[IMAGE]

Laurel forests in Japan with a temple near Kyoto, Japan (photo: Breckle).

[IMAGE]

Laurel forest (Zonobiom V) on the slopes of El Bailladero mountain on the island of La Gomera, Canary Islands with festoons of epiphytic mosses (photo: E. Fischer)

[IMAGE]

Tertiary relict forest (Zonobiome V) in the Surami Mountains in Colchis (Georgia) with endemic ivy (*Hedera colchica*) on *Fagus orientalis* (photo: Rafiqpoor)

**II Special part**

**Part H - ZB V: Zonobiome of the laurel forests or of the warm temperate humid climate**

1. General, climate and soils
2. Tertiary forests, lauriphylly and sclerophylly
3. Humid subzonobiome on the eastern sides of the continents
4. Subzonobiome on the western sides of the continents
5. Biomes of the Eucalyptus-Nothofagus forests of SE Australia and Tasmania.
6. Warm temperate biomes of New Zealand
7. Literature

[IMAGE]

Most of the lauriphyll relict forests (zonobiome V) on the Canary Islands have now given way to agricultural use and settlements. View from the foothills east of La Laguna towards Pico de Teide (3,700 m, top right in the background; photo: Rafiqpoor).

1**General, climate, soils**

**Zonobiome V** cannot be sharply delimited; it is a transition zone between the tropical-subtropical (ZB I - III) and the typically temperate areas (ZB IV, VI, VII). However, it covers too large an area to be treated solely as an ecotone.

The climate is a typical transitional climate, which can be very different, but is generally quite mild. The ecological climate diagrams (◘ Fig. H-1 and ◘ Fig. H-2) show the wide range of variation. Two main subzonobiomes can be distinguished:

1. The very humid **sZB V(s)** with rain throughout the year, with heavier summer rains, so with some minimum in the cool season. The main vegetation season is always humid and muggy because of the high temperature. These areas are mostly on the eastern sides of the continents about between the 30th and 35th degrees in the southern and northern hemispheres, and are under the influence of trade or monsoon winds. During the cool season, temperatures already drop quite low, light frosts may occur, but a cold season with temperatures below 0 °C is absent (► Fig. H-1); however, winter is already a dormant season for vegetation.

To **sZB V(s)** can be placed most of the E coast of Australia, most of New Zealand, the SW states of the United States, the SE corner of Brazil and Uruguay, the Scoastal strip in South Africa, much of C China, the S half of Japan, and SE Korea.

1. The other **sZB V(w)** is predominantly bound to the western sides of the continents, somewhat further poleward to 40° latitude, i.e. somewhat shifted with respect to the first sZB V(s); it mostly adjoins the humid subzonobiome of ZB IV, where, indeed, winter rains predominate, but the summer drought is largely absent (► Fig. H-2). Both subzonobiomes are characterized by lauriphyllous tree species and/or large-growing conifers, each often rich in relict forms from the Tertiary.

The **sZB V(w)** may include small parts of the NW USA and SW Canada, the W coast areas of Chile including and N of Chiloe Island, small parts of N Portugal and NW Spain, the SE coast of the Black Sea (Colchis) and the S coast of the Caspian Sea (Hyrcania). The isolated laurel forests of Macaronesia can also be included.

On the E sides of the continents, as a result of the trade or monsoon winds, we are dealing with an almost continuous series from zonobiome II via a humid subtropical ZE II/V to ZB V and via a ZE V/VI to ZB VI. This is realized at several regions, and they are often species-rich transition areas, but also densely populated.

◘ **Fig. H-1** Climate diagrams of the very humid sZB V(s) with rain in all seasons or especially in summer (Kanazawa in Japan; East London in South Africa; Invercargill in New Zealand; and Tallahassee in Florida, USA; Paso de los Toros in Uruguay and Brisbane in eastern Australia).

