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Some remarks on the *Leucobryo-Pinetum sylvestris* MATUSZK. 1962 at its southwestern limit in Bavaria

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ABSTRACT: A syntaxonomic and synecological analysis of the *Leucobryo-Pinetum* in Bavaria is presented. A description of the three subassociations recognized is given. The classification confirms the overregional validity of the concept of MATUSZKIEWICZ (1962). Each subassociation can be divided into two variants. The different degree of naturalness of the syntaxa is discussed.

KEYWORDS: Phytosociology, *Leucobryo-Pinetum*, Phytogeography, Synecology, Naturalness

Introduction

This study includes some remarks to the sociological variability of the *Leucobryo-Pinetum* in eastern Bavaria, where this association reaches its southwestern distribution limit. Westwards, the *Leucobryo-Pinetum* is naturally replaced by subatlantical wood-communities of oak and birch, for example the *Holco mollis-Quercetum* (LEMÉE 1937) OBERDORFER in OBERDORFER 1992 in the Oberrheinebene. To demonstrate the spectrum of subassociations and variants of the *Leucobryo-Pinetum* in our region we compare characteristic tables of relevés from the "Vorland Mittlere Frankenalb / Neumarkt i. d. Oberpfalz" (= province 1) and the "Vorderer Bayerischer Wald / Maign" (= province 2). In addition to these main research areas we analysed two further individual Pine stands in the "Donau-Isar-Hügelland / Siegenburg" and the "Mittlere Frankenalb / Kallmünz (fig. 1).

Climate and biogeographic situation

The following climatic data are taken from KNOCH (1952) and WITTMANN (1991). The average daily mean temperature amounts to 7 to 7,5°C/year. July is the warmest month (17°C), January the coldest (-2°C). The annual precipitation differs between 650 - 750 mm (Kallmünz) and 900 - 950 mm (Maign). The precipitation during the

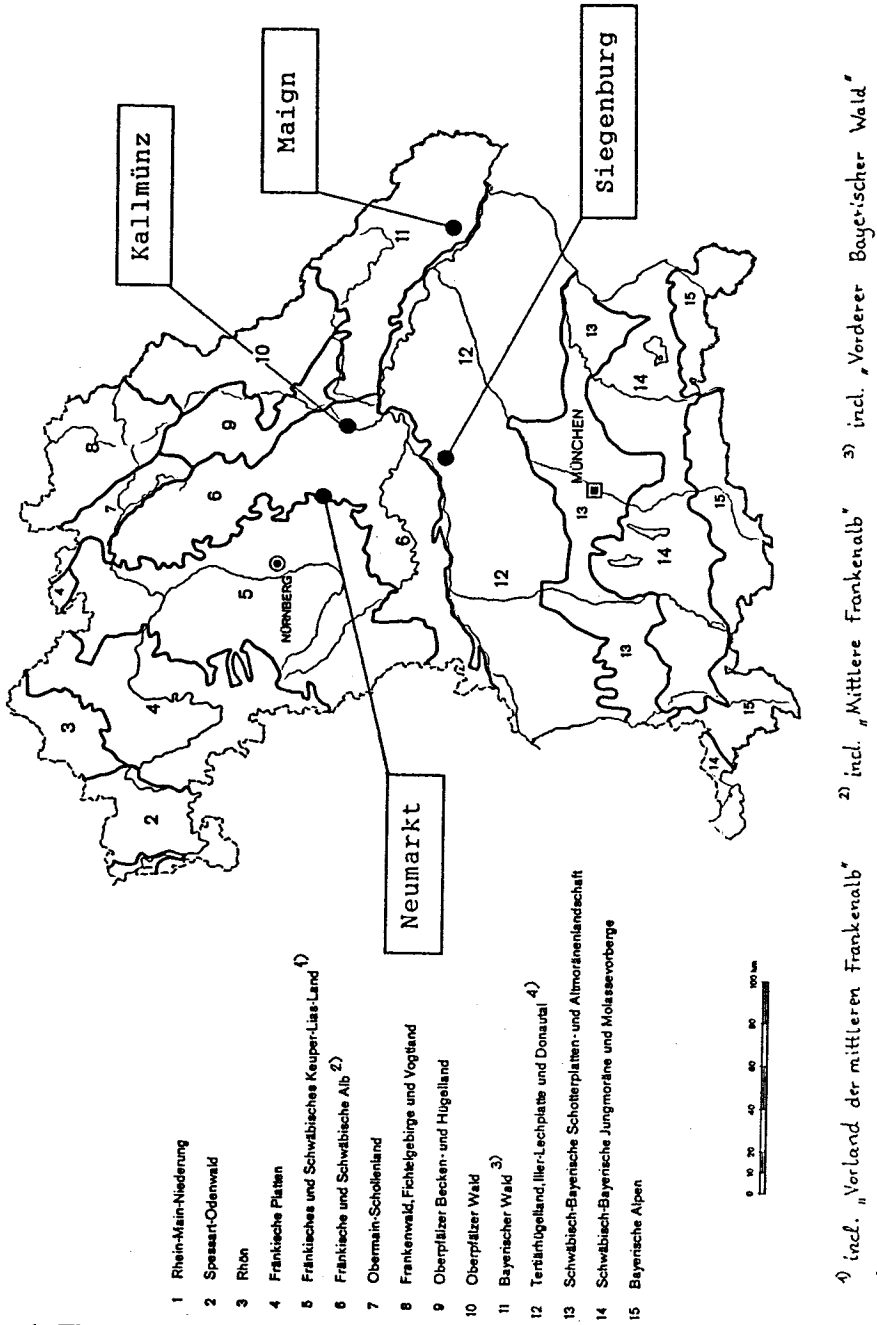

Fig. 1: The research area and relevé localities. Geographical division according to WITTMANN (1991), in footnote marked subdivisions according to MEYNEN & SCHMITHÜSEN (1962). Neumarkt (= province 1) and Maign (= province 2) are the main research areas.

vegetation period decreases from Maign over Siegenburg and Neumarkt to Kallmünz from 300 to 200 mm. The vegetation period lasts 200 to 220 days, whereat Maign has the lowest number of summer days. Also the index of aridity (HOCK 1955) from May to July (50 - 60 in Maign, 35 - 40 in Siegenburg) reproduces the following relation:

Province 1 and the other places of relevé samples are in comparison to province 2 altogether wormer and dryer.

The *Leucobryo-Pinetum* in the research area belongs - as for province 1 and 2 - to the submontane race MATUSZKIEWICZ (1962) with *Picea abies* and *Abies alba*. The cool and humid climate in the province 2 has its biological expression beyond that in high abundance of *Sphagnum nemoreum* in the *Leucobryo-Pinetum* and shows so far significant relationship to the boreal race (KIELLAND-LUND 1967).

