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Fir-dominated forests in Bavaria, Germany

Helge W a l e n t o w s k i, Michael F i s c h e r, Rudolf S e it z

Abstract
The map of "Regional natural forest composition by main tree species" (WALENTOWSKI et al. 2001) depicts Bavaria as a region largely predominated by the European beech (*Fagus sylvatica*). Analyses of climatope, hygrotope and trophotope of fir-dominated regional natural units make evident that the reasons for the preponderance of the European silver fir (*Abies alba*) are edaphic. In terms of regeneration vigour, growth and yield the fir particularly dominates in habitats with a combination of humus cover, acid-oligotrophic topsoils and clayey or waterlogged subsoils, where the beech usually exhibits stunted and malformed growth forms. This ecological preference has the effect that Bavarian *Abies alba*-forests are restricted to small patches within a matrix of potential natural vegetation formed by mixed deciduous-coniferous mountain forests. Within European Natura 2000 areas *Abies*- forests should be recorded carefully as special habitats. Their transitional character between temperate beech forests (habitat type 9130) and boreal spruce forests (habitat type 9410), the ecological preference of *Abies alba* as an endangered tree species and their sensitivity against environmental stressors, including changes in forest structure, air quality, and climate, make them important objects for nature conservation.

Introduction
Forest sites naturally dominated by European sliver fir (*Abies alba*) cover about 58.000 ha [1)] in Bavaria (= 2 % of the forest area), mainly in the eastern mountain ranges, the Alps and the Alpine foothills. From an evolutionary point of view, *Abies alba* forest associations are mainly characterized by species of ancient primitive plant groups, which are weak competitors under the current climatic conditions in Europe. The tree layer is dominated by wind pollinated conifers of the genera *Abies*, *Picea* and *Pinus*. Broadleaved trees (like *Fagus sylvatica*, *Acer pseudoplatanus* or *Betula pendula, B. pubescens*) occur as understorey or subdominant species. The most frequent and dominant dicotyledonous plant in the ground layer is the dwarf shrub *Vaccinium myrtillus*. Many bryophytes and pteridophytes cover the forest floor. In phytosociological terms *Abies alba* forests show a transitional character between beech- and spruce-forests (WALENTOWSKI 1998, EWALD 2004). Despite their transitional floristic composition (temperate and circumboreal species intermingle in varying degrees), *Abies alba* forests have been labelled as distinct community groups by a variety of authors (HORVAT 1962, LINGG 1986, OBERDORFER 1992, GAFTA 1994, MUCINA et al. 1993, ELLENBERG 1996, and others). The present investigation had the following goals:

- The presentation of a regionalized phytosociological classification for the whole of Bavaria (regional scale),
- investigation of the role of *Abies alba* forests in a Bavarian Natura 2000 area (case study, local scale),
- the definition of concrete and regionally explicit conservation objectives for *Abies alba* forests.

Additionally the results are supposed to be a reference for
- potential distribution modelling,
- identification of actual stands by remote sensing.

A study dealing with this problem is presented by FÖRSTER et al. (2005),

Material and Methods
Presampling. To begin with, regions with potential occurrence of natural forests with *Abies alba* as a dominant or co-dominated tree species were pre-selected by reviewing all available sources of information, e.g. on forest ecology (SEIBERT 1968, FOERST & KREUTZER 1978, SEITSCHEK 1978), phytosociology (OBERDORFER 1992) and phytogeography (SCHÖNFELDER & BRESINSKY 1990).

[1)] Databank informations from the national forest inventory (DEPT. OF FOREST SITE AND ENVIRONMENT).

Sampling. Pollen-analytical data for the earlier subatlantic period (defined as the post-glacial maximum of *Fagus sylvatica* pollen) were compiled from published diagrams. Fir-dominated stands within the pre-selected regions were sampled according to the method of BRAUN-BLANQUET (1964). Field work was conducted between May and October 1993 to 1996 (328 relevés), complemented by 5 relevés from Taubenberg made in October 2004. Within each 200 – 250 m^2 plot, presence and cover (classes +, 1, 2, 3, 4, 5) of all ground- plant species were recorded. Forest sites were described based on drillings with a 1 m PÜRCKHAUER auger, as well as on literature on soil conditions and local climate. 68 relevés were extracted from the literature (SEIBERT & PFADENHAUER n.p., FELDNER 1978, GÖTZ & RIEGEL 1989, EWALD & FISCHER 1993, TÜRK 1993, WINTERHOLLER 1990, AUGUSTIN 1991), thus obtaining a dataset representative of the regions and environmental situations in which *Abies alba* forests occur.

Data analysis. Average proportions of pollen of *Abies, Fagus, Picea* and *Pinus* were calculated for the selected forest regions based on GULDER (2001). 396 relevés were sorted subjectively following recommendations by KREEB (1983), DIERSSEN (1990) and DIERSCHKE (1994), resulting in a synthetical constancy table. Data were handled using BSVEG software (STORCH 1985, version from July 1998), also allowing computation of community properties – means for columns in the constancy tables are presented throughout - like species number, similarity (CZEKANOWSKI 1909 in GOODALL 1973), species diversity (SHANNON 1948, 1976) and evenness (HAEUPLER 1982), uniformity (DAHL 1960) and homotonity (TÜXEN 1977).

Average ELLENBERG-indicator values (ELLENBERG et al. 1991) for light (L), temperature (T), continentality (K), moisture (F), acidity (R), and macronutrient availability (N) were weighted by species cover. R and N were combined in their product (humus value, ROGISTER 1981). Ecological plant indicator groups are mentioned following WALENTOWSKI et al. (2004). Structural measures (vertical structure, life form spectra) are presented at association level.

For the Taubenberg case study (18 relevés), detrended correspondence analysis (DCA, HILL & GAUCH 1980, detrending by 30 segments) was performed to extract main gradients of floristic composition using PC-Ord software (MC CUNE & MEFFORD 1998).

The terminology of site ecology refers to GREEN et al. (1984), SCHROEDER (1984) and AK STANDORTSKARTIERUNG (1996).

Regions in Bavaria with natural pre-dominance of fir

Pollen records suggest that mixed coniferous forests of *Abies* and *Picea* forests became prominent around 4,700 – 2,600 years BC (FIRBAS 1949, LANG 1955, KRAL 1979, STALLING 1987, KNIPPING 1989). *Abies* gained predominance and persisted through the optimum of *Fagus* in intramontane basins of North-eastern Bavaria (NE) and along the Western foothills of the Alps (SW; Fig. 1).

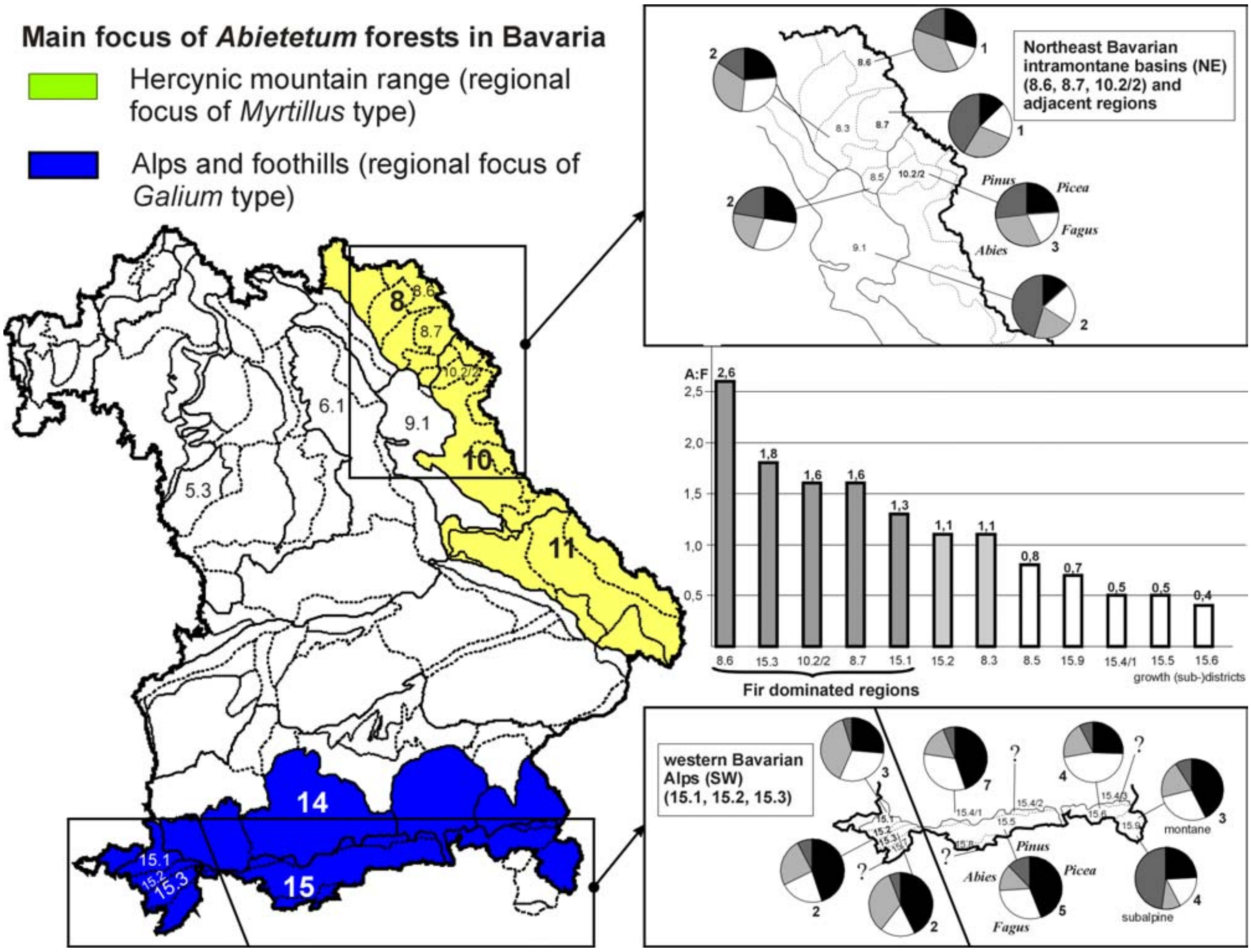

Fig. 1: Regions with *Abies alba*-forests in Bavaria (forest regions based on GULDER 2001). Inset maps show mean proportions of pollen during the early subatlantic (zone IX, ca. 2.000 years B.P.) number next to the pie diagrams shows the number of pollen archives per region. The histogram shows the regional *Abies* to *Fagus* ratio .

Edaphically, both regions with natural fir dominance are known for the widespread occurrence of particular soils:

In Northeastern Bavaria (regions 8.6, 8.7, 10.2.2) acid-oligotrophic two-layer-soils (fine sandy-silty cover overlying silty-loamy or loamy-clayey horizons) with podzolized topsoils and waterlogged subsoils (Podzol-Pseudogley) are widespread on palaeozoic slates, phyllites, mica schists and on tertiary layers.

In the Western foothills of the Alps (regions 15.1, 15.2 and 15.3) the Helvetikum, Flysch and Molasse geologic formations consist of alternating layers of marls, sandstones and conglomerats providing slopes prone to landslides, interspersed with rocky outcrops. Especially on flat slopes with silty-clayey subsoil horizons, transition types between Pseudogley and Pelosol are developed. Sites with medium to high nutrient content, often calcareous, predominate.

Climatically, Northeast Bavaria can be characterized as “subboreal” with cold winters (average in January: -3 to -4°C, severe frosts) and rather low precipitation (750 – 850 mm / year) due to location in the lee of mountains. The Western foothills of the Alps have a “prealpine” climate with high precipitation (1,400 – 1,900 mm / year), a pronounced peak of rainfall in summer (July and August), high air humidity and frequent cloud and fog cover.