◘ **Fig. H-2** Climate diagrams of sZB V(w) with rain at all seasons or a small maximum in winter (Khoramabad on the Caspian Sea, Iran; Queimadas in Madeira; Samtredia in the Colchis region in Georgia; and Temuco in central Chile; Tillamook in NW USA, Washington and Cap Leeuwin SW Australia - the latter is ZE IV/V).

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| Box H-1 The zonobiome V is a transition zonobiome |
| sZB V(s): On the eastern sides of the continents transition from ZB I and ZB II rather with summer rains to temperate regions (ZB VI) with light frost.  sZB V(w): On the western side of the continent’s transition from ZB IV rather with winter rain to ZB VIII with oceanic character |

Both the climatic and the vegetation-ecological demarcation of the above-mentioned sections is difficult. The tropics cease to exist where frosts become noticeable or the mean annual temperature falls below 18 °C when there is no frost, so that tropical crops such as coffee, cocoa, cocos, pineapple, etc. are no longer profitable and only tea, citrus and individual palms remain. In the area of zonobiome V, slight frosts already occur, but the mean daily minima of the coldest month are still above 0 °C, which means that a cold season does not occur. The annual means are slightly above or below 15 °C, the tree species of the forests are at least partly evergreen, while in ZE V/VI this is only true for some shrub species. For the ZB VI, a cold season of two or more months is already typical; the woody species almost all shed their leaves in autumn. Ecologically, the different regions of ZB V have probably not yet been studied intensively, nor can details be given about the ecosystems. It is also, particularly, difficult because most of the forests are rich in species and the growing conditions are favourable, so that the settlement density is usually high and the natural vegetation has almost completely disappeared. One must assume that the decisive factor is certainly the competition between the evergreen and the other species, but this is elusive.

2 **Tertiary forests, lauriphylly and sclerophylly**

If the sclerophyllous vegetation of ZB IV evolved from a lauriphyllic vegetation form in geologically recent times, then lauriphyllic relict species should still be found in the Mediterranean region. Laurus nobilis occurs in the areas with higher precipitation and in diverse protected sites, especially also in the W Mediterranean. Arbutus (► Fig. G-5) is also lauriphyllic rather than sclerophyllic. Lauriphyllous species occur azonally in canyon forests or orozonally as cloud forest plots. Sclerophylls with woody cellular elements in the leaf (sclereids) have failed to displace lauriphylls only in very temperate sites and in nearly permanently humid areas.

As zonal vegetation, laurel forests occurs over large areas only in East Asia (China, Japan) and in the SE USA. But many of the evergreen temperate forests are now only present in remnants, their species richness (for example in China, Korea or Japan, but also in the SE USA) is remarkably high, especially in S Brazil. Many species are endemic to their respective regions.

The impoverished remnants of ZB V are the stands in NPortugal, which are often degraded to heaths.

The Euxinian (Colchis) and Hyrcanian relict forests (◘ Fig. H-3) are characterized by their Tertiary relict species (e.g. on the S coast of the Caspian Sea in Iran), where numerous genera are closely related to the Tertiary representatives attested by fossils. This is equally true for the other ZB V regions.

◘ **Fig. H-3** The hyrcanian forests in northern Iran along the Caspian Sea show Tertiary relict species. The forests are small-scale and under considerable anthropogenic pressure (photo Breckle).

The laurel forests, which today still occur to a considerable extent on the E coasts of the continents, are classified by Klötzli (1987) as thermophilic (20 to 25 °C monthly mean in the vegetation period) and frost-sensitive (minima hardly below -10 °C) as well as drought-sensitive (hardly any arid months in the annual cycle). The distinction of ZB V from subtropical/tropical rainforests is given by their more and more regular precipitation and more balanced temperatures, from sclerophyllous forests by their lower and more sporadic precipitation (winter) and regular fires, from deciduous broadleaf forests by their colder winters with late frosts and often drier summers.