Geology

The sandy soils in our research area have a different geological basis. With the exception of province 2, the substrate of pine-forests is to be classified as an allochtonous blown sand overlying the autochthonous rocks (deposited during the pleistocene and holocene period). The sandy substrate in province 2 is on the contrary a product of weathering of the autochtonous parent rock.

The geological situation for each investigated area is the following:

- Maign: sandy weathering of miocene and pliocene sediments (Tertiary bay on the edge of the moldanubian cristalline).
- Neumarkt : pleitocene and holocene blown sand forming dunes (10 to 20 m and higher).
- Kallmünz: blown sand overlying jurassic limestone, in the geological map classified as "Tertiary". SCHEUERER (verbal information) presumes of course, that the sands are quartary driftings from the valley of river Naab.
- Siegenburg: during the pleistocene period drifted dune fields (up to 10 m in higth) overlying Tertiary sediments.

Methods

The phytosociological investigations were made from May 1991 to December 1992 using the BRAUN-BLANQUET methods. Within the main regions of investigation there were taken 25 (province 1) and 26 (province 2) relevés. In addition we took in each case 1 relevé in Kallmünz and Siegenburg. Nomenclature of vascular plants follows OBERDORFER (1990), of lichens WIRTH (1980) and of mosses FRAHM & FREY (1983). For the synecological comparison we investigated three soil profiles in three different pine stands to describe them (according to AG BODENKUNDE (1982)) and to gain soil samples (each 500g) for lab analysis. In the lab we determined according to an instruction of Prof.Dr. GEROLD (University of Göttingen) the soil structure, the soil pH (in water and KCl) as well as the water soluble phosphorus. Finally we computed the available water capacity (AWC) according to tab. 43 - 44 in AG BODENKUNDE (1982).

Results

Description of communities

According to new syntaxonomic studies of SEIBERT (1988) the *Leucobryo-Pinetum* belongs within the alliance *Dicrano-Pinion* to the suballiance *Dicrano-Pinenion* SEIBERT in OBERDORFER 1992. The closest relationships exist to the second suballiance of the *Dicrano-Pinion*, called *Piceo-Vaccinienion uliginosi* SEIBERT in OBERDORFER 1992. On the other hand, we find also relations to the *Pyrolo-Pinetum* (LIBBERT 1933) E. SCHMID 1936 (= *Peucedano-Pinetum* MATUSZKIEWICZ 1962), which belongs according to OBERDORFER (1992) to the vegetation class of the *Pulsatillo-Pinetea* (alliance *Cytiso-Pinion*). This concept of the classification of pine forests in the new edition of the "Süddeutsche Pflanzengesellschaften" is an expression of the extended knowledge since MATUSZKIEWICZ (1962). It is a logical consequence in the process of buildung the phyto-sociological system, which is developed "organically" from the basic unit (association) to the highest syntaxon (vegetation class).

1. The *Leucobryo-Pinetum* in province 1 (relevé tab. 1)

The relevé table 1 of from Neumarkt (Vorland Mittlere Frankenalb) shows a relatively uniform picture. Under close stands of *Pinus sylvestris* mainly *Vaccinium*-species predominate in the undergrowth (both *Vaccinium myrtillus* and *V. vitis-idaea*). Below more diaphanous pine stands *Calluna vulgaris* is the most competitive species in the undergrowth. This reciprocity has generally no edaphical reason: dominance of *Calluna* marks an initial or, respectively, a degradation phase of wood. It goes conform with a soil degradation. Typically enough, this early succession stage of the *Leucobryo-Pinetum* shows a close relationship to the heath community of the *Vaccinio-Callunetum* PREISING 1942. On the contrary predominance of *Vaccinium* in the undergrowth of the *Leucobryo-Pinetum* is an indicator for mature stage of the wood.

According to the water regime we can distinguish two subassociations. At first the subassociation typicum, which is the most common one in the research area. Especially on very dry and poor edges of the forests, e.g. near wood-paths there grows the subassociation with *Cladonia*. Because of a relatively favourable situation in nutrients in the research area (see below) both of these subassociations belong to the variant with *Festuca ovina*.

On the margins of pine forests that are influenced by fertilizers from the adjacent grassland (*Arrhenatherion elatioris* W. Koch 1926), there grows a subvariant of *Hieracium murorum*.

Tab. 1. *Leucobryo-Pinetum* in the province 1 (Vorland Mittlere Frankenalb /Neumarkt)

Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Number of relevés	16	17	20	24	25	26	27	29	1	2	3	6	9	16	17	20	24	25	26	27	29	1	2	3	6	9
Number of species	16	19	15	17	17	22	19	18	17	13	11	14	14	11	10	15	15	12	13	13	11	25	22	18	12	19
d subassociation 1:																										
Cladonia rangiferina	·	1	1	2	1	+	1	2	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia furcata	1	r	+	·	+	+	1	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia fimbriata	·	r	+	+	1	·	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia arbuscula	·	+	1	1	·	·	+	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Leucobryum glaucum	+	r	·	+	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia gracilis	·	·	·	+	·	r	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia squamosa	·	·	·	·	+	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cetraria islandica	·	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia pyxidata	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
a variant 1:																										
Hylocomium splendens	·	·	+	·	+	+	+	1	2	+	1	·	2	1	+	2	1	2	2	3	2	2	1	1	2	1
Festuca ovina s.str.	·	·	·	·	·	·	·	+	1	·	·	·	·	·	·	1	+	·	·	·	+	1	1	+	+	+
Eurhynchium striatum	1	+	·	1	+	+	·	·	·	+	·	1	1	·	·	·	·	·	+	·	·	1	·	1	·	+
Epilobium angustifolium	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
a subvariant:																										
Hieracium murorum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	+	r	r	+
Sorbus aucuparia juv.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	+	·	+
Quercus robur shr.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·	·
Luzula multiflora	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	+	+	·	·	+
Pimpinella saxifraga	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Taraxacum officinale	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	r	·	·
Poa nemoralis	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	+	·	·	·
Rubus fruticosus coll.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·
All.-Cl. Vaccinio-Piceetea:																						1	·	·	·	·
Vaccinium myrtillus	1	2	+	2	3	2	1	+	+	1	3	2	3	1	1	2	2	2	1	3	+	4	1	4	2	+
Vaccinium vitis-idaea	2	1	3	1	1	1	3	2	2	2	1	1	1	3	2	1	2	2	2	2	3	2	1	+	1	3
Viscum a.ˢ austriacium	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	+	·	+	+	·	·	·	+	·	·	+
Picea abies juv.	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	r	·	·	r	·	·	·	·	·	r
Monotropa h. ˢ hypopitys	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Companion species:																										
Calluna vulgaris	1	2	2	2	1	2	3	3	2	3	3	3	2	1	1	2	1	2	1	1	+	1	1	1	2	1
Pinus sylvestris tr.₁	3	3	3	3	4	3	2	3	2	3	4	3	3	3	2	3	3	3	2	4	3	4	3	4	3	3
Deschampsia flexuosa	1	2	1	2	2	1	+	+	1	1	+	2	2	2	3	1	3	1	2	2	1	1	2	1	2	2
Melampyrum pratense	+	₁	+	₁	+	+	+	·	·	₁	₁	1	·	·	·	+	1	1	+	1	·	1	1	+	1	1
Pinus sylvestris tr.₂/shr.	·	1	2	·	1	·	3	1	1	·	·	·	·	1	3	2	2	2	3	·	3	+	1	2	1	2
Quercus robur juv.	r	·	r	+	r	r	·	r	r	r	+	·	r	r	·	r	r	r	·	r	·	+	+	·	·	1
Pinus sylvestris juv.	1	2	·	·	·	+	·	r	·	1	·	+	1	·	·	3	·	·	·	·	·	·	·	·	1	·
Anthoxanthum odoratum	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r
Quercus rubra juv.	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Fagus sylvatica juv.	·	·	·	·	r	·	·	·	·	r	·	·	·	·	·	·	r	·	·	·	·	·	r	·	·	·
Arrhenatherum elatius	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·
mosses:																										
Pleurozium schreberi	1	3	3	2	3	2	1	3	3	2	5	2	3	1	3	3	3	3	3	3	3	4	4	4	4	3
Dicranum polysetum	2	2	1	1	1	2	2	+	1	1	·	+	1	+	+	1	+	1	1	1	+	·	1	·	+	+
Hypnum jutlandicum	3	3	2	3	2	3	2	1	·	3	·	3	2	3	3	1	1	1	+	+	1	·	·	1	·	1
Campylopus flexuosus	+	+	·	·	·	+	+	+	·	·	·	+	·	+	+	·	·	·	·	·	·	·	·	·	·	·
Dicranum spurium	+	+	·	+	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	-	·	·	-	·	·	·
Thuidium tamariscinum	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Rhytidiadelphus triquetrus	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	1	·	·	·	·

species present in only one relevé: Luzula pilosa (12-1), Dactylis glomerata (22-r), Galium album (22-+), Galium rotundifolium (22-+), Fragaria vesca (23-r), Coronilla varia (23-+), Deschampsia cespitosa (23-+), Sorbus aucuparia shr.(24-r), Rosa canina juv.(25-r), Hieracium caespitosum (24-+), Polytrichum formosum (6-+), Pohlia nutans (6-+), Dicranum scoparium (12-r), Ptilium ciliare (17-+), Lophocolea bidentata (24-+).

Syntaxa:

Column 1 - 9: Leucobryo-Pinetum cladonietosum, variant with Festuca ovina

Column 10 - 26: Leucobryo-Pinetum typicum, variant with Festuca ovina
10 - 21: typical subvariant
22 - 26: subvariant with Hieracium murorum

abbreviations: juv. = juvenile
shr. = shrub
tr. = tree (₁ = layer of trees 1, ₂ = layer of trees 2)

2. The *Leucobryo-Pinetum* in province 2 (relevé table 2)

In province 2, called "Vorderer Bayerischer Wald" we can distinguish all the three subassociations described by MATUSZKIEWICZ (1962): *cladonietosum, typicum* and *molinietosum*. Besides these subassociations related primarily to the water gradient we find again diverse species combinations, which differentiate several successional stages (e.g. initial stage with abundant *Calluna* and *Betula pendula*). In comparison to province 1 the soils are poorer in nutrients, and therefore the variant of *Festuca* is absent.

Tab. 2. *Leucobryo-Pinetum* (and *Vaccinio uliginosi-Pinetum*) in the province 2 (Vorderer Bayerische Wald

Column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of relevés	10	3	10	9	11	0	11	3	22	28	9	14	3	10	18	33	21	2	6	14	11	42	81	36	17
Number of species	13	14	15	17	13	19	17	19	13	11	19	10	10	16	16	22	30	17	17	16	20	15	14	17	12
D1 (Diff. Dicrano-Pinenion):																									
Dicranum polysetum	r	+	+	·	1	2	1	1	1	+	+	+	1	2	·	+	r	1	1	·	r	·	·	·	·
Leucobryum glaucum	1	+	+	1	+	1	+	2	2	1	r	·	+	+	·	+	·	r	+	+	1	·	·	·	·
Hypnum jutlandicum	·	·	·	·	+	+	+	1	1	·	+	1	·	1	r	+	·	r	+	1	·	·	·	·	·
Polytrichum formosum	·	·	·	r	·	·	+	·	+	·	·	·	·	+	+	+	r	·	·	+	r	·	·	·	·
Dicranella heteromalla	·	1	+	·	·	1	·	+	·	·	·	+	r	·	·	r	+	·	·	·	·	·	·	·	·
Quercus robur juv.	·	·	·	·	r	·	+	r	r	·	·	·	·	·	1	·	·	+	·	+	·	·	·	·	·
Betula pendula juv.	+		+	r	·	r	·	·	r	+	·	·	·	·	·	·	·	·	r	+	·	·	·	·	·
Dicranum scoparium	·	·	·	·	·	+	·	+	·	·	+	·	·	·	·	·	·	r	·	·	+	·	·	·	·
Campylopus flexuosus	·	·	·	·	·	·	1	·	1	r	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
D2 (Diff. Piceo-Vaccinienion):																									
Polytrichum commune	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	3	2	1
Oxycoccus palustris	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	3	3
Eriophorum vaginatum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	r	·
Sphagnum magellanicum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	2
Pinus rotundata tr.	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Melampyrum paludosum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Drosera rotundifolia	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1
d1 (subass. cladonietosum, a var.1):																									
Cladonia fimbriata	2	2	1	r	r	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia gracilis	+	r	+	r	r	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·
Cladonia arbuscula	·	·	r	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·
Cladonia coniocraea	·	r	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·
Cladonia chlorophaea	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia squamosa	·	·	·	·	r	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cladonia rangiferina	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Cladonia pyxidata	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
a 2 (variant with Rubus):																									
Rubus fruticosus coll.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	·	·	·	·	·	·	·	·	·
Equisetum sylvaticum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	1	·	·	·	·	·	·	·	·
Oxalis acetosella	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	·	·	·	·	·	·	·	·
d2 (subass. molinietosum)																									
Molinia arundinacea	r	·	·	·	·	·	·	·	·	·	·	·	·	·	5	4	1	1	·	·	·	3	·	4	+
Pteridium aquilinum	·	·	·	·	·	·	·	·	·	·	r	·	·	·	1	3	2	2	+	·	·	4	2	2	·
Sphagnum nemoreum	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	4	5	5	3	·	·	·	·
Betula pubescens shr.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	+	+	·	·	1	·	·
Betula pubescens juv.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	+	·	r	r
Betula pubescens tr.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	1	·	·
Bazzania trilobata	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	·	·	+	·	·	·	·
Sphagnum palustre	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3	·	·	·	·	3	·	3	·
Sphagnum recurvum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	1	3	·	·
Dicranodontium denudatum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·

