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Test and application of a vegetation-based CO_2 and CH_4 flux estimate from three ombrogenic and topogenic peatlands in Southern Germany

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Independent project in Biology, Masterthesis
Environmental Science- Soil, Water and Biodiversity
Uppsala / Stuttgart-Hohenheim, December 2010
Examensarbete 2010:19

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Credits: 30 hec
Level: E-level
Course title: Independent project in Biology – Master thesis
Course code: EX0565
Programme/education: Environmental Science- Soil, Water and Biodiversity

Place of publication: Uppsala, Sweden/ Stuttgart-Hohenheim, Germany
Year of publication: 2010
Picture Cover: *Drosera rotundifolia* on *Sphagnum* mosses in the raised bog 'Gründlenried'
ISBN: 978-91-576-9015-9
Online publication: http://stud.epsilon.slu.se

Key Words: greengouse gas, GEST, peatland

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Abstract

A stabilisation and restoration of peatlands is seen as a sustainable strategie for climate change mitigation. To find the most suitable target areas, greenhouse gas fluxes have to be quantified. A vegetation-based flux estimate is seen as cost-effective alternative to avoid time consuming and expensive flux measurements. The present study aims to define current obstacles and limitations to a vegetation-based flux estimate and define a possible scope for vegetation-based flux estimates in Baden-Württemberg. A case study was performed in three ombrogenic and topogenic mires in Southern Germany using the tools Greenhouse Gas Emission Site Type (GEST) for non-forest sites and IPCC's 'Good Practise Guidance for Land Use, Land Use Change and Forestry' (GPG-LULUCF) for forest sites. The study was limited to carbon dioxide (CO_2) and methane (CH_4) fluxes, shown as CO_2 equivalents (CO_2e). Based on 115 vegetation relevés, three vegetation classification systems on non-forest sites 'vegetation forms', 'phytosociological plant communities' and 'Biotope types of Baden-Württemberg' were compared to test if they can replace each other in a flux estimate. Calculation parameters for forest-sites were chosen for the study area. A greenhouse gas balance was established for the study area. The reviewed vegetation classification systems showed inconsistent overlaps. Hence, the vegetation classification systems were considered to be not completely compatible. As descripition of vegetation forms was considered to be insufficient for Southern Germany, an application of vegetation-based CO_2 and CH_4 flux estimates was considered to be difficult in Baden-Württemberg. Mean CO_2 and CH_4 emissions of 9,7 t CO_2e ha^{-1} yr^{-1} were estimated in the study area. Emissions from forested peat were smaller than from mire and from grassland on peat. However, the selection of parameters for GPG-LULUCF and associated inaccuracies influenced the estimate. Footpaths and roads, watercourses and lakes, pastures, cropland and clearcut were not considered and N_2O emissions were excluded from the estimate. Considering these limitations of the estimate, vegetation-based carbon estimates should be verified and refined before a statewide application.

Acknowledgements

Many people supported me during the time of my thesis. I want to thank

my supervisor Prof. Dr. rer. nat. Reinhard Böcker, Universität Hohenheim, who supported the phytosociological classification, the identification of vascular plants and who was always open to any kind of questions.

my supervisor Dr. Peter Eliasson, Swedish University of Agricultural Sciences, who supported me in all questions concerning the carbon cycle and forests and helped me to sort out all administrational issues. Special thanks for reading my draft and giving helpful feedback on my work.

Prof. Göran Ågren, Swedish University of Agricultural Sciences, for reviewing my work.

Dr. Markus Röhl, Institute of Applied Research Nürtingen, for suggesting the topic of this thesis.

Dr. Ingo Holz, Universität Hohenheim, for his support in the identification of moss species.

Dr. Björn Schäfer, Universität Hohenheim, for giving feedback on my work.

my friends Julia Sauer and Katrin Wuchter for reviewing my draft and supporting me in all matters during the time of thesis writing.

my husband Martin Weber, who diligently checked my vegetation tables and supported me all the time.

This thesis was performed within the scope of the regional peatland development project (Regionales Moorentwicklungskonzept), Institute of Applied Research in Nürtingen.

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Abbreviations

AONB	Area of Outstanding Natural Beauty
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalents
EC Habitats Directive	EC Council directive 92/43/eec of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
GEST	Greenhouse Gas Emission Site Type
GHB_{100}	Greenhouse gas balance for the time frame of 100 years
IAF	Institute of Applied Research Nürtingen
n	Sample number
N_2O	Nitrous oxide
SAC	Special Area of Conservation according to EC Council directive 92/43/eec of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

1 Introduction

Since the adoption of the Kyoto Protocol, greenhouse gas emissions are a topic that raises concern on a global scale. Besides typical anthropogenic carbon emitters like traffic, industrial processing and agriculture, there exist various carbon sources and sinks also in nature. Intact peatlands are considered to be carbon sinks, because they accumulated carbon in the form of peat for millenia. Drained peatlands are considered to be a carbon source.

The most important greenhouse gases in the climate discussion are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Greenhouse gases in the atmosphere trap heat, that otherwise would be radiated back to space. They therefore cause a slow warming of the atmosphere. CO_2 is one of the most important greenhouse gases, because it has a residence time of ca. 100 years in the atmosphere, which is especially critical as emissions accumulate (EEA 2005). Considering a time span of 100 years, CH_4 has a 21 times stronger impact on climate than the same amount of CO_2 (SOLOMON et al. 2007).

Generally, atmospheric CO_2 is one of the fundamental raw materials in plant's photosynthesis. Plants take up the carbon in CO_2 and assimilate it into their structure. Some of the organic matter of living plants is consumed by herbivores that exhale the carbon in the form of CO_2 back to the atmosphere. However, most of the organic carbon assimilated by plants is transferred to the soil when parts of plant tissue are renewed, die and fall off and is then decomposed by aerobic soil organisms that also respire CO_2. However, when there is a shortage of oxygen in intact, wet peatlands, anaerobic organisms can exist in the absence of oxygen. They produce CH_4 instead of CO_2 when they consume organic carbon. In an intact, wet mire, the major amount of CH_4 produced by anaerobic organisms does not reach the atmosphere, because in ascending to the surface CH_4 oxidation starts where oxygen is present near the water surface. Peat mosses can build up large stocks of carbon as long as their productivity is higher than the consumption by decomposers. Therefore intact peatlands are considered to be moderate carbon sinks having accumulated large amounts of carbon over long time. If the water table is lowered soil condition switches from anaerobic to aerobic, enabling aerobic organisms to colonise and start decomposing organic carbon in the peat. Hence, the consumption of organic carbon (peat) by soil organisms will increase after drainage and they will release more carbon (loss of CO_2) to the atmosphere exceeding the growth of the plants (uptake of CO_2). Therefore drained peatlands are expected to become carbon sources.

According to the German soil classification system, peatlands are defined as soils with a 30 cm deep peat horizon containing more than 30% organic matter (SCHEFFER & SCHACHTSCHABEL 1979). There are approximately 1.300.000 ha peatlands in Germany. More than 80 % of those have been converted into agriculture and approximately 2% are used for peat production (BYRNE et al. 2004). In the federal state of Baden-Württemberg there are ca. 60.000 ha peatlands (LFU 2001).