3 **Subzonobiome on the western sides of the continents**

3.1 **North America, forests with giant conifers**

The sZB V(w) with winter rain extends in N America from N California to S Canada in the coastal zone (► Fig. G-17, Vancouver). It is the zone of Sequoia sempervirens forests, followed further N by forests of Tsuga heterophylla, Thuja plicata, and Pseudotsuga menziesii (◘ Fig. H-4). Prunus laurocerasus and Rhododendron ponticum, but also Araucaria excelsa, thrive luxuriantly in the gardens here - a sign of the mild winters. Further N, temperatures slowly drop. The climate becomes increasingly humid, with little diurnal or annual variation in temperature. The maritime-toned and frost-sensitive Sitka spruce (Picea sitchensis) comes to dominate. In this meridional zone, which extends into the subarctic on Alaska, sections corresponding to ZB VI or ZB VIII can hardly be identified. It is an extremely humid oceanic ecotone in which no agriculture can be practiced, which is therefore sparsely populated.

Within the framework of the International Biological Programme (IBP), probably the most productive coniferous forests in the world, especially Douglas-fir (Pseudotsuga) ecosystems, were studied here. Edmonds (1982) contains the results of the work from 1971 to 1978 in eleven articles. Klötzli (1987) has given an overview of the distribution of evergreen forests.

In the western USA, in Oregon and Washington, these are humid, less frost-resistant coniferous forests, which have reached stand heights of over 100 m. The relict species Sequoia sempervirens (◘ Fig. H-5), which occurs partly mixed with Abies grandis, Pseudotsuga menziesii, or is replaced to the N by Tsuga heterophylla and Thuja plicata, forms an upper canopy. Many deciduous tree species are represented in the lower tree layer (Acer macrophyllum, Alnus rubra, etc.). Many of the trees are richly covered with epiphytic ferns, mosses and lichens. These conifer forests of the warm-temperate zone, which are photosynthetically active almost all year round, must be regarded as relict forests of Tertiary origin. They were apparently little affected by the ice ages due to the N-S running mountains. Further S, larger refugial areas for vegetation were preserved during the ice age, so that, in contrast to the W-E mountain barriers in Europe, northward dispersal could take place rapidly.

◘ **Fig. H-4** Oceanic coniferous forest of the humid and mild western side with Pseudotsuga menziesii (Olympic National Park, USA) (photos: Barthlott).

◘ **Fig. H-5** The Sequoiadendron giganteum forests, along with the redwood forests (Sequoia sempervirens) as Tertiary relicts, are famous and enormous forests of the temperate zones of the earth. The height of the sequoia trees exceeds with >100 m the highest rainforest trees on earth (photo: M. Neumann).

3.2 **Valdivian rainforest in Southern Chile**

In **southern Chile,** quite analogous conditions prevail. The sZB with winter rains, but without summer drought, corresponds to the likewise very lush Valdivian evergreen rainforest. The climate is permanently humid with high annual precipitation (◘ Fig. H-6).

**Fig. H-6** The climate diagram of Valdivia demonstrates the ecological conditions of the Valdivian rainforests in southern Chile.

Here in southern Chile**,** the Valdivia rainforest corresponds to ZB V(w). It is species-rich and its lushness reminds us of tropical rainforests. The climate is cool, without frost and permanently humid. Several relict conifers occur (among others Fitzroya cupressoides, Austrocedrus chilensis, Podocarpus nubigenus, Dacrydium foncki, Araucaria araucana), but never dominantly. Forest-forming are Nothofagus species (◘ Fig. H-7, ► Fig. H-26); deciduous N. obliqua can grow over 40 m tall, and evergreen N. dombeyi, Eucryphia cordifolia, and others reach 35 to 40 m. The adjoining Magellanic forest to the S, with evergreen but also deciduous Nothofagus species and the strong formation of bogs, forms the perhumid transition zone to the subantarctic of Tierra del Fuego and the islands.