Tab. 2 - continued

Column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Differential species initial phase)																									
Calluna vulgaris	3	3	3	r	4	1	3	2	2	1	1	+•	.	+	.	.	.	.	+	+	.	.	.	r	+
Betula pendula tr.	3	3	2	3	.	.	.	.	1	2	2	.	+	.	1	.	.	.	.	+	+	.	.	.	.
Betula pendula shr.	2	+	.	1	.	.	1	+	.	1	1	.	.	r	.	.	.	.	.	1	r	.	.	.	.
All.- Cl. Vaccinio-Piceetea:																									
Vaccinium myrtillus	.	2	1	4	+	3	2	2	4	4	3	r	4	5	1	.	2	5	2	4	3	3	2	1	.
Vaccinium vitis-idaea	.	.	.	.	2	+	.	.	.	.	1	.	1	r	.	.	r	.	3	+	1	+	r	+	+
Picea abies juv.	.	.	.	r	.	r	+	+	.	+	+	r	.	.	.	r	.	.	.	+	.	.	.	r	.
Picea abies shr.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	+	+	2	+	.	+	.	.	+	1	+
Picea abies tr.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	1	+	.	.	.	.	1	+	.
Sphagnum girgensohnii	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.	+	.	.
Companion species:																									
Pinus sylvestris tr.	2	.	1	+	2	3	3	3	3	3	2	4	3	4	3	4	3	4	2	2	3	4	3	3	.
Pinus sylvestris shr.	2	+	1	.	+	1	2	1	.	r	1	+•	+	.	.	.	r	1	+	+	4	+	.	2	.
Frangula alnus shr.	.	2	2	+	.	.	+	.	.	.	.	.	.	2	.	1	3	2	+	.	2	4	2	2	.
Sorbus aucuparia shr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	r	r	r	.	.	+	.	.	.
Pinus strobus juv.	.	.	.	.	.	r	r	+	.	r	r	.	.	.	.	.	.	.	.	r	+	.	.	.	.
Frangula alnus juv.	.	+	+	+	.	r	.	r	.	.	r	+	+	.	+	.	+	.	+	.	.	+	r	r	r
Sorbus aucuparia juv.	.	+	.	+	.	.	.	.	.	.	r	.	.	1	.	2	r	.	.	.	.	.	1	.	.
Abies alba juv.	.	.	.	.	.	.	r	r	r	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.
Pinus sylvestris juv.	+	r	+	.	r	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Pinus strobus shr.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	.	.	.	.	r	r	.	.	.	.	.
Melampyrum p. commutatum	.	.	.	r	.	.	.	+	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Abies alba shr.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Quercus rubra juv.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia flexuosa	r	.	.	r	.	.	+	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Carex pilulifera	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Abies alba tr.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Quercus robur tr.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alnus glutinosa tr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Alnus glutinosa shr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
Phragmites australis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Polygonatum verticillat.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Anemone nemorosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Dryopteris carthusiana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Peucedanum palustre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Lysimachia vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Potentilla erecta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Carex brizoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Carex echinata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Climacium dendroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	1
Maianthemum bifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Juniperus communis shr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Juncus effusus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Carex elata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Agrostis capillaris	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
mosses, fungi:																									
Pleurozium schreberi	r	1	1	2	3	1	3	2	3	4	3	1	3	3	+	+	r	1	+	1	+	r	.	r	.
Polytrichum juniperinum	-	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hylocomium splendens	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plagiothecium curvifol.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Brachythecium rutabulum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Plagiomnium cuspidatum	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Eurhynchium striatum	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Thuidium tamariscinum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Scleroderma vulgare	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
																		r	.	.	.	.	.	.	.

Syntaxa:

Dicrano-Pinenion:
Column 1 - 21: Leucobryo-Pinetum

1 - 6: Leucobryo-Pinetum cladonietosum

7 - 14: Leucobryo-Pinetum typicum
7 - 11: " " " initial phase

15 - 21: Leucobryo-Pinetum molinietosum
15 - 20: " " " typical variant
21: " " " variant with Cladonia

Piceo-Vaccinienion uliginosi:
Column 22 - 24: Vaccinio uliginosi--Pinetum sylvestris

abbreviations: juv. = juvenile
shr. = shrub
tr. = tree

3. The *Leucobryo-Pinetum* from provinces 1 and 2 in a synoptical comparison

The synthetical tab. 3 shows the exact syntaxonomical division as it results from the original tables from province 1 and 2. To elucidate the ecological limits of the *Leucobryo-Pinetum* we supplemented relevés from the *Pyrolo-Pinetum* (All. *Cytiso ruthenici-Pinion* KRAUSCH 1962, Cl. *Pulsatillo-Pinetea* OBERD. 1962) on the one hand, and from the *Vaccinio uliginosi-Pinetum sylvestris* on the other hand.

The floristic analysis of our relevé material leads naturally to a classification in three classical subassociations as described by MATUSZKIEWICZ (1962). These subassociations are also mentioned by SEIBERT (1988) in the new edition of the "Süddeutsche Pflanzengesellschaften" (OBERDORFER 1992).