Diversity of Fir-dominated forest types

According to palynological evidence, fir-dominated forests were naturally restricted to areas with special edaphic habitas and subboreal or prealpine mesoclimatic conditions (Fig. 1). Conifers have gained dominance in A b i e t e t u m forests because they are able to withstand extremes of cold, heat, drought or waterlogging. Topsoils under A b i e t e t u m ecosystems tend to accumulate organic horizons, since site conditions reduce the activity of microorganisms and conifer needles and dwarf shrubs produce poorly digestable litter. Natural *Abies alba* forests are important reservoirs of biodiversity. Based on the classification of OBERDORFER (1950, 1957, 1962, 1992) for South Germany two groups of communities are distinguished:

- The *Myrtillus* type communities belong to the P i c e i o n a b i e t i s alliance, in the class of evergreen boreal conifer-forests (V a c c i n i o – P i c e e t e a). According to the EU Habitats Directive (Directive 92/43/EEC) these are "94 - Temperate mountainous coniferous forests" of type "9410 - Acidophilous Picea forests of the montane to alpine levels (*Vaccinio-Piceetea*)".
- The *Galium* type communities with higher occurrence of beech and its companion plant species can be assigned to the alliance of mixed beech-forests (F a g i o n s y l v a t i c a e, class Q u e r c o – F a g e t e a). The Habitats Directive allocates them to "91 - Forests of temperate Europe", subtype "9130 - *Asperulo-Fagetum* beech forests".

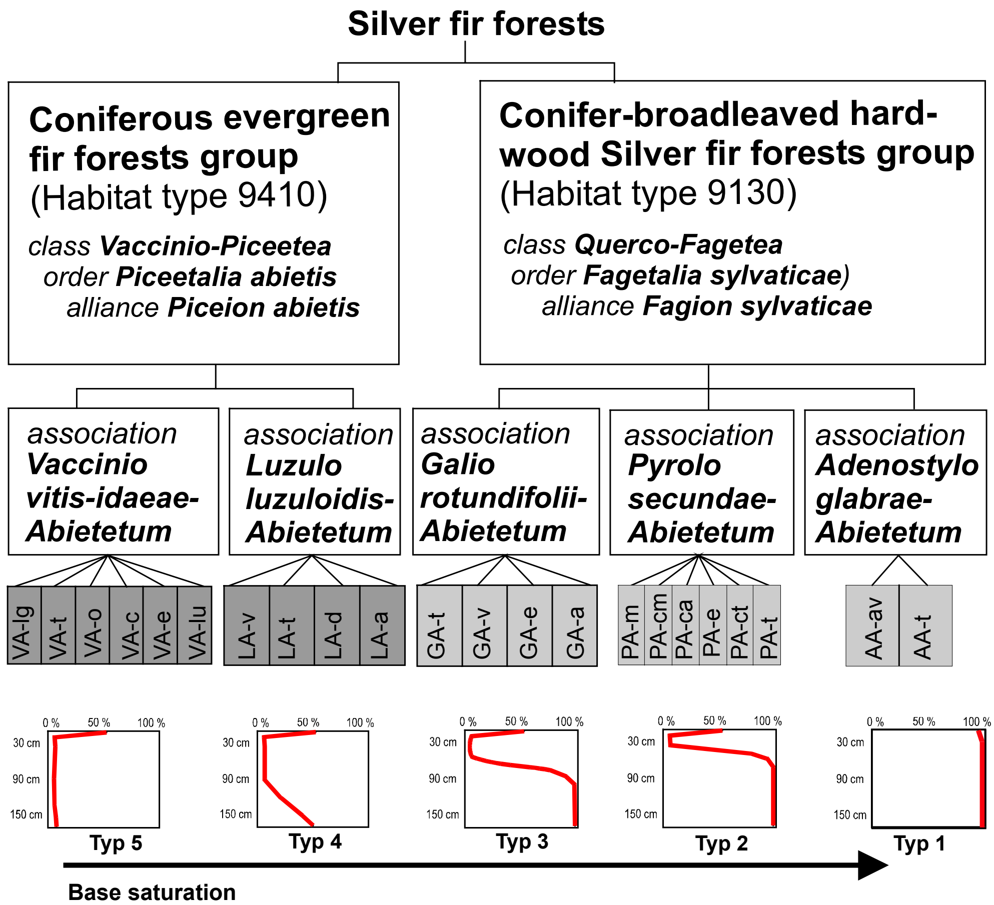

Fig. 2: Synsystematical classification of the bavarian silver fir forests. The subdivision of the five A b i e t e t u m -associations into subassociations is presented in appendices 1 and 2.

In Fig. 3 community types and their subassociations are arranged in an ecogram of water- and soil nutrient regime/humus forms based on ELLENBERG-values. Details of the classification, symmorphological and environmental characteristics of the subassociations are presented in appendices 1 and 2.

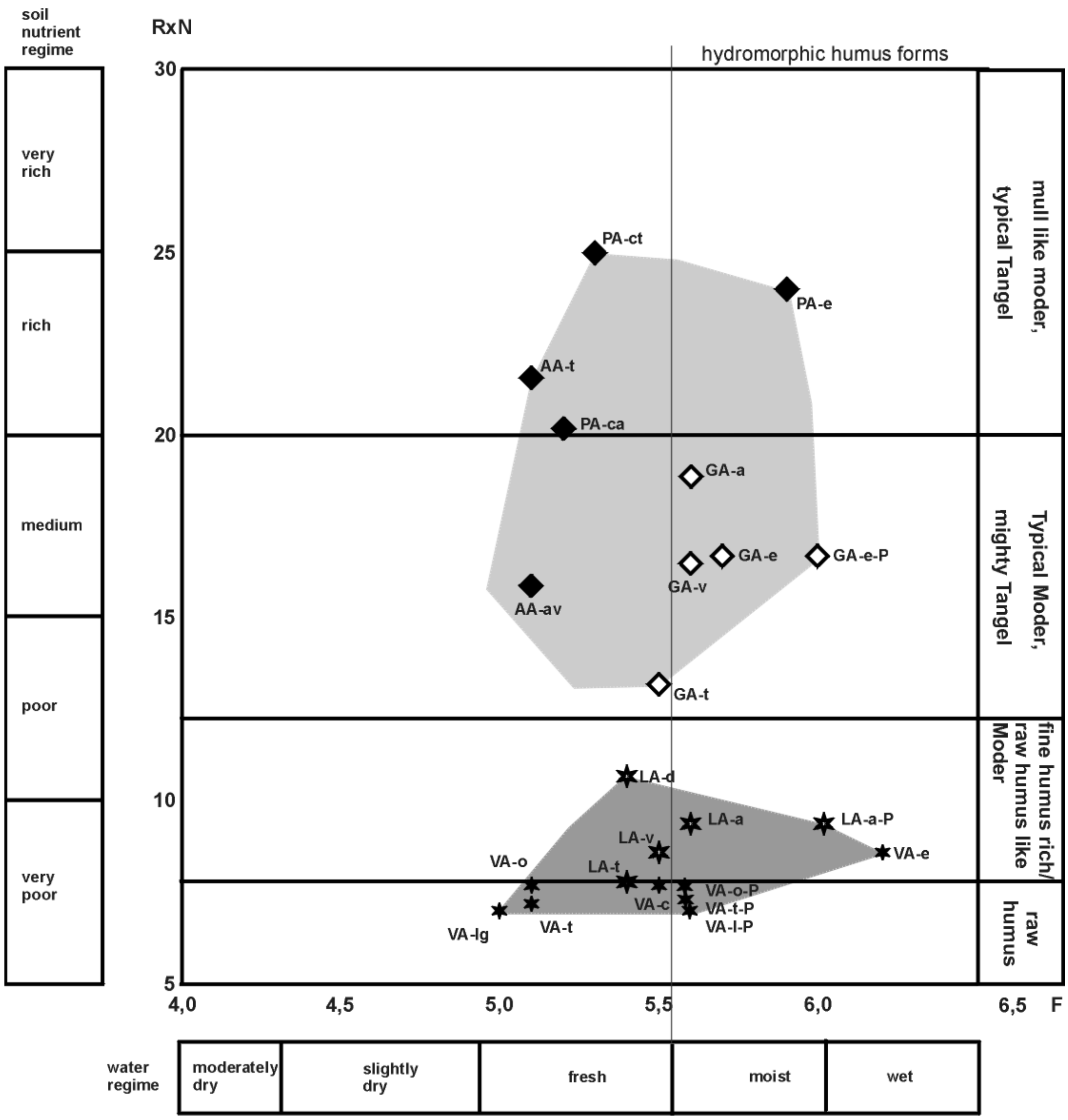

Fig. 3: Ecogram ordination along the gradients of moisture, nutrient availability and humus forms based on average ELLENBERG-values (F: moisture, RxN: humus value, ROGISTER 1981) of the subtypes (at least 4relevés).
Myrtillus type communities (Habitat type 9410) are highlighted by dark shading, *Galium* type communities (Habitat type 9130) by light grey. For subassociations see appendices 1 and 2. Developments dominated by *Sphagnum* sp. are marked by the letter "P" (e.g. GA-e-P = G a l i o – A b i e t e t u m e q u i s e t e t o s u m, variant with peatmosses).

Myrtillus type (annex I habitat type 9410):
The acidophytic community group consists of two associations.

The V a c c i n i o - A b i e t e t u m (VA) is a spruce-fir-pine forest and thrives on podzolic soils with low base saturation prevailing throughout the entire soil profile. The activity of soil organisms is drastically reduced not only by unfavourable soil chemistry, but also by cyclic changes between waterlogging (oxygen deficiency) and drought. The consequence is an accumulation of very acid and poorly decomposed humus cover (raw humus/Rohhumus, peaty humus/Anmoor). The potential area of this community in Bavaria is estimated at 24,500 ha. Typical species are *Leucobryum glaucum, Vaccinium vitis-idaea* and other species of the *Leucobryum-,* Lichen- and *Molinia*-groups. *Sphagnum* sp. indicate long waterlogging.

The L u z u l o - A b i e t e t u m (LA) is a pure spruce-fir forest. It is restricted to conditions with ample water supply (very fresh to moist sites). Its characteristic species combination (CSC, BRAUN-BLANQUET 1964) is adapted to cool-humid conditions, tolerating no drought during the vegetation period. As biological activity is not reduced by desiccation, there is no raw humus accumulation. The prevailing humus form is mor ('Moder'). The potential area of this type is estimated at about 9,000 ha. Besides indicator plants for fresh mors (species of *Blechnum*-group like *Luzula sylvatica*, *Thelypteris limbosperma* and *Blechnum spicant*) some 'moder' - indicators like *Luzula luzuloides* occur.

Galium type (annex I habitat type 9130):
Plant species demanding a sufficient nutrient supply cover the forest floor of the species-rich *Galium* type fir-spruce forests (habitat type 9130), e.g. *Carex sylvatica* and *Galium odoratum* (indicator species for mull like moder to F-mull). Three associations can be distinguished:

The G a l i o - A b i e t e t u m (GA) is a fir-spruce-beech forest with ca. 10 % beech in the canopy. Considering the moisture gradient it occurs on the same sites as the L u z u l o - A b i e t e t u m, its CSC however demanding better nutrient supply in the rooting zone and more favourable humus forms (moder). Frequent species are *Galium rotundifolium* and *Equisetum sylvaticum* - the latter an indicator of moving ground water within the rooting zone. Potential area of this type in Bavaria is estimated at 17,500 ha.

The P y r o l o - A b i e t e t u m (PA) is a fir-spruce forest with participation of deciduous trees, esp. *Acer pseudoplatanus*. The type is mostly limited to highly base-saturated soils with mull-like moder humus. Typical species depend on very rich trophotopes (e.g. *Mercurialis perennis*). However, frequent indicators of free carbonate (e.g. *Carex alba*, *Epipactis atrorubens*) are typical for sites with moderate N-supply (EWALD 1999). In warm regions, character species like *Melica nutans, Pyrola secunda* and *Melampyrum sylvaticum* can even occur on podzolic soils with rather low pH. The type has the highest plant species diversity and provides habitats for many endangered species.

