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**On the global position of the evergreen broad-leaved
(non-ombrophilous) forest in the subtropical and temperate zones ***

Zur globalen Stellung des «Lorbeerwaldes» in den
subtropischen und temperierten Zonen

by

Frank KLOETZLI

1. INTRODUCTION

Evergreen broad-leaved forests occur all over the world in the warmer zones, from the warm-temperate zone, where they form the climax, to the drier (sub-)tropical high mountains, where they may grow from the montane to the subalpine belt.

* Herrn Prof. Dr. Dr. h.c. Heinrich Walter zum 90. Geburtstag gewidmet

Certainly, the latest monograph on the 'Evergreen Broad-leaved Forest' gives a thorough and valuable picture of all types of this kind of forest in all parts of the world. It includes all types of more or less humid forests between the tropical rainforest and the sclerophyllous woodland. The question of feasibility of such a simplification arises, however. Is it realistic to include such different forest types as the temperate rainforests of New Zealand and Chile (e.g. the 'Valdivian'), the laurineous forests of Japan and China and the eastern African oreal/subalpine forests into one unit?

With the following I shall try to point out the special transient position of the 'Laurineous Forest' (or 'Evergreen Broad-leaved Forest s.str., compare SONG 1983 'Vegetation region'; ELLENBERG and MUELLER-DOMBOIS 1967, 'temperate evergreen, seasonal broad-leaved forest'; WALTER 1979, 'temperierter immergrüner Wald') towards wetter and drier types (e.g. temperate rainforest, tropical montane sclerophyllous woodland), and to define the specific characteristics of such a biome under the so-called 'Shanghai-climate', dominated by monsoon influence.

2. LIMITING FACTORS

a. **Laurineous forests are thermophilous**, with higher temperatures during the growing season than the average summergreen deciduous forests. Although there is considerable overlap between these two types, the limits may be given by the number of days and intensity of frost or late frost (see b). However, during the growing season the average temperature lies around 20-25°C from July to September, and is often higher, especially in eastern China, southern Japan and southern Florida (SONG YONGCHANG 1983; Table 1).

b. **Laurineous forests are sensitive to frost.** Temperatures rarely are much lower than -5°C. When temperatures are lower there is often a protective snow layer (Japan), or temperatures do not remain as low for a long time. Late frosts are rare, they always leave their marks and give a harsh draw-back in vitality of the typical laurineous species.

c. Laurineous forests are sensitive to drought, thereby separated well from sclerophyllous woodlands where a special type occasionally occurs, but only on edaphically or mesoclimatically more favourable situations, e.g. on ravine sites. Horizontal precipitations (mist) may also allow their installation, e.g. oreal to subtropical forests on (sub-)tropical high mountains. On the average, precipitations are high all year over (Japan, Florida), except under typical monsoon climates, where two months of drought may be tolerated, in many cases softened by the effect of mist banks.

Table 1. Climatic differences between laurineous and deciduous forest
(after SONG YONGCHANG 1983, 'Vegetation region II')

Tab. 1. Klima-Unterschiede zwischen Lorbeer- und sommergrünem Laubwald

| Climatic parameters | laurineous forest | deciduous forest |
|--|------------------------|------------------|
| mean annual temperature (in °C) | 16-20 (E) 15-18 (W) | 8 - 14 |
| mean minimum temperatures of the coldest month (in °C) | 3- 8 (E) 8-10 (W) | -15 - -1 |
| mean maximum temperatures of the warmest month (in °C) | 26-29 (E) 20-22 (W) | 24 - 28 |
| frost-free period (in days) | 240-330 | 180-220 |
| precipitations: (% during growing season) | | |
| 900-2000 mm/year | 20-40 (E) | 60-70 |
| 500-900, respectively | 5-15 (W) | |

3. CHARACTERISTICAL FEATURES

Laurineous forests generally have oak-like ('gnarled') to beech-like (slender, smooth-barked) stems and show all forms between the typical sclerophyllous to the omphrophilous tree (compare e.g. Castanopsis, Cinnamomum and Persea resp.).

Normally, laurineous forests bear soft-leathery to almost sclerophyllous, nearly mesophyllous and partly even larger leaves. Some genera may be called typically 'laurophyllous' (evergreen broad-leaved), e.g. Camellia, Citrus, Persea, Rhododendron ponticum, Castanopsis, Cinnamomum in eastern Asia, Rapanea, Syzygium, Maesa etc. in eastern African high mountains).

Table 2. Characteristical genera in laurineous forests in China
(after SONG 1983)

Tab. 2. Charakteristische Gattungen in den Lorbeerwäldern Chinas

trees, evergreen broad-leaved (mostly Fagaceae, Lauraceae)

| | | |
|------------------------|----------------------|--|
| <i>Cyclobalanopsis</i> | <i>Elaeocarpus</i> | <i>Acer</i> |
| <i>Castanopsis</i> | <i>Sloanea</i> | <i>Prunus</i> |
| <i>Lithocarpus</i> | <i>Michelia</i> | |
| <i>Machilus</i> | <i>Altingia</i> | more xeromorphic character |
| <i>Phoebe</i> | <i>Symplocos</i> | where winters are warm/dry |
| <i>Cinnamomum</i> | <i>Daphniphyllum</i> | |
| <i>Schima</i> | <i>Manglietia</i> | where limestone parent rock prevails additional occurrence of deciduous species of the same genera |

trees, coniferous (mostly montane)

| | | |
|---------------------|-------------------|-----------------|
| <i>Cephalotaxus</i> | <i>Podotaxus</i> | <i>Cathya</i> |
| <i>Taxus</i> | <i>Keteleeria</i> | <i>Fokienia</i> |
| <i>Pseudotaxus</i> | | |

shrubs

| | | |
|---------------------|-------------------|---------------------|
| <i>Rhododendron</i> | <i>Lindera</i> | <i>Gardenia</i> |
| <i>Vaccinium</i> | <i>Neolitsea</i> | <i>Dammaranthus</i> |
| <i>Camellia</i> | <i>Lisea</i> | <i>Ardisia</i> |
| <i>Eurya</i> | <i>Lasianthus</i> | <i>Maesa</i> |
| <i>Symplocos</i> | <i>Randia</i> | |

herblayer with

| | | |
|-------------------|------------------|----------------------|
| <i>ferns</i> | <i>Poaceae</i> | <i>Zingiberaceae</i> |
| <i>Cyperaceae</i> | <i>Liliaceae</i> | <i>Araceae</i> |

Only few creepers are conspicuous, but plenty of epiphytes (ferns, incl. Hymenophyllaceae) cover the older branches. The herb layer is generally rich in ferns; sometimes coriacious or hydrophilous plants may also prevail. (Table 2).

4. DELIMITATIONS TOWARDS OTHER FORMATIONS (BIOMES)

Temperate rainforests (e.g. Valdivian rainforest, rainforests in southwestern New Zealand as typical examples; photos 16-18) have more (and more) evenly distributed rainfalls, more even temperatures, and have more or less no frosts (see HUECK 1966, OBERDORFER 1960). They may show similar features, but are more hydrophilous and present more biomass. Subtropical rainforests are warmer, similar to montane tropical rainforests and often transitional to tropical rainforests.