3.1. *Leucobryo-Pinetum typicum*

The centre of *Leucobryo-Pinetum* is represented by the subassociation *typicum* MATUSZKIEWICZ 1962. Within this subassociation our material shows significant differences between province 1 and 2. The typical variant that represents the centre of the association is only recognized in province 2 with its extremely oligotrophic soils. The character species, *Leucobryum glaucum*, shows an optimal growth in this variant. A second characteristic of the typical variant of the *Leucobryo-Pinetum typicum* in the "Vorderer Bayerischer Wald" is a successive transition of the species combination to the subassociation *L.-P. molinietosum*. Especially *Sphagnum nemoreum*, *Frangula alnus* and - as a geographical speciality - *Pinus rotundata* overlap from *the L.-P. molinietosum*. On the other hand *Dicranum spurium* and *Ptilidium ciliare* are absent in the relevés of the *Leucobryo-Pinetum typicum* in province 2. In province 1 (incl. Siegenburg and Kallmünz) they have their optimum in the subassociation *L.-P. cladonietosum*, and overlap into the subassociation *L.-P. typicum*. Also MATUSZKIEWICZ (1962) mentions in his original description, that *Dicranum spurium* and *Ptilidium ciliare* are mostly concentrated on the dryest sector of the *Leucobryo-Pinetum* ("*cladonietosum*"). The given examples (*Sphagnum nemoreum* on the one hand, *Dicranum spurium* and *Ptilidium ciliare* on the other hand) represent good floristic indicators for the different climatic situation of the compared provinces.

The pine-stands of the *Leucobryo-Pinetum typicum* in province 1 ("Vorland Mittlere Frankenalb") belong to the variant with *Festuca ovina*. In this variant *Leucobryum glaucum* shows only a low abundance, whereas more pretentious mosses, especially *Hylocomium splendens* show high abundance and dominance. A very similar floristic composition (except for some geographical differential taxa) described KUROWSKI (1976) from Lasow near Łódź (Central Poland) as "*Leucobryo-Pinetum typicum*, typical variant, subvariant with *Festuca ovina*". Our recognized variant with *Festuca* shows a close relationship to the *Pyrolo-Pinetum* (LIBBERT 1933) E. SCHMID 1936 (= *Peucedano-Pinetum* MATUSZK. 1962). There is a group of differential species both in the variant and in the *Pyrolo-Pinetum*, as the comparison in the synoptic table and in the following figure shows. For the calculation in Tab. 3 we used each one relevé from Maign, Siegenburg and Kallmünz.

Tab. 3: Similarity coefficients of species content (SÖRENSEN (1948))
Maign: ***Leucobryo-Pinetum cladonietosum***
Siegenburg: ***Leucobryo-Pinetum typicum,*** variant with ***Festuca***
Kallmünz: ***Pyrolo-Pinetum typicum***

		Maign	Siegenburg	Kallmünz
L. - P. cladonietosum	(1)	-	75 %	41.4 %
L. - P. typicum, variant with *Festuca*	(1)	75 %	-	62.2 %
Pyrolo -Pinetum typicum	(1)	41.4 %	62.2 %	-

The Sörensen-coefficient is calculated as follows:

$$Ss = \frac{2c}{a + b + 2c} \cdot 100$$

a = quantity of species, which are resticted to sample 1
b = quantity of species, which are restricted to sample 2
c = quantitiy of common species in sample 1 and 2

3.2. *Leucobryo-Pinetum cladonietosum*

The *Leucobryo-Pinetum cladonietosum* shows significant differences between province 1 and province 2, too. According to the climatic conditions it is no surprise, that this subassociation with regard to its species diversity is optimally developed in province 1. First it is suspicious, that *Cladonia furcata* and *Cetraria islandica* are concentrated on the *Cladonia*-subassociation in the province 1 and are absent from province 2 (above we directed attention to the absence of *Dicranum spurium* and *Ptilidium ciliare*). The circumstance that the species combination of lichens in the peat-moss dominated stands of the *Leucobryo-Pinetum* is mostly reduced to *Cladonia rangiferina* and *arbuscula*. The latter species combination yet belongs to the subassociation *molinietosum* (column 8 in Table 4).

3.3. *Leucobryo-Pinetum molinietosum*

The third subassociation we recognized was the *Leucobryo-Pinetum molinietosum*. This subassociation grows on a soil with a high ground water level. This subassociation was only recognized in province 2. The name-giving genus *Molinia* (in the place of research *Molinia arundinacea* SCHRANK, in other regions also *Molinia caerulea*, e.g. AUGUSTIN (1990)) is in our relevé table not restricted on this subassociation and grows also in the *Piceo-Vaccinienion uliginosi*. The same condition is demonstrated by further differential taxa, *Betula pubescens* and *Pteridium aquilinum*. More fined to the subassociation, thus the most loyal differential species in the place of research, are the mosses *Sphagnum nemoreum* and *Bazzania trilobata*. For other differential species look relevé table 2. The common growth of *Leucobryum glaucum, Sphagnum nemoreum* and *Cladonia arbuscula* in the variant with *Cladonia* (column 7 in Tab. 4) is also a typical phenomenon in dry heather bogs (e.g. *Sphagnetum magellanici cladonietosum arbusculae* DIERSS. apud OBERD. 1977). In our relevé tables *Molinia* shows only a scanty growing in this variant. Not exclusively in the table demonstrated is a variant with *Rubus fruticosus* coll. within the subassociation *molinietosum*. This

Tab. 4. The subassociation of the *Leucobryo-Pinetum* and comparison with related associations in a synoptic table (shortened: species with low constancy are not considered)