3.3 **Western Australia**

In **Australia,** the SW tip belongs to this sZB with winter rainfall without summer drought (karri forest). This is indicated by the climate diagram of Dwellingup (► Fig. H-1). The Karri tree (Eucalyptus diversicolor) (◘ Fig. H-8) reaches heights of growth not infrequently exceeding 60 m, in some cases up to 90 m; they are giant trees. The famous Gloucester Tree (► Fig. H-8b) near Pemberton, for example, has a viewing platform at 61 m, which used to serve as a monitoring hut to spot forest fires in the area in time. But not only this species is endemic for SW-Australia. Also the Eu. calophylla (up to 60 m) and Eu. jacksonii (up to 70 m), which also form mighty trunks, are the western tree species of this tall mixed forest on partly very poor and boggy soils. The streams and rivers carry brown humus-rich water. Carnivorous species, such as several Drosera species (including the climbing Drosera macrantha) or on rocks the red-flowered Urticularia menziesii (◘ Fig. H-9), occur in the understory of the forest and on small interspersed bog areas, and on larger bog areas the ground-growing Australian pitcher plant Cephalotus follicularis. In the mostly very open shrub layer grows the myrtaceous Calytris and grass trees such as Dasypogon hookeri and Kingia australis.

◘ **Fig. H-8** Karri forests of the Australian winter rainfall area with Eucalyptus jacksonii, Eu. calophylla (**a**) (photo: Breckle) and Eu. diversicolor (**b**: here the 72 m high famous Gloucester tree; photo: Sean Mack, http://t1p.de/gxpo) at the SW tip of the continent near Nornalup partly consist of tree giants, which not infrequently exceed growing heights of 60 m, sometimes even up to 90 m.

◘ **Fig. H-9** In SW Australia, carnivorous plants reach their highest diversity on ancient nutrient-poor soils. Here are two examples: Utricularia menziesii (**a**) and the Australian pitcher plant Cephalotus follicularis (**b**) (photos: Breckle).

**3.4. Western Europe**

In **Western Europe,** the frost-sensitive large conifers of the Pacific coast of North America are completely absent. They became extinct during the Pleistocene ice ages (fossils in the Rhineland lignite coal district in Germany). The closest equivalent to the sZB is the N Spanish and SW French coast with heath formations (Les Landes). The perhumid transition zone is as fragmented as the W European coastal zone. It is spread over Wales, W Scotland, the island groups with Ireland and the wettest parts of the Norwegian west coast with the Lofoten Islands, and extends into the subarctic. Heath moors with birch and willow species are the predominant vegetation today.

In Western Europe, therefore, there is a lack of vegetation corresponding to ZB V, although the climate today would allow such vegetation. Remains of some relict species can be found in the mountains near Algeciras (Campo de Gibraltar), where the evergreen Rhododendron ponticum ssp. baeticum, Quercus lusitanica and Prunus lusitanica still occur. In addition, the partly epiphytic fern Davallia canariensis and the primitive fern Psilotum nudum occur. The carnivorous plant Drosophyllum lusitanicum also indicates that these soils are poor in nutrients.

**3.5 The Colchis and Hyrcania**

In the Euxinian forest area of N Anatolia and W Georgia, only deciduous trees are found, although a whole range of evergreen species occur in the understory (Prunus laurocerasus, Ilex, Buxus, Daphne pontica, Vaccinium arctostaphylos, Ruscus, etc.). Similarly, the Colchis on the E shore of the Black Sea and the Hyrcanian forests on the S shore of the Caspian Sea. This area of N Anatolia and W Georgia, belonging to sZB V(w), with Colchian forests inhabited by Rhododendron ponticum and Prunus laurocerasus (◘ Fig. H-10), is an offshoot of the lush forests in the Colchian Triangle between the Caucasian mountains and the Black Sea with evenly distributed precipitation up to 4000 mm. In this Tertiary relict forest, the evergreen understory has been preserved, but the tree layer with the relict species Zelkova and Pterocarya as well as Dolichos and the lianas (Vitis, Periploca), shed their leaves. Isolated cold spells occur, but Citrus and tea (Camellia sinensis) crops are present (◘ Fig. H-11), showing that the climate is mild, as indicated by the climate diagram of Rize (◘ Fig. H-12). The occurrence of the delicate skin ferns (Hymenophyllum, ◘ Fig. H-13) also documents this. Skin ferns also occur in most other regions of ZB V.

