Definition of relevant botanical terms and vegetation units

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1. Growth forms (Wuchsformen)

1.1. **Trees** (Bäume): Woody plants in which the growth of apical/peripheral buds and axes is prevalent (acrotony). The annual growth is mainly restricted to the crown which is on top of mostly one stem.

1.2. **Shrubs** (Sträucher): Woody plants with distinct growth of the basal buds and branches causing basal branching (basitony).

1.3. **Perennial herbs** (Stauden): plants living longer than one or two seasons; lower parts of their axes partly woody.

1.4. **Herbs** (Kräuter): Plants largely not woody; therefore reaching usually a few decimeters in height at maximum.

2. Temperature requirements

2.1. **Megatherm** plants growing under MAT (mean annual temperature) of ≥ 24° C (tropic regions).

2.2. **Mega-mesotherm** plants growing under MAT of 20-24° C (subtropical regions).

2.3. **Mesotherm** plants growing under MAT of 14-20° C (warm temperate regions). Many of them are sensible to frost.

2.4. **Meso-microtherm** plants growing under MAT of 10-14° C (cool temperate regions).

2.3. **Microtherm** plants growing under MAT < 10° C (boreal regions).

3. Leaf size classes

after WEBB

leptophyll 0-0.25 cm2

nanophyll 0.25-2.25 cm2

microphyll 2.25-20.25 cm2

mesophyll 20.25-182.25 cm2

macrophyll 182.25-1640.25 cm2

megaphyll >1640.25 cm2

after RAUNKIER

microphyll < 20.25 cm2

notophyll 20.25-45 cm2

mesophyll >45 cm2

4. Vegetation units

4.1. **Natural vegetation**

Vegetation in equilibrium with climatic and edaphic factors. It includes zonal, extrazonal, and azonal vegetation. Due to human impact natural vegetation does not exist over large regions today. It is usually reconstructed and then called potential natural vegetation.

4.1.1. **Zonal vegetation** or climax vegetation: Large-scale vegetation developing under mesic soil conditions (no extremes). It is more distinctly influenced by climatic factors than by edaphic ones.

4.1.2. **Extrazonal vegetation**: Due to more extreme climatic conditions at the geographic limits of their natural distribution area the vegetation may change its habitat (e.g. from low to higher elevation). One

example: Moving further south, temperate, deciduous forests are restricted to increasingly higher altitudes in their natural distribution area on the northern hemisphere. There, they constitute the extrazonal vegetation where the zonal vegetation (at lower altitudes) is largely broad-leaved evergreen.

4.1.3. **Azonal vegetation**: The development of plant communities is more severely influenced by edaphic factors than by climate (e.g. wetland, alluvial vegetation, mangroves, halophytic vegetation).

Differentiation according geographic latitude:

4.2. **Extratropical** regions (boreal, cool temperate, warm temperate, subtropic):

In the extratropical regions the seasons are primarily determined by the year round temperature changes. Depending on different authors the boundaries between subtropic and temperate zones lack exact definition. For the subtropic zone in a wide sense (from tropics to temperate) there exists also the term meridional (Meusel et al. 1965). (see also 4.2.7.)

4.2.1. **Taiga**: Conifer forests (Picea, Abies, Pinus, Larix) developing under cool temperate, boreal climate. They are further devided according to humidity (dry variant are Larix-rich forests in E-Sibiria).

4.2.2. **Steppe**: Semiaride grassland of the temperate zones. However, they may be well devided further into “warm” steppes (e.g. Morocco) and “cold” steppes (e.g. Anatolia).

4.2.3. **Forest steppe** (Waldsteppe): A macro-mosaic of deciduous forest and grassland patches. It develops in the ecotone (transition) between deciduous broad-leaved forests (oceanic climate) and steppes (continental climate). With increasing continentality grassland dominates over forest patches.

4.2.4. **Deciduous broad-leaved forests** (sommergrüne Laubwälder) are distributed in the temperate regions. Woody taxa form a one or two-storied tree layer and often also a shrub layer. They shed their leaves due to the cold season (? semi-evergreen forests of the tropics). The microclimate of the forest floor is very different from open habitats (as steppe). On the forest floor insolation is far less, the temperature conditions are more equable, the atmospheric humidity as well as the humidity of the upper soil layers are higher. Plants of the forest floor (ferns, herbs, grasses) therefore are shade tolerating mesophytes. Characteristic is also the presence of vernal geophytes (Frühlingsgeophyten) on

the forest floor. Their vegetation period is bound to the time before and at the beginning of the vegetation period of woody species. So they profit from the better light and temperature conditions on the forest floor during spring time. For climatic conditions see table below.