column	1	2	3	4	5	6	7	8	9
		L e u c o b r y o - P i n e t u m							
communities	A	B1		B2	C1	C2	D1	D2	E
number of relevés	1	1	17	8	9	6	1	6	4
average number of species	33	23	15	14	18	15	20	20	15
Ch + Diff. A-K1:									
Cytisus ratisbonensis	1^2	·	·	·	·	·	·	·	·
Orthilia secunda	1^+	·	·	·	·	·	·	·	·
Chimaphila umbellata	1^1	·	·	·	·	·	·	·	·
Lembotropis nigricans	1^+	·	·	·	·	·	·	·	·
Goodyera repens	1^+	·	·	·	·	·	·	·	·
Diff. var. 1:									
Hylocomium splendens	1^1	1^3	V	·	IV	·	·	·	·
Festuca ovina s.str.	1^+	1^1	III	·	II	·	·	·	·
Eurhynchium striatum	·	·	III	·	III	·	·	·	·
Epilobium angustifolium	·	1^+	r	·	1	·	·	·	·
Hieracium murorum	1^1	·	II	·	·	·	·	·	·
Festuca trachyphylla	1^3	1^+	·	·	·	·	·	·	·
d subass., d var.:									
Cladonia fimbriata	·	·	·	·	IV	V	·	·	·
Cladonia gracilis	·	·	·	·	II	V	1^r	·	·
Cladonia arbuscula	·	·	·	·	IV	III	1^1	·	·
Cladonia coniocraea	·	·	·	·	·	II	1^r	·	·
Cladonia chlorophaea	·	·	·	·	·	II	·	·	·
Cladonia squamosa	·	·	·	·	II	II	·	·	·
Cladonia rangiferina	·	·	·	·	V	·	1^+	·	·
Cladonia pyxidata	·	·	·	·	I	II	·	·	·
Cladonia furcata	1^+	·	·	·	V	·	·	·	·
Cetraria islandica	·	·	·	·	II	·	·	·	·
Diff.SA Dicrano-Pinenion:									
Dicranum polysetum	1^+	1^2	V	V	V	V	1^r	IV	·
Leucobyrum glaucum	.	1^1	r	V	III	V	1^1	IV	·
Hypnum jutlandicum	1^3	1^3	IV	IV	V	II	·	V	·
Quercus robur juv.	·	1^1	IV	II	IV	I	·	III	·
Polytrichum formosum	1^+	1^2	·	II	r	I	1^r	IV	·
Dicranella heteromalla	·	·	·	II	·	III	1^+	II	·
Betula pendula	1^r	·	V	II	·	V	1^+	II	·
Dicranum scoparium	·	1^+	r	II	·	I	1^+	I	·
Campylopus flexuosus	·	1^+	I	III	III	·	·	·	·
Dicranum spurium	·	1^+	I	·	III	·	·	·	·
Diff. subass. 3:									
Sphagnum nemoreum	·	·	·	·	·	I+	1^3	IV	·
Bazzania trilobata	·	·	·	·	·	·	1^+	II	·
Dicranodontium denudatum	·	·	·	·	·	·	·	II	·
Rubus fruticosus coll.	·	·	·	·	·	·	·	II	·
Equisetum sylvaticum	·	·	·	·	·	·	·	II	·
Oxalis acetosella	·	·	·	·	·	·	·	II	·

Tab. 4. - continued

column	1	2	3	4	5	6	7	8	9
Indicators for damp and wetness:									
Molinia arundinacea	·	·	·	·	·	I	·	IV	IV
Pteridium aquilinum	·	·	·	I	·	·	·	V	IV
Betula pubescens	·	·	·	·	·	·	1^{+}	IV	II
Sphagnum palustre	·	·	·	·	·	·	·	I	III
Sphagnum recurvum	·	·	·	·	·	·	·	I	III
Diff. SA Piceo-Vaccinenion:									
Polytrichum commune	·	·	·	·	·	·	·	·	V
Oxycoccus palustris	·	·	·	·	·	·	·	·	IV
Eriophorum vaginatum	·	·	·	·	·	·	·	·	III
Sphagnum magellanicum	·	·	·	·	·	·	·	·	II
Pinus rotundata	·	·	·	I	·	·	·	·	II
Melampyrum paludosum	·	·	·	·	·	·	·	·	II
Drosera rotundifolia	·	·	·	·	·	·	·	·	II
A - Cl. Vaccinio-Piceetea:									
Vaccinium myrtillus	1^{2}	1^{3}	V	V	V	V	1^{3}	V	IV
Vaccinium vitis-idaea	1^{+}	1^{3}	V	III	V	II	1^{1}	III	V
Picea abies	1^{+}	1^{+}	II	IV	·	II	·	V	IV
Sphagnum girgensohnii	·	·	·	I	·	·	·	I	II
Viscum album * austriacum	v	·	III	·	·	·	·	·	·
Monotropa h. * hypopitys	·	·	r	·	·	·	·	·	·
Companion species:									
Pinus sylvestris	1^{4}	1^{4}	V	V	V	V	1^{5}	V	IV
Pleurozium schreberi	1^{+}	1^{3}	V	V	V	V	1^{+}	V	III
Calluna vulgaris	·	1^{1}	V	V	V	V	·	II	III
Deschampsia flexuosa	1^{1}	1^{1}	V	I	V	II	·	·	·
Frangula alnus	·	1^{+}	·	IV	·	IV	1^{2}	V	V
Sorbus aucuparia	·	·	II	·	·	II	·	V	II
Pinus strobus	·	·	·	III	·	I	1^{+}	II	·
Melampyrum pratense	·	·	IV	II	V	I	·	·	·
Abies alba	·	·	·	IV	·	·	1^{r}	I	·
Quercus rubra	·	·	I	II	·	·	·	I	·
Luzula multiflora	·	·	II	·	·	·	·	·	·

communities:

A: Pyrolo-Pinetum (Libbert 1933) E. Schmid 1936
B: Leucobryo-Pinetum typicum Matuskiewicz 1962
   B1: variant with Festuca ovina
   B2: typical variant
C: Leucobryo-Pinetum cladonietosum Matuszkiewicz 1962
   C1: variant with Festuca ovina
   C2: typical variant
D: Leucobryo-Pinetum molinietosum Matuszkiewicz 1962
   D1: variant with Cladonia
   D2: typical variant
E: Vaccinio uliginosi-Pinetum sylvestris (de Kleist 1929) Matuszkiewicz 1962

variant grows on the contrary to the variant of *Cladonia* on rich slope feets and has a greater production of biomass (look co. 14 + 15 in Table 2). The synoptic table shows a close relationship from the *Leucobryo-Pinetum molinietosum* to the *Vaccinio uliginosi-Pinetum sylvestris*. The demonstrated relevé samples of the later association represent only a fragmentary development of an isolated occurence outside its closed area. Not only *Ledum palustre*, a very significant species in the centre of the natural area of the *Vaccinio uliginosi-Pinetum* is absent, but also *Vaccinium uliginosum*. For that the occurrence of *Pinus rotundata* gives a pre-alpine note and signals relationship to the *Vaccinio uliginosi-Pinetum rotundatae* OBERDORFER 1934 em. SEIBERT in OBERDORFER 1992.

As the given examples show, the systematical diversity of the *Leucobryo-Pinetum* and its ecological amplitude in the southwestern border area is as big as in the centre of the area. All the from MATUSZKIEWICZ (1962) in his origin discription for the european continent mentioned subassociations (*cladonietosum, typicum* and *molinietosum*) can be identified in our region.

4. Synecology

All syntaxa are related to specific environmental conditions. In the above text we described already the modifications in the species combination implied by climate. In this chapter we'll especially consider the physico-chemical properties of soils for the qualitative development of the *Leucobryo-Pinetum*. Therefore we investigated three relevé samples:

- *Leucobryo-Pinetum cladonietosum* ("Vorderer Bayerischer Wald": Maign),
- *Leucobryo-Pinetum typicum*, variant with *Festuca* (Donau-Isar-Hügelland: Siegenburg),

  and for comparison with the *Leucobryo-Pinetum*
- *Pyrolo-Pinetum typicum* (Mittlere Frankenalb: Kallmünz).