The A d e n o s t y l o g l a b r a e – A b i e t e t u m (AA) shows a similar floristic composition and could be regarded as a subtype of PA (WALENTOWSKI 1998, HÄRDTLE et al. 2004). It is restricted to the Limestone Alps. Sites are extremely localized in the montane belt and on humus-carbonate soils (O-C profile) with strong accumulation of organic matter (on crests, scree fans and rocky places). The estimated potential area of types PA and AA is 6,500 ha.

Diversity of species and functional groups
We found high evenness (0.6 to 0.8) in all A b i e t e t u m communities, meaning that mono-dominant stands are rare. Species diversity (SHANNON´S H´) depends on nutrient levels: H´ x 100 reaches only 90 – 100 in the *Myrtillus* type, but 105 – 140 in the *Galium* type communities.

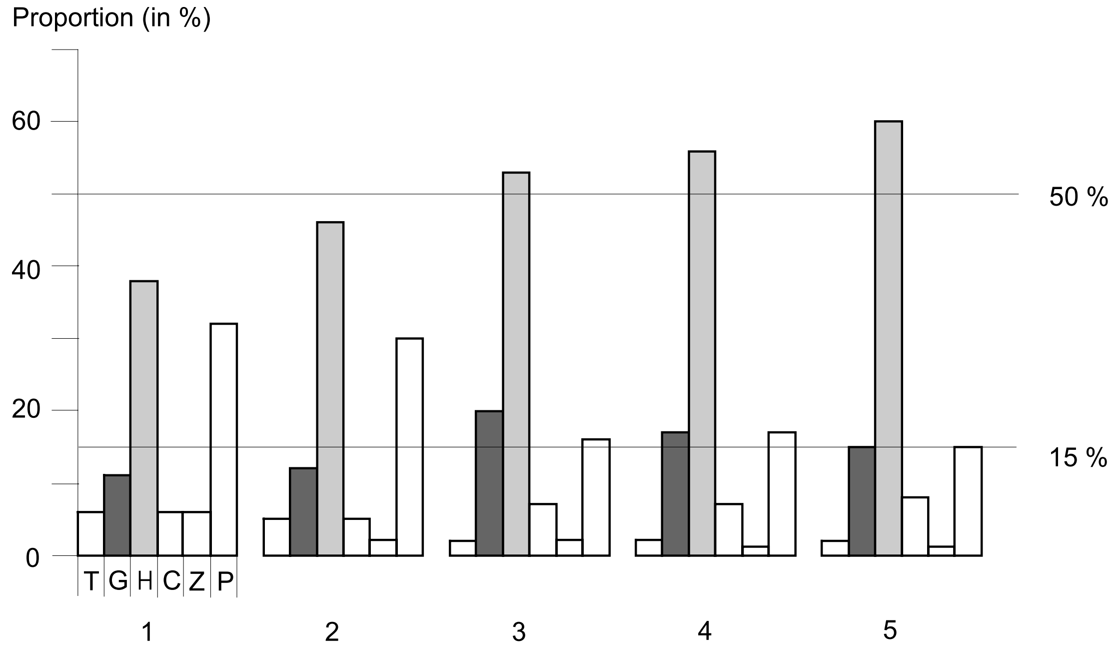

Fig. 4: Life form spectra. **1** = V a c c i n i o – A b i e t e t u m, **2** = L u z u l o – A b i e t e t u m, **3** = P y r o l o- (incl. A d e n o s t y l o g l a b r a e-) A b i e t e t u m, **4** = G a l i o – A b i e t e t u m, **5** = A c e r i – F a g e t u m (relevés from Black Forest; OBERDORFER 1957). Life form types (RAUNKIAER 1934, ELLENBERG et al. 1991): T = therophytes, G = geophytes, H = hemicryptophytes, C = chamaephytes, Z = dwarf shrubs, P = phanerophytes.

A b i e t e t u m forests offer niches for a wide variety of life forms, reflecting a large variety of microhabitats (Fig. 4). The proportions of hemicryptophytes and geophytes are low in the species-poor *Myrtillus* type communities (p_{hem} < 50 %, p_{geo} < 15 %). In contrast, the ground vegetation of the *Galium* type communities is dominated by hemicryptophytes and geophytes. Thus, not only species richness but also the expansion of herbs in the ground layer closely depends on the soil nutrient regime. The herbal flora includes species known as indicators of ancient forests (e.g. *Lamium galeobdolon*, *Galium odoratum* and *Paris quadrifolia;* WULF 1997), characterized by short-distance dispersal strategy, low diaspore production and poor ability to colonize new forests stands.

Finally mosses and lichens make a remarkable contribution to the biodiversity of the A b i e t e t u m forests. Permanently moist humus layers promote the diversity of ground-dwelling bryophytes.

Besides these forest floor habitats represented in vegetation relevés, micro-structures like rock outcrops, stumps, windfall pits and downed logs provide habitats for cryptogams. While humid regions support hygrophilous peatmosses and liverworts, the drier subboreal regions are richer in lichens like *Cetraria* or *Cladonia*. Stems and branches of living trees and snags are habitats of acidophytic lichen communities, including old-growth indicators as *Arthronia leucoppellea, Cetraria laureri* and *Lecanactis abietina*.

Structure and dynamics

Structural complexity and dynamics of forest canopies are of fundamental importance to the spatial and temporal heterogeneity in understorey vegetation, regeneration mosaics and microclimatic variation (NORMAN & CAMPBELL 1989, SONG et al. 1997). Physiognomicly, the *Myrtillus* type communities are coniferous forests, the *Galium* type communities conifer-broadleaved forests. According to our results and to the investigations of LEIBUNDGUT (1982) we assume, that spatial structures of fir-dominated virgin forests are vertically multi-structured and horizontally clumped, caused by extreme edaphic conditions and diverse micropatterns (EWALD 1999). On rocky soils and on wet sites with distinctive concave and convex microsite patterns ("pit-and-mound topography", ULANOVA 2000), rejuvenation takes place in a spatial cluster and temporal pulses.

Some A b i e t e t u m stands in Bavaria show old growth characteristics: Trees aged >200 years, very large overstory trees (3 – 6 trees > 100 cm DBH), multi-layer stands with rather low densities. The upper tree layer (T1) of old growth stands had 106 – 152 trees per hectare (predominated by fir and spruce) and a highly variable understory of seedlings, saplings, and shrubs. Little evidence of human disturbance was present in oldgrowth stands. *Abies alba* can reach a remarkable age (400 - 500 years), mostly dying back slowly in upright position and finally decaying in the form of standing, dead snags. The spruce often does not reach its physically possible age of 300 - 400 years. On natural habitats of A b i e t e t u m stands, the shallow-rooted spruce is especially vulnerable to windthrow, frequently responsible for gaps in the forest canopy, and it is responsible for most of the existing treefalls.

The lower forest strata usually are well developed in *Abies alba* forests. As a shade-tolerant climax tree, *Abies alba* is able to rejuvenate under dense canopies, tolerating long suppression periods. In the second tree and shrub layers we can also find higher proportions of beech (reaching 200 – 300 years in A b i e t e t u m forests). The significance of the spruce is rather low in the lower strata, due to reduced rejuvenation. It is often limited to decaying downed logs (“Rannen”) and canopy gaps. Likewise, light-demanding pionieer trees (e.g. sycamore, European larch, Scotch pine, birches) show low abundance. Such seral species can only germinate and establish locally on standing root plates, bare mineral soil etc. in large scale canopy gaps (e.g. caused by large windstorm damages and attacks by woodboring insects like *Ips typographus* following dry years). Among the pioneer trees, the long-lived pine can persist in fir-dominated forests, but is mostly restricted to very poor, waterlogged sites under leeward climate.

Stable, multi-layered structures and continuous rejuvenation under the canopy of old stands guarantee both a mitigation of climatic extremes (heat, frost, radiation, drought) as well as reduced damages by wind and snow-break.

Secondary stands of A b i e t e t u m forests

The accumulation of poor organic layers is a prerequisite for the "characteristic species combination" (BRAUN-BLANQUET 1964) of all A b i e t e t u m-associations in the phytosociological sense. Under natural conditions, suitable humus forms originate from extreme environmental conditions (e.g. waterlogged subsoils in combination with oligotrophic topsoils). However, secondary mor- and raw humus forms were created artificially by various human activities: Due to the higher market value of conifers, beech was often eliminated for economic reasons. Certain single tree selection systems ("Plenterwald") favoured *Abies* over centuries. Litter raking and other forms of biomass export have led to nutrient depletion and regressive succession, which could result in an exclusion of beech and other deciduous trees. On the other hand, A b i e t e t u m forests have not been planted in recent times. Due to its frost susceptibility, *Abies alba* was never cultivated in the open, but naturally regenerated under canopy. Therefore, even secondary stands of *Abies alba* are considered as relatively natural communities and often indicate ancient forests with long habitat traditions, in which the continuous appearance of old-growth-trees has never been interrupted.

Taubenberg case study

The Taubenberg is situated ca. 15 km north of the Alps close to Miesbach /Upper Bavaria and covers an area of approx. 1,600 ha. Like the back of a whale the Taubenberg rises up above the surroundings. The altitude ranges from 620 to 896 m ASL. The hill is built from an alluvial fan of the "Obere Süßwassermolasse" (upper tertiary epoch). The basic material was deposited 10 – 15 million years ago, when the rivers transported debris from the raising Alps to the foothills and heaped up massive deltas. The unconsolidated fluvial sediments were transformed to conglomerates by diagenesis (dehydration, mechanical pressure, cementation by carbonates etc.). The distinctive meso-relief, as visible in Fig. 6 (page 78), is caused by soft clay marls lying in between the hard conglomeratic banks, visible in spring horizons and slope slides. The impervious clay prevents a rapid infiltration of the rainfall, so the large surface flow has created gully erosion and ravines. The foot of the hill and the surroundings are covered by old glacial moraines and river terraces of the Riss era. Mean annual precipitation is around 1,500 mm (800 mm from Mai to September), mean annual temperature ranges at 6.2 to 7.6°C. Main wind directions are southwest to west and northeast. The area has recently been classified as protection area according to the Habitats and the Birds Directives of the European Union (Natura 2000 area 8136-302).

The Taubenberg region is an important drinking water reserve of the city of Munich which owns around two thirds of the area. With respect to the water protection function, forest management attempts to emulate natural processes. Clear-cutting is avoided. Large areas are in transition from monotonuous spruce stands to mixed mountain forests of spruce, fir and beech. In many of these transitional stands *Abies alba* participates substantially in stand regeneration.

With regard to ß-diversity of *Abies*-forests the Taubenberg is of outstanding importance, not only for the "Alpine foothills" (nature unit D 66), but for the whole "continental biogeographic region". A nutrient gradient from very poor to rich soils effects a remarkable species turnover within Silver fir forests on the local scale. Four different Silver-fir associations were recorded (Fig. 5; Tab. 3 attached). Of special relevance is the most extensive occurrence of *Myrtillus* type spruce-fir-forests within the Bavarian Alpine foothills. They correspond to the spruce-fir-forests of the Swiss midland (M a s t i g o b r y e t o – P i c e e t u m a b i e t e t o s u m MEYER 1949, Q u e r c o – A b i e t e t u m FREHNER 1963, B a z - z a n i o – A b i e t e t u m ELLENBERG & KLÖTZLI 1972, summarized by KELLER 2003).