A stabilisation and restoration of peatlands is seen as a sustainable strategie for peat preservation and climate protection (UMMV 2009, NEUFELDT 2005). The Institute of Applied Research in Nürtingen (IAF), that kindly suggested the topic of this thesis, combines nature and climate protection with social and technical purposes in its regional peatland development project (Regionales Moorentwicklungskonzept). The case study aims to prioritise peatland sites that are especially suitable for restoration. In the priorisation process, the potential biodiversity and greenhouse gas fluxes as well as the technical possibilities for restoration and social factors like ownership are considered. However, as the four factors have to be weighted against each other, they have to be quantified.

Currently, the most common methods to quantify greenhouse gas fluxes are measurements by chamber method or eddy covariance method (BYRNE et al. 2004). As they are very time consuming and expensive there is a demand for cost effective, easy and fast methods to estimate the source and sink function of peatlands. JOOSTEN & COUWENBERG 2009 describe three cost efficient, but less accurate alternatives: (1) water table monitoring, because the water table controls aerobic or anaerobic conditions in the soil and therefore the peat decomposition rate, (2) peat subsidence monitoring as indicator for the decomposition rate of peat, (3) vegetation monitoring, because the vegetation cover depends among others on the water table and the water table controls the decomposition of peat.

For vegetation monitoring COUWENBERG et al. 2008 introduce a concept called Greenhouse Gas Emission Site Type (GEST) for the carbon flux estimate of CO_2 and CH_4 from non-forest peatland vegetation. N_2O efflux and flux estimates on forest sites are not included in GEST. In the development of GEST 130 CH_4 flux measurements and 53 CO_2 flux measurements were evaluated and correlated with the composition of the vegetation cover. To apply the developed GESTs in the field, the vegetation has to be mapped at the scale 1:2500 as so called ‘vegetation forms’, a classification system mainly applied in northeastern Germany. In GEST, emissions are shown as greenhouse gas balance within a time frame of 100 years (GHB_{100}). GHB_{100} is the amount of CH_4 and CO_2 emitted or sequestered by a peatland vegetation type, quantified in CO_2 equivalents (CO_2e) for a time frame of 100 years. CO_2e is the sum of CH_4 multiplied by the factor 21 (see above, SOLOMON et al. 2007) and CO_2.

The development of a vegetation-based quantification of greenhouse gas efflux from afforested peatlands is uncertain, as there are only few CO_2 and CH_4 flux measurements from peatland soils with stands of forest trees (e.g. VON ARNOLD 2005a-c, JUNGKUNST 2004 and others). Measurements of the net ecosystem exchange (NEE) of forest ecosystems are currently infrequent. They are performed with expensive eddy covariance towers. Hence, correlations between reliable greenhouse gas flux measurements and forest vegetation as used in the GEST concept are not feasible. However, the carbon uptake in terms of productivity of forest trees minus the loss of organic soil can indicate if an afforested peatland is a carbon source or a sink. The method for flux estimates of forests considering the above relations used in this study is provided by the International Panel on Climate Change and its “Good Practice Guidance for Land Use, Land-Use Change and Forestry” (GPG-LULUCF, PENMAN et al. 2003) for national greenhouse gas inventories.

This thesis aims to test the applicability of a vegetation-based quantification of greenhouse gas efflux from peatlands in a sample area in Southern Germany by defining obstacles and limitations

(1) of the applied methods.

(2) to adjustments of the IPCC’s GPG-LULUCF parameters (PENMAN et al. 2003) to a sample area.

Furthermore it will be tested, if the vegetation classification used in GEST (‘vegetation forms’) may be replaced by a nationally accepted classification system in Germany (phytosociology according to Braun-Blanquet’) or vegetation classification applied in the federal state of Baden-Württemberg (‘Biotope types of Baden-Württemberg’) and upcoming obstacles and limitations will be defined.

Finally a possible scope for a vegetation-based greenhouse gas flux estimate from peatlands in the federal state of Baden-Württemberg will be described.

2 State of the Art

2.1 Vegetation classification systems

The vegetation classification systems ‘vegetation form concept’, ‘phytosociological system according to Braun-Blanquet’ and ‘Biotope types of Baden-Württemberg’ are explained in the following paragraphs. Vegetation forms are the basic vegetation unit applied in the GEST concept (see chapter 2.2). The phytosociological system is a classification system used in central Europe to describe stereotype species combinations. Biotope types of Baden-Württemberg are an uniform, standard vegetation mapping tool in the federal state of Baden-Württemberg. The systems vary in the definition and delimitation of plant communities as well as in the nomenclature. It would be useful to apply the regionally most common vegetation classification system to simplify the application of GEST. Time and money could be saved, if the most common classification system was used, because the period of vocational adjustment would reduce. However, the phytosociological system according to Braun-Blanquet or Biotope types of Baden-Württemberg could only replace vegetation forms as basic mapping unit, if the classification of the plant communities in the single systems would be in the range of the classification of GEST. In comparing the different classifications in a study area, inconsistencies between the systems can be defined.

2.1.1 Vegetation form concept

The vegetation form concept was developed in Eastern Germany and mainly applied for site characterisation on forestland and in agriculture (KOSKA et al. 2004). Initially, vegetation forms were developed for bioindication and as basis for a physiographic division. Therefore, a vegetation form is defined as a vegetation type that represents clearly a distinct combination of site conditions in a macroclimatically uniform region. Every vegetation form is defined by ecological-sociological species groups. These species groups are distinguished from each other by the statistically significant high mutual abundance of species in a group. Species within one group can substitute each other, because the group reflects the ecological amplitude of the group members. Different vegetation forms are distinguished from each other by the abundance or lack of species groups. The abundance or dominance of single species however is of minor importance (SUCCOW & JOOSTEN 2001).

The published species groups can be used to sort a vegetation table and to assign the vegetation form. However, not all ecological-sociological species groups have to be abundant on a site, but every vegetation form has to be represented by several constantly present species groups. The basic methodology for data handling is, like in some other vegetation classification systems, based on ELLENBERG 1956. Generally the work with vegetation relevés and vegetation tables precedes the description of vegetation forms. Each vegetation form is named after one to three important species (SUCCOW & JOOSTEN 2001).

2.1.2 Phytosociological system according to Braun-Blanquet

In the phytosociological system according to Braun-Blanquet, plant communities (called associations) are defined as regular, stereotype species combinations, that can be distinguished from other vegetation types by character species and differential species (DIERSCHKE 1994).

The basic unit in phytosociology is the association as described above. Associations are summarised to a hierarchical system in inductive steps, where a different ending denotes each level. Associations (ending –etum) are summarised to alliances (ending –ion), alliances to orders (ending -etalia) and orders to classes (ending -etea). The appendix ‘community’ is used in combination with species names, if there are low rank species combinations without distinct character species (DIERSCHKE 1994).

The phytosociological system according to Braun-Blanquet is based on the principle, that all vegetation surveys have to relate to floristical units that can clearly be distinguished from each other. Only in this way the results are reproducible. Similar to the vegetation form concept, phytosociology according to Braun-Blanquet works with floristical comparison of vegetation relevés in vegetation tables (DIERSCHKE 1994).

It has to be emphasized that in the last decades incountable descriptions of associations just for Germany have been produced. There are discussions on the existence of various described associations. Hence, phytosociology is a hierarchical system, but the single units are not static. Transitions and deviations from the standard are normal.

