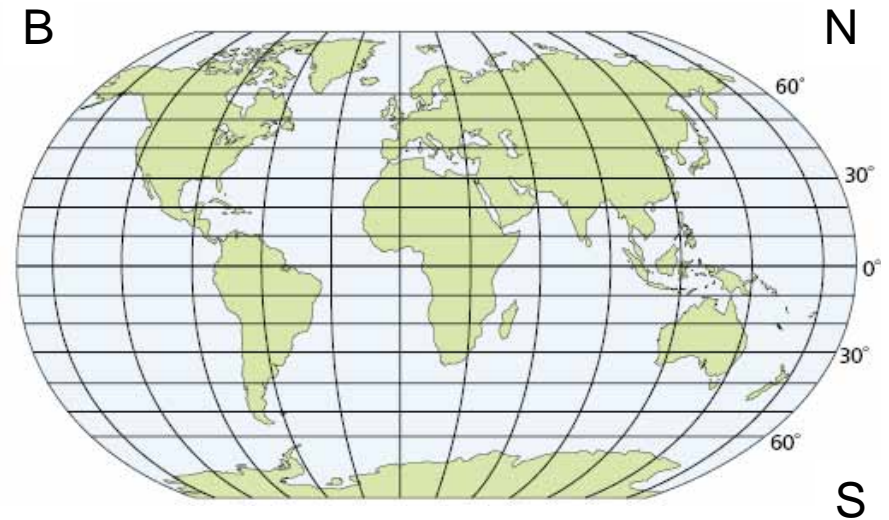
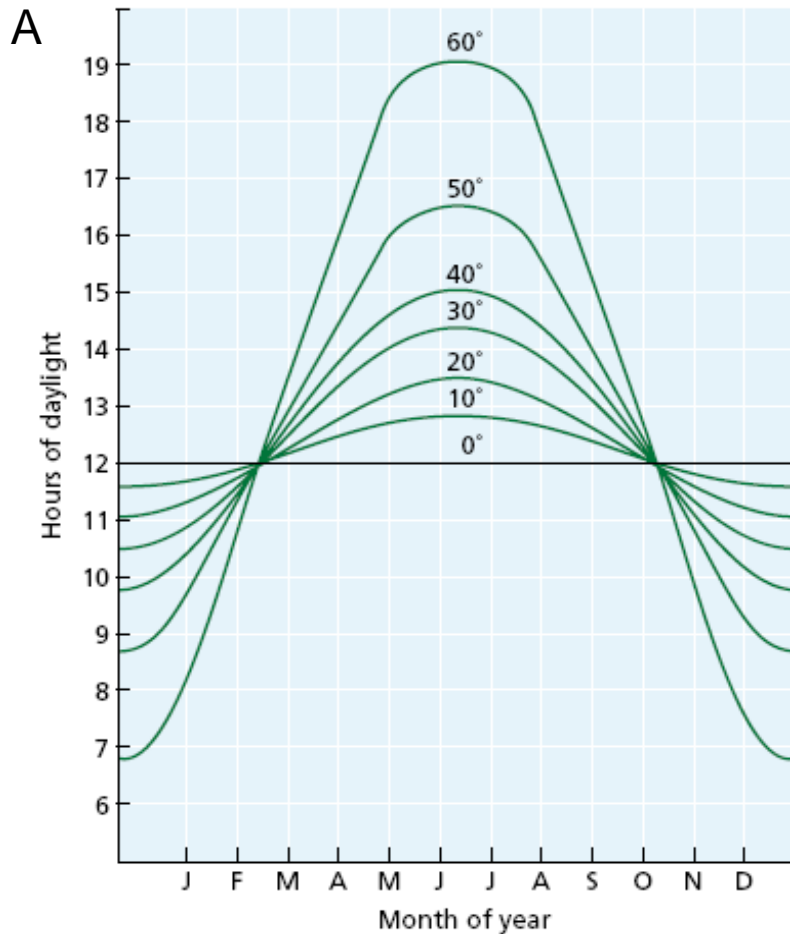
Solar radiation



Light is a transverse electromagnetic wave, consisting of oscillating electric and magnetic fields that are perpendicular to each other and to the direction of propagation of the light. Light moves at a speed of $3 \times 10^8 \text{ m s}^{-1}$. The wavelength (λ) is the distance between successive crests of the wave.



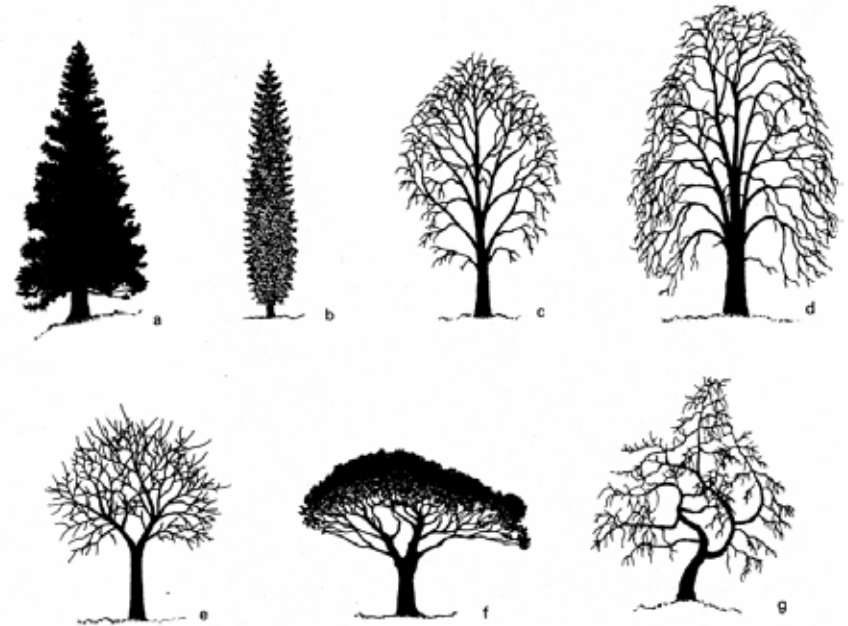
Solar radiation – day length



(A) The effect of latitude on day length at different times of the year. Day length was measured on the twentieth of each month.
(B) Global map showing longitudes and latitudes.

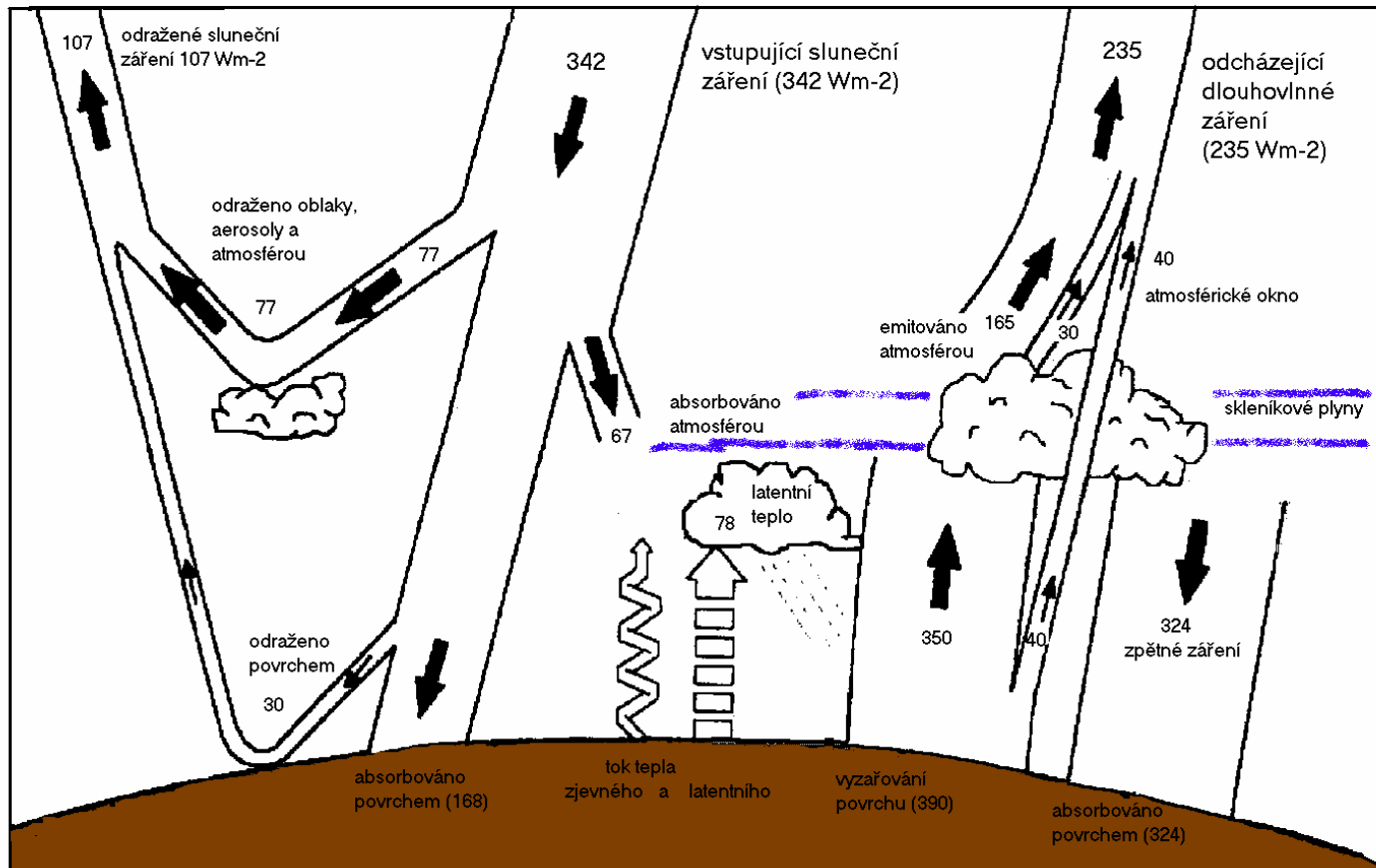
Light modify

- Unequal distribution of light may indirectly affect the **form of trees**. Greater development of the crown on the lighted side of the tree than on the shaded side results in asymmetrical growth of the bole. Regular spacing of trees to ensure better distribution of light thus tends to promote good form.
- Light may also be a factor in epicormic **sprouting**. On many tree species, dormant buds on the bole are stimulated and sprouts develop after trees are exposed when surrounding trees are cut.
- +Photoperiodicity - flowering

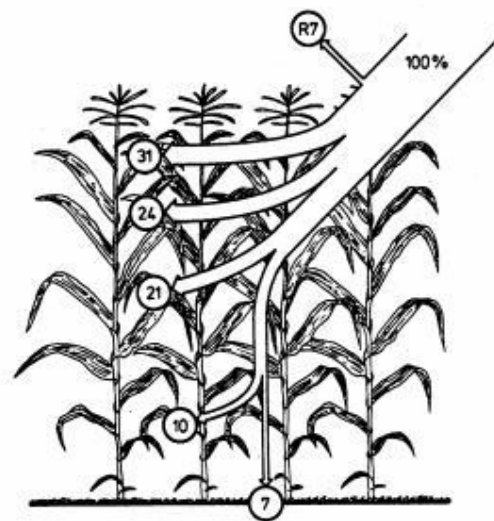
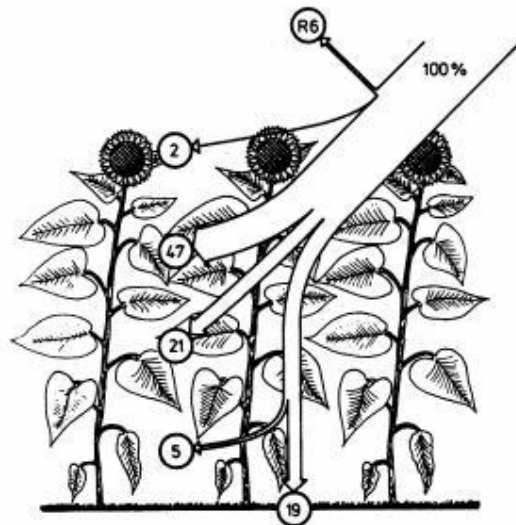
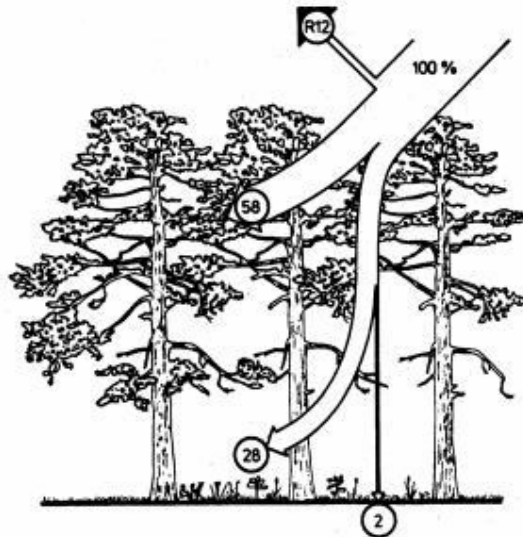
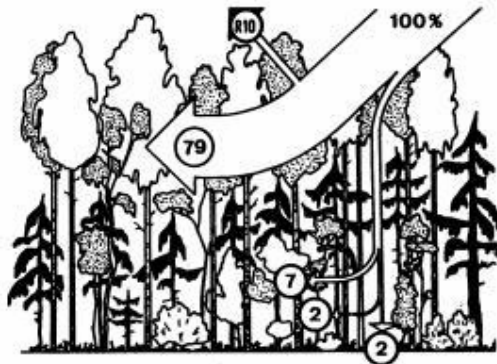


Solar radiation

Scheme of Sun – Earth counteraction, solar constant ($1369 \text{ W}\cdot\text{m}^{-2}$)