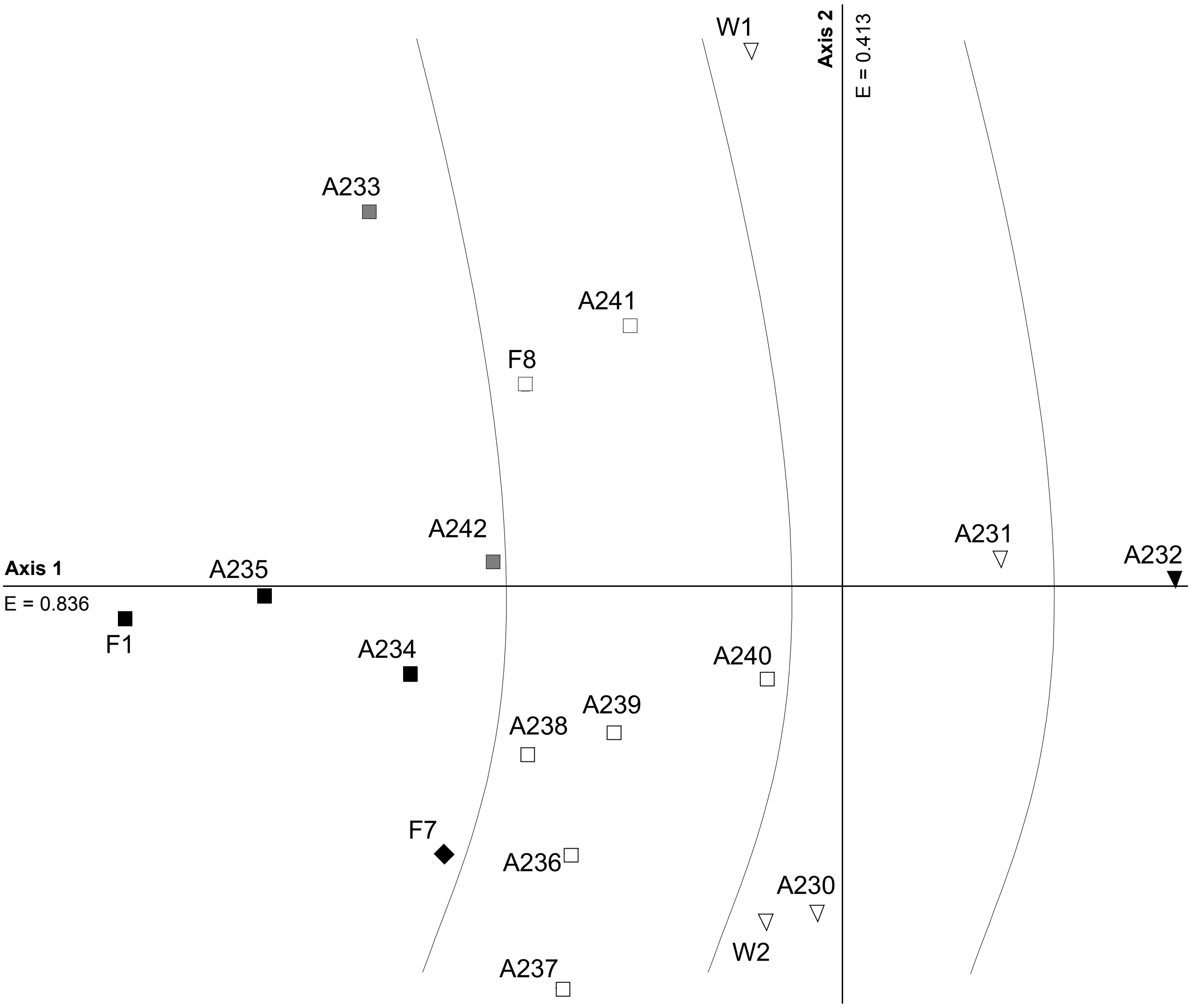

Fig. 5: DCA-diagram of the relevés from Taubenberg (FFH-area 8136-302), based on 18 relevés and 111 plant species.
Rhombic symbol: F7: L e u c o b r y o – P i n e t u m m o l i n i e t o s u m. Quadratic symbols: Myrtillus type (A234, A235, F1: V a c c i n i o v i t i s – i d a e a e – A b i e t e t u m; A233, A242: L u z u l o – A b i e t e t u m v a c c i n i e t o s u m, typical variant, A236 – A241, F8: L u z u l o – A b i e t e t u m v a c c i n i e t o s u m, *Carex pilulifera*-variant). Triangular symbols: *Galium* type (A230, A231, W1, W2: G a l i o – A b i e t e t u m, A232: P y r o l o – A b i e t e t u m e q u i s e t e t o s u m).

At the Taubenberg, fir forests are represented both as primary forests and as semi-natural anthropogenic stands, replacing mixed mountain “F a g e t u m” forests (Table 1).

We identified waterlogged soils (e.g. “Schwarzer Berg”, Fig. 6) and moist, cold and shady strips along creeks (e.g. “Dorfbach” in the western part of the Taubenberg area) as the primary habitats, where fir forms the natural edaphic climax. Secondary stands of fir (first grade substitute communities) can mainly be found on emaciated crests, ridges and forest verges. These locations – mainly developed along the western slope of the Taubenberg exposed to the prevailing winds – present unfavourable conditions with regard to

- humus properties (biomass export by wind-blown litter; reduced acitivy of soil organisms),
- chemical properties (acidification of the topsoils and impoverishment of nutrients),
- drought (phases of desiccation by wind),
- soil structure (reduced infiltration because of lacking large pores like earthworm channels).

Under these deteriorated soil conditions, deciduous trees have problems to regenerate. Soils originate from tertiary layers of the “Obere Süßwassermolasse” and around the foot of the hill from old moraine (Riss-glacial; Table 1).

Tab. 1: Soil map units (according to GROTTENTHALER 1985) and the corresponding forest communities at the Taubenberg.

Soils from mudstone (tertiary sediments of "Obere Süßwassermolasse" and pleistocene regoliths originating from soil creep and solifluction)

1a. Prevailing: slopes are mostly characterized by medium acid, deeply weathered brown earth; soil texture: silty-sandy and sandy loam overlying clayey loam

natural forest community	first grade substitute community	second grade substitute community
Galio-Fagetum *(developed as mixed mountain forest)*	***Galio-Abietetum***	*Galium rotundifolium*-spruce forest

1b. Like the previous, but stronger acidic. Depleted soils effected from ridge crest position or more gritty-sandy substrates with high contingent of skeletal materials (bleached grains of quartz)

natural forest community	first grade substitute community	second grade substitute community
Luzulo-Fagetum *(developed as mixed mountain forest)*	***Luzulo-Abietetum*** ***Vaccinio vitis-idaeae-Abietetum***	bilberry-spruce forest

2. Soils with stagnant moisture (pseudogley) on lower slopes, flats and depressions. Additionally, ground-water influenced soils at the valley bottoms prone to late frost

natural forest community	first grade substitute community	second grade substitute community
Luzulo-Abietetum	bilberry-peatmoss-spruce forest	-

3. Like the previous, but stronger acidic soils (podzol-pseudogley). Topsoils with gritty-sandy substrates and high content of bleached grains of quartz; podzolising favoured by pre-weathering and leaching under pre-pleistocene subtropical conditions; impermeability of subsoils caused by solifluction under periglacial conditions

natural forest community	first grade substitute community	second grade substitute community
Vaccinio vitis-idaeae-Abietetum	***Leucobryo-Pinetum molinietosum***	-

4. Slope gley-pelosol, medium to rich in nutrients and bases. Water logging results from clayey marl layers reaching the surface on lower slopes

natural forest community	first grade substitute community	second grade substitute community
Galio-Abietetum equisetetosum ***Pyrolo-Abietetum equisetetosum***	horsetail-spruce forest	-

soils from "Riss" glacial moraine and river terraces

5. Prevailing: deeply weathered brown earth, often coined by lessivation; only slight pseudogley-tendency because of gravel subsoil.

natural forest community	first grade substitute community	second grade substitute community
Luzulo-Fagetum *(developed as mixed mountain forest)*	***Luzulo-Abietetum***	bilberry-spruce forest

Based on the units defined in Tab. 1, the following key for the local mapping of habitat types according to the “Habitats Directive” was developed:

1a +4 mapped as type 9130 (treshold for canopy composition: beech + fir cover at least 30 % of crown projection),
1b+5 mapped as type 9110 (treshold: beech + fir cover at least 30 % of crown projection),
2 mapped as 9410 (treshold: fir covers at least 10 % of crown projection),
3 mapped as 9410 (no treshold for fir; also stands dominated by pine and spruce).

Forest types not fulfilling these criteria were identified as non-Natura 2000 habitats (Fig. 7).

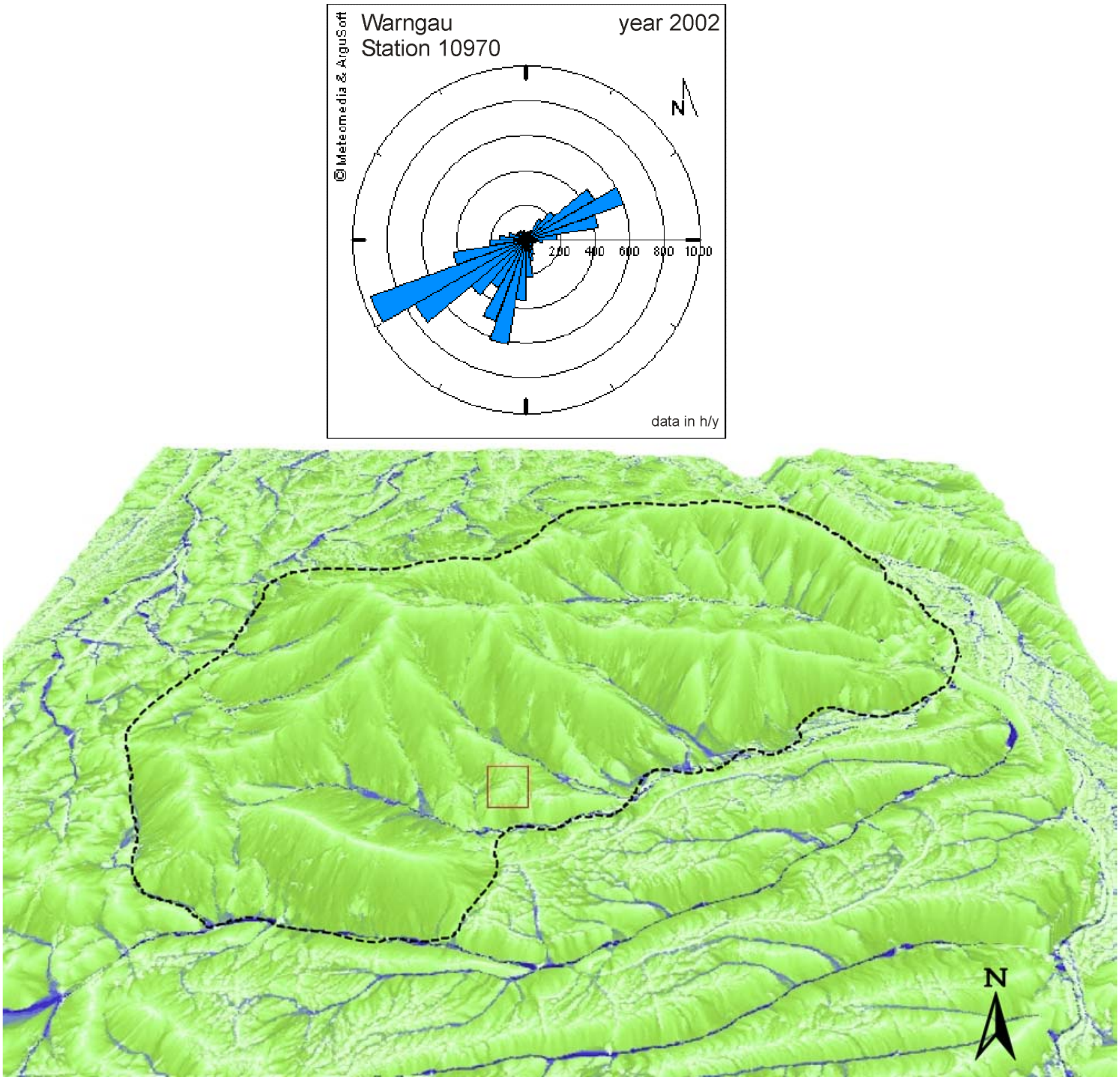

Fig. 6: The Taubenberg area as 3D-view. During the two last glaciations it was circumflowed by the glaciers of the river 'Isar' (Southwest) and 'Inn-Mangfall' (Southeast), but never overflowed. Dashed line: border of the Taubenberg-area. Square: location of the lower slope of Schwarzenberg. Above: digram showing wind directions (http://www.argusoft.de/austmet/imap/att/2002gif/w10970_2002.gif).