2.1.3 Biotope types of Baden-Württemberg

The Biotope types of Baden-Württemberg were developed as a statewide, uniform mapping system. It provides standard mapping parameters to gather nature conservation information like abundance and dispersal of species or land use type and intensity. The reference system for all surveys of the nature conservation authorities in the federal state of Baden-Württemberg is the standard mapping key for Biotope types (LUBW 2009).

The mapping key is structured hierarchically. A project-specific accuracy can be chosen. Furthermore, the hierarchically higher and therefore more extensive notation can be used in case of doubt. All Biotope types are denoted with a name and a hierarchical number code. Biotopes are defined as parts of a landscape that can be distinguished from its surroundings by the vegetation type or the landscape ecology. A Biotope type however is a summary of congeneric biotopes (LUBW 2009).

All Biotope types of Baden-Württemberg and their identification parameters are described in LUBW 2009.

2.2 The GEST-Concept

The GEST concept (Greenhouse Gas Emission Site Type concept) tries to determine the GHB_{100} of drained and natural peatlands. It was created as an instrument to quantify the success of rewatering measures in peatlands and is based on the assumption, that peatland drainage causes decomposition of organic carbon- and nitrogen stocks. Hence, carbon and nitrogen are released to the atmosphere as CO_2, CH_4 and N_2O. Rewatering of peatlands rises the water level and therefore decreases the peat decomposition (and CO_2 and N_2O emission). Production and release of CH_4 is closely related to the status of the water table. CH_4 is produced under anaerobic conditions in the ground water and rewatering can lead to large quantities of CH_4 release (see Table 1).

To avoid very complex and expensive gas flux measurements, the GEST concept is based on the assumption that greenhouse gas emission values depend on site parameters as reflected by the composition of vegetation.

COUWENBERG et al. 2008 evaluated 130 emission measurements for CH_4, 53 for CO_2 and 84 for N_2O from Europe. As N_2O emissions were found to decrease in an unpredictable magnitude while rewatering and this was evaluated as a general success of rewatering mesures, COUWENBERG et al. 2008 finally decided to omit N_2O emissions in the GEST concept, because the actual magnitude of N_2O seemed to be neglectable.

However, a strong correlation between greenhouse gas emission values and annual median water level could be detected. Table 1 shows, that if the water level is below –20 cm, the GHB_{100} is mainly due to CO_2 emissions. If water levels are above –20 cm there are mainly CH_4 emissions.

GHB_{100} of peatland vegetation types combining CO_2 and CH_4 emissions is related to the water level as shown in Table 2. In this context, GHB_{100} is the expected amount of CH_4 and CO_2 emitted by a peatland vegetation type. It is quantified in CO_2e for a time frame of 100 years.

COUWENBERG et al. 2008 relate the water level classes to vegetation forms. Depending on the water level class, vegetation forms with comparable environmental settings are summarized to GESTs that have a distinct GHB_{100}. The so derived GESTs can be used to predict CO_2-carbon and CH_4-carbon efflux or uptake from vegetation (see chapter 5.3.1).

Table 1: Annual median water level, water level class and emission values for CO_2 and CH_4, COUWENBERG et al. 2008 and SUCCOW & JOOSTEN 2001

<table>
<tr><th>Median water level per year</th><th>Water level class</th><th>Emission class CO_2</th><th>Emission class CH_4</th></tr>
<tr><td>Ca. > 80 cm under soil surface</td><td>2-</td><td rowspan="3">High CO_2 emission
> 20 t CO_2 ha^{-1} yr^{-1}</td><td rowspan="5">Hardly any CH_4 emission</td></tr>
<tr><td>Ca. 45-80 cm under soil surface</td><td>2+</td></tr>
<tr><td>Ca. 45-80 cm under soil surface, strongly varying</td><td>2~</td></tr>
<tr><td>Varying water table between 45-80 cm and 20-45 cm under soil surface</td><td>3+/2+</td><td rowspan="3">Mean CO_2 emission
10-15 t CO_2 ha^{-1} yr^{-1}</td></tr>
<tr><td>Ca. 20-45 cm under soil surface</td><td>3+</td></tr>
<tr><td>Varying water table between 20-45 cm and 0-20 cm under soil surface</td><td>4+/3+</td><td rowspan="3">Mean CH_4 emission</td></tr>
<tr><td>Ca. 0-20 cm under soil surface</td><td>4+</td><td>Mean CO_2 emission
10 t CO_2 ha^{-1} yr^{-1}</td></tr>
<tr><td>Varying water table between 0-20 cm under soil surface and 140-20 cm over soil surface</td><td>5+/4+</td><td rowspan="2">Low CO_2 emission
< 3 t CO_2 ha^{-1} yr^{-1}</td></tr>
<tr><td>Ca. 20-0 cm over soil surface</td><td>5+</td><td>High CH_4 emission</td></tr>
<tr><td>Ca. 140-20 cm over soil surface</td><td>6+</td><td>No measurements available</td><td>Low CH_4 emission</td></tr>
</table>

Table 2: GHB_{100} range for different water levels with a 95% and a 70% propability respectively, COUWENBERG et al. 2008

Waterlevel class	95% propability		70% propability	
	GHB_{100} higher than	GHB_{100} lower than	GHB_{100} higher than	GHB_{100} lower than
2+	20	25	23	25
3+/2+, 3+, 4+/3+	8	22	10	18
4+	5	12	6	10
5+/4+	-5	5	-3	2
5+	-5	18	-2	8

3 Study area

3.1 Size and location

The study area is located in the federal state of Baden-Württemberg in Southern Germany. It is situated in the county of Ravensburg and consists of three subareas: Herrgottsried in the north, parts of Gründlenried in the centre and the eastern part of Arrisrieder Moos in the south (Fig. 1). The total study area is 436,5 ha, that belong to the municipalities Bad Wurzach, Leutkirch i.A. and Kißlegg (Fig. 1). The study area was delimited according to peatlands reported by GÖTTLICH 1968 and 1971. In detail, the subareas are situated as follows:

a) Herrgottsried

The study site "Herrgottsried" with a size of 199 ha is situated ca. 2 km south of the city of Bad Wurzach between the villages Gospoldshofen, Bauhofen and Truschwende. Its elevation above sea level is between ca. 641 m in the southeast and ca. 650 m in the northeast.

b) Gründlenried

The study site "Gründlenried" is located ca. 2 km north of the city of Kißlegg. The part of the Gründlenried that was included in the study area is delimited by the villages Rahmhaus and Neurötsee in the north, the road between Neurötsee and Hasenfeld in the east, the river Moosbach in the south and the river Gründlenach in the west. The subarea Gründlenried is 166 ha. The elevation above sea level ranges from ca. 643 m to ca. 653 m.

c) Arrisrieder Moos

Arrisrieder Moos is located ca. 3 km south of the city of Kißlegg. Due to nature protection reasons, only the area east of the main drainage channel of Arrisrieder Moos was included in the study area. This 71,5 ha large area is elevated between ca. 645 m and ca. 650 m above sea level.