For these examples we give informations to the most significant soil conditions (terms according to SCHROEDER 1984) like

- the pore volume
- the water capacity
- the air capacity,
- the soil pH
- the nutrient supply.

After that, we'll comput the indicator values according to ELLENBERG et al. (1991) and give a summary for the ascertained relationship between the environmental factors and the qualitative development of the pine forests.

4.1. Significant soil conditions

The geological parent material is different for each investigated example. Common is the soil texture (mainly sand with different parts of silt and clay). Because of its pedogenesis (weathering of autochthonous parent material) Maign shows the highest part of silt and clay. In both localities with allochthone blown sand (Siegenburg and Kallmünz) the part of sand amounts to more than 90 %, in the dune walls even more

than 93 % weight of the Fine earth. According to the pedogenesis Skeletal material in form of gravel (not drifted by wind) is restricted on Maign. The soil texture determines the water regime. Also under this aspect Maign shows the best water supply. The dune sands show the lowest field capacity. The air capacity is very good in each of the investigated examples (both sands from autochthone weathering and blown sands).

Tab. 5: total soil volume in % (PV, SV)

Abbreviations:

AC = Air capacity
AWC = Available water capacity
FC = Field capacity
PV = total Pore volume
SV = Substancial volume

textural soil classes according to the German system:

c = coarse
m = medium
f = fine
S,s = Sand, sandy
l = loamy
u = silty
t = clayey

	depth in cm	Soil Texture	Equivalent diameter µm >2000	>630	>200	>63	Σsum Silt	Σsum Clay	Σ SV	AWC	FC	AC	Σ PV
Maign	8	u'csmS	5	12	20	7	9	1	54	13	20	26	46
	17-21	u'csmS	14	11	15	6	7	1	54	13	20	26	46
	35-39	l'csmS	9	12	14	7	9	3	54	13	19	27	46
	60-70	l'csmS	9	12	21	6	4	2	54	13	19	27	46
Siegenburg	8-11	msfS	0	0	21	31	1	1	54	11	18	28	46
	11-18	msfS	0	0	21	31	1	1	54	11	18	28	46
	50-60	fsmS	0	0	30	28	0	1	59	8	12	29	41
Kallmünz	3-5	mS	0	4	43	8	3	0	58	8	12	30	42
	10-20	mS	0	5	41	8	2	2	58	8	12	30	42
	20-40	t'csmS	1	11	33	4	3	3	55	11	19	26	45
	40-60	csmS	0	11	39	4	1	2	57	6	11	32	43
	80-90	mS	2	7	42	5	1	1	58	8	12	30	42

The analyse of the soil pH is very significant for the qualitative development of the pine-forests on sandy soils. Principally the soil pH has lower values in the *Leucobryo-Pinetum*, higher values in the *Pyrolo-Pinetum*. This concerns especially the mineral soil. The highest value we measured in the *Leucobryo-Pinetum* reached pH 5,0 (significantly in the variant with *Festuca*), in the *Pyrolo-Pinetum* the soil pH increased to 6,35. The average pH in the organic layer shows the same value. Especially values in the KCl solution confirm an evident difference between the *Leucobryo-Pinetum* and the *Pyrolo-Pinetum*.

Also interesting are different relationships between the pH values measured in water and in KCl solution. For example of the *Leucobryo-Pinetum* the values approximate from soil surface to bottom (indeed Siegenburg shows a distinct difference of pH in water and KCl solution, but less than one pH unit). On the contrary in the *Pyrolo-Pinetum* the difference between the pH values measured in water and KCl solution increases from the surface to the bottom until more than one pH unit. This fact proves, that in the *Pyrolo-Pinetum* the supply with mineral nutrients as well as the Buffering is more favourable.

Tab. 6. Total pore volume (PV), available water capacity (AWC), field capacity (FC), air capacity (AC) in mm/horzion according to "AG Bodenkunde" (1982), soil pH in H_20 und KCl and P-provision.

Abbreviations Soil Texture (German system):

c	= coarse	S,s	= Sand, sandy
m	= medium	u	= silty
f	= fine	t	= clayey

	depth in cm	Soil Texture	AWC	FC	AC	PV	Soil pH in H_2O	Soil pH in KCl	H_2O-KCl	mg P/100g soil
Maign							3.6	2.5	1.1	27.2
	8	u'csmS	7	10	13	23	4.15	2.9	1.25	7.5
	17-21	u'csmS	23	36	47	83	4.5	3.7	0.8	3.4
	35-39	l'csmS	33	47	68	115	5.0	4.8	0.2	0.0
	60-70	l'csmS	42	61	86	147	4.7	4.6	0.1	1.5
Σvolume			105	154	214	368				
Siegenburg							3.3	2.8	0.5	21.8
	8-11	msfS	3	5	9	14	3.9	3.05	0.85	5.8
	11-18	msfS	8	12	20	32	4.05	3.4	0.65	2.3
	50-60	fsmS	54	84	203	287	5.0	4.1	0.9	6.3
Σvolume			65	101	232	333				
Kallmünz							3.9	3.1	0.8	78.7
	3-5	ms	3	5	12	17	3.85	3.2	0.65	8.2
	10-20	ms	9	13	33	46	5.4	4.45	0.95	23.6
	20-40	t'csmS	22	38	52	90	5.7	4.7	1.0	21.9
	40-60	csmS	12	22	64	86	5.9	5.15	0.75	14.9
	80-90	mS	20	30	75	105	6.35	5.25	1.1	11.3
Σvolume			66	108	236	344				

With the soil pH the nutrient supply correlates: in the *Pyrolo-Pinetum* there is a better nutrient supply then in the *Leucobryo-Pinetum*. The highest content of water soluble P is stored in the organic layer on the soil surface, whereas the maximum in the *Pyrolo-Pinetum* shows a five times higher amount as in the *Leucobryo-Pinetum*. In the mineral matter the differences are not as distinct as in the organic matter, but it's the same relationship. Generally the B_w horizon contains less P than the A_h horizon with exception of Kallmünz, where the profile is built up from different layers of a relictic soil formed by landslide and solifluction.

Also in the pedogenetic classification of the soil types there are differences between the *Leucobryo-Pinetum* and the *Pyrolo-Pinetum*.

Under the Pine forests of the *Leucobryo-Pinetum* in Maign we found an iron-Podzol (B_s ep. B_{fe} very strong). On the contrary under the Pine-forests in Siegenburg (L.-P., variant with *Festuca*) and Kallmünz (*Pyrolo-Pinetum*) we recognized a Brown earth, of course a degradated one (with blanched A_{he} horizon).