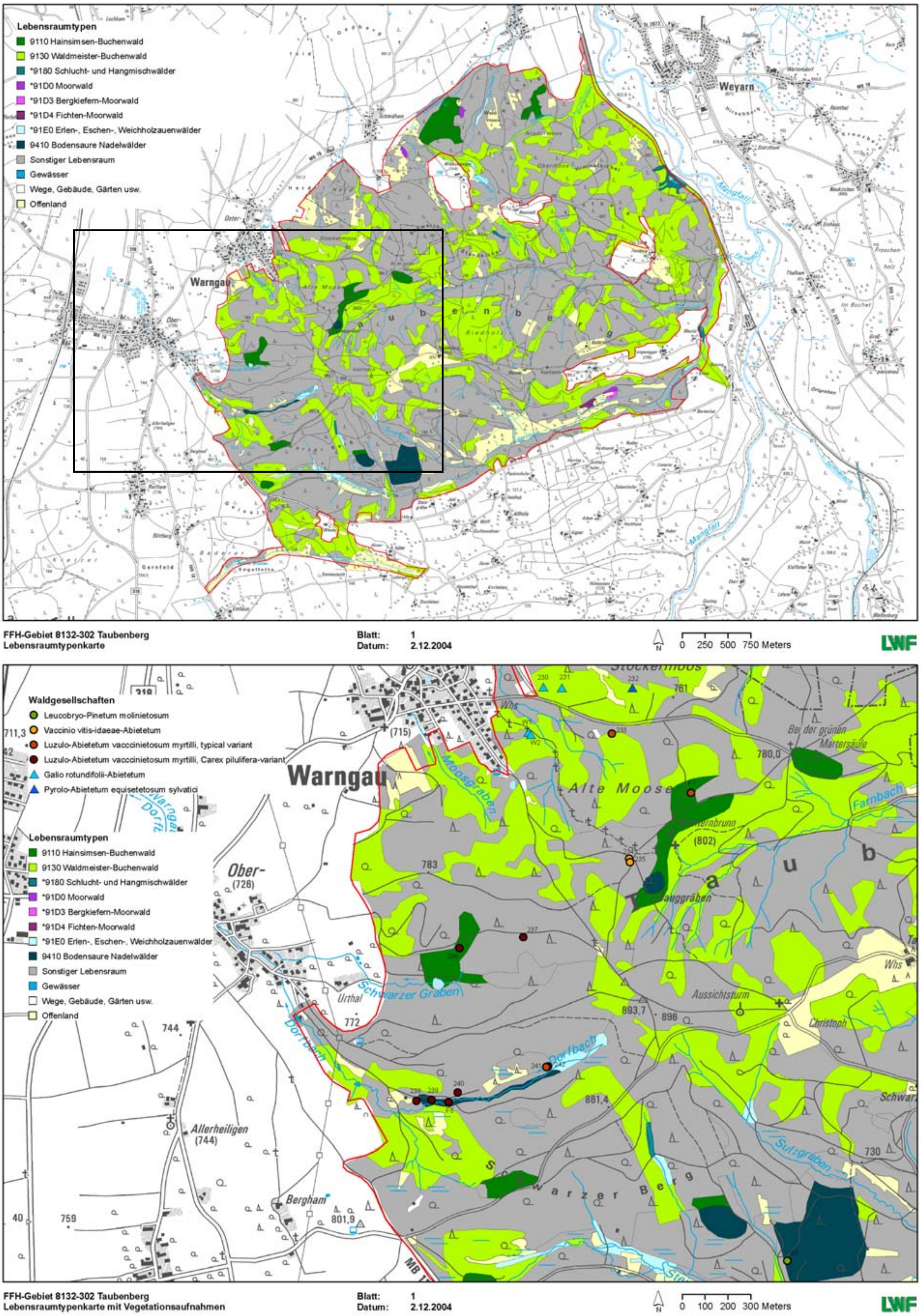

Fig.7: Vegetation map (above) and zoomed segment with locations of the fir-forest relevés (below).

Fig. 8: Podzol-pseudogley with strongly bleached eluvial horizon at the lower slope of the "Schwarzer Berg", stocked by pine-dominated conifer forest (L e u c o b r y o – P i n e t u m m o l i n i e t o s u m) replacing the natural cowberry-fir-forest (V a c c i n i o v i t i s – i d a - e a e – A b i e t e t u m). Photographs by C. KÖLLING. Ecological conditions: Permanently waterlogged (± stagnant moisture), very poor in nutrient supply (N and P), very low base saturation.

Recommendations for forest use

Composition, structure and dynamics of A b i e t e t u m forests are caused by specific site conditions, but may also be influenced by human interference (forest management, deteriorated humus forms). They are certainly textbook examples for the necessity of adaptive `close to nature´ management techniques (HORNDASCH 1993). A combination of sustainable timber production and biodiversity conservation must be based on scientific results from pristine forests as preserved in National Parks (e.g. LEIBUNDGUT 1982, JEHL 1995). Furthermore, the analysis of individual stand characteristics (stand history, genetics, actual and natural vegetation, succession stage, ecological site characteristics) is crucial to develop differentiated silvicultural recommendations on a sound economic and ecological basis.

Site-adapted biodiversity and structural heterogeneity of stands are crucial for the highest possible security of both protection functions as well as sustainable forest management under the risks of climatic change (e.g. FERRIS & HUMPHREY 1999). Single tree ('Plenter') or group selection ('Femel') systems allow the most flexible management for the desired stand characteristics, favouring a polycyclic development.

In their natural range, re-establishing A b i e t e t u m forests in a natural state is a desirable goal. An essential prerequisite for successful forest management is a tolerable game density. However, this alone may not be sufficient in some landscapes of Northeastern Bavaria, where Silver fir has disappeared completely or become so rare, that re-colonization will not take place spontaneously. Under such conditions even moderate game pressure, unfavourable microclimate and competing ground vegetation will hamper resettlement, so that underplanting and fencing may be indispensable.

In A b i e t e t u m habitats on steep slopes prone to erosion and with a high precipitation rate, as well as on gleys or histosols, silvicultural options are constrained by soil conditions. As a matter of priority special attention must be devoted to maintaining old trees, multi-layered structures and small-scale heterogeneity in microhabitats. Protection functions and the desirable stand characteristics (compostion, structure and dynamics) can only be realized with high proportions of *Abies alba*.

Last but not least, silviculture should respect the intrinsic value of *Abies* forests for conservation. Due to their sensitivity to clear-cutting, deer-browsing and atmospheric pollution, Silver fir forests with their typical ground and epiphytic vegetation

- are regionally endangered, locally even threatened by extinction,
- harbour specialized lichen communities that can serve as bioindicators of environmental stressors resulting from changes in forest structure, air quality, and climate
- are highly valuable objects for the conservation of habitats and species.

Close-to-nature forests combine the functions of wildlife habitat, recreation, soil protection and commercial timber harvest. To maintain the value of *Abies* forests in areas where timber harvesting has become chief activity, cutting techniques should be adapted and snags and downed logs should be preserved.

Comments to nature conservation

The A b i e t e t u m forests in Bavaria's areas protected under the Habitats Directive, in natural forest reserves and and in National Parks should be objects of long-term studies and of monitoring species and habitats of Community interest.

Despite their large importance for nature protection A b i e t e t u m forests have been far-reaching ignored by legislation. From the technical point of view it is incomprehensible, why they are not listed in article 13d (conservation of special site habitats) of the Bavarian Nature Conservation Law.

In the European network 'Natura 2000' they are also at risk to be neglected: The Habitats Directive does not list *Abies alba* forests as a distinct habitat type according to Annex I. How should they be dealt with in protected areas? It is certainly not tenable to classify them as Non-EU-habitat and thus equate them to coniferous plantations. Alternatively, they are assigned to the annex I-habitat types 9110, 9130 and 9410, which appear to be closest in synsystematical terms. However, subsuming natural coniferous stands to the beech forest habitats 9110 and 9130 is problematic when it comes to defining thresholds of tree species composition for delimiting habitats and evaluating their conservation status. Detailed management instructions for such a heterogeneous habitat type will be either inappropriate or vague. The mosaic of natural communities can only be evaluated and managed properly if the types 9110, 9130 and 9410 are clearly distinguished in the management plan.

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Appendix 1: Subdivsion of the Silver fir forests in Bavaria

Tab. 2a: Constancy table of the nutrient- and species poor coniferous Silver fir forests (excerpt)
(Myrtillus type spruce-fir forests, alliance P i c e i o n a b i e t i s; habitat type 9410)

VA - Vaccinio vitis-idaeae-Abietetum:
VA-t - typicum, VA-lg - leucobryetosum, VA-lu - luzuletosum luzuloidis, VA-o - oxalidetosum acetosellae, VA-e - equisetetosum sylvatici, VA-c - calamagrostietosum arundinaceae.

LA - Luzulo luzuloidis-Abietetum:
LA-v - vaccinietosum myrt., LA-t - typicum, LA-a - athyrietosum filix-feminae, LA-d - deschampsietosum cespitosae.