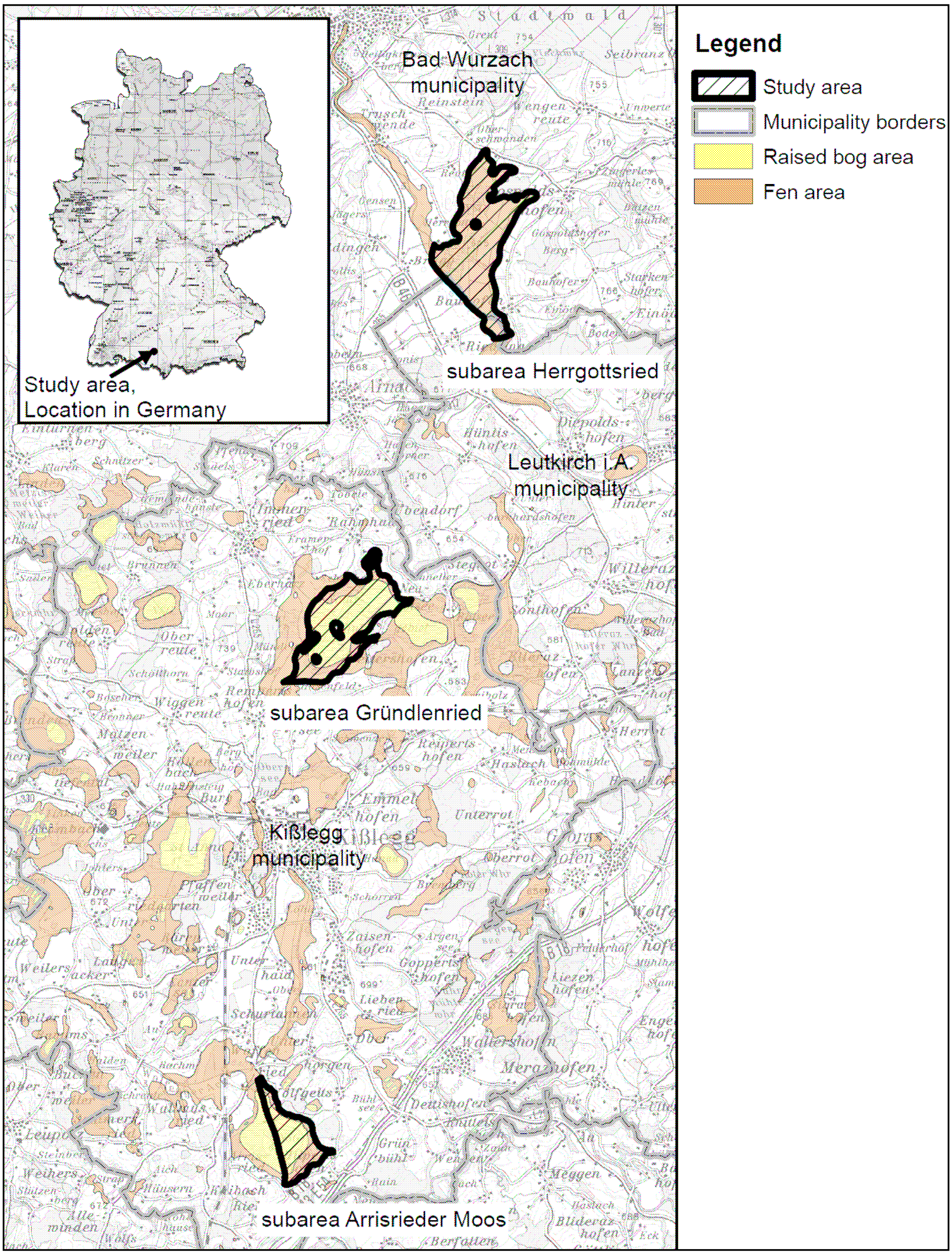


Fig. 1: Location of the study area in Germany (without scale) and location of the three subareas Herrgottsried, Gründlenried und Arrisrieder Moos, peatlands and municipality borders, scale 1:100.000. Map based on BUNDESAMT FÜR KARTOGRAPHIE UND GEODÄSIE 2009, LANDESAMT FÜR GEOINFORMATION UND LANDESENTWICKLUNG 2005 and GÖTTLICH 1968, 1971.

3.2 Physiographic division

Physiographic units are geographical areas with distinct relief, vegetation, geology and climate. Depending on the given scale, Germany can be divided into four first-order physiographic units and 6 second-order physiographic units, while the study area is situated in the ‘Alpenvorland’ region (LUBW 2010).

In detail, Herrgottsried is located in the macrochore ‘Donau-Iller-Lech-Platte’ (unit no. 04) in the subunit ‘Riß-Aitrach-Platten’ (unit no. 041). The unit is delimited southwards by the terminal moraine of the Würm glaciation and its broad drainages and northwards by the moraines from former glacial periods (MEYNEN & SCHMITHÜSEN 1953).

Gründlenried and Arrisrieder Moos are in the macrochore ‘Voralpines Hügel- und Moorland’ (unit no. 03) in the subunit ‘Westallgäuer Hügellland’ (unit no. 033). The morphology of the area is mainly due to the sedimentations of the Rhine-glacier in the last glacial period. Important elements of the landscape are the remains of the terminal moraines from the last glacial period. Especially in the study area low drumlins, numerous lakes and depressions with fens and reeds can be found (MEYNEN & SCHMITHÜSEN 1953).

3.3 Protection status

All three subareas are at least partly protected as Special Area of Conservation (SAC) by EC Council directive 92/43/eec of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive). Herrgottsried belongs to SAC no. DE8026341 ‘Aitrach und Herrgottsried’, while Gründlenried and Arrisrieder Moos are part of SAC no. DE8225341 ‘Weiher und Moore um Kißlegg’. The share of the designated SACs in the total size of each subarea is shown in Table 3.

Table 3: Share of Special Area of Conservation (SAC), Nature Reserves and Areas of Outstanding Natural Beauty (AONB) in the study area, shown in ha and in percentage of the respective subarea. Overlap of SAC, Nature Reserve and AONB are possible.

	Total area	**SAC**		**Nature Reserve**		**AONB**	
	ha	**ha**	**%**	**ha**	**%**	**ha**	**%**
Herrgottsried	199	67,7	34	68,9	34,6	79,1	39,8
Gründlenried	166	156,1	94	156,6	94,3	9	5,4
Arrisrieder Moos	71,5	58,2	82	58,4	82,25	13	18,3

Parts of Herrgottsried, Gründlenried and Arrisrieder Moos are protected as Nature Reserve according to § 23 and as Area of Outstanding Natural Beauty according to § 26 in Germany's National Nature Protection Act (Bundesnaturschutzgesetz (BNatSchG), enacted 01.03.2010) and in § 26 (Nature Reserve) and § 29 (AONB) of the federal state's Nature Protection Act (Naturschutzgesetz Baden-Württemberg (NatSchG), enacted 13.12.2005, latest amendment 17.12.2009), see Table 3.

Additionally, parts of the study area are protected habitats according to § 32 of the federal state's Nature Protection Act (NatSchG) and § 30 a of the federal state's Forestry Act (Waldgesetz für Baden-Württemberg (LWaldG), enacted 31.08.1995, latest amendment 10.11.2009).

3.4 Climate

The Alpenvorland region is characterised by a cool and moist climate. Due to the rising elevation above sea level and the diminishing distance to the Alps from north to south, there is a clear gradient in temperature and precipitation. Mean annual temperature decreases from north to south, while mean annual precipitation rises.

However, in the study area the climate can be considered as homogenous, because the distance between the subareas is comparably short and microclimate and morphological settings supersede the general trend. Fig. 2 shows, that Herrgottsried, Gründlenried and Arrisrieder Moos possess cold winters and medium warm summers with maximum precipitation in summertime.