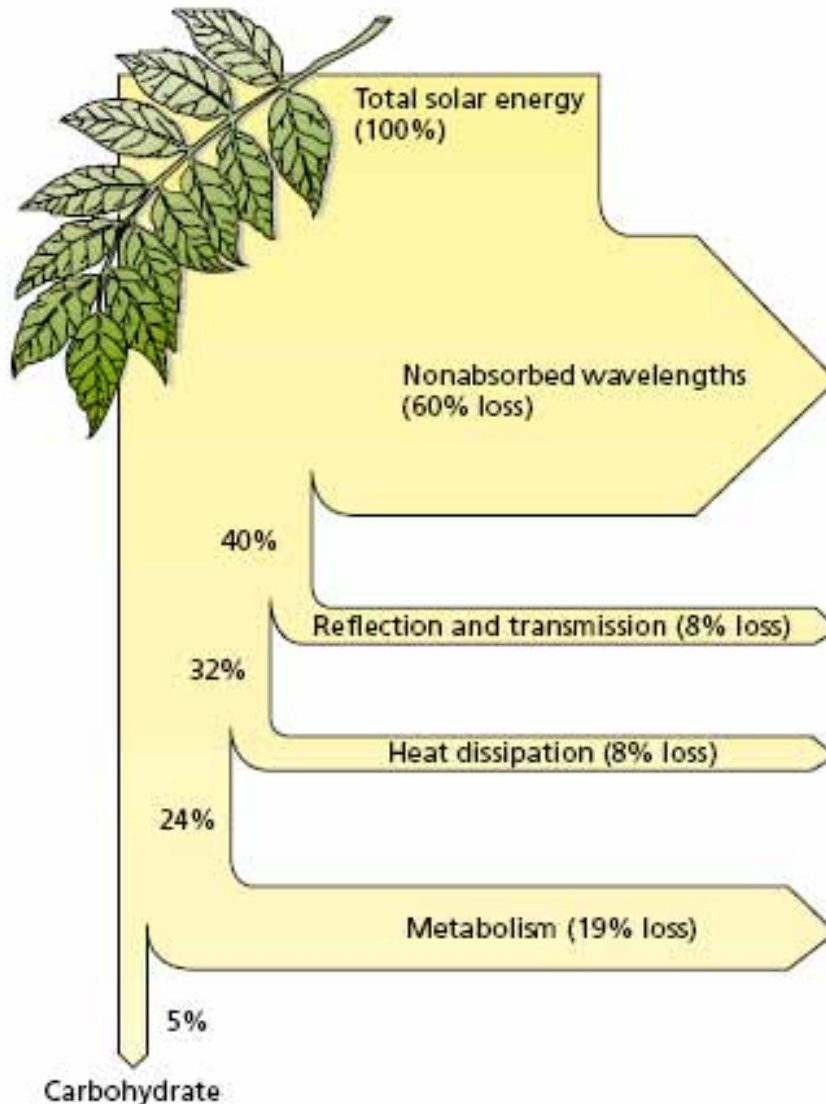
Radiation balance



- Reflection
- Absorption
- Transmission

Crowns of the overstory absorb part of the blue and red light and reflect or transmit green and yellow. Thus, light in the understory is relatively higher in green and yellow light.

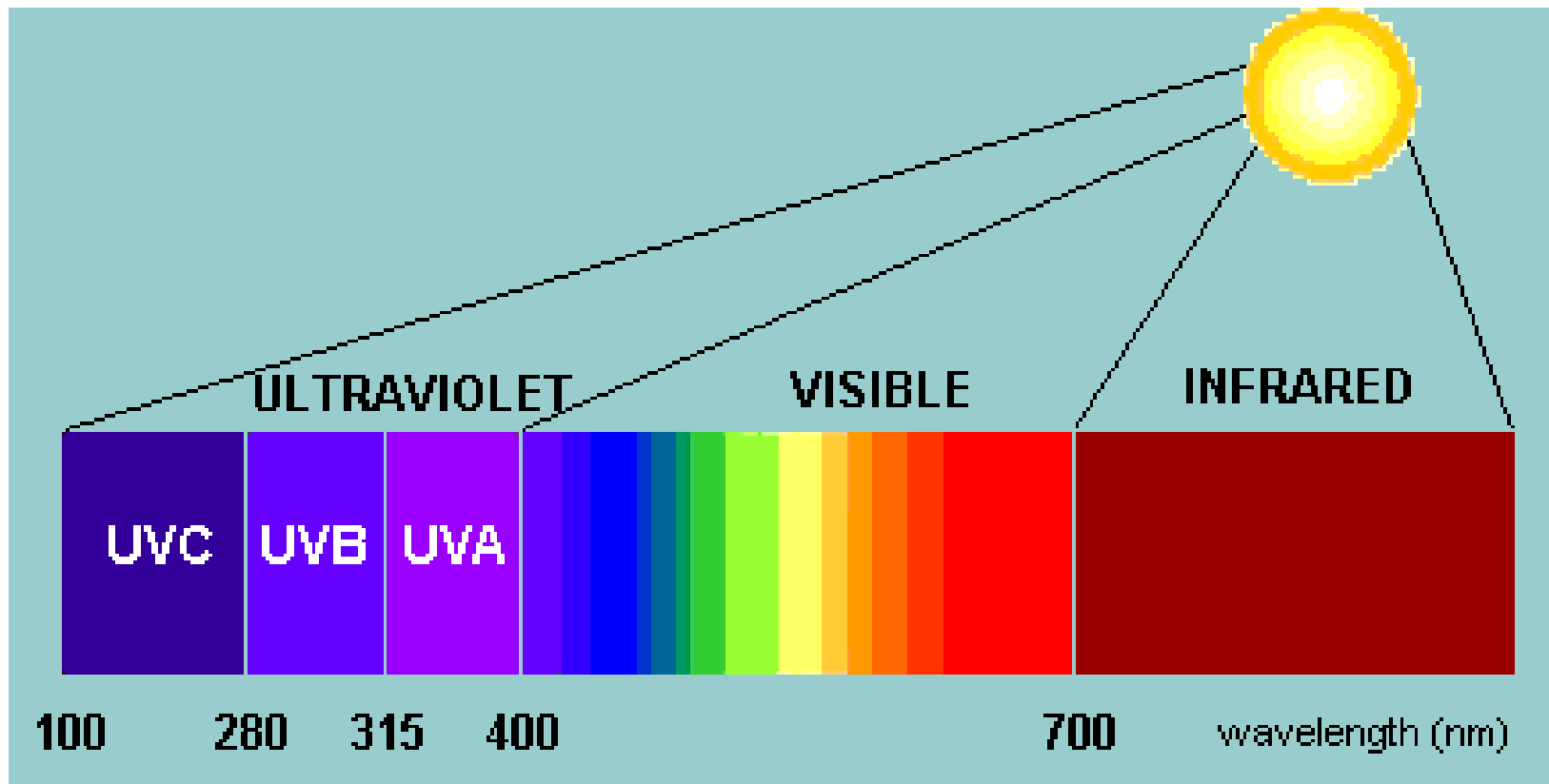
Interaction of radiation with leaf



Conversion of solar energy into carbohydrates by a leaf. Of the total incident energy, only 5% is converted into carbohydrates.

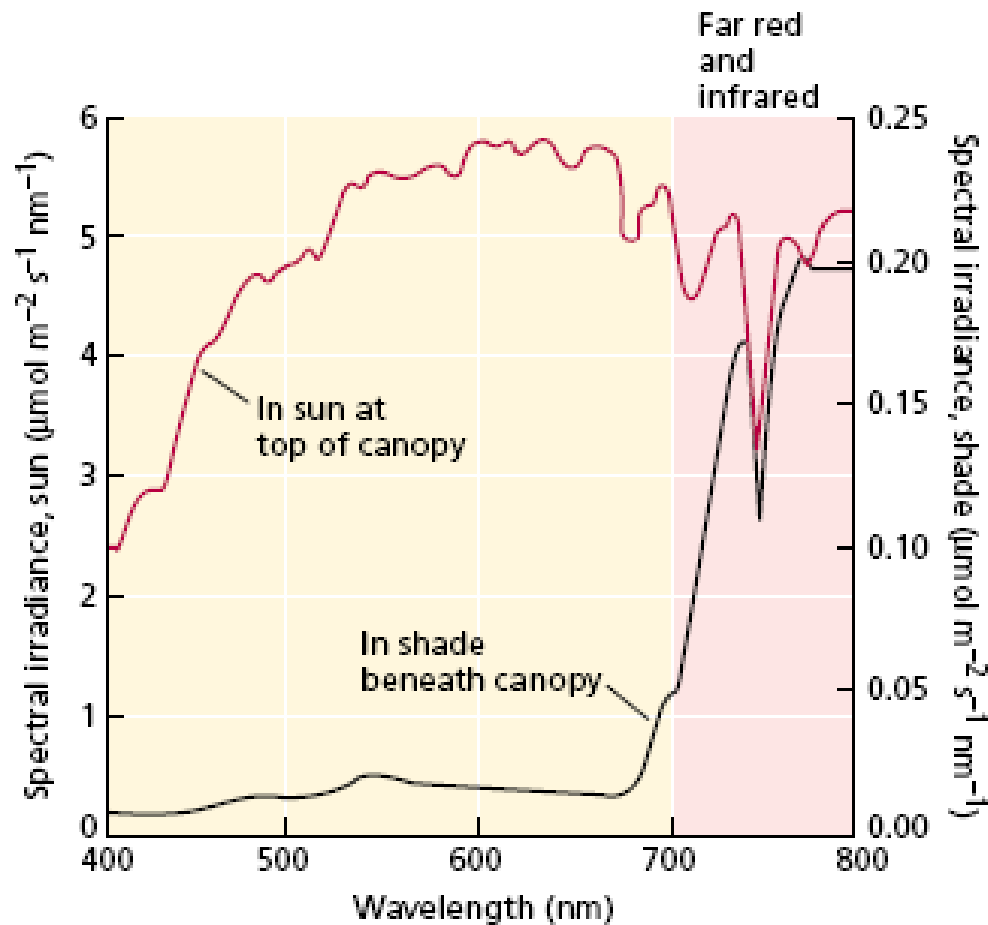
Solar radiation

Solar spectra



- ▣ Quality, intensity, and duration of light energy
- ▣ Photosynthetically active radiation (PAR)

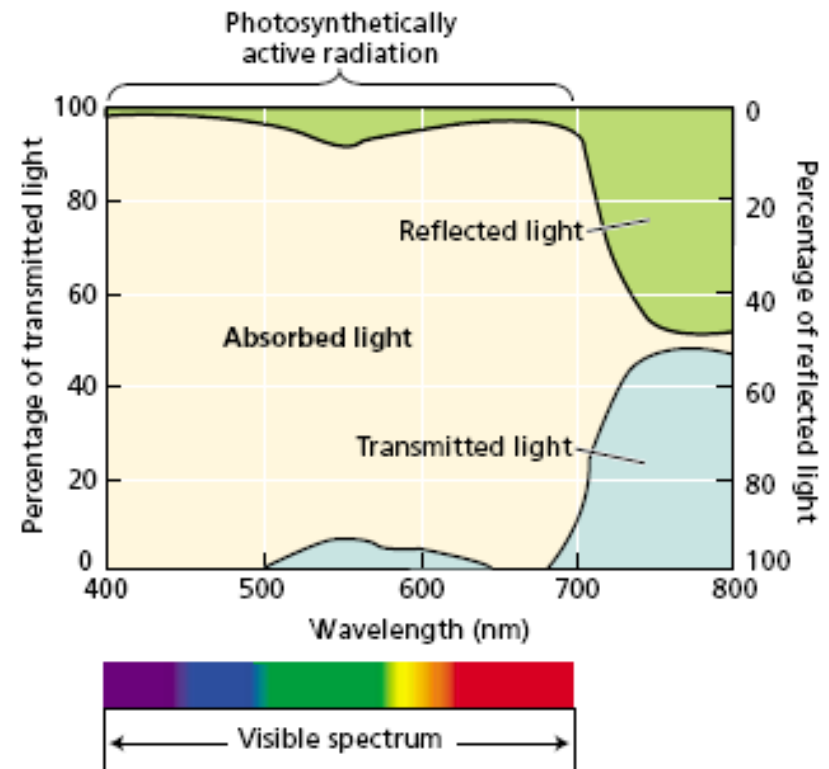
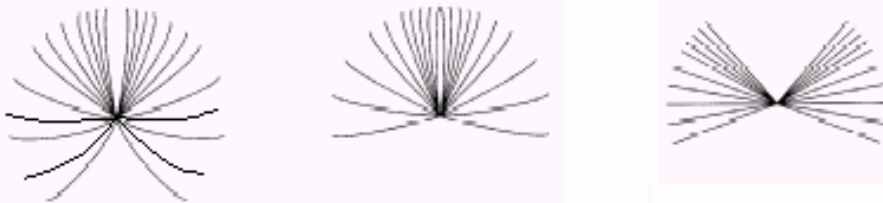
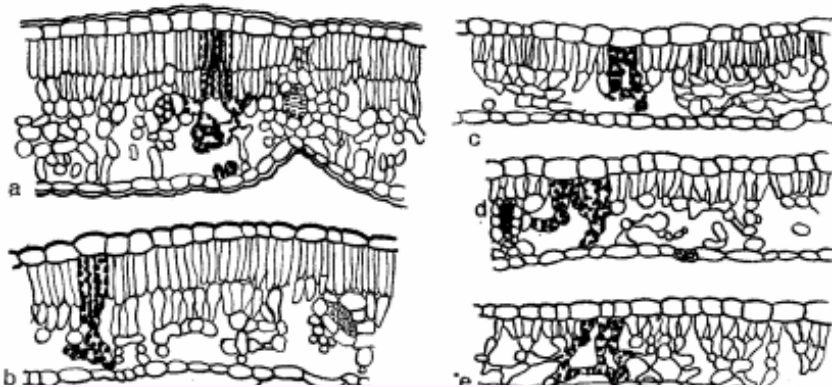
Light spectral composition above and under canopy



The spectral distribution of sunlight at the top of a canopy and under the canopy. For unfiltered sunlight, the total irradiance was $1900 \mu\text{mol m}^{-2} \text{s}^{-1}$; for shade, $17.7 \mu\text{mol m}^{-2} \text{s}^{-1}$. Most of the photosynthetically active radiation was absorbed by leaves in the canopy. (From Smith 1994.)