	association	**Vaccino vitis-idaeae-Abietetum**						**Luzulo luzuloidis-Abietetum**			
	subassociation	**VA-t**	**VA-lg**	**VA-lu**	**VA-o**	**VA-e**	**VA-c**	**LA-v**	**LA-t**	**LA-a**	**LA-d**
	number of relevés	**31**	**31**	**2**	**16**	**5**	**5**	**22**	**12**	**24**	**8**
	average species number	**20**	**24**	**25**	**26**	**36**	**29**	**20**	**20**	**29**	**35**
	association VA:										
	Pinus sylvestris T1	65/1-2	68/1-3	100/2-3	37/1-2	60/1-2	-	-	-	-	-
	Pinus sylvestris T2	3/2	39/1-2	-	12/1-2	20/2	-	-	-	4/1	-
Ecological	Pinus sylvestris S	6/1	26/r-2	-	-	20/1	-	-	8/+	-	-
groups: [1]	Pinus sylvestris F	19/r-1	48/r-2	100/+	19/r-+	20/+	-	-	-	-	-
Vaccinium myrtillus	Pohlia nutans M	74/+-2	48/+-2	50/1	62/+-1	40/+	100/+-1	-	-	8/+	-
Cladonia	Hypnum jutlandicum M	39/+-2	65/1-3	50/3	56/+-2	40/+-1	25/1	-	-	-	-
Cladonia	Vaccinium vitis-idaea	48/+-1	71/+-2	100/+-1	25/+-1	40/+	-	-	-	-	-
	Campylopus flexuosus M	58/+-2	52/+-1	-	19/+-1	60/+-1	-	-	8/1	-	-
Vaccinium uliginosum	Sphagnum capillifolium M	45/+-2	39/+-1	-	19/+-1	80/+-2	-	-	-	-	-
Vaccinium myrtillus	Ptilidium ciliare M	39/+-2	42/+-2	50/1	25/+-2	-	-	5/1	8/1	8/+-1	-
Vaccinium myrtillus	Dicranum polysetum M	19/1-2	35/+-2	50/+	25/1-2	-	-	-	-	-	-
Molinia caerulea	Molinia arundinacea	-	32/+	-	-	80/+-2	-	-	-	-	-
	Orthodontium lineare M	6/+	-	-	31/+-2	-	50/+-1	-	-	-	-
	subass. VA-lg:										
Leucobryum glaucum	Calluna vulgaris (DA 1)	-	81/r-1	-	19/+	20/1	-	-	-	-	-
Vaccinium myrtillus	Barbilophozia barbata M	-	26/+-2	-	-	-	-	-	-	4/1	-
Pteridium aquilinum	Pteridium aquilinum	-	26/+-2	-	-	-	-	-	-	4/1	-
Cladonia	Cetraria islandica F	-	16/r-1	-	-	-	-	-	-	-	-
	subass. VA-o,e,c; LA:										
Oxalis acetosella	Maianthemum bifolium	-	-	-	44/+-2	100/+-2	100/1-2	55/+-2	8/+	25/+-2	100/2
Oxalis acetosella	Oxalis acetosella	-	-	-	62/+-1	40/+-1	75/1	32/+-2	-	100/+-2	100/2-3
Oxalis acetosella	Galium harcynicum	-	-	-	25/+-1	20/1	75/+	5/+	8/r	-	-
Gymnocarpium dryopteris	Athyrium filix-femina	-	-	-	19/+-1	40/r-+	75/+	9/+	-	67/r-2	87/1
	association LA:										
Luzula luzuloides	Luzula luzuloides (+ Subass. VA-lu)	-	-	100/+-2	-	-	-	-	58/r-1	33/r-1	-
Blechnum spicant	Blechnum spicant	-	-	-	-	-	-	-	92/r-2	87/+-2	100/1-2
Blechnum spicant	Luzula sylvatica sieberi + sylvatica	-	-	-	-	-	-	5/+	33/+-2	79/r-3	100/1-4
Blechnum spicant	Thelypteris limbosperma	-	-	-	6/r	-	-	-	33/+-2	62/+-2	75/+-1
	subass. LA-a, d:										
Anemone nemorosa	Prenanthes purpurea	-	-	-	-	-	-	9/+	-	71/+-2	100/1-2
Anemone nemorosa	Hieracium murorum	-	-	-	-	-	-	-	-	46/r-1	100/+-2
Oxalis acetosella	Homogyne alpina	-	-	-	-	-	-	-	-	33/+-2	50/2
Anemone nemorosa	Polygonatum verticillatum	-	-	-	-	-	-	-	-	21/r-1	75/+-2
	subass. VA-e:										
Vaccinium uliginosum	Sphagnum palustre M	13/r-1	10/+-1	-	12/+	100/1-3	-	-	-	8/+-1	-
Deschampsia cespitosa	Carex brizoides	-	3/+	-	19/+	80/1-3	-	5/+	-	-	-
Carex remota	Equisetum sylvaticum	-	-	-	-	80/+-3	-	5/r	-	4/+	-
	Alnus glutinosa B, F	-	-	-	-	60/+-1	-	-	-	4/2	-
Potentilla palustris	Viola palustris	-	-	-	-	40/+	-	-	-	4/1	-
Anemone nemorosa	Plagiomnium affine M	-	-	-	-	40/+	-	5/+	-	4/+	-
	subass. VA-c:										
Luzula luzuloides	Calamagrostis arundinacea	-	-	-	6/+	-	100/+-1	-	-	-	-
	subass. VA-c, LA-a, d:										
Gymnocarpium dryopteris	Thelypteris phegopteris	-	-	-	-	-	50/+	5/+	-	21/+-1	37/1
Gymnocarpium dryopteris	Gymnocarpium dryopteris	-	-	-	-	-	25/+	-	-	21/+-1	12/1
	subass. VA-c, LA-d:										
Anemone nemorosa	Senecio nemorensis agg.	-	-	-	-	-	25/+	-	8/+	-	50/+-1
Anemone nemorosa	Solidago virgaurea	-	-	-	-	-	50/r-+	-	-	4/+	37/+-1
Anemone nemorosa	Milium effusum	-	-	-	-	-	25/+	-	-	-	12/+
	subass. LA-d:										
Deschampsia cespitosa	Deschampsia cespitosa	-	-	-	-	20/2	-	-	-	8/+	75/+-2
Chaerophyllum hirsutum	Adenostyles alliariae	-	-	-	-	-	-	-	-	-	50/+-1
Anemone nemorosa	Phyteuma spicatum	-	-	-	-	-	-	-	-	-	50/+-1
Chaerophyllum hirsutum	Streptopus amplexifolius	-	-	-	-	-	-	-	-	-	37/+
	alliance Piceion abietis:										
	Bazzania trilobata M	84/+-4	81/+-3	50/1	87/+-2	80/+-2	100/1	95/+-3	83/+-2	79/+-2	37/1
	Sphagnum quinquefarium M	55/+-3	58/+-4	-	62/+-3	60/1-2	-	73/1-3	17/1-2	21/+-2	-
	Melampyrum p. oligocladum	3/+	42/+-2	50/1	12/+	-	-	-	8/1	12/+-2	-
	Plagiothecium undulatum M	10/1-2	13/+-2	-	12/+-1	-	-	14/+-2	42/+-1	25/+-1	100/+-2
	Calamagrostis villosa	3/+	3/+	-	6/+	-	-	9/+-1	8/2	17/+-2	-
	Luzula luzulina	-	-	-	-	-	-	-	17/+	29/+	-

[1] (from WALENTOWSKI et al. 2004).

Tab. 2b: Constancy table of the nutrient- and species rich conifer-broadleaved hardwood-Silver fir forests (excerpt)
(Galium type fir-spruce forests, alliance F a g i o n s y l v a t i c a e; habitat type 9130)

GA - Galio rotundifolii-Abietetum:
GA-t - typicum, GA-v - vaccinietosum myrtilli, GA-a adenostyletosum alliariae
GA-e - equisetetosum sylvatici

PA - Pyrolo secundae-Abietetum:
PA-e equisetetosum sylvatici, PA-ct - cardaminetosum trifoliae,
PA-ca caricetosum albae, PA-cm caricetosum montanae, PA-m - melampyretosum pratensis, PA-t - caricetosum montanae

AA - Adenostylo glabrae-Abietetum:
AA-t typicum, AA-av asplenietosum viridis

Ecological groups: 1)	Assoziation	Galio rotundifolii-Abietetum albae				Pyrolo secundae-Abietetum albae						Adenostylo glabrae-Abietetum albae	
	subassociation	GA-t	GA-v	GA-a	GA-e	PA-e	PA-ct	PA-ca	PA-cm	PA-m	PA-t	AA-t	AA-av
	number of relevés	13	18	6	41	5	5	13	2	2	3	7	10
	average species number	35	44	53	60	76	66	61	57	54	60	66	53
	association GA:												
Blechnum spicant	Blechnum spicant	77/r-2	22/r-+	50/+-1	46/+-2	20/+	-	8/r	-	-	-	12/1	-
Chaerophyllum hirsutum	Stellaria nemorum	-	17/+-1	33/1	32/r-2	-	-	-	-	-	-	-	-
	associations PA + AA:												
Carex montana	Carex digitata	23/+-1	6/1	-	15/+-1	20/1	80/1	92/+-2	100/+-2	50/+	67/+-2	14/+	100/+-2
Lamium galeobdolon	Mercurialis perennis	15/+	6/1	-	15/+-2	60/+-1	100/1-3	77/+-2	100/1-2	50/+	67/2-3	100/+-1	30/1-2
Lamium galeobdolon	Daphne mezereum	8/r	6/+	-	15/r-+	40/+	60/+	77/r-1	50/+	-	100/+	86/+	40/+
Lamium galeobdolon	Melica nutans	-	-	-	2/+	40/+	60/+-2	62/+-2	100/1-2	50/1	-	86/+-2	50/1
Lamium galeobdolon	Epipactis helleborine	-	-	-	-	40/+-1	60/+	77/r-1	-	-	-	43/r-+	30/r-+
Vaccinium myrtillus	Melampyrum sylvaticum	-	-	-	5/+-1	-	-	31/r-2	100/1-2	100/r-1	-	86/+-2	60/1-2
Sesleria albicans	Carex alba	-	-	-	-	-	40/1-3	54/+-2	-	-	-	100/1-2	80/1-3
Sesleria albicans	Carex ornithopoda	-	-	-	5/r-+	-	40/+	69/+-2	-	-	-	12/r	40/+-1
Carex montana	Pyrola secunda	8/+	-	-	-	-	-	23/+-1	50/1	50/+	33/1	12/+	80/1-2
Carex montana	Rubus saxatilis	-	-	-	2/+	-	-	23/+-1	100/+-1	-	-	71/+-1	50/1-2
Lamium galeobdolon	Bromus ram. benekenii	-	-	-	-	60/+-1	-	46/r-1	50/+	-	-	-	10/r
Asplenium	Valeriana tripteris	-	-	-	-	20/+	-	8/+	-	-	-	25/+	70/+-2
Cephalanthera damasonium	Epipactis atrorubens	-	-	-	-	20/+	80/r-+	15/r	-	-	-	25/r	-
	Crataegus monogyna agg.	-	-	-	-	-	100/r-+	15/r-+	50/r	-	-	-	-
	Galium mollugo s.str.	-	-	-	-	40/+-1	20/+	-	-	-	-	71/+	-
Lamium galeobdolon	Lilium martagon	-	-	-	-	-	-	-	50/r	-	33/+	12/+	-
Carex montana	Goodyera repens	-	-	-	-	-	-	8/+	-	-	-	-	10/+
Cephalanthera damasonium	Cypripedium calceolus	-	-	-	-	-	-	-	-	-	33/+	-	-
Vaccinium myrtillus	Monotropa hypopitys	-	-	-	-	-	-	-	50/r	-	-	-	-
	association AA:												
Thlaspi rotundifolium	Adenostyles glabra	-	-	-	-	-	-	-	-	-	-	100/+-1	10/2
Thlaspi rotundifolium	Gymnocarpium robertianum	-	-	-	-	-	-	-	-	-	-	71/+-1	50/+-1
Sesleria albicans	Sesleria albicans	-	-	-	-	-	-	-	-	-	-	71/+-1	60/1
Sesleria albicans	Lonicera alpigena	-	-	-	-	-	-	-	-	-	-	25/+-1	10/2
Petasites albus	Rosa pendulina	-	-	-	10/+-1	20/+	-	-	-	-	-	71/+	30/+
Petasites albus	Thelypteris phegopteris	-	-	-	-	-	-	-	-	-	-	12/+	60/+-1
Lamium galeobdolon	Hepatica nobilis	-	-	-	-	-	-	-	-	-	-	57/+	-
	subass. GA-v, PA-e, ca, cm, m												
Vaccinium myrtillus	Pleurozium schreberi M (weakly)	38/+-1	89/+-2	50/+	54/+-2	100/1-2	-	54/+-2	100/2	100/1-2	33/+	-	-
Deschampsia flexuosa	Deschampsia flexuosa	-	61/+-2	-	2/+	40/+	20/+	23/+	100/1-2	100/2	-	-	-
	Sambucus racemosa F,S	8/+	33/r-+	-	-	-	-	8/+	50/+	-	-	-	-
Luzula luzuloides	Luzula luzuloides	-	17/r-1	-	-	-	-	15/r-+	-	100/r-+	-	-	-
	subass. GA-a, e:												
Chaeropyhllum hirsutum	Adenostyles alliariae	-	-	83/+-5	41/r-3	20/+	-	8/2	-	-	33/+	-	-
Chaeropyhllum hirsutum	Senecio alpinus	-	-	17/+	17/+	-	-	-	-	-	-	-	-
Carex pendula	Chrysosplenium alternifolium	-	-	33/+	15/+-2	-	-	-	-	-	-	-	-
	subass. GA-e, PA-e:												
Carex remota	Equisetum sylvaticum	-	6/r	-	59/r-3	100/+-3	-	-	-	-	-	-	-
Carex remota	Cardamine amara	-	-	-	15/+-2	40/2	-	-	-	-	-	-	-
Chaerophyllum hirsutum	Viola biflora	-	-	-	41/r-2	40/+	-	-	-	-	-	12/1	-
Solanum dulcamara	Caltha palustris	-	-	-	51/+-2	50/+-1	-	-	-	-	-	-	-
Carex remota	Valeriana dioica	-	-	-	17/+	40/+-1	-	-	-	-	-	-	-
	subass. PA-e, ct:												
Cardamine trifolia	Cardamine trifolia	-	-	17/1	12/+-1	80/+-3	100/1-2	-	-	-	-	-	-
Cardamine trifolia	Equisetum arvense	-	-	-	10/+-1	60/r-1	60/+-2	-	-	-	-	-	-
Cardamine trifolia	Vinca minor	-	-	-	-	-	80/+-2	-	-	-	-	-	-
	subass. PA ca, cm:												
Carex montana	Carex montana	-	-	-	-	-	20/+	46/r-+	100/+-1	-	-	12/+	-
Galium odoratum	Galium sylvaticum	-	-	-	-	-	-	23/+-1	100/+-1	-	-	-	10/r
Galium odoratum	Potentilla sterilis	-	-	-	-	-	-	38/+-1	-	-	-	-	-
	subass. PA-cm:												
Lamium galeobdolon	Lathyrus vernus	-	-	-	-	-	-	-	100/+	-	-	-	-
Carex montana	Convallaria majalis	-	-	-	-	-	-	8/r	100/1	-	-	-	-
Carex montana	Aquilegia vulgaris	-	-	-	-	-	-	-	50/+	-	-	-	-
Carex montana	Prunus spinosa	-	-	-	-	-	-	-	50/+	-	-	-	-
Carex montana	Trifolium alpestre	-	-	-	-	-	-	-	50/r	-	-	-	-
Anemone nemorosa	Dactylis polygama	-	-	-	-	-	-	-	50/+	-	-	-	-
Lamium galeobdolon	Campanula trachelium	-	-	-	-	-	-	-	50/+	-	-	-	-
	subass. PA-cm, m:												
	Pinus sylvestris T1,2	-	11/1	-	-	-	-	-	100/1-3	100/2-3	-	-	-
	Pinus sylvestris F	-	-	-	-	-	-	-	50/+	100/r-+	-	-	-
Vaccinium myrtillus	Hypnum jutlandicum M	-	-	-	-	-	-	-	100/1-2	50/+	-	-	-
Vaccinium myrtillus	Pohlia nutans M	-	-	-	-	-	-	-	50/+	50/+	-	-	-
Vaccinium myrtillus	Dicranum polysetum M	-	6/+	-	-	-	-	-	50/1	50/2	-	-	-
	subass. AA-av:												
Asplenium	Asplenium viride	-	-	-	-	-	-	-	-	-	-	-	80/+-1
Asplenium	Clematis alpina	-	-	-	-	-	-	-	-	-	-	-	60/r-1
Asplenium	Frullania tamarisci M	-	-	-	-	-	-	-	-	-	-	-	40/+-1
Asplenium	Neckera crispa	-	-	-	-	-	-	-	-	-	-	-	30/1-2
	alliance Galio-Fagion sylvaticae:												
	Galium rotundifolium	23/+-1	50/+-1	100/+-1	78/r-2	80/+-1	100/1	100/+-2	100/+-2	100/+-2	100/+-2	12/1	40/r-+
	Prenanthes purpurea	46/+-2	50/r-+	100/+	63/+-2	40/+	-	54/r-1	-	50/+	67/+-1	71/+-1	50/+-1
	Galium odoratum	15/+	22/+-1	33/+	32/+-2	-	100/1-2	31/+	50/1	-	100/+-2	43/+-1	10/+
	Lonicera nigra	8/+	11/r-+	17/+	24/r-2	-	20/+	-	-	-	33/+	43/r-+	70/+-1
	Hordelymus europaeus	8/+	-	17/+	24/+-2	20/1	100/+-2	62/r-1	50/1	-	67/+-1	43/+-2	-
	Festuca altissima	38/+-2	6/1	-	15/+-2	20/+	-	8/1	-	-	-	12/+	-
	Neottia nidus-avis	-	6/r	17/+	5/+	-	-	23/r-+	-	-	67/r-+	12/+	-
	Dentaria enneaphyllos	-	-	-	5/+	-	-	-	-	-	-	-	-