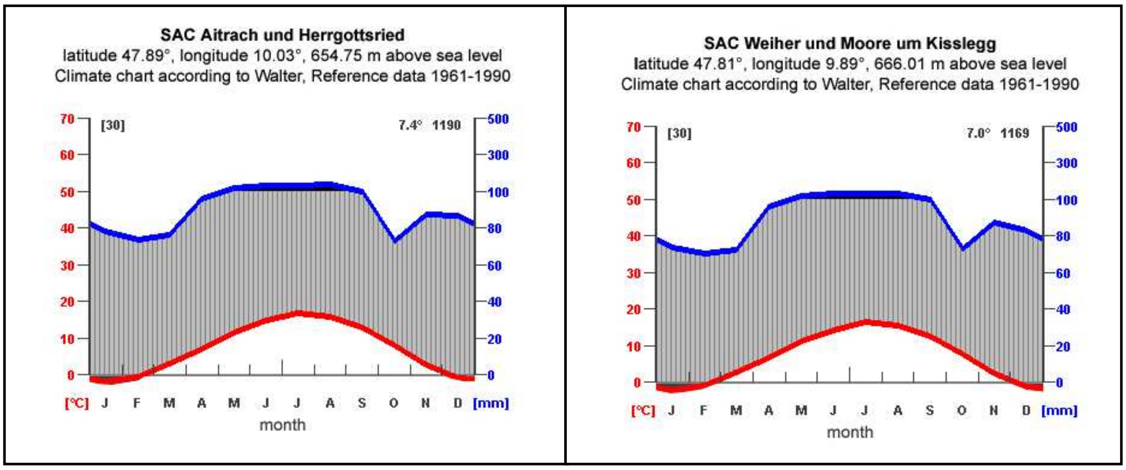


Fig. 2: Climate charts according to Walter for Herrgottsried (SAC 'Aitrach und Herrgottsried'), Gründlenried and Arrisrieder Moos (SAC 'Weiher und Moore um Kißlegg'). Average values for a 30 year period from 1961 till 1990. Upper line: mean precipitation in mm, lower line: mean temperature in °C. (POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH 2010a, b, translated)

Mean annual temperature in the study area is between 7° C and 7,4° C and mean annual precipitation is between 1169 and 1190 mm. The maximum temperature in the period from 1961 till 1990 was 36,05° C, the absolute minimum temperature –25,8° C. Juli is the warmest month and January is the coldest month respectively. Daily temperature fluctuations of 8,3° C to 9,1° C are common. The climatic water balance (balance of precipitation and potential evaporation) shows an all year water surplus between 20 and 80 mm per month in the study area. (POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH 2010a, b)

3.5 Bedrock and soil

For the location of fen peat and raised bog peat see Fig. 1, p.10. The nomenclature fen peat and raised bog peat is related to their development. Fen peat is exposed to ground water; whereas raised bog peat develops in ombrogenic environments.

a) Herrgottsried

The peatlands of Herrgottsried are holocene fen peat aggregations, that are embedded between tertiary sediments from the miocene (‘Obere Süßwassermolasse’), quartenary sediments from the Riss-glaciation and the glacifluviatile sediments along the river Wurzacher Ach (BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE et al.1991).

The peat formation starts above coarse-grained bedrock with a nearly complete layer of peat mud (‘Torfmudde’) or sedimentary peat (‘Schwemmtorf’). Above these allochthonous peats and muds there is mainly sedge and sedge-reed-peat. There are a few depressions, where the peat depth is up to 450 cm. All peat layers are enriched with clay deposits. Bulk density of peat layers and decomposition is low due to a strong diffused discharge of groundwater (GÖTTLICH 1968).

b) Gründlenried

The holocene fen peat and raised bog peat aggregations of Gründlenried developed in a depression on glacial moraine sediments from the Würm-glaciation in the Pleistocene (BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE et al.1991). Relicts of the underground mineral bedrock can still be seen in the mineral peaks ‘Burgstall’ in the centre of the subarea and

'Volkenbühl' in the north of the subarea. The mineral peaks are excluded from the study.

Peat depth is up to 10 m in the raised bog area in the northern Gründlenried. A drill in the middle of the northern half of subarea Gründlenried shows the following soil profile (Table 4):

Table 4: Soil profile in the Gründlenried subarea (GÖTTLICH 1968)

Depth	**Peat type**
0-60 cm	Living peat moss (*Sphagnum* spec.)
60-80 cm	*Sphagnum-Eriophorum*-peat with twigs
80-200 cm	*Eriophorum-Sphagum*-peat
200-250 cm	Twig-*Eriophorum*-peat with moss
250-300 cm	Sedge-reed-peat with twigs
300-380 cm	Reed-sedge-peat
380-450cm	Moss-sedge-peat
450-490 cm	Moss peat
490 cm +	Clay mud

In the middle of subarea Gründlenried, east of the mineral island 'Burgstall', there is 300 cm of raised bog peat and 30 cm of peat mud above sandy clay (GÖTTLICH 1968). Further detailed information on the soil parameters of Gründlenried can be found in BLOCH 1996.

c) Arrisrieder Moos

Arrisrieder Moos consists of holocene fen peat and central raised bog peat aggregations that are incorporated into the landscape of pleistocene moraine sediments from the Würm-glaciation (BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE et al.1991).

The peat formation of Arrisrieder Moor startet without siltation processes only by paludification on the Würm-glaciation ground moraine. A drill up to 350 cm showed the layer from bottom to top as follows: coarse-grained clay, sedge-moss-peat, sedge- and reed-sedge-peat, *Scheuchzeria-Eriophorum*-peat, *Sphagum*-peat with *Scheuchzeria.* In the raised bog area peat was cut with machines and by hand. Relicts of this land use can be seen in remaining, up to four meter high peat walls in the raised bog area (GÖTTLICH 1971).

3.6 Groundwater and watercourses

a) Herrgottsried

The minerotrophic fen Herrgottsried is northwards adjacent to the river Wurzacher Ach. Main watercourses in the area are the streams Vögelesgraben and Gospoldshofener Bach, which cross Herrgottsried from north to south and open out into the Wurzacher Ach.

b) Gründlenried

Along the eastern border of the Gründlenried subarea the European Watershed is placed. Hence, Gründlenried subarea belongs to the drainage system of the river Rhine. Receiving streams are Moosbach in the south and Gründlenach and Immenrieder Ach in the west of the subarea.

A geomorphological speciality is the Gründlenried underground drainage system. Approximately in the middle of the raised bog area, there are two funnel like depression, called “Großes Schlucklock” and “Kleines Schluckloch”, where drainage water percolates to an underground tunnel system. The seepage water leaves the underground system in the south of the Gründlenried subarea (see BLOCH 1996).

c) Arrisrieder Moos

The ombrogenic raised bog of Arrisrieder Moos has been subject to drainage since 1935 (GEMEINDE KIßLEGG / ARBEITSGEMEINSCHAFT HEIMATPFLEGE IM WÜRTTEMBERG. ALLGÄU E.V. 2010). Therefore a regular pattern of drainage ditches crosses the central core. To stop further drainage, deep ditches were blocked in 1983 and initiated a rewetting of parts of the central raised bog core (REGIERUNGSPRÄSIDIUM TÜBINGEN 2006).