Sclerophyllous forests (woodlands) (e.g. Mediterranean area, California, central Chile, South Africa, subtropical to tropical high mountains) have less and more sporadical rain, especially in winter, regular frosts, summer-drought and mostly or partly regular fires (see DI CASTRI et al. 1981). In transitional situations features may be very similar (limits of sclerophyllous to laurineous biome).

Temperate deciduous forests (e.g. in contacting areas: northern Japan, southeastern America, etc.) are rather similar, but have extremer (minimum-) temperatures and colder winters. There are many transitional zones with laurophyllous species in the bottom-layer and shrub-layer, some even reach the warmer central European regions (see details in SONG YONGCHANG 1983).

Figure 19 gives a general view on types 1 to 5, their position regarding climatic conditions, and their transitional types; Fig. 20 shows their position on a worldwide scale giving typical climate diagrams.

5. TYPES OF LAURINEOUS FORESTS

According to the above mentioned factors the following types of laurineous forests can be distinguished (compare also Table 3):

First type: Climax (Zonobiom)

This type is represented by the lowland forests in eastern Asia, south-eastern America as well as by the subtropical highland forests in the Himalaya which are very similar in structure (see e.g. SONQIAO 1985, MIYAWAKI and OKUDA 1979, DOBREMEZ and SHAKYA 1975, KNAPP 1973; OHSAWA et al. 1986, for the Himalaya in subtropical to cool-temperate examples). (Figs. 1, 2, 3).

Second type: Climax (Orobiom)

High montane to subalpine tropical forests form a scattered area in eastern Africa, northwestern Andes and southeastern Asia but are very much alike due to the convergence in the form of leaves and stems (KNAPP 1965, OVINGTON 1983). (Fig. 7).

Third type: Climax (partly Zono-biom, partly Orobiom)

In the southern hemisphere they occur either in the montane area or e.g. in the southern longitudinal valley in Chile, as a transitional zone between temperate rainforest and deciduous forests (KLOETZLI 1983). (Fig. 4).

Fourth type: Cloud forest (Orobiom)

Some cloud forests belong to the laurineous forest. They occur on (sub-) tropical mountains (e.g. Canary Islands and eastern Africa), above (sub-)tropical dry forests (and thorn scrub) and below the actual subalpine tropical forest of the sclerophyllous or ericaceous type (OVINGTON 1983, KLOETZLI in print, KNAPP 1973, KUNKEL 1976). (Fig. 6).

Fifth type: Ravine forest (Pedobiom)

The last somewhat aberrant type occupies ravine(-like) sites in the sclerophyllous biome (e.g. Mediterranean mountains, western Himalaya, southern Californian ranges, southwestern/southeastern Australia; see also KEAST 1981, KNAPP 1965).

6. TRANSITIONAL TYPES

As can be concluded from the mentioned situations, the laurineous forest is bordered by many other biomes (e.g. rainforest, dry forest, deciduous forest, coniferous forest, to mention just a few). Due to the central position of 'Laurineous Forests' a great number of transitional types may be seen in the mountains, e.g.:

- from boreal coniferous forests to coniferous forest with laurophyllous species (e.g. British Columbia, moist montane coniferous forest with Tsuga, Thuja, Abies, from the Himalaya to Japan)
- from temperate deciduous forest to deciduous forest with laurophyllous species (e.g. pontical and hyrcanic deciduous forest in Turkey and Iran, southwestern Ireland, northern parts of southeastern America) (Figs. 10, 11)
- from sclerophyllous forest to ravine forest with laurophyllous species
- from temperate rainforest to sclerophyllous forest with laurophyllous species in different gradations (e.g. edaphically drier areas in the southern longitudinal valley of Chile; compare also Fig. 10)
- from subtropical or temperate rainforests to actual laurineous forest due to accentuated periods with less rain (but no drought) and mostly deeper temperatures, also in mountainous areas (e.g. in subtropical to temperate mountains of the Australian eastern coast) (Figs. 8, 9)
- from (tropical montane) laurineous forests to tropical montane dry forests with less influence of mist (Fig. 12)
- from laurineous forest to sclerophyllous forest or woodland with laurophyllous species (e.g. thermophilous coastal areas in southeastern Japan) (Figs. 13, 14)
- from laurineous forest to coniferous forest with laurophyllous species due to unfavourable climatic and/or edaphic conditions (e.g. mire-margin, rock-site, frost-hollow in southeastern Asia). (Fig. 15).

Table 3. Legends of the figures 1-20 of different types of laurophyllous (= laurineous) forests and examples of transitional types
 Tab. 3. Legenden zu den Abbildungen 1-20 der verschiedenen Laorbeerwälder und Beispiele der Übergangstypen

| Fig. | Type | Locality | Tree species |
|------|---|--|--|
| 1 | 1, lowland | Japan, Kyushu, Kirishima near Kagoshima, ca. 600 m, 1.9.1984 | <i>Machilus thunbergii</i> , <i>Cinnamomum japonicum</i> , <i>Actinodaphne lancifolia</i> , <i>Distylium racemosum</i> |
| 2 | 1, (sub-)montane | Nepal, Gokarna Forest, near Kathmandu, ca. 1300 m, 21.8.1983 | <i>Quercus glauca</i> , <i>Castanopsis tribuloides</i> , <i>Schima wallichii</i> , <i>Ilex</i> sp., <i>Acer oblongum</i> , <i>Osmanthus fragrans</i> , <i>Alnus nepalensis</i> , <i>Myrsine semiserrata</i> , <i>Ehretia acuminata</i> , <i>Engelhardtia spicata</i> , <i>Stranvaesia glaucescens</i> , <i>Michelia kisopae</i> |
| 3 | 1, montane | Nepal, near Kathmandu, on Phulchoki, ca. 1900 m, 22.8.1983 | <i>Quercus glauca</i> , <i>Q. lanata</i> , <i>Lithocarpus spicata</i> , <i>Carpinus viminea</i> , <i>Symplocos</i> spp., <i>Sorbus cuspida</i> , <i>Acer oblongum</i> , <i>Quercus lamellosa</i> , <i>Rhododendron arboreum</i> , <i>Lyonia ovalifolia</i> , <i>Litsea pulcherrima</i> , <i>L. citrata</i> , <i>Pieris formosa</i> , <i>Berberis wallichiana</i> , <i>Mahonia acanthifolia</i> , <i>Rubus</i> spp. |
| 4 | 3, montane laurophyllous forest | Australia, New South Wales, Barrington Tops, ca. 900 m, in bassin, 18.8.1981 | <i>Nothofagus moorei</i> , <i>Doryphora sassafras</i> , (ridge: <i>Eucalyptus obliqua</i>), <i>Anodopetalum bigandulosum</i> , <i>Zieria arborea</i> etc. |
| 5 | 1, lowland laurophyllous forest, transition to subtropical moist forest | U.S.A., Florida, Everglades, ca. 10-20 m, 20.3.1980 | 'Hammock vegetation' with <i>Osmanthus americanus</i> , <i>Quercus</i> sp., <i>Brumelia</i> sp., <i>Callicarpa americana</i> , <i>Myrica cerifolia</i> , <i>Ilex vomitoria</i> , <i>Persea borbonia</i> , <i>Sabal palmetto</i> (in the understorey) |