The Hyrcanian relict forest (► Fig. H-3) on the S coast of the Caspian Sea (► Fig. H-12) is similarly formed with the relict species Parrotia (Hamamelidaceae) and Albizzia julibrissin (Mimosaceae), among others.

◘ **Fig. H-10** The Fagus orientalis forests (**a**) with Rhododendron ponticum (**b**, **d)**, Rhododendron luteum (**e**) Prunus laurocerasus (**c**, **f**) in the isolated sZB V in the Colchis, Georgia (photos: Rafiqpoor).

◘ **Fig. H-11** In Colchis, tea (Camellia sinensis), a plant of cool-humid tropical regions, is also grown as a sign of lack of prolonged and severe frosts in winter (photos: Rafiqpoor).

◘ **Fig. H-12** Climate diagrams of Rize as an example of the mild climate of the Colchis and the Hyrcanian forests in the S of the Caspian Sea (Rasht).

◘ **Fig. H-13** Hymenophyllaceae skin ferns occur in the ever-humid forests of Batumi on the eastern Black Sea in Colchis (Georgia) (photo: Rafiqpoor).

**4. Humid subzonobiome on the eastern sides of the continents**

**4.1 East Asia, China, Japan**

In **East Asia**, which is exposed to the E Asian monsoon and therefore has a ZB II, this humid sZB of ZB V occupies a particularly large area. The N boundary at about 35°N still reaches the S tip of the Korean Peninsula with its many islands, bends northward in the Sea of Japan, and passes through the S part of the main Japanese island of Honschu (► Fig. H-1, Kanazawa). The island of Cheju-Do and Ullung-Do (◘ Fig. H-14) in SW Korea (◘ Fig. H-15, ◘ Fig. H-16) have corresponding laurophyllous forest vegetation, to the extent that these still survive. Here, in addition to the evergreen Fagaceae Cyclobalanopsis, Quercus and Castanopsis, the Myrsinaceae Ardisia and the Lauraceae Machilus, among others, occur as forest-forming tree species. But also the ornamental shrubs Aucuba japonica, Euonymus japonica, Ligustrum japonicum and the frost-sensitive Camellia, which are commonly cultivated in N Italy (Insubria), originate from there. Further north, deciduous tree species gain the upper hand (Numata et al. 1972), as do higher elevations (► Fig. H-16), even with beech species, on Ullung-Do the relict species Fagus multinervis, on Japan with Fagus japonica and F. crenata. Surprisingly, an elevationalbelt (>2,800 m) with the relict species *Fagus* hayatae is also developed on Taiwan (above the tropical lowland forests).

◘ **Fig. H-14** Climate diagram of Ullung-Do as an example of the climatic region of laurophyllous forest vegetation in South Korea.

◘ **Fig. H-15** Laurel forest remnants on Ullung-Do Island (South Korea) in individual valleys, transitioning on the upper mountain slopes to a beech forest with Fagus multinervis, as a relict forest (photo: Breckle).

In China, the N border recedes somewhat inland to the S, to the extent that the cold spells from the Siberian high make themselves felt in winter. Much less sharp is the S boundary towards the evergreen tropical-subtropical forests of S China. Canton still belongs to ZB II. We bring here the division according to Ahti & Konen (1974) (◘ Fig. H-17). The orobiome in Japan is also discussed there.

◘ **Fig. H-16** Open, young beech forest on upper mountain slopes of Ullung-Do Island (South Korea) with numerous Fagus multinervis stems. In the understory, individual evergreen laurel forest species still occur (e.g. Euonymus japonicus), but also many herbaceous species (cf. also Albert 1997) from the genera Helleborus, Hepatica, Maianthemum and Sasa (photo: Breckle).