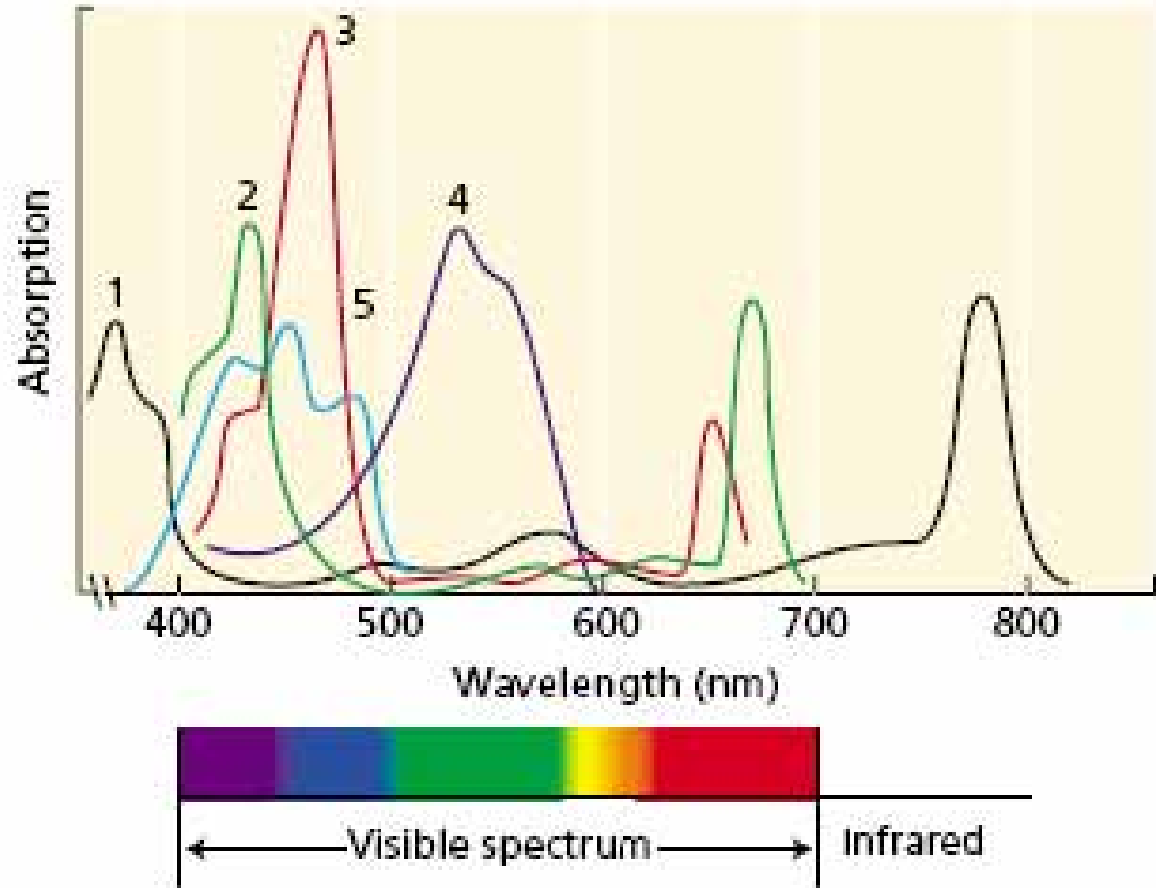
Interaction of radiation with leaf

Sun adapted – Shade adapted



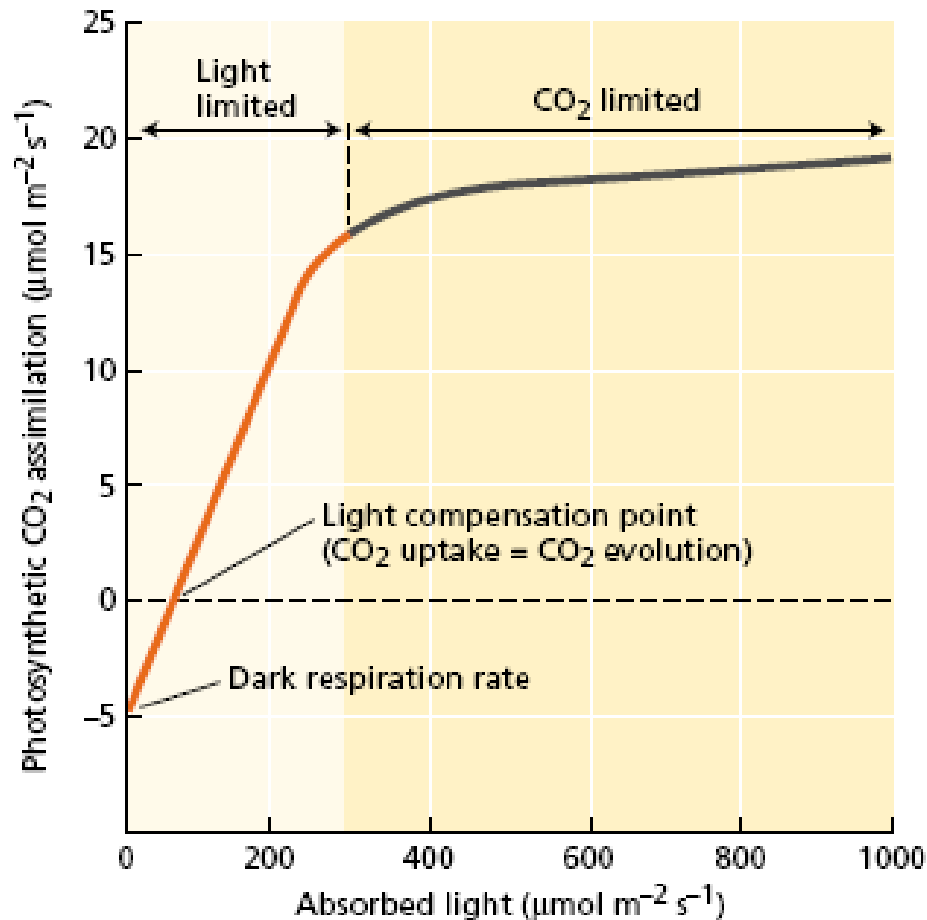
Optical properties of a bean leaf. Shown here are the percentages of light absorbed, reflected, and transmitted, as a function of wavelength. The transmitted and reflected green light in the wave band at 500 to 600 nm gives leaves their green color. Note that most of the light above 700 nm is not absorbed by the leaf. (From Smith 1986.)

#Note



Absorption spectra of some photosynthetic pigments. Curve 1, bacteriochlorophyll *a*; curve 2, chlorophyll *a*; curve 3, chlorophyll *b*; curve 4, phycoerythrobilin; curve 5, β -carotene. The absorption spectra shown are for pure pigments dissolved in nonpolar solvents, except for curve 4, which represents an aqueous buffer of phycoerythrin, a protein from cyanobacteria that contains a phycoerythrobilin chromophore covalently attached to the peptide chain. In many cases the spectra of photosynthetic pigments in vivo are substantially affected by the environment of the pigments in the photosynthetic membrane. (After Avers 1985.)

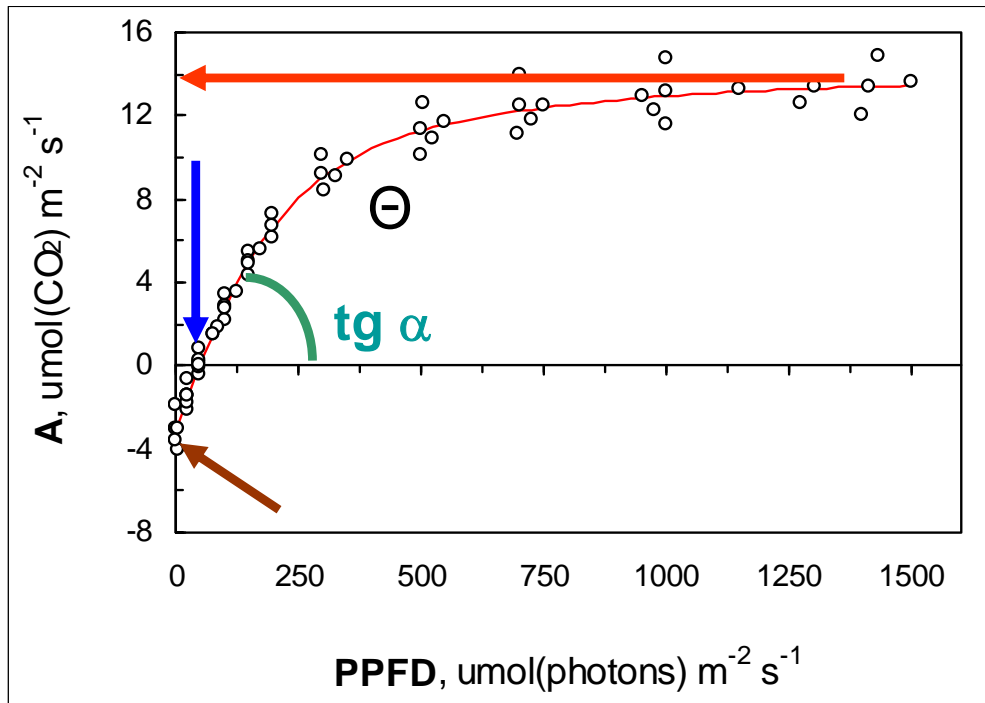
Photosynthesis



Response of photosynthesis to light in a C₃ plant. In darkness, respiration causes a net efflux of CO₂ from the plant. The light compensation point is reached when photosynthetic CO₂ assimilation equals the amount of CO₂ evolved by respiration. Increasing light above the light compensation point proportionally increases photosynthesis indicating that photosynthesis is limited by the rate of electron transport, which in turn is limited by the amount of available light. This portion of the curve is referred to as light-limited. Further increases in photosynthesis are eventually limited by the carboxylation capacity of rubisco or the metabolism of triose phosphates. This part of the curve is referred to as CO₂ limited.

Physiological processes and light

□ Photosynthesis



R_D – dark (mitochondrial) respiration

$$\mu\text{mol}(\text{CO}_2) \text{ m}^{-2} \text{ s}^{-1}$$

Γ_I – compensation irradiance

$$\mu\text{mol}(\text{photon}) \text{ m}^{-2} \text{ s}^{-1}$$

AQE (tg α) – apparent quantum efficiency

$$\text{mol}(\text{CO}_2) \text{ mol}^{-1}(\text{photons})$$

\ominus – curvature (0 – 1) dimensionless

A_{max} – light-saturated assimilation rate

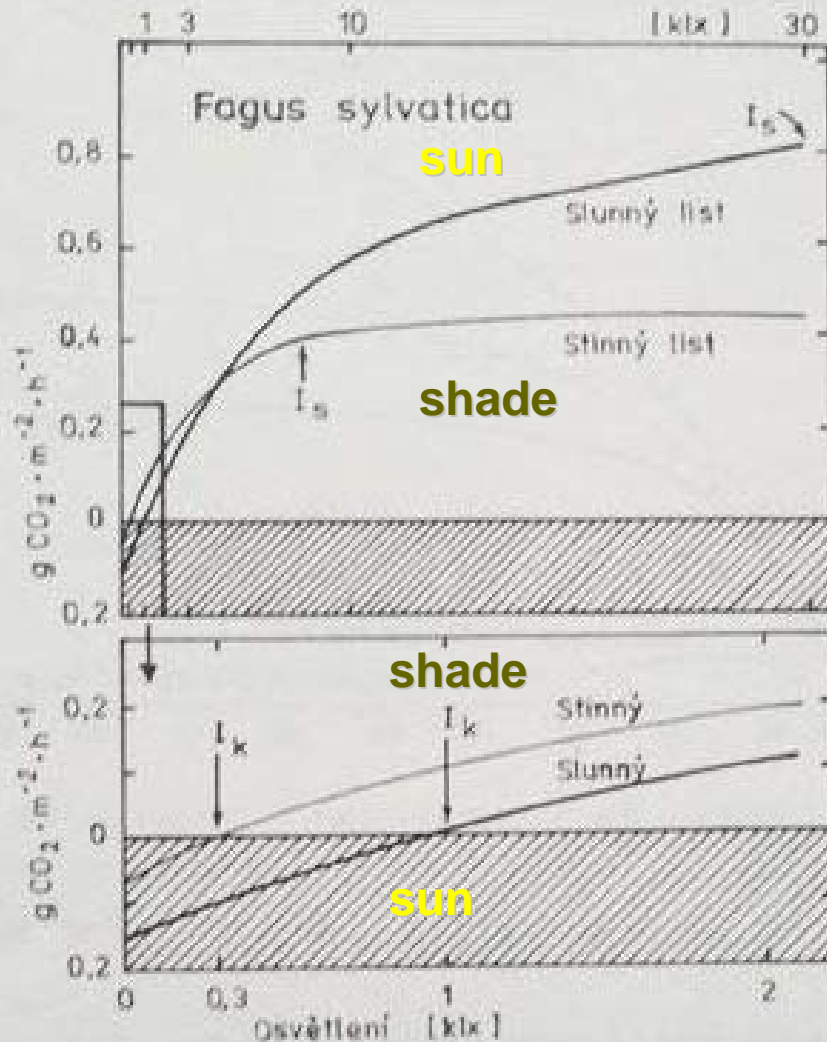
$$\mu\text{mol}(\text{CO}_2) \text{ m}^{-2} \text{ s}^{-1}$$

Photosynthesis: assimilation rate depending on irradiance (light intensity)

a) leaf/shoot level,

b) stand level

Differences in sun x shade leaves



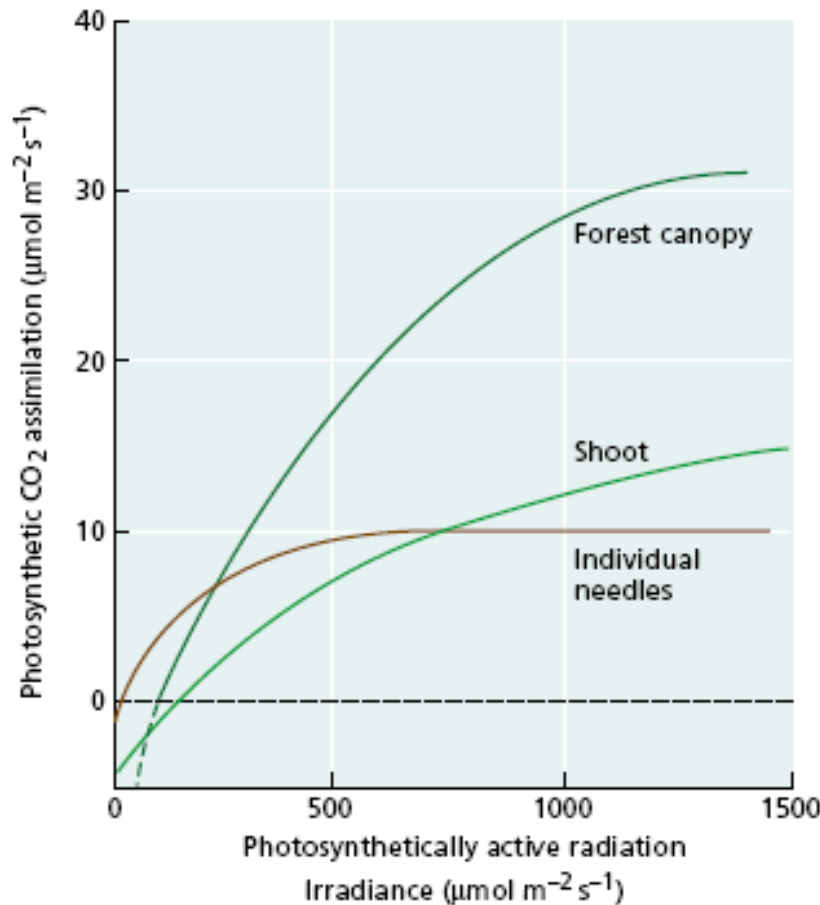
Shade acclimated leaves/plants:

- lower R_D
- lower Γ_l
- higher AQE
- lower A_{max}

Shade leaves are:

- thinner leaves but larger total leaf area (higher specific leaf area – SLA; cm² g⁻¹)
- lower number of stomata per unit leaf area
- higher chlorophyll and carotenoids content per unit mass (mg g_{DW}⁻¹)
- irregularly oriented granna
- lower Nitrogen content
- ...