Table 3 (continued)

| Fig. | Type | Locality | Tree species |
|------|--|--|---|
| 6 | 4, cloud forest | Kenya, Marsabit Nat. Park, ca. 1700 m, April 1977 | <i>Allophylus abyssinicus</i> , <i>Apodytes dimidiata</i> , <i>Pygeum africanum</i> , <i>Afrocrania volvensii</i> , <i>Cassipou-</i> <i>rea malosana</i> , <i>Olinia usambarensis</i> etc. |
| 7 | 2, tropical montane laurophyllous forest | Kenya, Aberdare Nat. Park, near Thomsons' Falls, ca. 2300 m, April 1977 | <i>Aningeria adolfi-friderici</i> , <i>Chrysophyllum gorun-</i> <i>gosanum</i> , <i>Ocotea kenyensis</i> , <i>Polyscias kikuyensis</i> , <i>Ekebergia</i> , <i>Macaranga</i> etc. |
| 8 | transition lowland warm-temperate rain- forest to laurophyllous forest | Northern New Zealand, 60 km E of Auckland (Waitakaruru), ca. 150 m, 13.9.1981 | <i>Nothofagus truncata</i> , <i>Knightia excelsa</i> , <i>Podocarpus</i> <i>ferrugineus</i> , <i>Phyllocladus trichomanoides</i> , <i>Cyathea</i> <i>dealbata</i> , <i>C. medullaris</i> , <i>Dacrydium cupres-</i> <i>oides</i> , <i>Metrosideros robusta</i> , <i>Beilschmiedia tawa</i> |
| 9 | transition laurophyll- ous to montane warm- temperate rainforest in bassin | Australia, New South Wales, Blue Mountains, ca. 1000 m 26.8.1981 | <i>Eucalyptus oreades</i> , <i>E. viminalis</i> , <i>Acacia elata</i> , <i>Ceratopetalum apetalum</i> , <i>Doryphora sassafras</i> , <i>Cyathea austalis</i> , <i>Dicksonia antarctica</i> |
| 10 | transition submontane laurophyllous to decid- uous forest with lauro- phyllous understory | Chile, N of Puerto Montt, near La Union and Ca. Pelada, ca. 450 m, 7.10.1981 | <i>Nothofagus obliqua</i> , <i>Laurelia philippiana</i> , <i>Persea</i> <i>lingua</i> (<i>Chusquea quila</i>) |

Table 3 (continued)

| Fig. | Type | Locality | Tree species |
|------|---|---|---|
| 11 | transition lowland deciduous to laurophyllous forest with laurophyllous understory | Ireland, near Killarney, ca. 150 m, 1971 (Photo N. Kuhn) | <i>Quercus petraea</i> (<i>Rhododendron ponticum</i>), |
| 12 | transition tropical montane dry forest with laurophyllous understory to laurophyllous mist forest | Kenya, Marsabit Nat. Park, ca. 1400 m April 1977 | <i>Combretum</i> sp., <i>Cordia</i> , <i>Diospyros</i> , <i>Dombeya</i> , <i>Croton</i> , <i>Terminalia</i> spec. understory partly as Fig. 6 |
| 13 | transition laurophyllous forest to sclerophyllous woodland | Japan, Honshu, near Shimoda (Izu-Peninsula), ca. 100 m 5.9.1984 | <i>Quercus phillyraeoides</i> , <i>Pittosporum tobira</i> , <i>Elaeagnus umbellata</i> |
| 14 | transition laurophyllous forest to mixed sclerophyllous/Juniperus rock scrub | Japan, Honshu, near Shimoda (Izu-Peninsula), ca. 50 m 5.9.1984 | <i>Juniperus chinensis</i> , <i>Pinus thunbergii</i> |
| 15 | transition laurophyllous/deciduous forest to bog scrub | Japan, Honshu, near Numata (Tanbara Bog), ca. 1200 m 15.8.1984 | <i>Fraxinus longicuspis</i> , <i>Fagus crenata</i> , (<i>Alnus</i> , <i>Acer</i> , <i>Sorbus</i> , <i>Prunus</i> , etc.), understory with <i>Ilex crenata</i> , <i>Menziesia pentandra</i> , <i>Thujopsis dolabratata</i> , <i>Vaccinium smallii</i> |

Table 3 (continued)

| Fig. | Type | Locality | Tree species |
|------|------------------------------------|---|--|
| 16 | submontane, subtropical rainforest | Australia, Queensland, Lamington Nat. Park, ca. 800 m 6.9.1981 | <i>Argyrodendron trifoliolum</i> , <i>Geissois benthamii</i> , <i>Ficus watkinsiana</i> (<i>Cyathea reichhoferi</i>) |
| 17 | lowland warm-temperate rainforest | Australia, Tasmania, Styx R., ca. 300 m 29.8.1981 | <i>Eucalyptus regnans</i> , <i>Nothofagus cunninghamii</i> , <i>Dicksonia antarctica</i> , <i>Atherospermum moschatum</i> , <i>Anodopetalum biglandulosum</i> , <i>Zieria arborea</i> etc. |
| 18 | montane cool-temperate rainforest | Southern New Zealand, near Haast Pass, Mt. Aspiring Nat. Park, ca. 560 m 19.9.1981 | <i>Nothofagus menziesii</i> (<i>Podocarpus hallii</i>) |
| 19 | | | Position of the evergreen broad-leaved forest in a diagram of yearly mean temperature and yearly mean precipitation |
| 20 | | | Distribution of laurineous forests on a worldwide scale and typical climate diagrams including the neighbouring biomes |

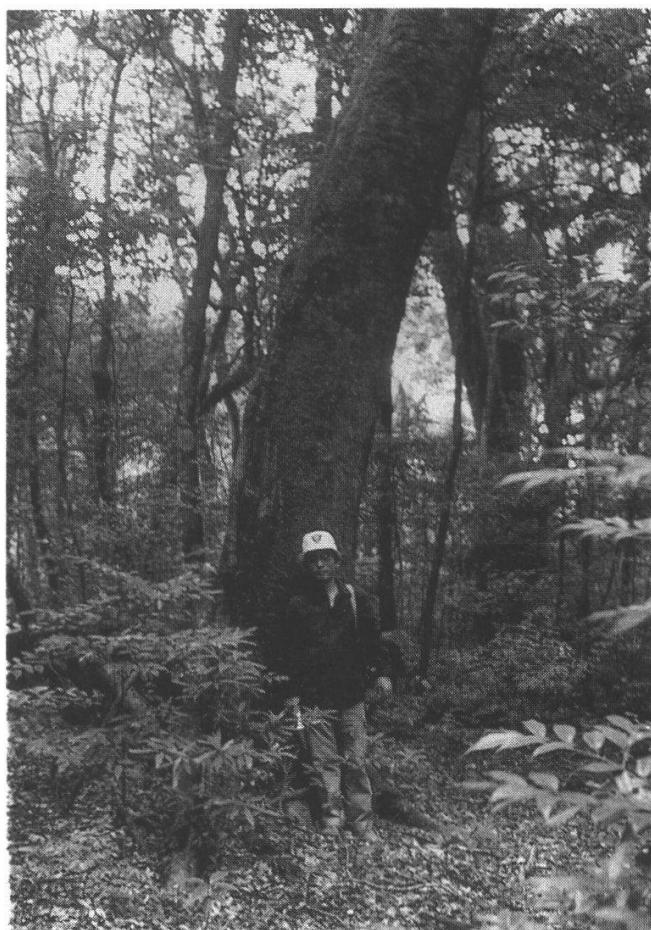


Abb. 1 (oben), Abb. 2 (unten) - Fig. 1 (above), Fig. 2 (below)
Legenden s. Tabelle 3 - Legends see Table 3