3.7 Historical land use and current vegetation structure

a) Herrgottsried

The northern area of Herrgottsried was used for peat cutting before the Second World War. In the southern area peat-dust was extracted, causing small, only a few m² wide depressions (METZ 1989). Herrgottsried was an open meadow landscape with shrub islands until around 1960. Most of the meadows were used as nutrient poor, moist litter meadows. Many were transformed later on into more intensively used grasslands (REGIERUNGSPRÄSIDIUM TÜBINGEN 2006). Reeds used to be cut in wintertime for litter.

Nowadays the vegetation is a mosaic of litter meadows, moist meadows and nutrient rich, intensively cut meadows in the periphery of Herrgottsried. Sedge fens, reeds and carr can be found in the central peat-cut areas. There are forest on drier spots. The fringe areas are mainly used as intensively fertilised and cut meadows.

b) Gründlenried

Most of Gründlenried`s raised bog area stayed untouched from land use. Former peatcuts that are currently regenerating can be found in small parts in the western subarea. The fen areas in the periphery of the subarea were used as litter meadows. Many of them were later transformed into nutrient rich meadows and pastures by fertilisation (REGIERUNGSPRÄSIDIUM TÜBINGEN 2006).

The current vegetation structure consists of large bog woodlands in the raised bog area, interrupted by three open raised bog areas with typical hummock and bog hollow structure. In the former peat-cut areas in the western periphery a mixture of intact, regenerating and degraded raised bog vegetation can be found. The fringe area with its fen peats is a mosaic of fragmentary low sedge fens and litter meadows, as well as intensively used meadows and pastures.

c) Arrisrieder Moos

Since 1805 peat was cut by the sovereignity Waldburg in Arrisrieder Moos. In the year 1908 the annual amount of cut peat was 1500 m³, mainly produced for heating. A peat work was founded in 1914 in the southern subarea. The central raised bog area was systematically drained since 1935. Peat-cutting was stopped in 1960 and some of the main drainage ditches were blocked in 1983 to stop further desiccation. Heather and meadow sites in the fringe area were used for litter production (REGIERUNGSPRÄSIDIUM TÜBINGEN 2006).

Today, Arrisrieder Moos is a mosaic of regenerating bog vegetation, heather moor and bog woodland. Litter meadows and intensively used meadows can be found in the fringe areas. Succession woodland is growing on former peat-cuts. Spruce forests are common on dry spots.

4 Materials and Methods

4.1 Selection of study area

For the selection of the study area a predefined region, currently subject to a regional peatland restoration project performed by IAF, was set. The IAF project area consists of all peatlands of the Kißlegg municipality and some small adjacent peatlands of the municipalities Wolfegg, Bad Wurzach, Leutkirch i.A., Wangen i.A. and Vogt.

For this thesis three peatlands were chosen according to the following criteria:

- The subareas had to be more or less equally distributed in the study area
- The subareas had to be representative for the land use and Biotope types in the IAF project area.
- The subareas had to be areas of statewide importance (e.g. Nature Reserve).

4.2 Assessment of non-forest sites

4.2.1 Data collection

The vegetation survey was conducted between 15th June 2010 and 15th August 2010. As basis for the identification of GESTs and phytosociological plant communities, 115 vegetation relevés were taken according to BRAUN-BLANQUET (1964). The selection of sample sites was biased. Only species compositions representative for the study area or especially rare species compositions were chosen. The relevés were preferably located in the middle of a vegetation plot that was structurally and ecologically homogenous. A plot size of 16 m² was chosen for meadows, heather and pastures (DIERSCHKE 1994) and also for raised bogs, reeds and sedge fens due to practical reasons. The relevés were located by visual assessment and marked on an aerial picture, scale 1:2.500. In the raised bog areas of Gründlenried, a handheld GPS-receiver (Garmin eTrex VISTA) was used to identify the position. The utilised coordinate system was German Grid, Gauß-Krüger-Sytem, Potsdam datum. The altitude was estimated from a topographical map, scale 1:25.000. However, altitude was considered to be neglectable in the further working process and was therefore not shown.

In the sample plots all plant species were identified and recorded separately as tree, shrub, herb and moss layer. Height and cover were estimated for each layer. For each species in the relevé the cover was estimated with the cover-abundance scale according to REICHELT & WILMANNS 1973 and transformed according to ELLENBERG et al. 2001, extended (Table 5).

Table 5: Cover-abundance scale according to REICHELT & WILMANNS 1973 and transformation according to ELLENBERG et al. 2001, extended.

Total estimate	Cover	Abundance	Transformation
r	-	1 individual	0,1
+	< 5%	2-5 individuals	0,2
1	< 5%	6- 50 individuals	2,5
2m	< 5 %	> 50 individuals	4
2a	5-15%		10
2b	16-25%		20
3	26-50%		37,5
4	51-75%		62,5
5	76-100%		87,5

The vegetation type was delimited in an aerial picture, scale 1:2.500, where no sample was taken. Those vegetation types were defined according to COUWENBERG et. al. 2008 or by taking note of the main species and subsequent identification. A digital photograph documented vegetation types for all plots.

4.2.2 Data evaluation

a) Identification of GESTs, vegetation forms, phytosociological plant communities and Biotope types in the study area

All vegetation relevés were entered into the software package VEGSTORE (DIRK et al. 2001) for the compilation of vegetation tables. Presence tables and sorted vegetation tables were processed with Microsoft Excel.

Mean quantitative Ellenberg indicator values (ELLENBERG et al. 2001) of the herb layer were calculated for most relevés with VEGSTORE using the transformation value for the cover-abundance scale shown in Table 5. For the relevés of raised bog vegetation (appendix 5: Tab. 3) no mean quantitative Ellenberg indicator values were calculated.

The position of the relevés and the vegetation types were digitised in ArcGIS 9 by ESRI™, using components ArcMap Version 9.3.1 and ArcCatalog Version

9.3.1. Base maps, digital aerial pictures and area specific information was kindly provided by IAF Nürtingen.

Vegetation was classified in vegetation forms as described in SUCCOW & JOOSTEN 2001, HUNDT & SUCCOW 1984, SUCCOW 1988 and COUWENBERG et al. 2008. The water level class described in the mentioned literature was derived for each vegetation form. Water level class was derived according to the species composition in cases where there was no specification available (especially for transition-, succesion- or fallow-communities). The corresponding GESTs were identified according to COUWENBERG et al. 2008. For vegetation forms and transition-, succesion- or fallow-communities where there was no explicit description in COUWENBERG et al. 2008, the corresponding GEST was estimated from the water level class and physiognomy of the community and comparison with the described vegetation forms.

Phytosociological communities were identified according to OBERDORFER 1992, 1993 and PASSARGE 1999.

Biotope types of Baden-Württemberg were derived according to LUBW 2009.

Each identified vegetation form and its phytosociological equivalent were described in a detailed text paragraph, because of its complexity. The more simple classification system Biotope types of Baden-Württemberg is only shown in Fig. 43 and Fig. 44.

4.2.3 Nomenclature of plant species and plant communities

The general nomenclature of plant species is shown in Table 6.