Photosynthesis per different levels



Changes in photosynthesis (expressed on a per-square-meter basis) in individual needles, a complex shoot, and a forest canopy of Sitka spruce (*Picea sitchensis*) as a function of irradiance. Complex shoots consist of groupings of needles that often shade each other, similar to the situation in a canopy where branches often shade other branches. As a result of shading, much higher irradiance levels are needed to saturate photosynthesis. The dashed line has been extrapolated from the measured part of the curve.

(From Jarvis and Leverenz 1983.)

Sunny x cloudy days – ecosystem level

Urban et al.: *Global Change Biology* 13: 157-168, 2007

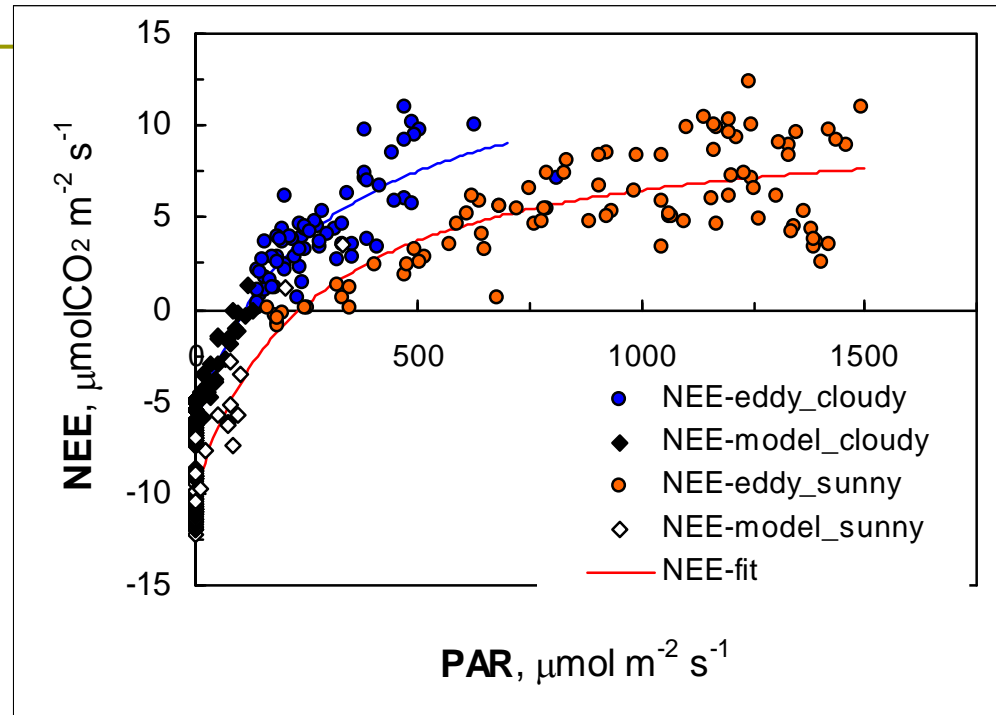
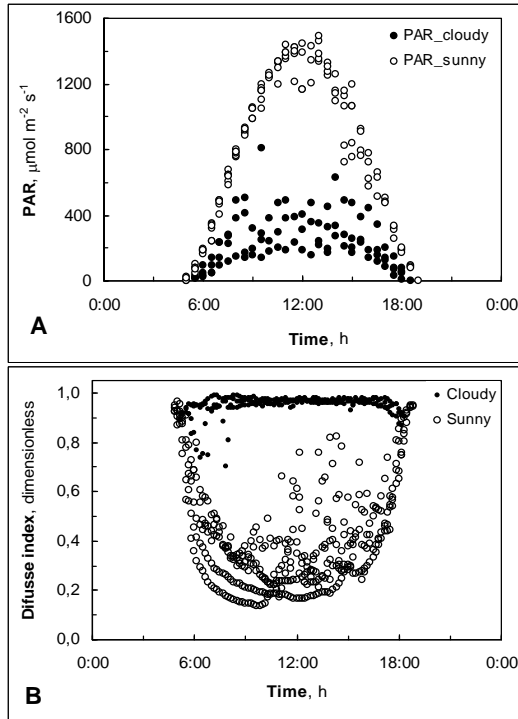


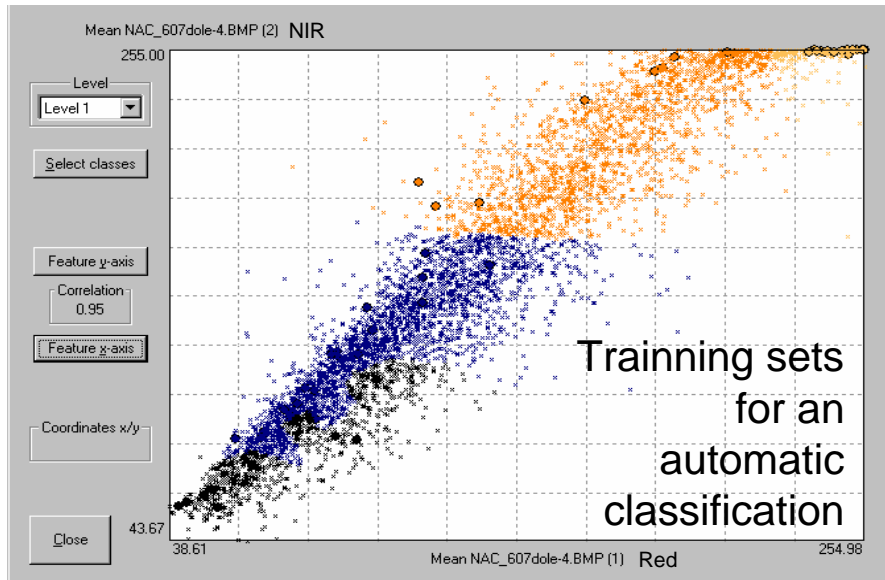
Fig.1A,B: Typical daily courses of photosynthetically active radiation intensity (PAR; A) and diffuse index (diffuse/global radiation; B).

Fig.2: Typical relationships between NEE and PAR over the day with prevailing direct (●) and diffuse (●) solar radiation.

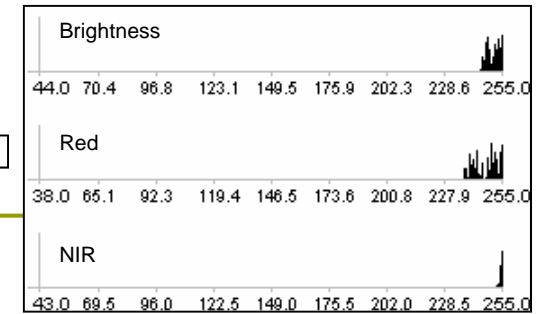
- significantly higher NEE during cloudy sky at corresponding PPFDs
 - diffuse index: > 0.7 (cloudy sky), < 0.3 (clear sky)
 - AQE higher by 20%, Γ_1 lower by 50% \Rightarrow energy of solar radiation is used more efficiently in CO_2 assimilation
- **dimming effect** \Rightarrow important global change

Classification of sunlit and shadowed spruce needles from colour image

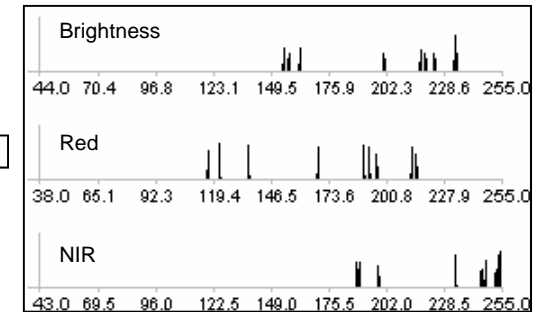
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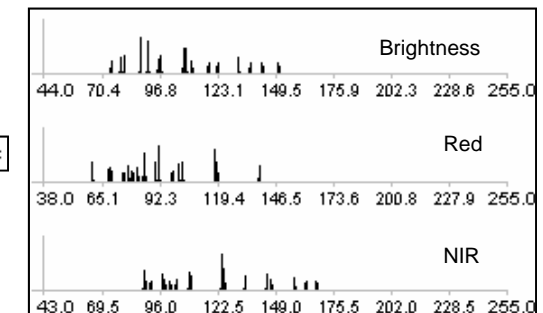
● high sunlit needles



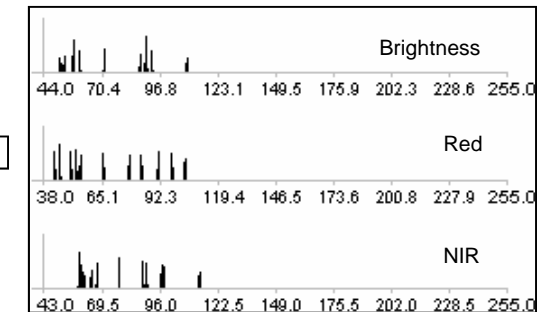
● low sunlit needles



● shadowed needles



● deep shadow



Radiation use efficiency (RUE)

RUE = $\Delta B / \text{APAR}$ resp. $\Delta B = \varepsilon \cdot \text{APAR}$

Monteith (1977)

Physiological processes interactions

- Photosynthesis
- Respiration
- Transpiration

Energy and mass fluxes

Morphological and physiological plant properties

- LAI, distribution..
- Tissue structure
- Chemical composition
- Stomatal conductance
- Pathway resistances
- Enzyme amount/ activity
- Pigment composition/amount

Geo-biological Functional interactions

Environment

– stand/ locality conditions

Soil + micro/climatic parameters

- Solar radiation
- Temperature
- Wind
- Water availability
- Nutrient availability

/build on physical, chemical and biological laws and principles/

Tree adaptation to sunlight

□ Sunlight requirements

- **Shade tolerant** - beech, hemlock, fir, sugar maple, red maple, dogwood, basswood (examples)
- **Intermediate tolerance** (semishade) - spruce, Douglas fir, pine, hornbeam, elm, limetree sycamore maple, some oaks, elm, white pine, white ash, wild service
- **Sun-loving** (shade intolerant) - larch, pine, birch, locust (robinia), aspen, mountain ash, yellow-popular, walnut, oaks, black cherry, yellow pine, hickory etc.

Temperature

directly affects the day-to-day **physiological processes** of plants

indirectly influences their **seasonal or cyclic development**.

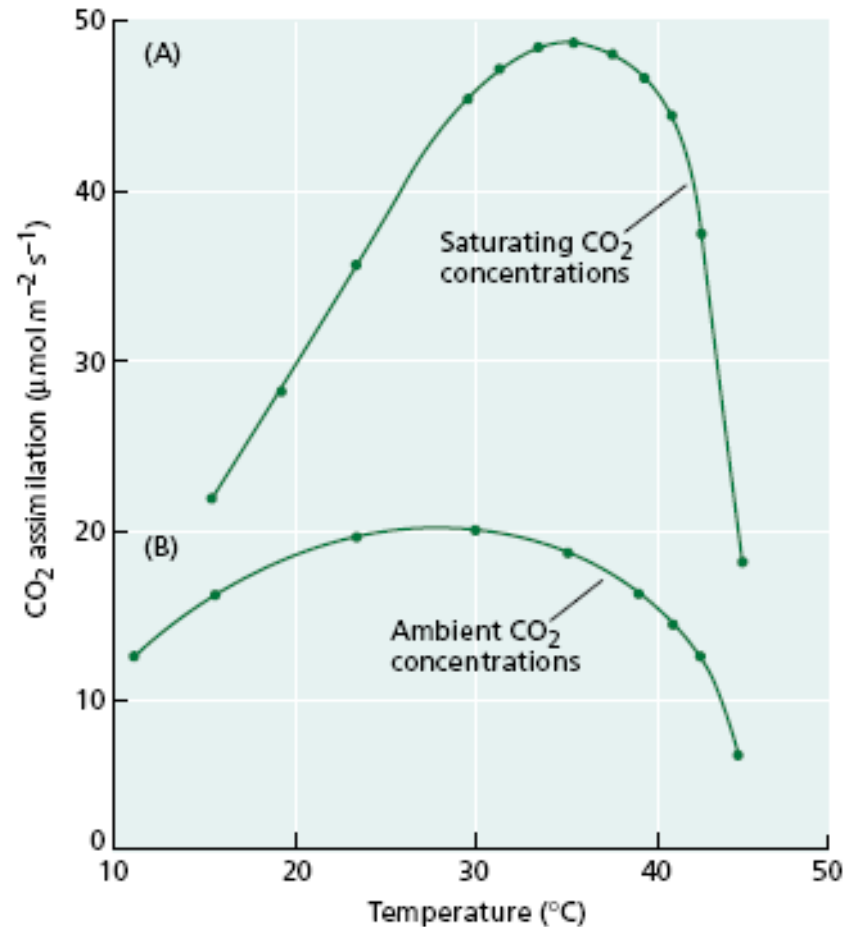
For each plant there is a set of cardinal temperatures that controls its growth and development and, in fact, its existence: **the minimum and maximum temperatures limiting growth and the optimum temperature for growth.**

- ❑ For alpine plants the minimum temperature is close to 0° C (32° F), the maximum 20° to 30° C (68° to 86° F), and the optimum 10° C (50° F).
- ❑ For temperate plants the minimum temperature is about 4° C (40° F), the maximum 41° C (106° F), and the optimum 25° to 30° C (77° to 86° F).
- ❑ For tropical plants the minimum is 10° C (50° F), the maximum 50° C (122° F), and the optimum 30° to 35° C (86° to 95° F).