Abb. 3 (oben), Abb. 4 (unten) - Fig. 3 (above), Fig. 4 (below)
Legenden s. Tabelle 3 - Legends see Table 3

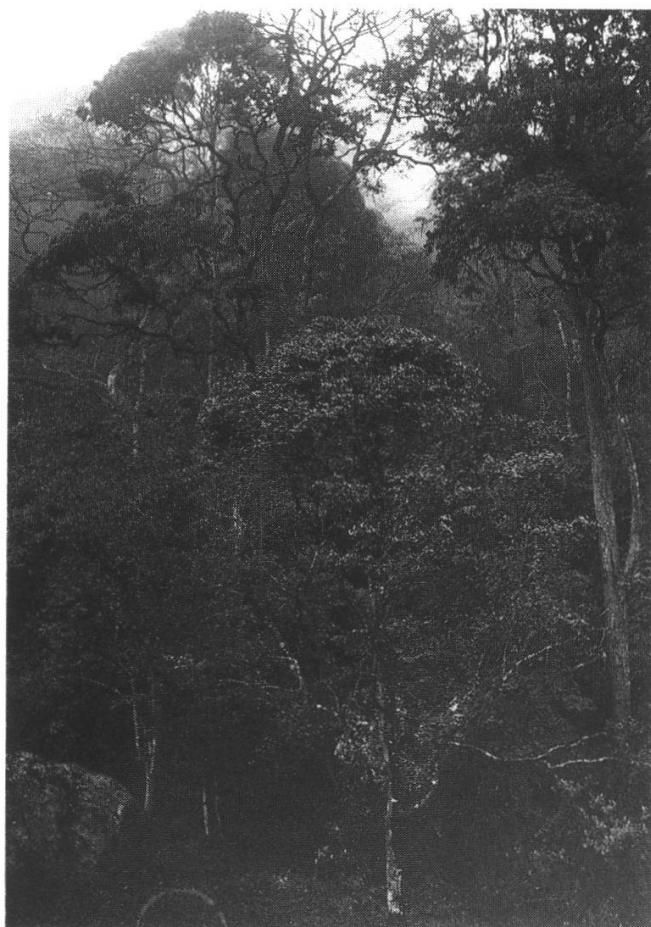


Abb. 5 (oben), Abb. 6 (unten) - Fig. 5 (above), Fig. 6 (below)
Legenden s. Tabelle 3 - Legends see Table 3

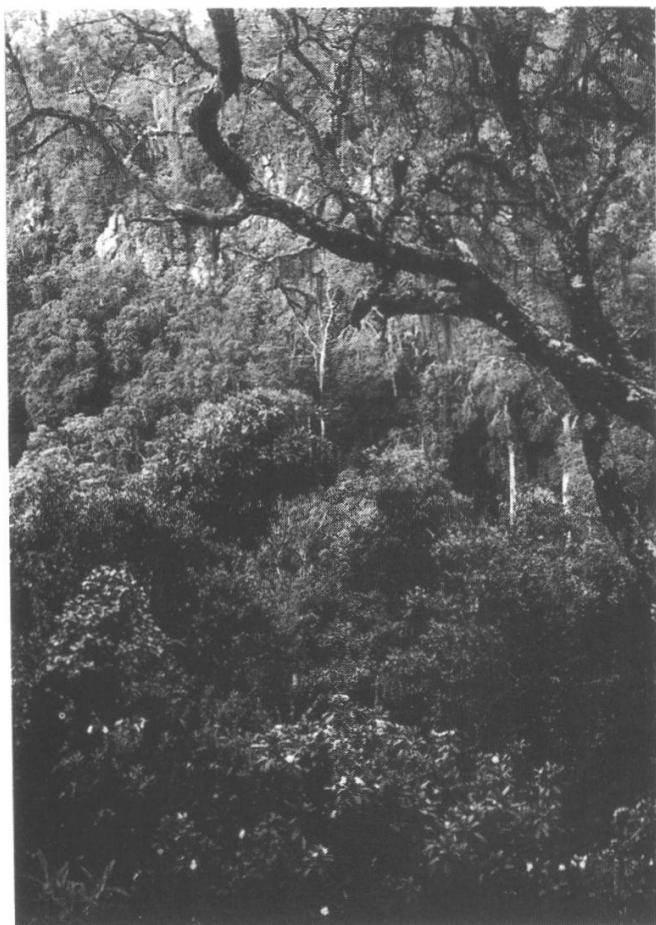


Abb. 7 (oben), Abb. 8 (unten) - Fig. 7 (above), Fig. 8 (below)
Legenden s. Tabelle 3 - Legends see Table 3



Abb. 9 (oben), Abb. 10 (unten) - Fig. 9 (above), Fig. 10 (below)
Legenden s. Tabelle 3 - Legends see Table 3



Abb. 11 (oben), Abb. 12 (unten) - Fig. 11 (above), Fig. 12 (below)
Legenden s. Tabelle 3 - Legends see Table 3



Abb. 13 (oben), Abb. 14 (unten) - Fig. 13 (above), Fig. 14 (below)
Legenden s. Tabelle 3 - Legends see Table 3



Abb. 15 (oben), Abb. 16 (unten) - Fig. 15 (above), Fig. 16 (below)
Legenden s. Tabelle 3 - Legends see Table 3

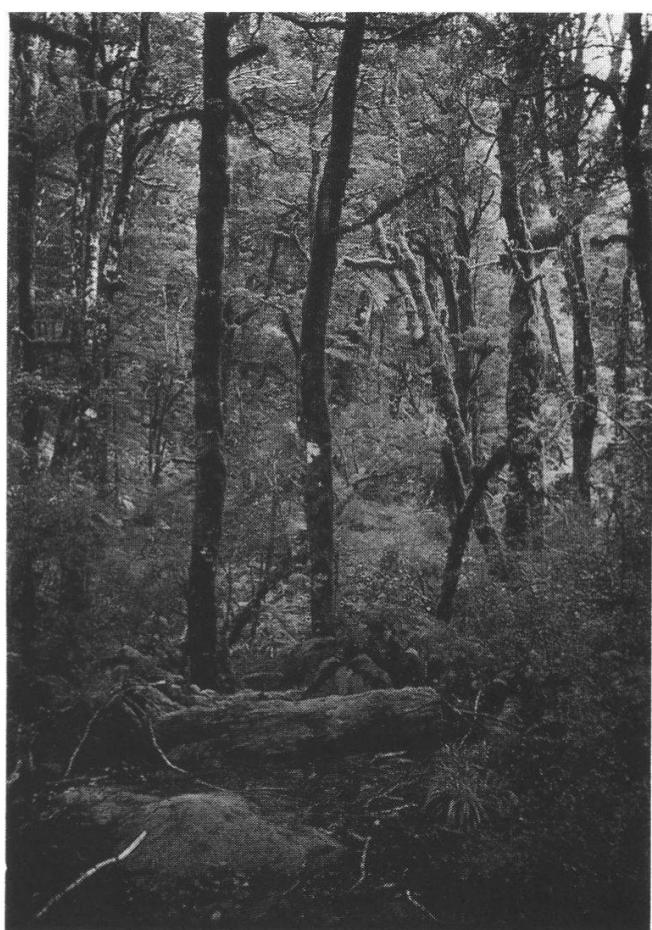


Abb. 17 (oben), Abb. 18 (unten) - Fig. 17 (above), Fig. 18 (below)
Legenden s. Tabelle 3 - Legends see Table 3