4.2.5. **Evergreen sclerophyllous forests and scrubs** (immergrüne Hartlaubwälder und -gebüsche) develop under summer dry and winter humide climate. Frost is possible but usually not long-lasting. The leaves of woody species are evergreen, their size ranges usually within nanophyll to small microphyll. They are drought resistant. As an example, in the main part of the Mediterranean region this vegetation type is represented by forests in which the closed tree layer consists of the monodominant Quercus ilex (up to 15-18 m height) (holly or holm oak, Steineiche) - Quercus ilex forests. Neither is the shrub layer species diverse nor is the herb layer well developped. Shrubs reach 3-5 (12) m height and herbs up to 0,5 m.

Furthermore according to altitude “thermomediterranean” (characterized by Ceratonia, Olea, …….), “mesomediterranean” (Quercus ilex, Phillyrea, …….), and “supramediterranean” (deciduous broad-leaved forest of montaneous areas, e.g. Quercus pubescens) are distinguished.

The term „ mediterranean type of vegetation“ should be used exclusively synonymous to evergreen sclerophyllous forest. Synonymous is also the term ethesian vegetation.

Macchie is an anthropogenous vegetation type of sclerophyllous shrubs and small trees characteristic of regions where the potential natural vegetation is evergreen sclerophyllous forest, e.g. in the Mediterranean region Quercus ilex forest. Macchie develops mainly after intensive forest harvesting and under distinctly seasonal climate (with sudden precipitation during the cold season and summer dryness). Macchie develops on siliceous soil while garigue is bound to calcareous soils. As macchie and garigue are not a natural vegetation unit these terms should be avoided for the interpretation of the fossil record.

4.2.6. **Mixed mesophytic forest** (MMF) is a species-rich forest whithout mono- or oligo-dominants in warm-temperate regions; most woody species are deciduous, while evergreens make up 15-30 %. The latter represent mostly small trees and shrubs. Conifers are present but less important. Leaf sizes are usually micro-, (nano)phyll. For climatic conditions see table below.

4.2.7. **Evergreen broad-leaved forest in warm temperate to subtropic regions**. They are mainly bound to the east coasts of the continents which are influenced by monsoons and passat winds. In east Asia evergreen oak-laurel forests (evergreen sclerophyllous broad-leaved forest sensu WANG 1961) are extending over large regions. Evergreen oaks, their related genera, and Lauraceae are dominant in the tree layer (oligo-dominance MMF, see 4.2.6.). Forest stands attain up to 30 m height. There is no sharp forest stratification (no distinct second crown layer). Understories (shrubs and the ground layer) often are not dense but rich in ferns. The leaves of nearly all crown trees and shrubs are uniformly glossy, coriaceous, with either entire or finely dentate/serrate margin. Hence, these forests are widely called

“laurel forests“. There is a wide spectrum of almost synonymous terms: subtropical broad-leaved evergreen forest, warm temperate broad-leaved evergreen forest, lucidophyll oak laurel forest. (See also 4.3. and for climatic conditions the table below).

4.3. **Tropics**

Year round precipitation distribution determines the seasons in the tropics and subtropics (dry/humid seasons) (temperate and boreal regions). The differentiation of the tropics from the subtropics is difficult. Usually the tropics end where frosts start to occur or where the MAT is < 18,3°C. (See also 4.2.)

4.3.1. In the **tropical grassland** woody plants are absent.

4.3.2. **Tropical moist semi-evergreen forests** (tropische laubwerfende/halb-immergrüne Wälder) develop between 10-23° N latitude in summer humide/“winter“ dry tropical regions. Woody plants shed their leaves due to dryness during the dry season. According to the intensity and duration of the dry period different vegetation units develop.

4.3.2.1. **Savanna open woodland, savanna forest** (lichte Savannenwälder) develop under driest conditions with only a grass layer in the undergrowth (Walter 1979: 87)

4.3.2.2. **Parkland savanna, savanna parkland** (Parkwald-Savanna) develops on flat land, with only slow drainage (after months) of the high summer rainfall. There, grassland develops while woody plants are restricted to (slightly) higher and therefore not flooded areas (Walter 197: 90 f.).

4.3.2.3. **Savanna**: A homogenous tropical grassland with more or less regularly scattered shrubs or small trees. It develops instead of semi-evergreen woods due to either edaphic or anthropogenous (pyrogenous) or climatic reasons.