In Japan, as in China - both densely populated countries - every easily cultivable spot is used for agriculture. It is therefore understandable that all deep, zonal soils are now cultivated land. The original vegetation has been completely repressed; it is found in remnants on lower slopes that are not suitable for either cropping or grazing. These give some idea of the original vegetation and show that it was extremely species-rich with numerous laurophyllous species. The climate is permanently humid (► Fig. H-1, Kanazawa). The area of evergreen forest extends over nearly 13 latitudes in Japan. The floristic composition also changes accordingly. In Kyushu, the evergreen forest reaches up to 800 m and is then replaced by a conifer-rich forest, but also with deciduous broadleaf forest species, which then dominate from 1,500 m and correspond to a ZB VI deciduous forest. The evergreen forests there consist mainly of Distilium racemosum, Castanopsis sieboldii, Cyclobalanopsis acuta and C. salicina in the canopy layer and the same species as well as Camellia japonica, C. sasanque, Machilus japonicus and Cleyera japonica in the lower tree layer.

**Fig. H-17** Bioclimatic classification of East Asia (modified after Ahti & Konen 1974). TR = humid tropics, STR = humid subtropics. M = maritime warm temperate ZB V. HT = ZE V/VI and T = temperate ZB VI. HB = hemi-boreal mixed forest zone. SB, MB and NB = southern, middle and northern boreal zone (= ZB VIII). HA and A = hemi-arctic and arctic zone (= ZB IX).

**4.2 Southeastern North America**

In **southeastern North America**, the S tip of Florida is still tropical, but even Miami and Palm Beach experience light frosts. The evergreen oak forests with Quercus virginiana extend along the coast into North Carolina. The total area of ZB V is not very large because inland cold snaps extend to the Gulf of Mexico (Klaus 1975, Lauer 1999). It can be seen on the climate diagram (◘ Fig. H-18) that the temperature gradient is already clearly continental. In addition, psammo-biomes are present on widespread sandy areas, namely pine forests of Pinus clausa, P. taeda, P. australis, and others, partly with evergreen understory. In addition, there are the extensive Taxodium-Nyssa swamp forests (hydrobiomes) and the evergreen Persea magnoia swamp forests as well as heather moors with the Venus flytrap (Dionaea muscipula) as helobiomes. Directly on the coast, salt marshes (halobiomes) occupy large areas.

**Fig. H-18** Climate diagram of Charlestonas an example of the marginal tropical climate region of SE North America with an already pronounced annual variation in temperature.

4.3 **Araucaria Forests of Southeast Brazil**

In **South America,** the evergreen forests in E Brazil extend from tropical to subtropical and warm-temperate far to the south. The tropics stop at the coast between Porto Alegre and Rio Grande. Even in N Argentina, in Misiones and Corrientes, one speaks of subtropical forests. Along the great courses of the rivers Paraná and Uruguay they penetrate the pampas as gallery forests. On the coast the ZB V stops at La Plata, the ZB VI is missing. The climate diagram from Uruguay (► Fig. H-1, Paso de los Toros) illustrates the typical year-round humid climate.

On the plateau above 500 m, especially in S Brazil, the area of conifer forests of Araucaria angustifolia can be found (◘ Fig. H-19). In any case, these would have to be counted as part of ZB V. In general, it is precisely in this part that the forest area has been greatly reduced by clearing.

◘ **Fig. H-19** Araucaria angustifolia forests in southeastern Brazil occupy larger areas but are now increasingly subject to deforestation (photo: Barthlott).

4.4 **South Africa**

In Africa, whose SE coast is also exposed to the SE trade wind and receives very heavy rainfall from the wind jam off the Drakensberg, evergreen tropical-subtropical forests are common near the coast as far as East London. The section along the S coast can be described as warm-temperate. In former times the forests extended without interruption to the E slope of Table Mountain near Cape Town. However, most of it has been cleared or secondarily occupied by the fynbos of ZB IV. A larger forest reserve with old tall Podocarpus trees and a large number of broadleaf evergreens, among which the "stinkboom" (Ocotea foetens) provides valuable timber, is preserved only at Knyshna (◘ Fig. H-20 and ◘ Fig. H-21).