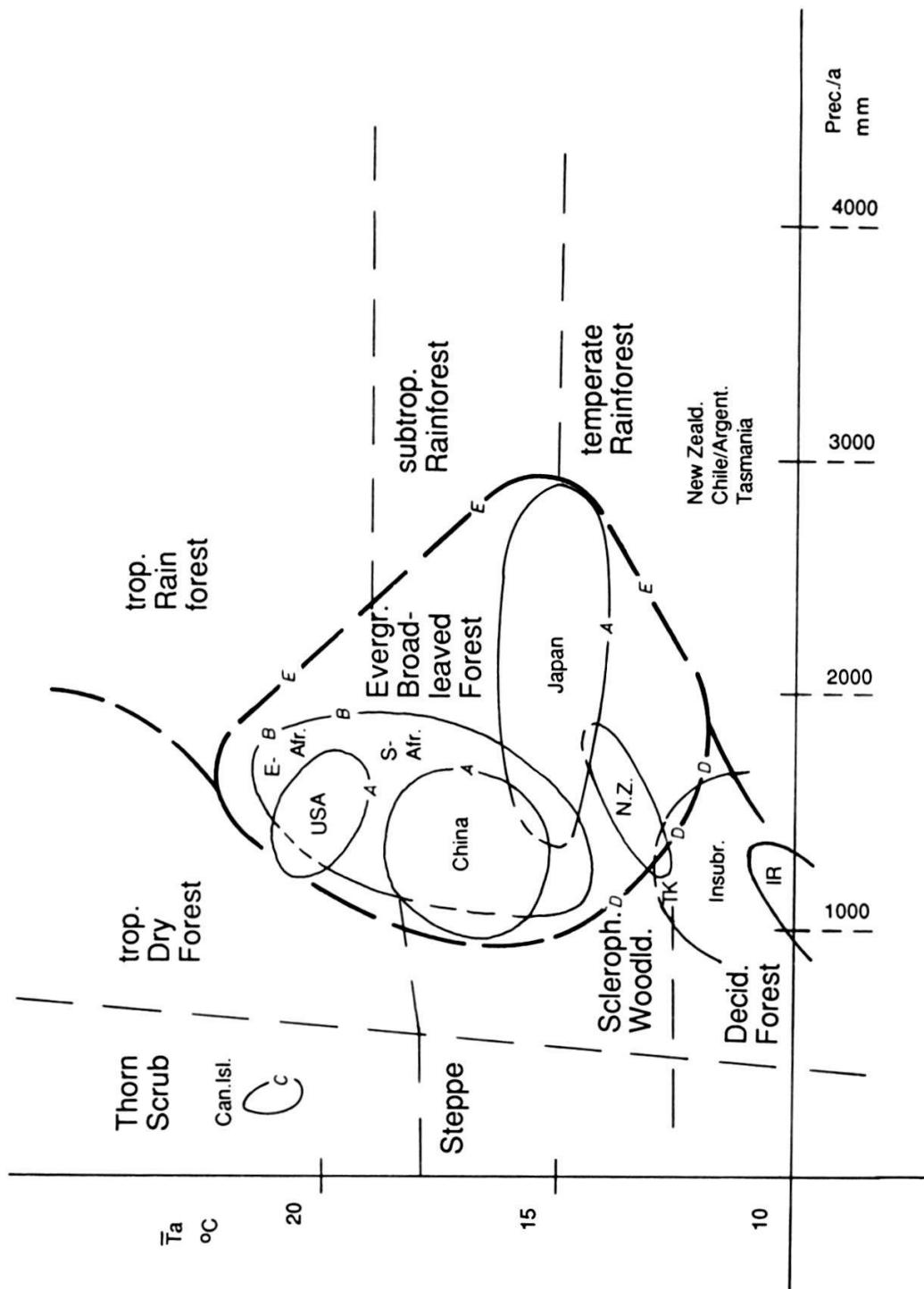


Fig. 19. Position of the evergreen broad-leaved forest in a diagram of yearly mean temperature and yearly mean precipitation.

Abb. 19. Diagramm der jährlichen Mitteltemperaturen und -niederschläge: Lage der immergrünen Laubwälder

Fig. 19 (continued)

Delimitations according to climate diagrams of WALTER and LIETH (1960-1967). Interrupted straight lines (after STOCKER 1965).

Insubr. = Cool to warm-temperate foothills of southern parts of the Central Alps
IR = Southwestern Ireland (Kerry). Stations of northwestern Turkey at the cooler end of New Zealand stations
Can.Isl. = Canary Islands. Cloud forest above thorn scrub, station in the lowlands

Letters A, B, C, D and E within the curves:

- A Typical stations
- B Tropical montane
- C Mist belt
- D Transitional types
- E True rainforest

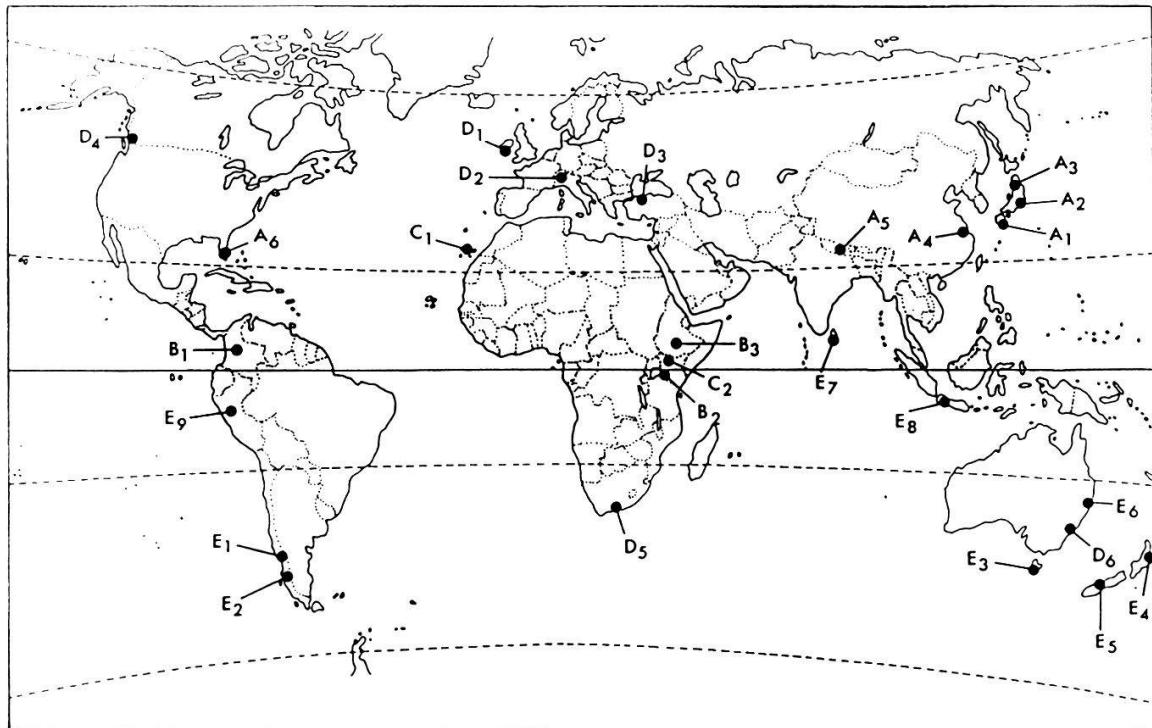
Differential factors besides medium temperature and precipitations are also late frost: limit to the deciduous forest.