4.3.3. **Evergreen tropical rain forests** are mostly extremely species divers. Due to the lack of seasonality woody species lack growth rings. Among the different regions there are big differences in species composition, diversity, and structure. Generally, the tree layer may be composed of up to three stories which may be hard to distinguish. The uppermost layer is often open; it is formed by singular towering above trees (up to 50-60 m). Depending on the position within one tree (insolation/humidity) the leaf size within one species may be highly variable (up to >20:1). Drip tips are commonly developped. The

periodicity in leaf dessication, growth, and flowering is not bound to annual seasonality; in one specimen one branch may shed its leaves while others are still green or opening their buds. Hence, there is no general flowering time in a tropical rain forest (autonomous periodicity). In the tropical rain forest about 70 % of all species are trees. They also dominate quantitatively. As a consequence of the struggle for light lianas and epiphytes are very common. Plants of the herb layer reach up to several meters height; hence, they are hardly to distinguish from the shrub layer. Smaller herbs must tolerate very poor light conditions (e.g.ferns).

4.3.4. **Mangrove** develops along tropical sea coasts in the tidal zone where the salt concentration is about 35 %o. Worldwide only 20 woody species participate in the formation of mangroves. Their distribution ranges from 30° N (32° N on the Bermudas) to 33° S (37-38° S in Australia, New Zealand) latitude. With increasing latitude species diversity decreases (to monospecific).

5. Vegetation units occurring in different climatic zones

5.1. **Alluvial vegetation**: Various plant communities e.g. riparian forests, flood plain meadows, aquatic plant communities in ponds, oxbow lakes and backswamps, accompaning river systems; they are influenced by regularly occurring floodings (changing groundwater table) and accompaning sedimentation as well as quality and quantity of nutrient input. The abundance and duration of floodings as well as the sedimentation rate and grain-size depend largely on the distance from the active channel system and ground elevation. These communities constitute successional (instable) stages in the vegetation development. Depending on the soil properties the communities are composed of plants tolerating episodic to permanent inundations. Plants tolerating „wet feet“ are bound to soils with low permeability. Well-permeable soils are the habitat of plants tolerating the often rapidly changing extremes of floodings and dryness.

5.1.1. **Riparian forests** (Auwald) are bound to river systems. They are composed of woody species that are able to tolerate periodical floodings. The composition of riparian forests within one fluviatile system is highly variable as it is dependant on soil properties, especially permeability/grain size and nutrient supply. E.g. on sandy, well permeable soils that are often flooded but also dry quickly species-poor pine stands may develop. On rich soils and with decreasing abundance of floodings the species diversity is increasing.

5.1.2. **Flood plain meadows**, bottomland meadows, “wet prairies” (Auwiesen): Wet to swampy area with herbaceous (and shruby) plant communities tolerating high groundwater table.

5.1.3. **Mire, bog** (Moor): Every distinct area of peat-forming vegetation. The accumulation of undecayed plant remains is caused by the deficiency of oxygen so that more plant detritus is accumulated than decaying.

5.1.4. In the **low-mire, low moor, fen** (Niedermoor) the vegetation is still in contact with the geological underground (water and nutrient supply).

5.1.5. In the **raised bog** (Hochmoor) the contact with the geological underground is successively interrupted due to the increasing thickness of the peat layer, which forms a characteristic convex (uhrglasförmig) shape. The vegetation depends increasingly on the precipitation (ombrotrophic) and suffers nutrient deficiency. In the vegetation of raised bogs mosses (especially Sphagnum), sedges, herbs, and low shrubs are characteristic. With increasing availability of nutrients (towards the margin of the bog) the growth height of woody taxa increases.

5.1.6. **Swamp forests** (Sumpfwälder) develop on soils that are inundated over long periods (stagnant water) e.g in low-mires (see 5.1.5.). Characteristically swamp forests show low species diversity (often monodominance) due to extreme living conditions. Most famous are the Taxodium-swamp forests in the (coastal) lowlands of Lousiana, Mississippi, Alabama, Georgia, and Florida in North America.

5.2. **Deserts** are aride regions occurring at different latitudes. In deserts the potential evaporation is much higher than the annual precipitation (usually ann. precipitation < 200 mm and the pot. evaporation >2000 mm - up to 5000 mm in the Central Sahara). In most of them the air is very dry and the daily temperature curve shows extreme fluctuations. The low density of the plant cover is characteristic of all deserts so that the landscape is not characterized by the plants but by pure soil and rocks.

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