Physiological processes and temperature

- Photosynthesis
- Respiration
- Transpiration

Changes in photosynthesis as a function of temperature at CO₂ concentrations that saturate photosynthetic CO₂ assimilation (A) and at normal atmospheric CO₂ concentrations (B). Photosynthesis depends strongly on temperature at saturating CO₂ concentrations. Note the significantly higher photosynthetic rates at saturating CO₂ concentrations.
(Redrawn from Berry and Björkman 1980.)



Temperature requirements

- ❑ Tree tolerate temperatures in a wide interval (there are differences due to elevation a.s.l. from lowland to hills, terrain relief and exposition; edafic factors, microclimate and concurent or symbiotic relations play important role too). Some tree species tolerate temperature extremes (larch, limba, birch), contrariwise other ones need steady temperature conditions (fir, tis, beech).
- ❑ *Trees can be divided, from the point of temperature tolerance, to the following groups:*
 - ❑ High temperature demands - kaštan jedlý a jírovec-maďál, dub, lípy, habr, javor mlíč
 - ❑ Low temperature demands- spruce, pine, birch, jeřáb

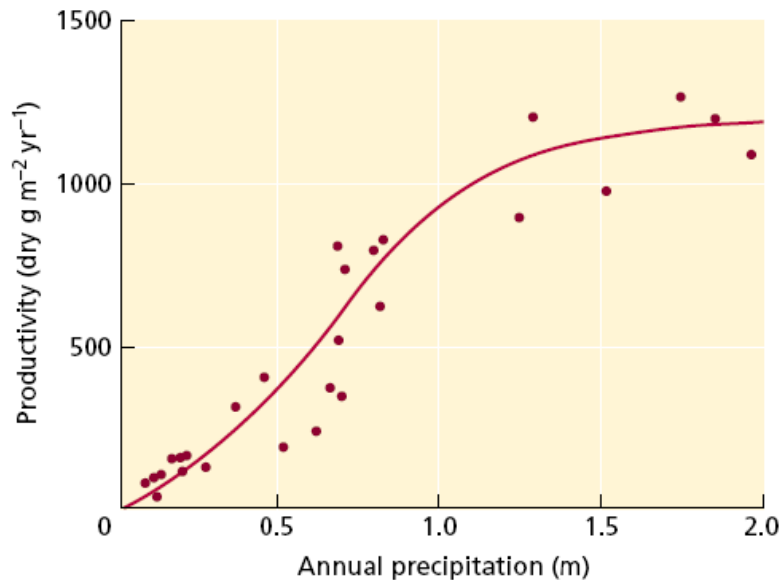
Mechanism of injury

- ❑ Resistance to freezing temperatures, or frost hardiness, may result from a change in the protoplasm. The osmotic concentration of the cell sap increases with the hydrolysis of insoluble carbohydrates to soluble sugars. Dehydration of the protoplasm leads to an increase in the apparent bound water content of the proteins. Frost injury results from the formation of ice crystals within the protoplasm or the dehydration of the cell by ice formation in the intracellular spaces.
- ❑ Heat resistance also appears related to a change in cellular proteins. The killing of cells by heat is brought about by denaturation of the proteins.

Thermoperiodicity

- Plants not only respond to maximum, minimum, and optimum temperatures, but some also grow or develop best with an alternation of daily or seasonal temperatures.
 - Different response of photosynthesis and respiration
 - Translocation of photosynthates
 - Low temperatures during plant dormant period
 - Sum of effective temperature

Humidity



Productivity of various ecosystems as a function of annual precipitation. Productivity was estimated as net aboveground accumulation of organic matter through growth and reproduction. (After Whittaker 1970.)

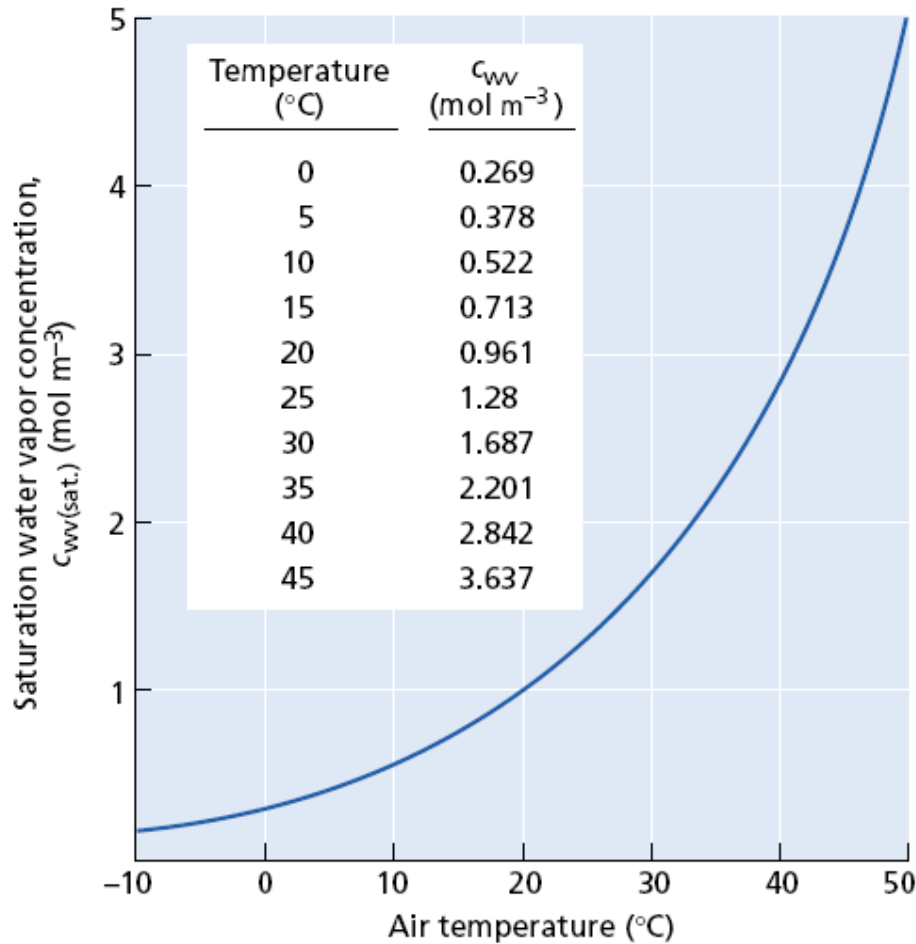
Negligible demands - pine, robinia, birch, juniper

High demands - poplar, wilow, common ash, common alder

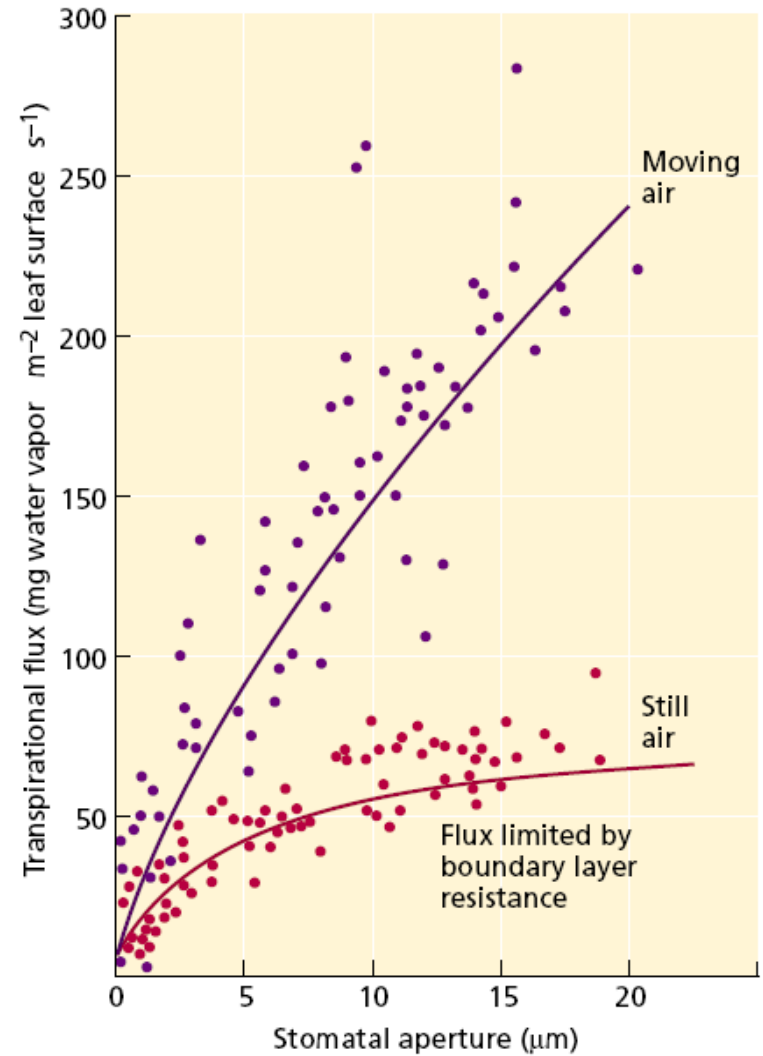
Middle demands - other tree species

Exceptions: e.g. grey alder can adapt to arid sites, however it grows lower there, similarly ash on calcareous soils.

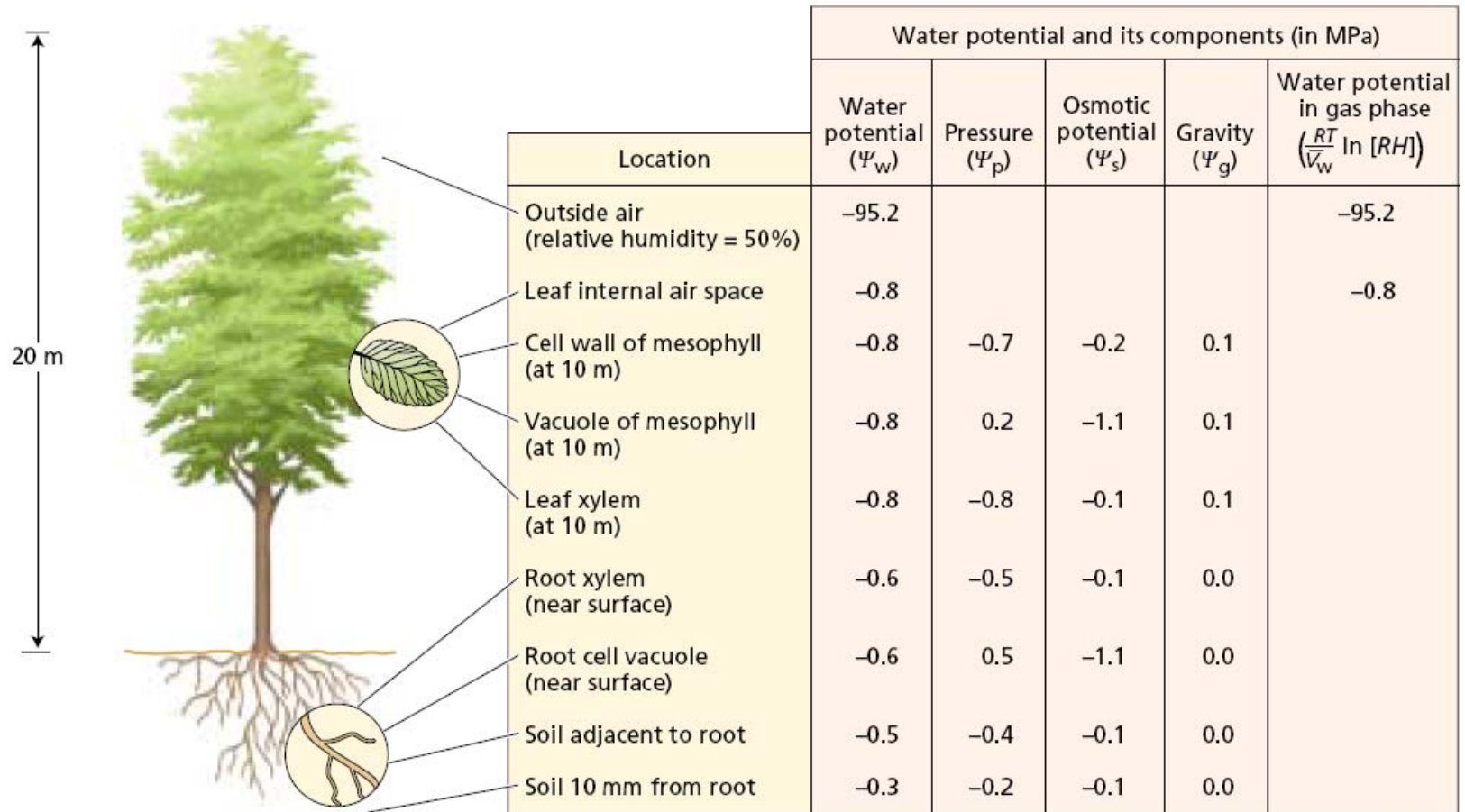
Usually, all tree species grow well on fresh soil sites with a certain degree of soil moisture (including *Pinus spp* and *Populus tremula*)



Concentration of water vapor in saturated air as a function of air temperature.