◘ **Fig. H-20** Remnants of the ever-humid Knyshna forests are preserved at the S tip of Africa in the vicinity of Knyshna. These forests owe their existence to the combination of summer and winter rains, which guarantee a year-round water supply. The forests get part of their moisture from frequent mist condensation (photos: Breckle).

◘ **Fig. H-21** Climate diagram of Georgeas an example of the ever-humid climate area of the Knyshna Forest in S Africa.

4.5 **Biomes of Eucalyptus-Nothofagus forests in southeastern Australia and Tasmania**

The moist tropical-subtropical evergreen forests of the E coast of Australia, which extend on nutrient-rich mostly volcanic soils into S New South Wales, consist predominantly of Indomalayan elements alien to Australis. Only in S New South Wales, Victoria and Tasmania does the Australis element predominate with the genus Eucalyptus. At the same time, however, some significant Antarctic elements are already mixed in. Here in the humid climate without cold season (◘ Fig. H-22), Eucalyptus regnans reached a proven height of up to 110 m (older statements of 145 m cannot be verified with certainty).

Today, tree heights of between 75 and 95 m can be found (◘ Fig. H-23). They were probably once the tallest giant trees on earth equal to the redwoods of California.

Eu. gigantea and Eu. obliqua grow almost as tall. The most important Antarctic species are the evergreen Nothofagus cunninghamii and the tree fern Dicksonia antarctica, in Tasmania also a number of other species as *Blechnum procera* and many mosses (Beadle 1981).

The particularly perhumid transition zone, on the other hand, comprises only W Tasmania with small Eucalyptus species and bogs as well as the SW of New Zealand's South Island with the offshore Stewart Island. Thus, the transition to the subantarctic islands is given.

◘ **Fig. H-22** Climate diagrams from the hardleaf region of S Australia and the warm-temperate region of Victoria and Tasmania.

◘ **Fig. H-23** Eucalyptus *regnans* high forestin Russel Falls National Park 60 km northwest of Hobart on Tasmania (photo: Meraj Amiri).

The composition of forests depends on the frequency of forest fires.

**1.** In the moist parts of W Tasmania, where forest fires do not occur, a tree layer of Nothofagus with *Atherosperma* moschata (Monimiaceae) 40 m high develops, and below this a 3 m high layer with the tree fern Dicksonia, which can still grow in illumination of 1% of daylight. In these humid forests, Hymenophyllaceae (► Fig. H-14) and mosses are very common as epiphytes.

**2.** If forest fires recur about every 200 to 350 years, then mixed forests are formed, which are three-layered. In addition to the above two layers, there is a 75 m (to 90 m) high layer of the three largest Eucalyptus species. This tree layer is of equal age, a sign that the germination of the trees occurred on larger areas after a forest fire. After such a forest fire, the tree layer of Eucalyptus and Nothofagus is destroyed, but the fruits open, and the intact seeds fall out and germinate. As Eucalyptus grows more rapidly, it overtakes Nothofagus, so that two layers of trees are formed. Tree ferns lose their leaves to fire, but regrow new ones at the top of the trunk. Regeneration of Eucalyptus under Nothofagus is not possible due to lack of light. It occurs again only after another fire.

**3.** If forest fires occur once or twice a century, Nothofagus is replaced by other fast-growing low tree species (Pomaderris, Olearia, Acacia).

**4**. After forest fires every 10 to 20 years, pure low stands of Eucalyptus develop.

**5.** Even more frequent fires cause degradation of the forests; an open moorland with the "button grass" Mesomelaena sphaerocephala (Cyperaceae) develops, in which Myrtaceae bushes are interspersed and Drosera and Utricularia occur alongside Restionaceae.

4.6 **Warm temperate biomes of New Zealand**

The forests of New Zealand deserve a special mention. Although the two islands are relatively close to the Australian continent and there was probably a direct connection in the geological past, this must have been interrupted before the Australis flora had developed. There is not a single native species of Eucalyptus or Acacia on New Zealand. The Proteaceae are also represented by only two species.