Type of precipitation line (less curved): limit to temperate rainforest; do. dropping in the season: limit to sclerophyllous woodland (to be considered with type of temperature line)

Limits between evergreen broad-leaved forest, deciduous forest, rainforest and sclerophyllous woodlands often depend on minimum temperatures and summer precipitations.

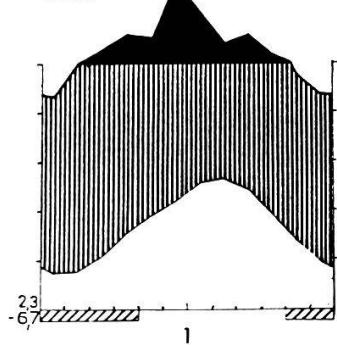
Fig. 20 (p. 191-193). Distribution of laurineous forests on a worldwide scale and typical climate diagrams including the neighbouring biomes.

Abb. 20 (S. 191-193). Weltweite Verbreitung der Lorbeerwälder mit typischen Klimadiagrammen der angrenzenden Biome.

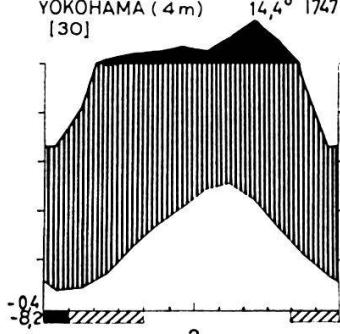


A. Typical stations

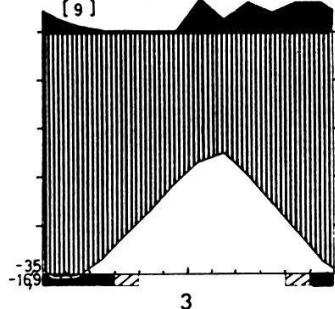
KAGOSHIMA (5 m) $16,6^{\circ} 2244$
[30]



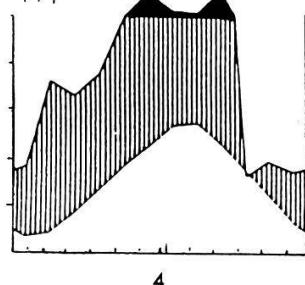
YOKOHAMA (4 m) $14,4^{\circ} 1747$
[30]



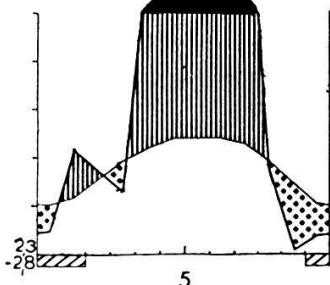
SAKATA (3 m) $11,4^{\circ} 1964$
[9]



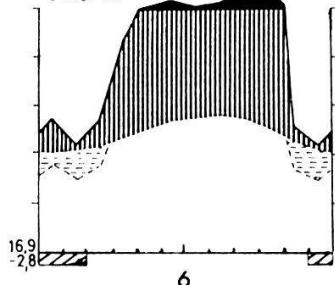
SHANGHAI (12 m) $15,5^{\circ} 1120$
[7]



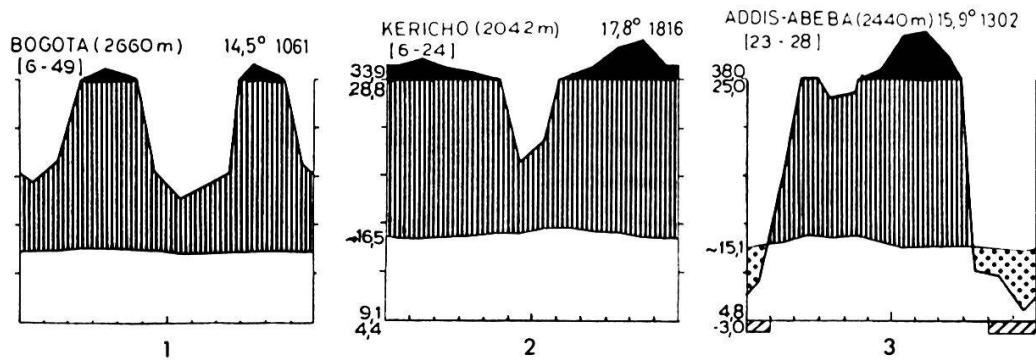
KATMANDU(1335m) $18,6^{\circ} 1418$
[40-6]



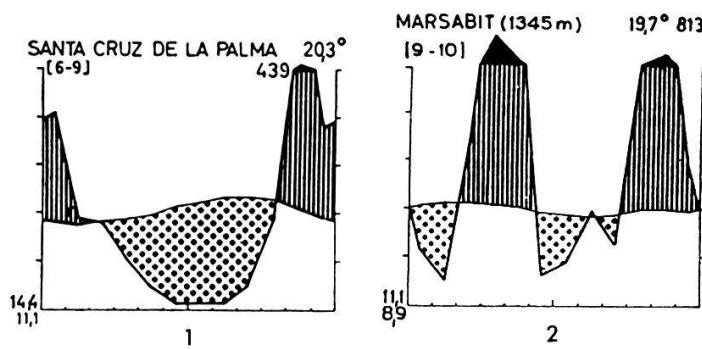
MIAMI (2 m) $24,1^{\circ} 1199$
[30] Fla.