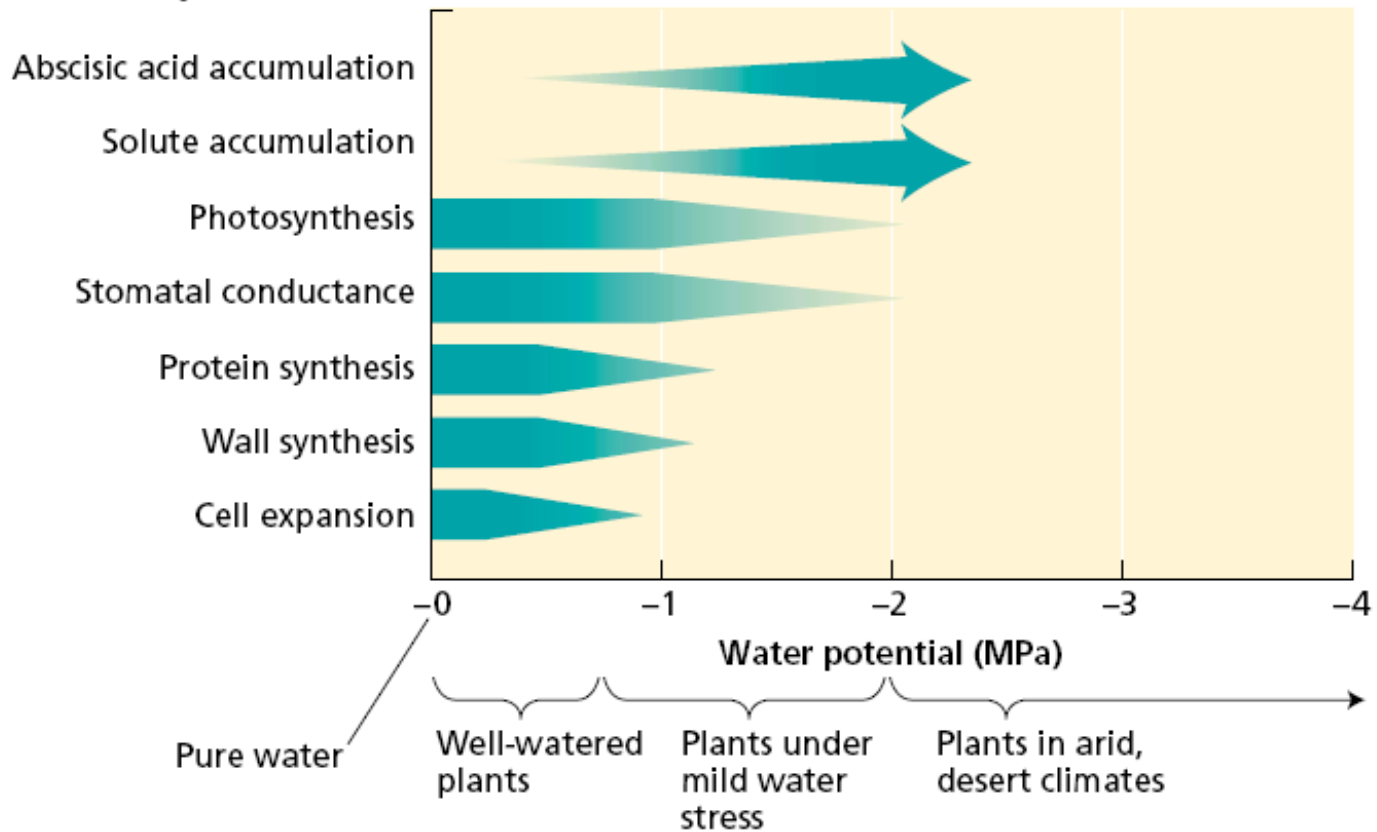


Dependence of transpiration flux on the stomatal aperture of zebra plant (*Zebra pendula*) in still air and in moving air. The boundary layer is larger and more rate limiting in still air than in moving air. As a result, the stomatal aperture has less control over transpiration in still air. (From Bange 1953.)



Representative overview of water potential and its components at various points in the transport pathway from the soil through the plant to the atmosphere. Water potential (Ψ_w) can be measured through this continuum, but the components vary. In the liquid part of the pathway, pressure (Ψ_p), osmotic potential (Ψ_s), and gravity (Ψ_g), determine Ψ_w . In the air, only the relative humidity ($\frac{RT}{V_w} \ln [RH]$) is important. Note that although the water potential is the same in the vacuole of the mesophyll cell and in the surrounding cell wall, the components of Ψ_w can differ greatly (e.g., in this case Ψ_p is 0.2 MPa inside the mesophyll cell and -0.7 MPa outside). (After Nobel 1999.)

Physiological changes
due to dehydration:



Water potential of plants under various growing conditions, and sensitivity of various physiological processes to water potential. The intensity of the bar color corresponds to the magnitude of the process. For example, cell expansion decreases as water potential falls (becomes more negative). Abscisic acid is a hormone that induces stomatal closure during water stress. (After Hsiao 1979.)

Wind

Soil

- ▣ **Soil classification**

FAO, soil properties (physical, chemical)

- ▣ **Soils in which a timber specie grow**

A brief guide to some of the major timber species and the soils they grow best in.

- ▣ **Fertilization**

Stand demand, nutrient supply, fertilizer materials and application, methods, and composting.

- ▣ **Visual estimation of nutrient insufficiency**

Adequate tissue levels of elements that may be required by plants

Element	Chemical symbol	Concentration in dry matter (% or ppm) ^a	Relative number of atoms with respect to molybdenum
Obtained from water or carbon dioxide			
Hydrogen	H	6	60,000,000
Carbon	C	45	40,000,000
Oxygen	O	45	30,000,000
Obtained from the soil			
Macronutrients			
Nitrogen	N	1.5	1,000,000
Potassium	K	1.0	250,000
Calcium	Ca	0.5	125,000
Magnesium	Mg	0.2	80,000
Phosphorus	P	0.2	60,000
Sulfur	S	0.1	30,000
Silicon	Si	0.1	30,000
Micronutrients			
Chlorine	Cl	100	3,000
Iron	Fe	100	2,000
Boron	B	20	2,000
Manganese	Mn	50	1,000
Sodium	Na	10	400
Zinc	Zn	20	300
Copper	Cu	6	100
Nickel	Ni	0.1	
Molybdenum	Mo	0.1	

Mineral elements classified on the basis of their mobility within a plant and their tendency to retranslocate during deficiencies

Mobile	Immobile
Nitrogen	Calcium
Potassium	Sulfur
Magnesium	Iron
Phosphorus	Boron
Chlorine	Copper
Sodium	
Zinc	
Molybdenum	

Note: Elements are listed in the order of their abundance in the plant.

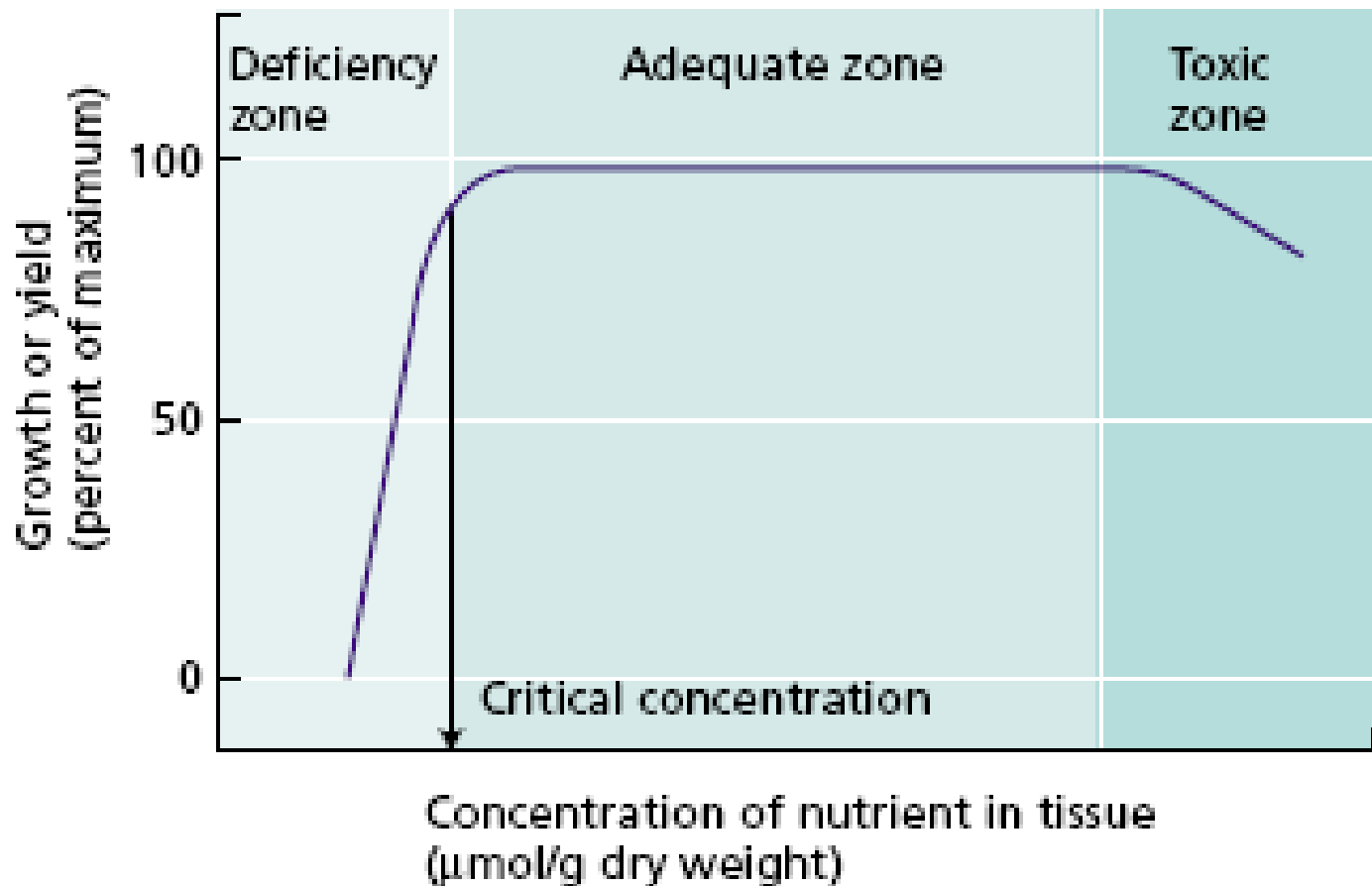
Source: Epstein 1972, 1999.

^aThe values for the nonmineral elements (H, C, O) and the macronutrients are percentages. The values for micronutrients are expressed in parts per million.

Classification of plant mineral nutrients according to biochemical function

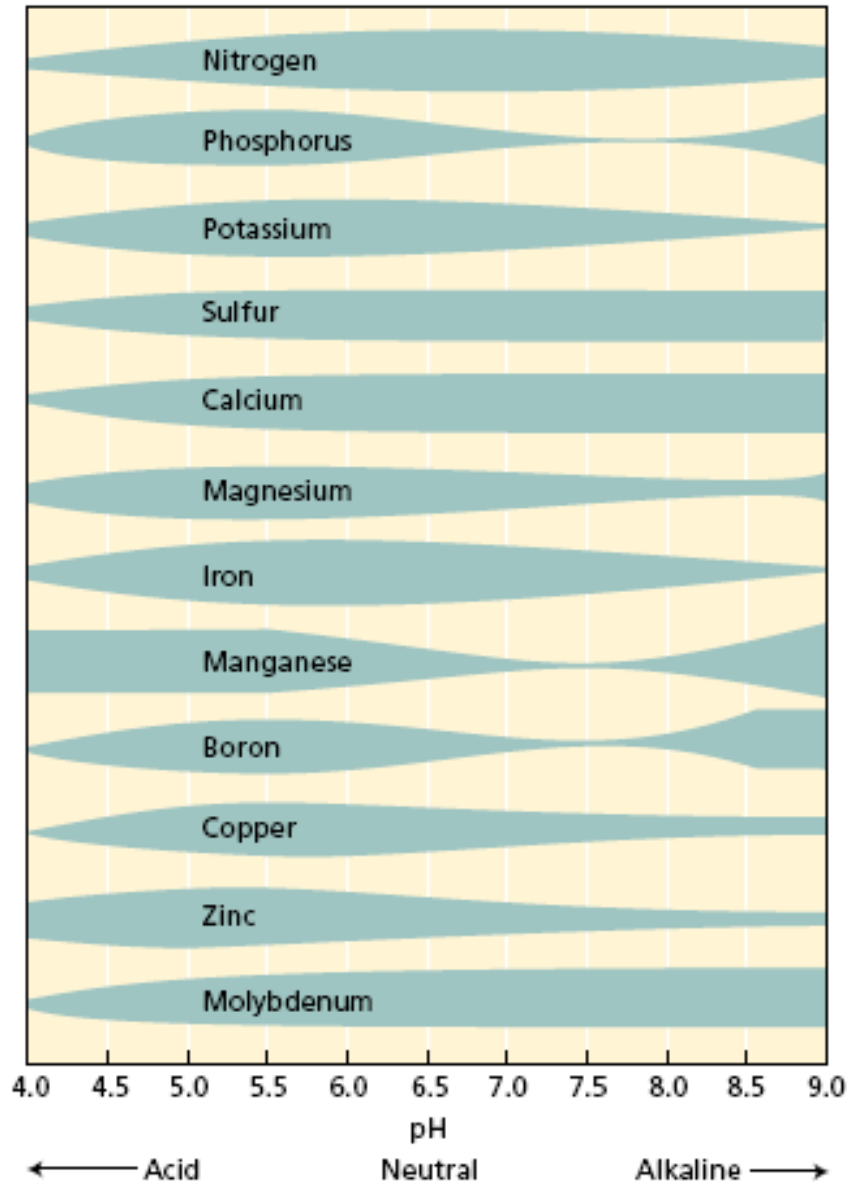
Mineral nutrient	Functions
Group 1	Nutrients that are part of carbon compounds
N	Constituent of amino acids, amides, proteins, nucleic acids, nucleotides, coenzymes, hexoamines, etc.
S	Component of cysteine, cystine, methionine, and proteins. Constituent of lipoic acid, coenzyme A, thiamine pyrophosphate, glutathione, biotin, adenosine-5'-phosphosulfate, and 3-phosphoadenosine.
Group 2	Nutrients that are important in energy storage or structural integrity
P	Component of sugar phosphates, nucleic acids, nucleotides, coenzymes, phospholipids, phytic acid, etc. Has a key role in reactions that involve ATP.
Si	Deposited as amorphous silica in cell walls. Contributes to cell wall mechanical properties, including rigidity and elasticity.
B	Complexes with mannitol, mannan, polymannuronic acid, and other constituents of cell walls. Involved in cell elongation and nucleic acid metabolism.
Group 3	Nutrients that remain in ionic form
K	Required as a cofactor for more than 40 enzymes. Principal cation in establishing cell turgor and maintaining cell electroneutrality.
Ca	Constituent of the middle lamella of cell walls. Required as a cofactor by some enzymes involved in the hydrolysis of ATP and phospholipids. Acts as a second messenger in metabolic regulation.
Mg	Required by many enzymes involved in phosphate transfer. Constituent of the chlorophyll molecule.
Cl	Required for the photosynthetic reactions involved in O ₂ evolution.
Mn	Required for activity of some dehydrogenases, decarboxylases, kinases, oxidases, and peroxidases. Involved with other cation-activated enzymes and photosynthetic O ₂ evolution.
Na	Involved with the regeneration of phosphoenolpyruvate in C ₄ and CAM plants. Substitutes for potassium in some functions.
Group 4	Nutrients that are involved in redox reactions
Fe	Constituent of cytochromes and nonheme iron proteins involved in photosynthesis, N ₂ fixation, and respiration.
Zn	Constituent of alcohol dehydrogenase, glutamic dehydrogenase, carbonic anhydrase, etc.
Cu	Component of ascorbic acid oxidase, tyrosinase, monoamine oxidase, uricase, cytochrome oxidase, phenolase, laccase, and plastocyanin.
Ni	Constituent of urease. In N ₂ -fixing bacteria, constituent of hydrogenases.
Mo	Constituent of nitrogenase, nitrate reductase, and xanthine dehydrogenase.