Table 6: Nomenclature of plant species

	nomenclature according to
Vascular plants, botanical name	SEBALD et al. (1990-1998)
Mosses, botanical name	NEBEL & PHILIPPI (2000-2005)
Vascular plants, english name	ZANDER et al. (2002)
Carex species, english name	JERMY et al. (2007)

Authors of the plant species are shown in the list of vascular plants and list of mosses in appendix 1 to assure a clear arrangement of the text. The treatment of taxonomically difficult species in this work is explained in appendix 2.

Vegetation forms are named according to SUCCOW & JOOSTEN 2001 and COUWENBERG et al. 2008 or in rare cases according to HUNDT & SUCCOW 1984 or SUCCOW 1988. The nomenclature of phytosociological plant communities is according to OBERDORFER 1992, 1993 and in special cases, which are highlighted as such, according to PASSARGE 1999.

Authors of phytosociological associations are shown in the list of described plant communities in appendix 3.

4.3 Assessment of forest sites

4.3.1 Data collection

Forest sites in the study area were distinguished from non-forest sites using an aerial picture, scale 1:2.500 during a vegetation survey between 15th June and 15th August 2010.

Forest type, approximated mean water level and stand age were gathered from a vegetation mapping provided by IAF Nürtingen. Where there was no information on stand age, sites were compared to the approximately 20 years old development plans of the nature reserve areas in Herrgottsried (METZ 1989), Gründlenried (NEUBAUER & WEIMERT 1990) and Arrisrieder Moos (DECHERT & DECHERT 1991). In this way it was possible to evaluate, if the sites were older or younger than 20 years. The IAF mapping was performed in summer 2010. Information was processed in ArcGIS 9.

Furthermore, forest management plans for Herrgottsried and Arrisrieder Moos (LANDRATSAMT RAVENSBURG 2010a, 2010b) were evaluated concerning the productivity of the stands.

4.3.2 Data evaluation

To simplify the estimates of CO_2 uptake by trees and the release of CO_2 and CH_4 from soils, forest data was classified into 20 groups. The groups are distinguished according to the factors water table depth, stand age, productivity and tree species.

Coniferous and deciduous forests were distinguished, because tree species is considered to be a major factor of biomass production (BERGER et al. 2010). Coniferous forest was defined as forest with ≥ 50% coniferous trees and deciduous forests containing ≥ 50% deciduous trees. *Picea abies* and *Pinus sylvestris* [often also *Pinus mugo* on peatlands] are important coniferous tree species in Southern German plantations (MLR 2010). They were treated as two different categories according to the predominant species in a stand. For deciduous trees the classes Natural deciduous forests on peatlands (short-lived specied like *Betula pendula, Salix* spec. and *Alnus glutinosa)* and *Salix*-shrub were introduced. Moreover mixed forests might occur containing nearly equal amounts of coniferous and deciduous species.

Furthermore, the forest sites were classified either wet sites (median water level higher than -20cm) or dry sites (median water level –20 cm to > -80 cm), because a median annual water level of -20 cm is seen as a critical threshold for CH_4 emissions in this thesis (see chapter 6.1.4).

Young tree's productivity differs from older individuals (BWI 2010a). Thus, two age classes, 0-20 and 20-100 (>20), were used for trees, based on the fact that forested land shows different emission pattern over time (e.g. SAIZ et al. 2006 and BALL et al. 2007).

4.4 Estimation of CO_2 and CH_4 flux

In the following chapters, the methodology for the CO_2 and CH_4 estimate from non-forest and forest sites is described. Net carbon efflux of a site is indicated by a positive value and uptake by a negative value.

4.4.1 Non-forest sites

To estimate the source and sink function of the identified vegetation forms, they were grouped into GESTs (COUWENBERG et al. 2008) based on vegetation and waterlevel class (SUCCOW & JOOSTEN 2001, see Table 7). The probable water level was derived from the given species composition in cases where there was no clear description in literature.

The GHB_{100} (t CO_2e ha^{-1} yr^{-1}) was attached to each GEST according to COUWENBERG et al. 2008 (Table 7). The emisson values were applied according to the proportion of the GESTs in the site in those cases where two GEST segments were too small (e.g. hummocks and bog hollows).

The measured surface area (A) of the categories was calculated with ArcGIS. The sum of the products of measured surface area (ha) * GHB_{100} (t CO_2e ha^{-1} yr^{-1}) provided the total GHB_{100} of non-forest sites (equation 1).

(1) $GHB_{100\ (total\ non\text{-}forest)} = \sum (A_1 * GHB_1)+(A_2 * GHB_2)+....+ (A_n * GHB_n)$

Table 7: GESTs (Couwenberg et al. 2008) and water level class according to Succow & Joosten 2001, translated

GEST	Waterlevel class	t CO_2e ha^{-1} yr^{-1}
Fen and bog grassland	2-, 2+, 2~	24
Fen and bog grassland	3+/2+, 3+	15
Fen and bog grassland	4+/3+	13
Fen and bog grassland	4+	8,5
Rewatered Fen and bog grassland	5+	1
Medium moist tall forbs and meadows	2-, 2+, 2~	24
Moist tall forbs and meadows	3+	16,5
Moist Calluna dwarf-shrub heath	3+	13
Moist bare peat	3+	10
Moist to very moist meadow	4+/3+	16,5
Very moist meadow, tall forbs and reeds	4+	11
Very moist Calluna dwarf-shrub heath	4+	9,5
Very moist Calluna dwarf-shrub heath with mud	4+	7
Very moist tall sedge fens	5+/4+	5
Very moist peat moss lawn	5+/4+	-1,5
Wet tall sedge fens	5+	7
Wet moss dominated low sedge swamp	5+	4
Wet low sedge swamps and tall sedge fens and reeds with moss layer	5+	12,5
Wet reeds	5+	10
Wet peat moss lawns	5+	3
Wet bog hollows	5+	8
Wet Polytrichum lawn	5+	2
Flooded reeds	6+	1

The anthropogenic site types ‘pasture’, ‘cropland, ‘footpaths and roads’ and ‘watercourses and lakes’ were excluded from the greenhouse gas estimates in this thesis.

4.4.2 Forest sites

IPCC’s “Good Practice Guidance for Land Use, Land-Use Change and Forestry” (Penman et al. 2003) was used for the estimation of carbon fluxes from forest sites.

The estimate presented here reflects only the current situation at the study site. Possible land use change is not included. Only CO_2 and CH_4 fluxes are considered in forests for consistenty with the GEST concept.

a) Calculation of CO_2 fluxes

The basis for annual CO_2 fluxes in forest stands on organic soils is the general equation (2) as given by Penman et al. 2003. Fluxes are calculated in t carbon per ha per year (t C ha^{-1} yr^{-1}) and transformed to CO_2-values. Denotation in the equations here differs slightly from those in PENMAN et al. 2003.

(2) $\Delta C_{Forest} = \Delta C_{living\ biomass} + \Delta C_{dead\ organic\ matter} + \Delta C_{soil\ organic\ matter}$

where:

- ΔC_{Forest} is the carbon flux to or from a forest ecosystem.
- $\Delta C_{living\ biomass}$ is defined as the annual change in all living biomass including above ground stem, stump, branches, bark, foliage/needles and forest understory as well as below ground roots.
- $\Delta C_{dead\ organic\ matter}$ is defined as the annual change in dead wood (non living woody biomass) and litter including fine roots (where they are not distiguishable from litter).
- $\Delta C_{soil\ organic\ matter}$ is defined as the annual change in organic carbon in the soil. In drained organic soils the estimated amount of carbon emission due to drainage is included in the calculation.