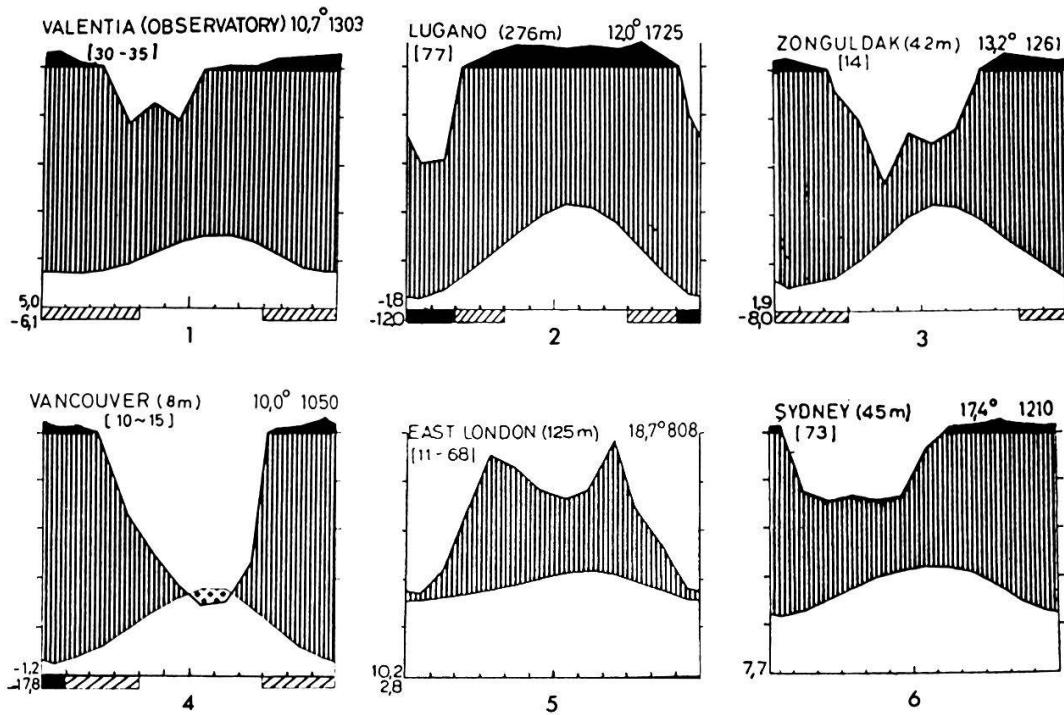
B. Tropical montane



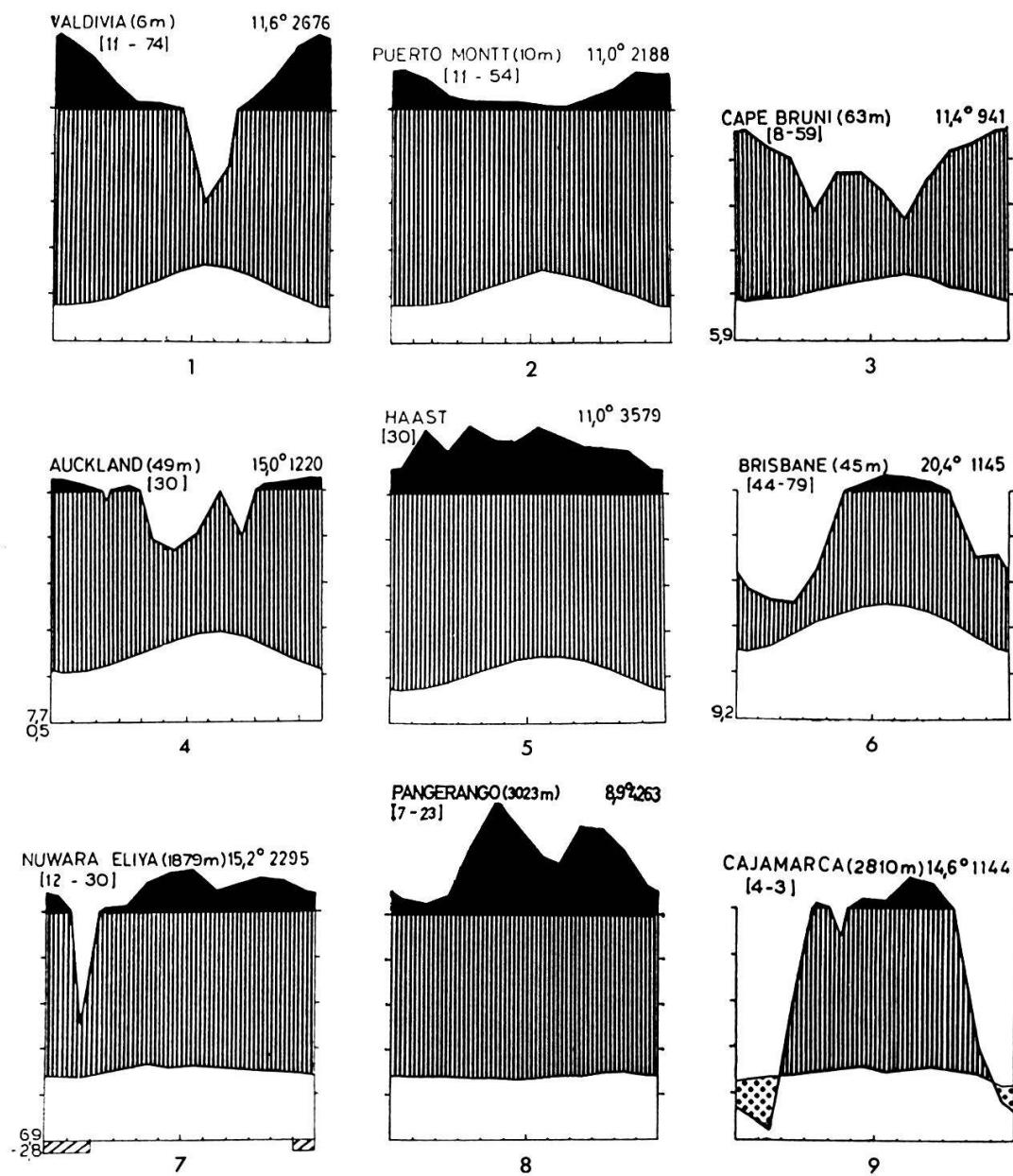
C. Mist belt



D. Transitional types



E. True rainforest



SUMMARY

1. **Limiting factors.** Evergreen broad-leaved forests are
 - thermophilous ($20-25^{\circ}\text{C}$ in the growing season)
 - sensitive to frost (around 0°C , rare down to -10°C , rarely late frosts)
 - sensitive to drought (precipitations generally high the year over or at least in the growing season or in drier seasons edaphically favourable or high horizontal precipitations [mist]).
2. **Characteristic features.** **Stems** show all forms between the typical sclerophyllous to the ombrophilous tree. **Leaves** are normally softly coriaceous to almost sclerophyllous and nearly mesophyllous, partly quite large. **Ferns** are often dominant as epiphytes and herb layer plants.
3. **Delimitations.**
 - **Temperate** (subtropical) rainforests have generally more and more evenly distributed precipitations, more even temperatures and hardly (severe) frost.
 - **Sclerophyllous woodlands** have less and more sporadic rainfalls, predominantly in winter, regular fire influence.
4. **Types**
 - a. **Climax** under so-called 'Shanghai-climate' (incl. lowland forests from 1000 m up to 2500 m a.s.l. in the eastern Himalaya) (Zonobiom).
 - b. **Climax** on drier oreal subalpine belts of (sub-)tropical mountains (mostly 2500-3000 m a.s.l.) (Orobiom).
 - c. **Climax** between temperate rainforest and deciduous forests of the humid southern hemisphere (partly Zonobiom, partly Orobiom).
 - d. **Cloud forest** on (sub-)tropical dry mountains above semi-arid submontane forests and below sclerophyllous or ericaceous subalpine woodlands (Orobiom).
 - e. **Ravine forest** as an exceptional type (Pedobiom) in the sclerophyllous biome.
 - f. There are many **transitional types** to the neighbouring biomes, also to coniferous forest (e.g. Pacific coast of northern America).