Source: After Evans and Sorger 1966 and Mengel and Kirkby 1987.



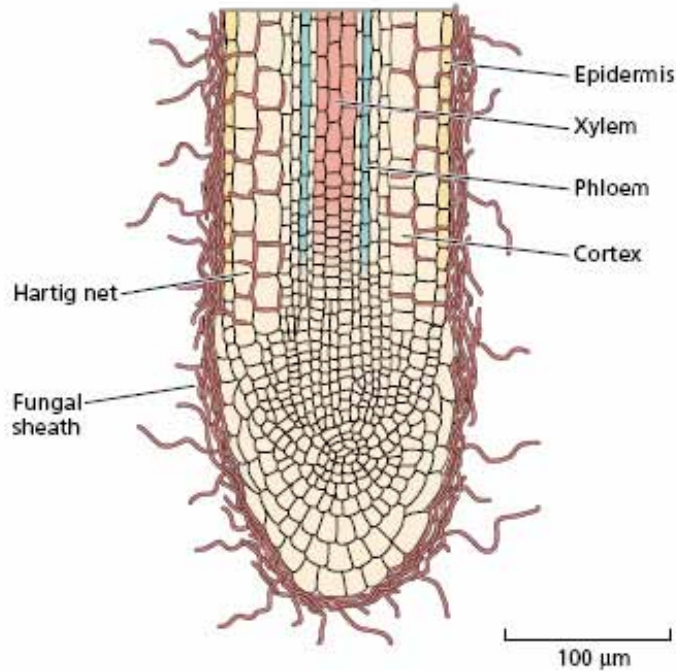
Relationship between yield (or growth) and the nutrient content of the plant tissue. The yield parameter may be expressed in terms of shoot dry weight or height. Three zones—deficiency, adequate, and toxic—are indicated on the graph. To yield data of this type, plants are grown under conditions in which the concentration of one essential nutrient is varied while all others are in adequate supply. The effect of varying the concentration of this nutrient during plant growth is reflected in the growth or yield. The critical concentration for that nutrient is the concentration below which yield or growth is reduced.

pH

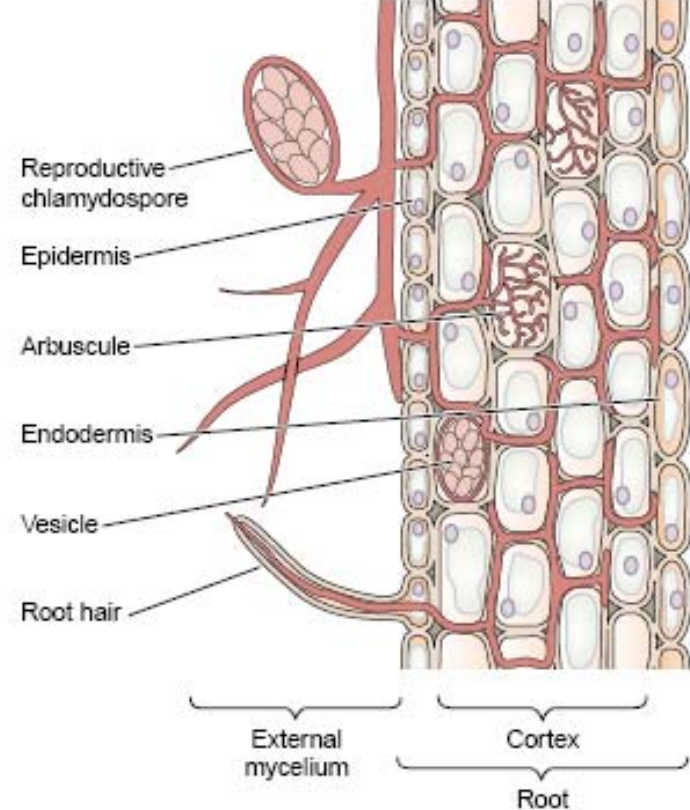


Influence of soil pH on the availability of nutrient elements in organic soils. The width of the shaded areas indicates the degree of nutrient availability to the plant root. All of these nutrients are available in the pH range of 5.5 to 6.5. (From Lucas and Davis 1961.)

Mycorrhizal Fungi



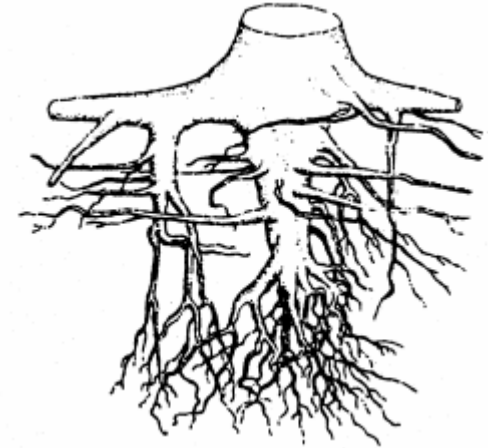
Root infected with ectotrophic mycorrhizal fungi. In the infected root, the fungal hyphae surround the root to produce a dense fungal sheath and penetrate the intercellular spaces of the cortex to form the Hartig net. The total mass of fungal hyphae may be comparable to the root mass itself. (From Rovira et al. 1983.)



Association of vesicular-arbuscular mycorrhizal fungi with a section of a plant root. The fungal hyphae grow into the intercellular wall spaces of the cortex and penetrate individual cortical cells. As they extend into the cell, they do not break the plasma membrane or the tonoplast of the host cell. Instead, the hypha is surrounded by these membranes and forms structures known as arbuscules, which participate in nutrient ion exchange between the host plant and the fungus. (From Mauseth 1988.)

Roots - Root System

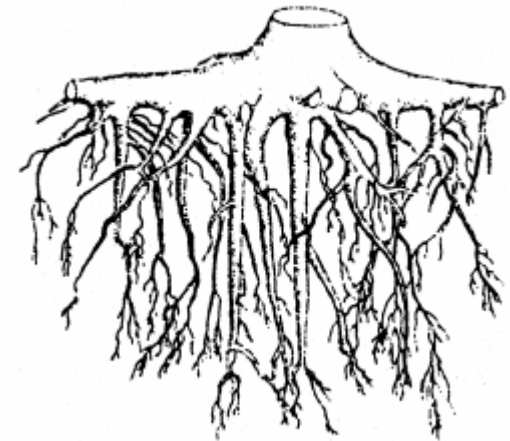
a) RS with one dominant stake root



b) heart-shaped RS



c) RS with dominant roots tracing closely beneath ground surface or in a shallow soil layer



Root system depth

- shallowly rooting – spruce, *sorbus*, common willow, aspen
- middle-depth rooting – common maple, Norway maple, willows, birch
- deeply rooting - fir, larch, pine, douglas fir, beech, oak, ash, limetrees, hornbeam

Trophic rank

A - oligotrophic (pure and acidic)

B - mezotrophic (middle rich)

C - nitrophilous (enriched by nitrogen)

D - basic (rich by nutrients on basic rock)

/inter-ranks AB, BC, BD, CD/

wide span trophic ranks and soil acidity - druhy euryekní

purely oligotrophic species, explicitly bound to A rank - stenoekní

Hydric rank

1 – ground/ dwarf (dry)

2 - limited

3 - normal

4 - waterlogged

5 - wet

6 - peaty

Horizontal zonation :

- polar zone
 - temperate zone
 - subtropic zone
 - tropic zone
- arctic (polar) zone, subarctic – forest-free area
 - tundra – partial shrub vegetation
 - taiga - evergreen coniferous forests
 - mixed and broadleaved forests
 - deciduous broadleaved forests
 - evergreen (hard-leaved) non-deciduous forest
 - tropical rain forests, virgin forests

European forest area is subdivided into several more zones according to dominant tree species representation (15) :

- Zone of coniferous forests in north Europe
- Zone of coniferous and broadleaved forests in northeast Europe
- Zone of beechwood forests in central Europe
- Zone of west European broadleaved forests
- Alpine zone
- oak and beech zone in east and southeast Europe
- oak and forest steppe zone in southeast Europe
- beech forest zone in Krym
- chestnut tree and hard-leaved tree zone in south Europe

Vertical zonation:

1. Planar level - alluvial and flat areas with low altitude above sea level – riparian woodlands, floodplain forest and oak-hornbeam forests
2. Hilly level - low hills and knolls interspersed throughout lowlands with
3. Submontane level - mostly beechforests
4. Montane level - mid-european edges and tops or highly elevated montane areas up to 800 m a.s.l. with prevailing broadleaved forests over coniferous
5. Oreal level /high mountain area from 800 to 1200 (1400)/ m a.s.l.-mostly coniferous forest, occasionally with beech
6. Subalpine level - high-mountain localities close upper forest boundary (limit)
7. Alpine level - vegetation above forest boundary, shrub vegetation, dwarf pine, alpine mountain meadow
8. Nival level (snow) - localities with permanent snow and ice

1. flood-plain and flat sands area - floodplain forests, pine forests, oak forests
2. stupeň pahorkatin - chlumní lesy, jejichž kostru tvoří dub
3. stupeň horský - spodní - podhůří, pásmo bučin
- horní - horský les, pásmo smrčin
4. stupeň alpínský - subalpínský - smrčiny, porosty modřínu, limby
- alpínský – porosty kleče, alpínské nivy, hole, poloniny

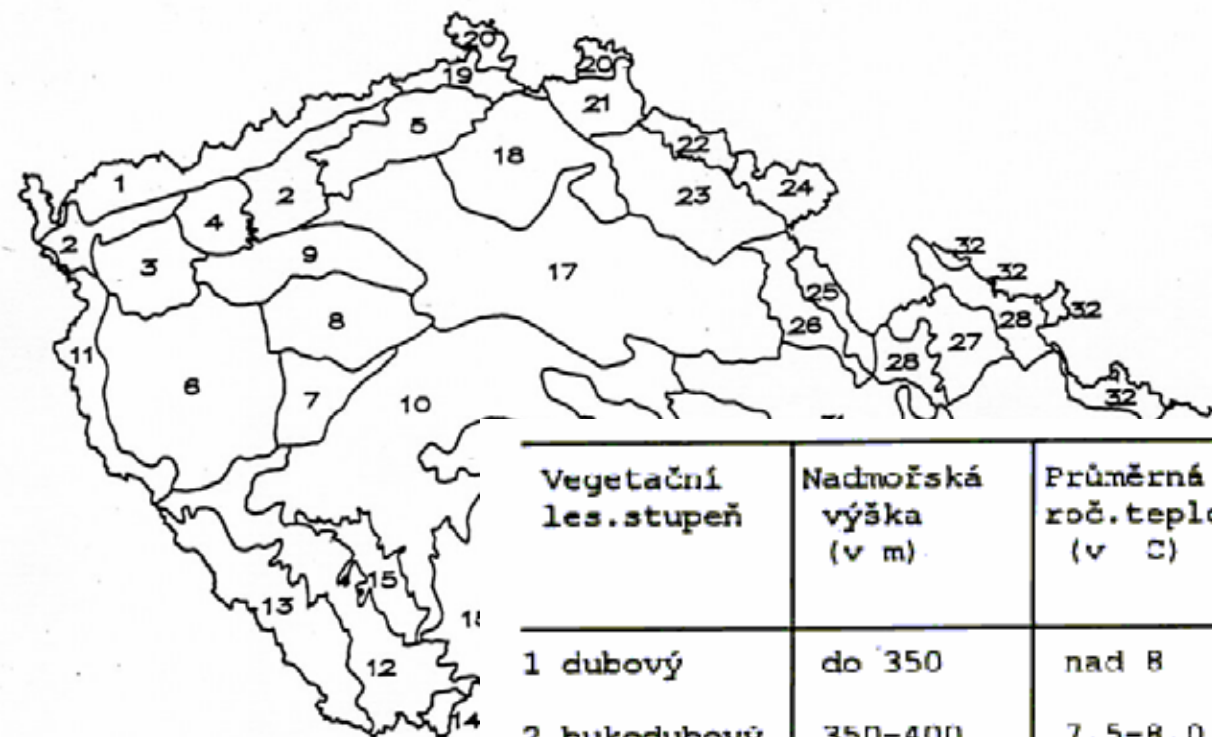
Spread of tree forest types



1_rain-tropical forests
2_evergreen forests

3_monsoon forests
4_temperate forests

5_boreal forests



1. Krušné hory
2. Podkrušnohorské pánve
3. Karlovarská vrchovina
4. Doupovské hory
5. České středohoří
6. Západočeská pahorkatina
7. Brdská vrchovina
8. Křivoklátsko a Český kras
9. Rakovnicko - kladenská pahorkatina
10. Středočeská pahorkatina
11. Český les
12. Předhoří Šumavy a Novohradských hor
13. Šumava
14. Novohradské hory
15. Jihočeské pánve
16. Českomoravská vrchovina
17. Polabí
18. Severočeská pískovcová plošina a Český ráj

19. Lu
20. Lu
21. Jz
22. Kr
23. Pt
24. St

Vegetační les.stupeň	Nadmořská výška (v m)	Průměrná roč.teplot (v C)	Roč.srážky (v mm)	Veget.doba (počet dnů s prům.teplot 10 C a vic)
1 dubový	do 350	nad 8	pod 600	nad 165
2 bukodubový	350-400	7,5-8,0	600-700	150-165
3 dubobukový	400-550	6,5-7,5		
4 bukový	550-600	6,0-6,5	700-900	130-150
5 jedlobukový	600-700	5,5-6,0		
6 smrkobukový	700-900	4,5-5,5	900-1200	100-130
7 bukosmrkový	900-1050	4,0-4,5		
8 smrkový	1050-1350	2,5-4,0	1200-1500	60-100
9 klečový	nad 1350	pod 2,5	nad 1500	pod 60

(dle ÚHUL; Plíva 1971)



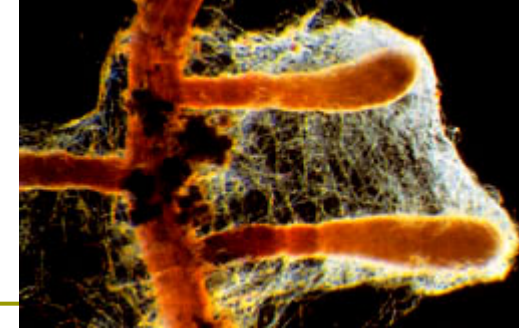
Mutualism

Most agree that mutualistic relationships evolved from more negative associations (predator prey, parasitism etc.). Basically the organism negatively impacted had two options: escape the relationship or adapt to it, and in the process make it advantageous to itself.