The numerical results for each recorded species include the constancy (number before the oblique stroke) and the amplitude

1) (from WALENTOWSKI et al. 2004).

Appendix 2: Environmental characteristics of the subassociations

Tab. 4. Symmorphological and environmental characteristics of the subassociations. Distribution in growth ranges (gr) and growth districts (gd) according to GULDER 2001 in WALENTOWSKI et al. 2001): gd 5.3. western Franconian hills (`Frankenhöhe´) , gr 8 - Franconian Forest, `Fichtelgebirge´ and `Steinwald´ (gd 8.1 - Franconian Forest), gr 10 – Upper Palatine Forest, gr 11 - Bavarian Forest (gd 11.2 - Eastern lower Bavarian Forest), gd 12.9 - Lower bavarian tertiary colline zone, gd 14.4 - Upper bavarian young moraine and molasse foothills, gd 15.3 - `Allgäuer´ Flysch and Helveticum prealps, gd 15.4 - Upper bavarian Flysch prealps, gd 15.5 - Bavarian limestone Alps.

sub-asso-ciation	sealevel from - to distribution	soil type	predominant humusforms	important ecological indicator groups for special site charac-teristics	degree of naturalness
Vaccinio vitis-idaeae-Abietetum: VA-t = typicum, VA-lg = leucobryetosum glauci, VA-o = oxalidetosum acetosellae, VA-c = calamagrostietosum arundinaceae, VA-e = equisetetosum sylvatici, VA-lu = luzuletosum luzuloidis					
VA-t	390 - 720 m gr 8 - 12	fresh to very fresh, podzolic brown earth; temporary waterlogged pseudogley	raw humus	usually bilbeery (*Vaccinium myrtillus*) in the main; the importance of lichens is small; heath is absent	peat moss dominated develoments are assessed as natural climax-formations other developments: anthropogenic semi-natural formation of natural *Luzulo-Fagetum*
VA-lg	380 - 910 m gr 8 - 12; gd 5.3	moderate fresh to fresh brown earth-podzol; temporary waterlogged podzol-slope pseudogley	raw humus	indicators of very poor and very acid sites (*Cladonia-, Leucobryum glaucum* -group) always present	peat moss dominated develoments are assessed as natural climax-formations other developments: anthropogenic semi-natural formation of natural *Luzulo-Fagetum*
VA-o	380 - 800 m gr 8 - 12	fresh to very fresh, podzolic brown earth; temporary waterlogged pseudogley	mor to hydromor	incdicators for shady, poor and fresh sites (*Oxalis acetosella-, Gymnocarpium dryopteris* -group)	peat moss dominated develoments are assessed as natural climax-formations other developments: anthropogenic semi-natural formation of natural *Luzulo-Fagetum*
VA-c	530 m gd 8.1	fresh podzol-brown earth warm steep slope	impoverished mor	indicators for moderate warm, semi-shaded, poor and fresh sites (*Calamagrostis arundinacea, Solidago virgaurea*)	anthropogenic degradation stage instead of natural *Luzulo-Fagetum*
VA-e	390 - 530 m gd 11.2	wet Gley to anmoor-Gley	hydromor to histomor	indicators for moist to wet sites (*Deschampsia cespitosa-, Vacci-nium uliginosum-, Potentilla - palustris-* group)	natural climax-formation
VA-lu	420 - 760 m gr 10 + 11	moderate dry podzol-brown earth	mor	indicators for poor and acid sites (*Luzula luzuloides-* group)	anthropogenic semi-natural formation instead of natural *Luzulo-Fagetum*
Luzulo luzuloidis-Abietetum: La-t = typicum, LA-v = vaccinietosum myrtilli, LA-a = athyrietosum filix-feminae, LA-d = deschampsietosum cespitosae					
LA-t	720 - 1170 m gr 11, gd 15.4	very fresh podzol-brown earth; cool-humid location	mor	indicators for cool-humid and fresh, poor and acid sites (*Blechnum spi-cant-* and *Oxalis acetosella* -group)	anthropogenic semi-natural formation instead of natural *Luzulo-Fagetum*
LA-v	400 - 950 m gr 11, gd 14.4 + 15.3	fresh podzol-brown earth, esp. on crests and flats	raw humus like mor	predominance of *Vaccinium myrtil-lus*; absence of hygrophilous species	anthropogenic semi-natural formation instead of natural *Luzulo-Fagetum*
LA-a	400 - 1080 m gr 11, gd 15.4	moist podzol-brown earth; moderate wet spring Gley	hygromor to histomor	indicators for cool-humid sites (*Blechnum spicant-, Gymno-carpium dryopteris* -group)	peat moss dominated develoments are assessed as natural climax-formations other types: anthropogenic semi-natural formation of natural *Luzulo-Fagetum*
LA-d	1040 - 1060 m gr 15	very fresh to moist, pseudogley-Brown earth	mor	indicators for cool-humid sites incfuenced by seepage water (*Deschampsia cespitosa-, Chae-rophyllum hirsutum* -group)	anthropogenic semi-natural formation instead of natural *Luzulo-Fagetum*

Tab. 5. Symmorphological and environmental characteristics of the subassociations. Distribution in growth ranges (gr) and growth districts (gd) according to GULDER 2001 in WALENTOWSKI et al. 2001): gd 5.3 - western Franconian hills (`Frankenhöhe´), gd 6.1 - northern Franconian Alb, gd 13.2/1 - Southern munich shingle-plain, gr 14 - Swabian-bavarian young moraine and molasse foothills (gd 14.3 - Swabian young moraine, gd 14.4 - Upper bavarian young moraine and molasse foothills), gr 15 - Bavarian Alps (gd 15.1 - `Kürnacher´ Molasse mountains, gd 15.5 - northern Limestone Alps).

sub-asso-ciation	sealevel from - to distribution	soil type	predominant humusforms	important ecological indicator groups for special site charac-teristics	degree of naturalness
Galio rotundifolii-Abietetum: GA-t = typicum, GA-v = vaccinietosum myrtilli, GA-a = adenostyletosum alliariae, GA-e = equisetetosum sylvatici					
GA-t	670 - 910 m gr 14 + 15	very fresh brown earth and lessivé	moder	-	anthropogenic semi-natural formation instead of natural Asperulo-*Fagetum*
GA-v	460 - 750 m gd 13.2/1, gr 14, gd 15.1	very fresh to temporary waterlogged lessivé to pseudogley	moder to hydromoder	acidophyts of *Vaccinium myrtillus-, Deschampsia flexuosa, Luzula luzuloides*-group	peat moss dominated types are assessed as natural climax-formation other developments: anthropogenic semi-natural formation of natural *Asperulo-Fagetum*
GA-a	1.050 - 1.330 m gr 15	very fresh to moist lessivé	moder	humidity and seepage-water indicators (*Chareophyllum hirsutum*-group)	anthropogenic semi-natural formation instead of natural Aceri-*Fagetum*
GA-e	470 - 1.170 m gr 14 + 15	moist lessivé to gley, moderate wet anmoor-Gley	moder to histomoder	indicators for waterlogged soils, rich in nutrients (*Chaerophyllum hirsutum*-, *Carex remota*- and *Solanum dulcamara*-group)	natural climax-formation
Pyrolo-Abietetum: PA-t = typicum, PA-ct = cardaminetosum trifoliae, PA-e = equisetetosum sylvatici, PA-ca = caricetosum albae, PA-cm = caricetosum montanae, PA-m = melampyretosum pratensis					
PA-t	720 - 1.080 m gr 14 + 15	inhomogenous soils complexes of steep valley flanks and their flatter socles	mull-like moder	-	natural climax-formation
PA-ct	830 - 840 m gr 14	fresh, clayey lessivé	mull-like moder	indicators for clayey soils (*Cardamine trifolia*-group)	natural climax-formation
PA-e	620 - 1.160 m gr 14 + 15	moist slope gley (pelosol), adhere wetness pseudogley	mull-like histomoder	indicators for waterlogged soils, rich in nutrients (species of *Chaerophyllum*-, *Solanum dulcamara*-group) combined with specialists of clayey soils (*Cardamine trifolia*-group)	natural climax-formation
PA-ca	730 - 1.180 m gr 14 + 15	skeletal brown pararendzina to lessivé	mull-like moder	lime indicators of the *Sesleria*-group (e.g. *Carex alba*) combined with acidophyts of *Vaccinium myrtillus-, Deschampsia flexuosa-* and *Luzula luzuloides*-group	anthropogenic semi-natural formation instead of natural *Aposerido-Fagetum*
PA-cm	430 - 460 m gr 5 + 6	moderate fresh loam rendzina to lessivé-Terra fusca	moder	thermal indicators of *Carex montana*-group	anthropogenic semi-natural formation instead of natural *Hordelymo-Fagetum*
PA-m	440 - 500 m gd 5.3 + 6.1	temporary fresh, podzolic lessivé to pseudogley-brown earth	moder	acidophyts of *Vaccinium*-group	anthropogenic semi-natural formation instead of natural *Luzulo-Fagetum*
Adenostylo glabrae-Abietetum: AA-t = typicum, AA-av = asplenietosum viridis					
AA-t	950 - 1.350 gd 15.5 - 15.9	rendzina	tangel	specialists of calcareous rubble, (*Thlaspi rotundifolium*-group), light demanding species of *Sesleria albicans*-group	naturalistic subclimax-formation
AA-av	720 - 1.200 m gd 15.5 - 15.9	rock rendzina	thick tangel	specialists of calcareous rocks (*Asplenium*-group)	naturalistic subclimax-formation