ZUSAMMENFASSUNG

1. **Begrenzende Faktoren.** Lorbeerwälder sind
 - thermophil ($20-25^{\circ}\text{C}$ in der Vegetationsperiode)
 - frostempfindlich (um 0°C , selten unter -10°C , selten Spätfröste)
 - trockenheitsempfindlich (meist hohe Niederschläge das ganze Jahr über, oder mindestens während der Vegetationsperiode, oder aber in Trockenzeiten zumindest unter edaphisch günstigen Bedingungen, oder schliesslich mit hohem Nebelniederschlag).
2. **Charakteristische Merkmale.** **Stämme** zeigen alle Formen zwischen dem typischen Hartlaub- und dem typischen Regenwaldbau. **Blätter** sind normalerweise schwach lederig bis fast sklerophyll oder mesophyll, teilweise ziemlich gross. **Farne** sind oft dominant als Epiphyten und in der Krautschicht.
3. **Abgrenzung**
 - **Regenwälder** (temperierte und subtropische) haben meist mehr und re-

gelmässiger verteilte Niederschläge, ausgeglichene Temperaturen und kaum (stärkere) Fröste.

- **Hartlaubwälder** haben weniger und eher sporadischen Niederschlag, vor allem im Winter sowie regelmässige Feuer.
- **Sommergrüne Laubwälder** ertragen kältere Winter und häufigere Spätfröste sowie extremere oft trockenere Sommer.

4. **Typen** (Schwerpunkte)

- a. **Klimax**. Ostasiatisches sog. "Shanghai-Klima" (inkl. Niederungs- und Hügelwälder bis 1000-2500 m ü.M. im östlichen Himalaya) (Zonobiom).
- b. **Klimax**. Im Bereich der trockneren orealen bis subalpinen Höhenstufen (sub-)tropischer Gebirge (meist um 2500-3000 m ü.M.) (Orobiom).
- c. **Klimax**. Zwischen temperiertem Regenwald und sommergrünem Laubwald der humiden südlichen Hemisphäre (z.T. Zonobiom, z.T. Orobiom).
- d. **Nebelwald**. Auf subtropischen trockenen Gebirgen oberhalb semiaridem submontanem Wald und unterhalb sklerophyllem oder erikoidem subalpinem Buschwald (Orobiom).
- e. **Schluchtwald**. In stärker abweichender Form. Verteilt im Hartlaub-Biom (Pedobiom).
- f. **Uebergänge**. Sehr häufig zwischen den benachbarten Biomen, auch zu Nadelwald (Pazifikküste im Nordwesten Nordamerikas).

REFERENCES

- DI CASTRI F., GOODALL D.W. and SPECHT R.L., 1981: Mediterranean-type shrublands. *Ecosystems of the world*. Elsevier, Amsterdam. 11, 643 pp.
- DOBREMEZ J.F. and SHAKYA P.R., 1975: Carte écologique du Népal. IV. Ré-gion Biratnagar-Kangchenjunga 1:250'000. *Doc.Cartoogr.Ecol.* 16, 33-46.
- ELLENBERG H. and MUELLER-DOMBOIS D., 1967: Tentative physiognomic-ecological classification of plant formations of the earth. *Ber.Geobot. Inst.ETH, Stiftung Rübel, Zürich*, 37, 21-55.
- HUECK K., 1966: Die Wälder Südamerikas. Oekologie, Zusammensetzung und wirtschaftliche Bedeutung. In: WALTER H. (ed.), *Vegetationsmonographie der einzelnen Grossräume*. Fischer, Jena. 2, 422 pp.
- KEAST A., 1981: Ecological biogeography of Australia. In: ILLIES J. (ed.), *Biography of Australia*. Elsevier, The Hague. Vol. 1, 41, 806 pp.
- KLOETZLI F., 1983: Standörtliche Grenzen von Fagaceen - ein Vergleich in beiden Hemisphären. *Tuexenia* (n.s.) 3, 47-65.
- KNAPP R., 1965: Die Vegetation von Nord- und Mittelamerika und der Hawaii-Inseln. In: WALTER H. (ed.), *Vegetationsmonographien der einzelnen Grossräume*. Fischer, Stuttgart. 1, 373 pp.
- KNAPP R., 1973: Die Vegetation von Afrika unter Berücksichtigung von Umwelt, Entwicklung, Wirtschaft, Agrar- und Forstgeographie. In: WALTER H. (ed.), *Vegetationsmonographien der einzelnen Grossräume*. Fischer, Stuttgart. 3, 626 pp.
- KUNKEL G. (ed.), 1976: *Biogeography and ecology in the Canary Islands*, Monogr.Biol. 30, 511 pp.
- MIYAWAKI A. and OKUDA S. (eds.), 1979: *Vegetation und Landschaft Japans*. *Festschr. Tüxen. Bull.Yokohama Phytosoc.Soc.* 16, 495 pp.
- OBERDORFER E., 1960: Pflanzensoziologische Studien in Chile. Ein Vergleich mit Europa. In: TUEXEN R. (ed.), *Flora et Vegetatio Mundi*. Cramer, Weinheim. 2, 208 pp.

- OHSAWA M., SHAKYA P.R. and NUMATA M., 1986: Distribution and succession of western himalayan forest types in the eastern part of the Nepal Himalaya. Mount.Res. and Dev. 6, 143-157.
- OVINGTON J.D., 1983: Temperate broad-leaved evergreen forests. Ecosystems of the World 10, 241 pp.
- PANDE P.R., 1967: Notes on flora of Rajnikunj (Gokarna forest). Dept. of Medicinal Plants, Kathmandu, Bull. 1, 55 pp.
- SONGQIAO Zh., 1985: Physical features and economic development of the mountain environment in China. Mount.Res. and Dev. 5, 319-328.
- SONG YONGCHANG, 1983: Die räumliche Ordnung der Vegetation Chinas. Tuxenia 3, 131-157.
- SUWAL P.N., 1969: Flora of Pulchoki and Godawar. Dept. of Medicinal Plants, Kathmandu, 2, 144 pp.
- WALTER H., 1968: Die Vegetation der Erde in ökophysiologischer Betrachtung. 2. Die gemässigten und arktischen Zonen. Fischer, Stuttgart. 1001 pp.
- WALTER H., 1979: Vegetation of the earth and ecological systems of the geo-biosphere. (2nd ed.; transl. 3rd rev. German ed. by WIESER J.). Springer, New York/Heidelberg/Berlin. 274 pp.
- WALTER H. and BRECKLE S.W., 1984: Oekologie der Erde. 2. Spezielle Oekologie der Tropischen und Subtropischen Zonen. UTB Gr.R. 461 pp.
- WALTER H. and LIETH H., 1960-1967: Klimadiagramm-Weltatlas. Fischer, Stuttgart. 8000 stations.

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