4.2. Indicator values according to ELLENBERG et al. (1991)

For the three named pine stands (Maign, Siegenburg and Kallmünz) we ascertained the following indicator values according to ELLENBERG et al. (1991):

Tab. 7. Indicator values according to ELLENBERG et al. (1991) relevé samples: **Maign:** ***Leucobryo-Pinetum cladonietosum*****, Siegenburg:** ***Leucobryo-Pinetum typicum*****,** variant with ***Festuca*****, Kallmünz:** ***Pyrolo-Pinetum typicum.***
Values transformed according to DURWEN (1982): Braun-Blanquet: r + 1 2 3 4 5
multiplier: 1 2 3 4 6 8 10

	Maign	Siegenburg	Kallmünz
L = light	6.0	5.6	5.8
T = temperature	3.5	3.5	4.5
K = continentality	4.4	5.3	4.8
F = moisture	4.1	4.2	4.0
R = reaction	2.0	2.6	3.9
N = nitrogen	1.3	2.7	3.4

The ascertained values lead to the following interpretation:

- Because of the poor biomass production on the primary oligotraphic substrate the pine forests in Maign are particularly permeable to light, which is indicated by the highest L-value.
- The comparatively cool and humid climate in Maign is expressed as well in low T- as in low K-values.
- Both the acidity and the unfavourable nutrient supply lead to the lowest R- and N-values for the *Leucobryo-Pinetum* in Maign. On the contrary the R- and N-values show for the *Pyrolo-Pinetum* in Kallmünz, growing on blown sand overlying limestone, significantly the highest values.
- Only the F-values seem at first to indicate no clearly significance in relationship to the ascertained ecological factors: In spite of cool and humid climate, in spite of the soil texture with the best water economy and in spite of a northern exposure there are no increased F-values for Maign in comparison with the other relevé! But this circumstance becomes understandable in coherence with the unfavourable conditions of nutrition in Maign. On the acid and oligotrophic substrate of a mainly siliceous parent material (low in Ca and Mg) the plants develop a dense network of roots in the layer of raw humus. In times of deficiency the plants will quickly deprive the water of the organic layer. The nutrient supply is evidently the minimum factor for the occurrence in Maign. Principally a minimum factor leads to the fact, that the same plant community becomes more pretentious against the water supply ("Gesetz der relativen Standortskonstanz", H. & E. WALTER (1953)). First, this stipulates the fact that the species combination of the *Leucobryo-Pinetum* in Maign indicates no increased F-value in comparison with the other relevé samples. Secondly, it accounts for the replacement of beech-forests by pine-forests and mixed fir-forests.

5. Concluding remarks to the naturalness of the investigated pine forests

Finally a few words to the degree of naturalness of the investigated pine forests of the *Leucobryo-Pinetum sylvestris*.

Because of the edaphic, climatic and floristic diagnoses we presume, that only the *Leucobryo-Pinetum* on the poorest soils in province 2 is at least partially identical with the potential natural vegetation. In this province the *Leucobryo-Pinetum* has its purest quality (typicum, typical variant) and a rich diversity (*cladonietosum, typicum, molinietosum*). But this is not the case of all the occurrences. Some of them are obviously only substitute communities of the potentially natural *Vaccinio-Abietetum* OBERDORFER 1957. In the complex of Pine forests in province 2 also the *Vaccinio uliginosi-Pinetum sylvestris* may represent the potential natural vegetation, although fragmentarily developed on the edge of its natural area (on the location without *Vaccinium uliginosum* and *Ledum palustre*).

On the contrary, *Festuca*-variants of the *Leucobryo-Pinetum* in province 1 has to be presumed exclusively as a man-made substitute community of a potential naturally *Vaccinio-Abietetum*, in Siegenburg (outside the submontane race) of a mixed Oak-forest (*Vaccinio vitis-idaeae-Quercetum* OBERDORFER 1957 (= *Pino-Quercetum* REINHARD (1939) 1944 p.p.). The variants with *Festuca* are also in an overregional context the most distributed subunits of the *Leucobryo-Pinetum*. This circumstance is very significant, because also in the area centre in Poland nearly all occurences of the *Leucobryo-Pinetum* are considered man-made degradation stages of mixed forests (especially the *Vaccinio-vitis-idaeae-Quercetum*). For example JAKUBOWSKA-GABARA (1992) shows in a table of relevés from Puszca Marianska Reserve, the degradation from a *Vaccinio-vitis-idaeae-Quercetum* to a *Leucobryo-Pinetum*, variant with *Festuca ovina*. On the contrary the occurrences of the typical variants are exceptional also in Poland.

Pyrolo-Pinetum described from the "Mittlere Frankenalb" presented in Table 3 is probably a substitute community of the *Carici-Fagetum pyroletosum* MOOR 1952 as described from KÜNNE (1969). According to our observations in Poland there exist nearly no natural occurrences of the *Pyrolo-Pinetum* (= *Peucedano-Pinetum*). In the area centre of North-eastern Poland we suppose mostly the *Tilio cordatae-Carpinetum betuli* TRACZYK 1962 in the subassociation *calamagrostietosum arundinaceae* as the potential natural vegetation. Again JAKUBOWSKA-GABARA (1992) elucidates in a table of relevés for Puscza Marianska the degradation phases of the *Tilio-Carpinetum calamagrostietosum* characterized by an increase of *Pinus sylvestris* and *Vaccinium myrtillus*. In the subboreal nuanced region of Puscza Kurpiowska it seems, that the *Vaccinio-Piceion* (occurrences with oak and spruce) represents the potential natural vegetation of a *Pyrolo-Pinetum cladonietosum* (subboreal race). This is a similar situation to the supposed development from the *Leucobryo-Pinetum* (submontane race) to the *Vaccinio-Abietetum* in eastern Bavaria.

Summary

The pine forests of the *Leucobryo-Pinetum* growing on sandy soils, which are permeable to the water, can nevertheless be classified as "xerothermic vegetation".

Those pine stands in the place of research, which give the impression of the most natural stands grow comparatively in the pine forest region with the highest precipitation, the coolest climate and on the soils with the best water supply. Neither dryness nor heat are the ecological factors, which exclude decidous forests, but the lack of nutrients is the decisive minimum factor. On the contrary to xerophilous and thermophilous communities of Pine forests in the research area like the *Cytiso nigricantis-Pinetum* BR.-BL. 1932 and the *Erico-Pinetum* BR.-BL. in BR.-BL. et al. 1939 the *Leucobryo-Pinetum* has to be classified as an oligotrophic vegetation, depending primarily on an extremely unfavourable nutrient supply.

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