Appendix 3: Fir forests at Taubenberg (FFH-area 8136-302)

		1	2			3.1		3.2							4				5
	N° of relevé	**F7**	**234**	**235**	**F1**	**242**	**233**	**239**	**238**	**236**	**237**	**240**	**241**	**F8**	**230**	**W1**	**W2**	**231**	**232**
	altitude (m a.s.l.)	740	830	830	815	800	800	770	770	800	850	770	80	760	720	730	740	720	740
	exposure (°)	180	270	270	360	180	360	180	180	360	180	180	180	0	0	360	360	0	360
	inclination	2	2	3	3	10	7	7	10	10	3	7	7	0	0	3	8	0	3
	species number	22	39	38	14	23	27	32	33	37	36	33	34	26	34	22	26	60	83
	tree layer 1 (T1) cover in %	50	40	75	90	60	70	60	65	65	50	50	60	60	80	70	85	85	65
	tree layer 2 (T2) cover in %	10	40	15	-	20	25	15	5	10	10	30	30	5	-	20	20	-	10
	shrub layer 1 (S1) cover in %	-	15	15	-	3	5	7	10	20	10	10	5	20	-	10	10	5	10
	shrub layer 2 (S2) cover in %	60	10	10	40	-	-	2	5	65	5	10	2	-	-	5	3	-	5
	fied layer (F) cover in %	90	100	50	100	90	50	75	95	65	65	95	85	40	85	15	75	90	100
	moos layer (M) cover in %	30	85	65	40	95	65	95	85	70	80	100	65	50	90	45	45	100	85
T1	Abies alba	.	2	1	2	4	3	2	2	3	2	3	3	2	3	4	4	3	3
T2	Abies alba	.	2	1	.	2	2	2	.	2	.	2	2	.	.	.	1	.	2
S1	Abies alba	.	.	.	.	1	.	2	1	.	.	2	.	1	.	1	2	.	2
S2	Abies alba	r	.	2	3	.	.	+	.	2	1	1	+	.	.	1	.	.	+
F	Abies alba	+	1	1	2	+	+	1	1	1	2	1	1	2	+	2	2	+	+
T1	Picea abies	2	2	3	4	1	3	3	3	2	3	2	2	3	1	2	2	3	2
T2	Picea abies	1	2	2	.	.	1	1	1	.	2	1	1	1	.	.	.	.	.
S1	Picea abies	.	2	.	.	.	+	.	.	.	2	.	2	1	.	2	+	.	1
S2	Picea abies	2	2	.	2	.	.	.	1	.	.	.	.	.	.	1	1	.	+
F	Picea abies	+	2	2	2	2	2	3	2	2	1	2	.	2	1	1	3	.	3
T2	Fagus sylvatica	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	2	.	.
S1	Fagus sylvatica	.	.	2	.	.	1	.	1	2	.	.	1	2	.	.	.	.	1
S2	Fagus sylvatica	.	.	.	.	.	.	.	.	2		1	.	.	.	.	+	.	.
F	Fagus sylvatica	.	+	+	1	+	+	+	1	1	+	+	+	+	+	.	+	+	+
	Quercus robur	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	Quercus robur	+	.	+	.	.	+	+	+	+	+	.	r	r	r	.	+	.	.
F	Sorbus aucuparia	.	+	.	+	.	.	.	+	+	+	.	.	.	1	.	.	+	+
F	Acer pseudoplatanus	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	1	.
	Leucobryo-Pinetum molinietosum:																		
F	Dicranum polysetum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	Vaccinium uliginosum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	Molinia arundinacea	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Vaccinio-Abietetum:																		
T1, F	Pinus sylvestris	3	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	Vaccinium vitis-idaea	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	Calluna vulgaris	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Myrtillus-type-spruce-fir-forests:																		
F	Vaccinium myrtillus (facies)	5	4	3	5	5	3	3	5	3	3	5	4	3	2	2	3	2	2
M	Campylopus flexuosus	+	+	+	.	.	.	.	.	.	1	.	+	+	.	.	.	.	.
M	Sphagnum fallax	.	1	1	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.
	Sphagnum capillifolium	3	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
	d Carex pilulifera-variant:																		
F	Dryopteris dilatata	.	+	.	.	.	.	1	+	+	+	2	+	.	2	.	.	3	+
F	Carex pilulifera	.	.	.	.	.	+	1	1	+	+	+	+	.	.	.	+	+	r
F	Oxalis acetosella	.	.	.	.	.	.	1	+	.	.	+	.	+	2	+	+	2	2
F	Carex brizoides	.	.	.	.	.	.	.	.	+	.	.	+	+	+	.	.	1	2
F	Maianthemum bifolium	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	+	+
	Galium-type-fir-spruce-forests (Fagion-/Fagetalia):																		
F	Galium rotundifolium	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	1	1
F	Festuca gigantea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	1	1
F	Lysimachia nemorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	1
M	Plagiochila asplenioides	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	1	2
M	Plagiomnium affine	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	3	1
F	Carex sylvatica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	2
F	Sambucus nigra	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	1	.
M	Plagiomnium undulatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	2	.
F	Geranium robertianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	+
F	Brachypodium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1
F	Sanicula europaea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
F	Viola reichenbachiana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
F	Festuca altissima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+
F	Prenanthes purpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+
F	Asarum europaeum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
F	Dryopteris filix-mas	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1
	Pyrolo-Abietetum:																		
F	Epipactis helleborine	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
F	Melica nutans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
F	Mercurialis perennis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
F	Aegopodium podagraria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
F	Bromus ramosus benekenii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
F	Carex digitata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	d equisetetosum:																		
F	Equisetum sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
F	Knautia dipsacifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
F	Cirsium oleraceum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
F	Crepis paludosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r

		1	2			3.1		3.2							4				5
	N° of relevé	**F7**	**234**	**235**	**F1**	**242**	**233**	**239**	**238**	**236**	**237**	**240**	**241**	**F8**	**230**	**W1**	**W2**	**231**	**232**
	Piceion/Piceetalia:																		
M	Bazzania trilobata	.	2	1	+	2	2	2	1	1	1	2	2	2	.	2	2	.	1
M	Plagiothecium undulatum	.	2	1	.	1	+	2	.	+	1	.	.	1	2	.	.	+	2
F	Lycopodium annotinum	.	1	.	2	.	.	.	1	2	2	.	.	+	.	.	.	.	1
M	Sphagnum girgensohnii	.	.	.	.	1	.	+	.	.	.	.	+	+	.	.	.	.	.
	Rhytidiadelphus loreus	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
F	Huperzia selago	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Blechnum spicant	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
	other companions:																		
F	Dryopteris carthusiana	.	1	+	+	+	.	+	+	1	+	+	+	+	+	.	1	+	+
	Deschampsia flexuosa	.	+	.	.	+	.	.	.	+	+	+	.	+	+	.	.	.	+
	Rubus pedemontanus	.	+	.	.	.	.	.	+	2	+	+	.	.	3	+	1	3	+
F	Pteridium aquilinum	2	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	+
	Frangula alnus	3	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
F	Luzula pilosa	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	+
F	Deschampsia cespitosa	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	2
F	Rubus idaeus	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	+	.
F	Primula elatior	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
F	Chaerophyllum hirsutum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2
F	Athyrium filix-femina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
F	Senecio fuchsii + nemorensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1
F	Solidago virgaurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
	mosses:																		
M	Polytrichum formosum	1	3	3	+	4	1	2	2	1	2	3	2	3	3	2	2	3	1
M	Thuidium tamariscinum	1	3	2	3	2	1	3	3	4	2	3	2	2	3	3	3	3	3
M	Dicranum scoparium	+	2	1	+	2	+	3	2	+	2	2	2	2	.	+	1	.	1
M	Pleurozium schreberi	3	2	2	.	1	.	2	3	.	1	2	.	+	.	.	.	.	1
M	Hypnum cupressiforme	+	1	1	+	.	+	+	1	+	1	1	+	2	.	+	+	.	.
M	Leucobryum glaucum	+	+	2	.	1	3	1	2	.	2	1	2	.	.	1	+	.	.
M	Hylocomium splendens	.	2	2	.	.	.	1	1	.	.	1	.	.	+	.	.	.	1
M	Eurhynchium striatum ssp. angustirete	+	.	+	.	+	.	+	.	+	.	+	.	.	2	+	1	2	2
M	Dicranodontium denudatum	.	1	+	.	.	1	+	.	.	+	+	1	1	.	1	.	.	.
M	Plagiothecium curvifolium	.	.	+	.	+	.	1	.	+	.	1	.	+	.	.	.	.	.
M	Calypogeia azurea	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
M	Cirriphyllum piliferum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1
M	Lepidozia reptans	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M	Lophocolea bidentata	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+
M	Scleropodium purum	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1

in 1 releve:

Acer platanoides K (231: r), Actaea spicata (231: r), Ajuga reptans (231: r), Betula carpatica S1 (235: +), Calamagrostis epigeios (237: +), Calliergonella cuspidata (232: 1), Carex remota (W2: +),Dactylis glomerata (232: +), Fragaria vesca (232: +), Fragnula alnus (230: +), Galeopsis tetrahit (231: r), Geum urbanum (W1: +), Hedera helix K (231: +), Hieracium sylvaticum (232: +), Hyericum perforatum (232: +), Knautia dipsacifolia (232: 2), Lamium gal. ssp. montanum (232:+), Lonicera nigra (231: r), Melampyrum pratense (241: +), Mycelis muralis (W1: r), Petsites albus (232: 1), Phyteuma spicatum (231: +), Polygonatum multiflorum (231: +), Pulmonaria officinalis (232: 1), Rhytidiadelphus triquetrus (231: +), Ranunculus lanuginosus (232: 1), Stachys sylvatica (W2:+), Streptopus amplexifolius (232: +), Veronica montana (232: +), Viburnum opulus (232: +)

types:

1	=	Leucobryo-Pinetum molinietosum
2	=	Vaccinio vitis-idaeae-Abietetum
3.1	=	Luzulo-Abietetum vacccinietosum myrtilli, typical variant
3.2	=	Luzulo-Abietetum vacccinietosum myrtilli, Carex pilulifera-variant
4	=	Galio rotundifolii-Abietetum
5	=	Pyrolo-Abietetum equisetetosum sylvatici

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Autorenanschrift:

Dr. Helge Walentowski
Bayer. Landesanstalt für Wald und Forstwirtschaft,
Am Hochanger 11, D-85354 Freising,
e-mail: wal@lwf.uni-muenchen.de
home: http://www.lwf.bayern.de/organisation/mitarbeiter-verzeichnis/wal.php

Dr. Michael Fischer
Ettaler Str. 9
82487 Oberammergau
e-mail: Fischer.MKH@t-online.de

Rudolf Seitz
Winterstraße 5,
D-86551 Aichach,
email: Seitz.Rudolf-0001@t-online.de