- ❑ Mutualism is a positive reciprocal relationship between two species. Through this relationship both species enhance their survival, growth or fitness. To a certain extent the relationship is more a reciprocal exploitation rather than a cooperative effort on the part of the individuals involved.

Mutualism can take on many forms:

- ❑ **Symbiosis:** in which both organisms live together in closely proximity, and in which both generally derive benefit. The relationship is **obligate**, meaning at least one of the species must be involved in the relationship to survive. If both species are obligate symbionts it means that neither can survive alone.
- ❑ **Non-symbiotic mutualism:** the species do not live together, nor are dependent on each other; the relationship is facultative or opportunistic but does profit the organisms when together. Many mutualistic relationships have been documented.



A potential example is the mycorrhizae- initially they may have been parasitic on the roots- but in those associations where mineral nutrients were leached to the plant host and they in turn survived better, thus allowing more carbohydrate nutrients to be released to the fungus, resulted eventually in a mutually beneficial association.

❑ **Functions of the mycorrhizae**

❑ *Nutrient exchange:*

The mycorrhiza is an organ in which substances are exchanged between the tree and the mycorrhizal fungus. While the tree is feeding the fungus with sugar as a product of the photosynthesis, in turn it receives from the fungus several different nutrients such as nitrogen and phosphorus, which the fungus takes up from the finest soil pores with its hyphae.

❑ *Protection from pollutants:*

Mycorrhizae are able to protect the trees from poisonous effects caused by pollutants. The fungi retain heavy metals which can be taken up by the tree. This characteristic is similar to a filter function. The disadvantage, however, is that these heavy metals are accumulated into the fruiting body of the fungus. This may lead to toxic concentrations within edible mushrooms.

❑ *Further functions:*

Mycorrhizal plants show an increased tolerance towards various stress factors. The trees are therefore less susceptible to frost and gain additional resistance against pathogenic microorganisms in the soil. Furthermore, the mycorrhizae cause an increase in plant growth.

Concrete forest measures for the stimulation of mycorrhizae

- ❑ The thinning of dense and dark old stands may stimulate the fruit body production of the mycorrhizal fungi. The more tree species growing in a forest, the higher the species diversity of mycorrhizal fungi. After storm damages, the remaining young seedlings are a hideaway for mycorrhizal fungi which have lost their tree partner. They assist in rescuing the fungi into the new tree generation.
- ❑ Do not burn the harvest which is left over. Leave single dead wood stems behind
- ❑ Birds, bats & insects who visited plants for a number of reasons and in the process picked up pollen, allowed those plants a greater opportunity for genetic diversity. If enhanced outcrossing lead to higher reproductive success, those plants who encouraged visitors with enticements of nectar, pollen or pseudo-mating opportunities naturally increased in frequency over time.

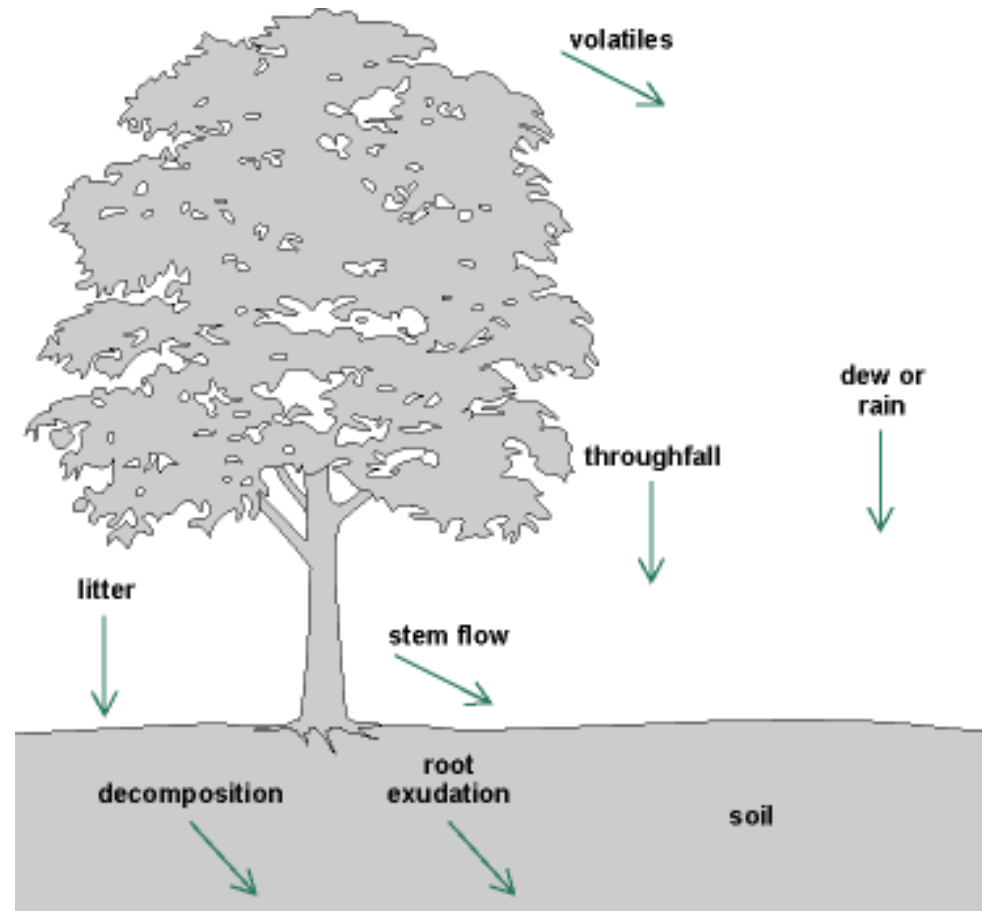
Commensalism means that one species benefits from the relationship, but the other is not affected.

An example of this is Spanish moss growing on the branches of an oak tree. The oak tree is not affected, but the Spanish moss benefits by being higher up, away from most herbivores, and also in the light (Spanish moss is photosynthetic, so is not a parasite).

Parasitism

Allelopathy

Allelopathy is one of the factors that determine interactions among plants. Allelochemicals have been found in many forest ecosystems, but the importance of allelopathic interactions depends on forest type and environmental conditions. Multiple factors influence allelochemical production or toxicity such as nutrient availability, soil moisture and texture, solar radiation, and temperature, among others. Ecosystem-level effects of allelopathy are changes in germination rates, inhibition of seedling growth, mycorrhizal function, insect and bacterial growth, inhibition of nitrification or litterfall decomposition and dieback of mature trees.



Release pathways of allelochemicals

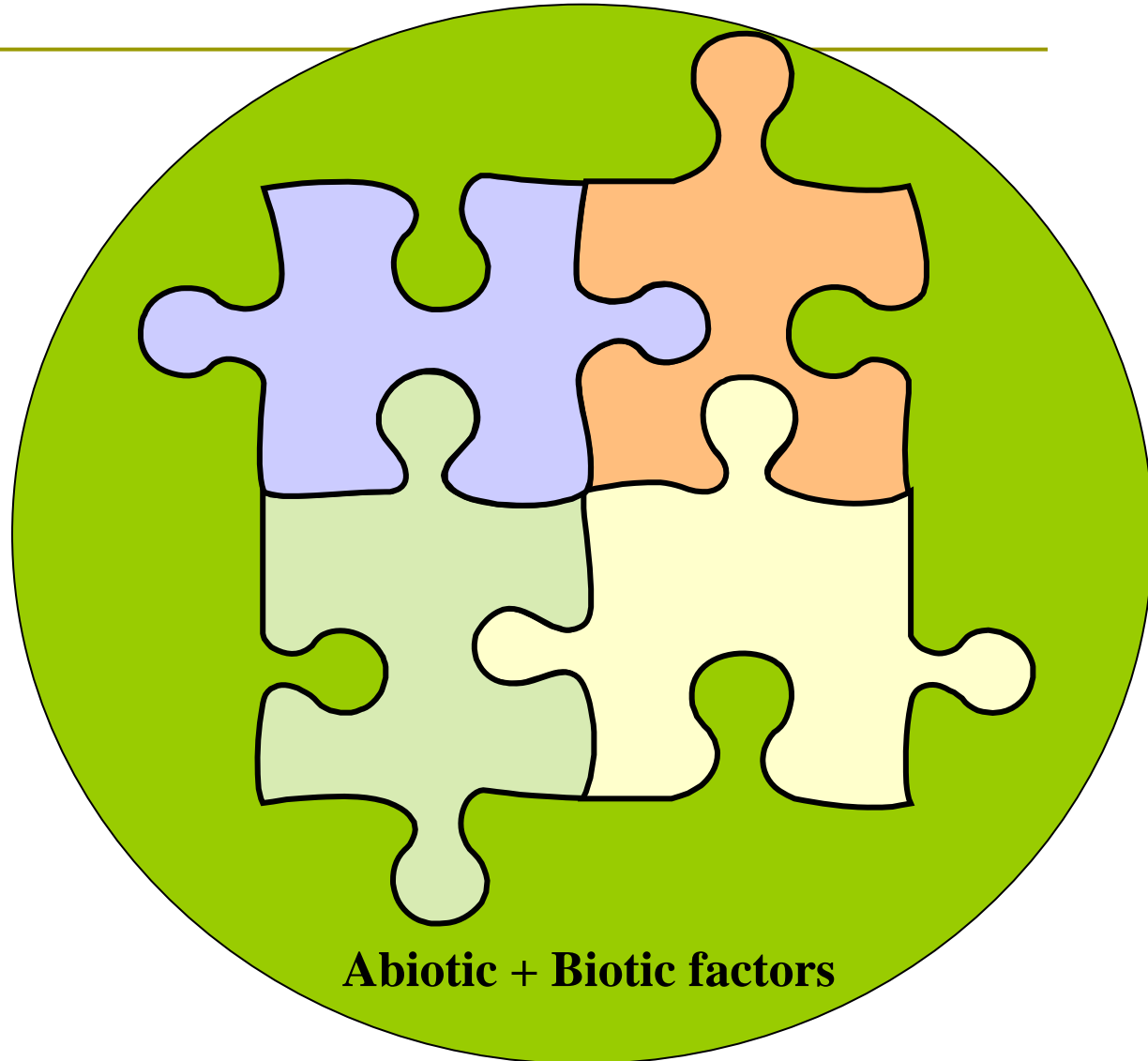
Biotic relations

□ Competition

- *Take for example plants in a forest community, there may be trees and herbaceous wild flowers both require light to make food and reproduce therefore competition. The trees, being taller, when leafed out, will prevent sunlight from reaching the smaller wild flower plants on the ground. In this case, the wild flowers accomplish their growth prior to the deciduous trees leafing out. The competition is not fatal to either as they each grow at different times.*
- Such interference or competition within the stand induce size variation and also density-dependent mortality or self-thinning.

Tree and its importance in landscape

- ❑ Temperature regime
- ❑ Humidity regime
- ❑ Soil protection, and melioration
- ❑ Air quality
- ❑ Wind movement
- ❑ Noise
- ❑ Hygienic effect
- ❑ Radioactivity



What is tree and what it could be.. ?

- ❑ Solar collector and energy transducer
- ❑ Oxygen producing factory
- ❑ Water pumper
- ❑ Air conditioner
- ❑ Fighter against global warming
- ❑ Esthetical nature element
- ❑ Chronicler

Tree life

ESECE - successfully embedded dispersion

SUCCESSION - evolution and successive development of plants

- initial stage
- successional stage
- final stage

CLIMAX - mature phytocoenose, the top level successional stage of natural community developing in given locality under local climatic conditions

Woody-plants reproduction:

- generative (propagation by seeds)
- vegetative (vegetative reproduction by a plant part)

Each woody-plant passing three developmental stages :

1st stage – development from seed, intensive growth period (juvenile) followed by tree growth culmination and beginning of fertility period (grown-upness period). This stage lasted differently from species to species (ca 30 – 50 years for slowly growing trees, ca 10 – 30 years for fast growing ones).

2nd stage - full fertility period, growth rate retardation and its stabilization

3rd stage - slumping trend, life activity attenuation, changes leading to destruction, disintegration

Growth rate

Fast-growing– poplar, wilow, aspen, alder

- Middle-fast- growing – spruce, field maple, douglas fir (as juvenile tree)
- Slowly growing – hornbeam, oak, yew

Height increment

- tree height depend on tree species and environmental conditions :
 - under 20 m : yew
 - 20 – 25 m : hornbeam, speckled alder, cembra pine
 - 25 – 30 m : oak, beech, ash, linden, maple, elm, poplar, common alder, birch
 - 30 – 50 m : spruce, fir, larch, pine, douglas fir
 - over 50 m

Reproduction

Onset of reproductive age :

- ❑ 10 – 20 years : fast-growing (tree) species:
 - ❑ populus, aspen, birch, pinus, robinia, larch
- ❑ 20 – 30 years: middle-fast-growing
 - ❑ linden (basswood), hornbeam, maple
- ❑ 30 – 40 years : slowly growing
 - ❑ oak, ash, elm, spruce
- ❑ 40 – 50 years : very slow growing
 - ❑ beech
- ❑ 50 – 70 years :
 - ❑ fir

- ❑ Annually fertile : birch, alder, hornbeam, aspen, goat willow (pioneer tree species)
- ❑ after 1 – 2 years : elm, maple, ash, linden (basswood)
- ❑ after 3 – 4 years : pine, spruce, fir
- ❑ after 5 – 6 years : oak (after 2 years in warm localities, after 7 years in cold ones)
- ❑ after 6 – 8 years : beech