In the north of the North Island, one still finds subtropical forests with the conifers Agathis australis as well as Agathis microstachya (◘ Fig. H-24) and palms; even mangroves of low Avicennia bushes grow along the coast. The species of the forests are Melanesian elements of the Palaeotropis. Agathis is also a giant conifer, with stem diameters measured up to 8.54 m and girth (BHD) of 26.6 m! but with not very high crown growth up to about 50 m.

Forests of this character extend even to the South Island, although the climate there is decidedly temperate, but at low altitudes without a cold winter season. The conifer genera Podocarpus and Dacrydium, which are widespread throughout the southern hemisphere, play a major role.

At the same time, however, the Antarctic element is important, with five evergreen Nothofagus species in the forests not only on the South Island, but also on the North Island. These mutually exclusive forest types are arranged in a mosaic fashion, with no clear climatic or ecological explanation for their distribution. One gets the impression that the plant cover is not in equilibrium with the present environment, but that historical factors play a very large role.

Large parts of the North Island were covered with a thick layer of hot volcanic ash by the massive eruption of Taupo 1830 years ago. The first pioneers to appear were the Podocarpaceae, which were spread by birds. They are slowly displaced by forests with tropical elements, and in the mountains partly by Nothofagus forests. The South Island was covered by large glaciers in the Pleistocene, so that recolonization is still in progress there as well, especially since Nothofagus is slow to spread (◘ Fig. H-25).

◘ **Fig. H-24 a**: Kauri forests with giant specimens of Agathis microstachya in northern New Zealand; **b:** Fruit stand of Agathis (photos: Breckle).

In the extremely humid SW Fjordland with more than 6000 mm rainfall, the Nothofagus forests are already quite similar to those of S Chile. A special feature here are the forest fall strips reminiscent of avalanches, which, however, begin in the middle of the forest on steep slopes and are 2 to 6 m wide (◘ Fig. H-26). When the weight of the trees with heaps of epiphytic mosses growing on rock faces becomes too great, gravity causes the entire layer of vegetation, including the root system and the soil layer, to be removed. The bare rock left behind is recolonized with lichens, mosses and ferns until shrubbery and finally a stand of trees develops, whereupon another fall occurs.

A grave danger to the forests of New Zealand, where originally there was no mammalian species except bats, is represented by the abandoned European red deer, whose reproduction is beyond all control and which prevents regeneration of the often inaccessible Nothofagus forests, causing very great damage in the mountains by soil erosion and flooding. Equally dangerous is the Australian opossum (Kuzu: ◘ Fig. H-27), introduced as a fur-bearing animal, which specialises on a tree species that forms the tree line, completely defoliates it and causes it to die, which also increases the risk of soil erosion on steep slopes.

New Zealand is an example of how dangerous it is when humans interfere with the natural balance by introducing new animals or plants. The damage often cannot be repaired.

◘ **Fig. H-25** The Nothofagus forests in Tianau, South Island of New Zealand (**a**), belong to the Antarctic elements and occur in all continents of the Southern Hemisphere as evidence of their former connection (Gondwana continent). **b**: Leaves of Nothofagus from left to right Loranthus micranthus (as parasite), Nothofagus fusca, Nothofagus menziesii and the small-leaved Nothofagus solandri. In these forests all three species occur with a slight dominance of Nothofagus fusca (photos: Breckle).

◘ **Fig. H-26** Forest fall tracks in the Nothofagus forests of the South Island (Milford) in New Zealand (photo: Breckle).

◘ **Fig. H-27** Opossum, an invasive imported species that has become an ecological threat to New Zealand (photo: http://bit.do/bjTw6).

**5 Literature**

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Temperate nemoral deciduous forest with beech, oaks and hornbeam (Zonobiome VI) in the Eifel, Germany (Photo: E. Fischer)

The New Zealand edelweiss (Leucogenes leontopodium) in the alpine altitudinal zone of the New Zealand Alps (Orobiom V) between rocks densely covered with lichens (Photo: Breckle)