Step 1: Carbon in living biomass

The carbon pool in living biomass is mainly determined by the carbon increase due to biomass growth and the carbon decrease due to biomass loss (mortality and fellings), according to equation (3)

(3) $\Delta C_{living\ biomass} = \Delta C_{biomass\ growth} - \Delta C_{biomass\ loss}$

where the the growth of living biomass per year in an area A is determined by above ground and below ground biomass growth as in equation (4):

(4) $\Delta C_{living\ biomass} = [I_v * BEF_1 * D * (1+R) * CF * A]$

The above ground biomass growth is derived from wood production suitable for industrial processing (solid cubic meter stem wood) I_v, the wood density D and a biomass expansion factor BEF_1, that tranforms the annual net increment of wood I_v to aboveground annual tree biomass increment. In applying an appropriate root-shoot ratio R, the below ground living biomass is taken into consideration. The carbon fraction of dry matter (CF) finally leads to the amount of carbon in living biomass.

There was no wood extraction in Herrgottsried since 2006 according to the forestry office Ravensburg, branch office Leutkirch (e-mail from Stefan Laur, 6th August 2010). For Arrisrieder Moos and Gründlenried there was no sufficient information on the wood extraction. Therefore, the biomass loss due to fellings was not considered in the calculation. The equation presented by PENMAN et al.

2003 also includes a biomass loss by fuelwood gathering and carbon losses from disturbances like windstorms and fires. These factors were assumed to play a minor role and were not considered here.

The productivity I_v for the age class 0-20 years was provided by the German National Forest Inventory (BWI 2010a). For trees 20-100 years (>20) years the productivity was calculated from the forest management plans for Herrgottsried and Arrisrieder Moos (LANDRATSAMT RAVENSBURG 2010a, 2010b). The default values from PENMAN et al. 2003 were applied for the parameters BEF_1, D, CF and R. Area (A) was set to 1 ha.

Table 8: Parameters used in the calculation of Carbon in living biomass for fiveforest types in two age classes.

Factor	**Picea abies**		**Pinus sylvestris**		**Mixed**$^{a)}$		**Natural deciduous**		**Salix shrub**	
	0-20	**>20**	**0-20**	**>20**	**0-20**	**>20**	**0-20**	**>20**	**0-20**	**>20**
$\mathbf{I_v}$ (m^3 $ha^{-1}yr^{-1}$)	0,18	10	0,02	5	0,08	6,3	0,03	4	0,02	3
$\mathbf{BEF_1}$	1,15	1,15	1,05	1,05	1,13	1,13	1,2	1,2	1,2	1,2
D (t dry matter/ m³ fresh vol.)	0,4	0,4	0,42	0,42	0,43	0,43	0,47 $^{b)}$	0,47 $^{b)}$	0,45	0,45
R (t dry matter/ t dry matter)	0,32	0,32	0,32	0,32	0,35	0,3	0,43	0,26	0,43	0,26
CF	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
A(ha)	1	1	1	1	1	1	1	1	1	1

a) mean of Picea abies, Pinus sylvestris and Natural deciduous, b) mean of values *for Alnus, Betula* and *Salix* or value for short-lived trees

Step 2: Carbon in dead organic matter

The carbon pool of dead organic matter is controlled by the rates of carbon input of dead wood and litter and output of decay as described in equation (5).

(5) $\Delta C_{dead\ organic\ matter} = \Delta C_{dead\ wood} + \Delta C_{litter}$

The change in the dead wood carbon pool was calculated from dead wood input (DW_{in}) minus dead wood output. As the total dead wood carbon stock was not known, output was defined here by dead wood input * tree specific decay rate (dr) to account for the known fraction of carbon transfer. Here again the multiplication of the result with the carbon fraction in dry matter (CF) gave the amount carbon in the dead wood pool as shown in equation (6).

(6) $\Delta C_{dead\ organic\ matter} = (DW_{in} - (DW_{in} * dr)) * CF + \Delta C_{litter}$

The mean dead wood input (DW_{in}) in t $ha^{-1}yr^{-1}$ was derived from mean values (m^3 ha^{-1} yr^{-1}) provided by the German National Forest Inventory (BWI 2010b), multiplied by the wood density D (Table 8). Decay rates (dr) were taken from ROCK et al. 2008 for different tree species. For all deciduous trees the decay rate of *Fagus sylvatica* was used. Carbon fraction in dry matter (CF) and accumulation of litter C (ΔC_{litter}) for deciduous and coniferous trees was taken from PENMAN et al. 2003 (Table 9).

Table 9: Values for the calculation of carbon content in dead organic matter for five forest types in two age classes

Factor	Picea abies		Pinus sylvestris		Mixed forest [a]		Natural deciduous		Salix shrub	
	0-20	>20	0-20	>20	0-20	>20	0-20	>20	0-20	>20
DW_{in}(t)	0,08	0,08	0,03	0,03	0,04	0,04	0,02	0,02	0,02	0,02
dr	0,0525	0,0525	0,0575	0,0575	0,059	0,059	0,067	0,067	0,067	0,067
CF	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
ΔC_{litter} (t C $ha^{-1}yr^{-1}$)	0,4	0,4	0,4	0,4	0,5	0,5	0,6	0,6	0,6	0,6

a) mean of Picea abies, Pinus sylvestris and Natural deciduous

Step 3: Carbon in soil organic matter

The data and knowledge on forested organic soils is largely site-specific according to PENMAN et al. 2003. They suggest rough guidelines for estimating CO_2 emissions from forest soils with a default value of 0,68 t C ha^{-1} yr^{-1}, ranging from 0,41 to 1,91 t C ha^{-1} yr^{-1}. The above value of 0,68 t C ha^{-1} $year^{-1}$ was applied to wet soils with a median annual water table higher than –20 cm in this thesis. For drained soils, a value of 2,5 t C ha^{-1} yr^{-1} was applied, considering that O'CONNELL et al. 2003 estimated CO_2 efflux of up to 5,64 t C ha^{-1} yr^{-1} (see chapter 6.1.4).

b) Calculation of CH_4 fluxes

Table 10: CH_4 flux measurements for different forest stands on organic soils in relation to the water table, measured efflux shown in t CO_2e ha^{-1} yr^{-1}

Reference	Site descripition/ tree species	Mean water table	t CO_2e ha^{-1} yr^{-1}
JUNGKUNST 2004	Fibric Histosol, Black Forest, Southern Germany, Picea abies	-9 cm	7,93
VON ARNOLD et al. 2005a	Drained birch, southern Sweden	-15 cm	0,189
	Drained alder, southern Sweden	-18 cm	0,189
	Undrained alder, southern Sweden	+ 1 cm	1,596
VON ARNOLD et al 2005c	Coniferous, southern Sweden	-14 cm	0,099
	Coniferous, southern Sweden	-17 cm	0,338
	Coniferous, southern Sweden	-13 cm	0,993
	Coniferous, southern Sweden	-12 cm	0,124
	Coniferous, southern Sweden	-17 cm	0,725
JUNGKUNST &FIEDLER 2007	Histosol, Kendlmühlfilze, Bavaria, Southern Germany, Heathland with pine and birch	-17 cm	0,252
JUNGKUNST et al. 2008	Sapric Histosol, Black Forest, Southern Germany, Picea abies	-5 cm	0,346

PENMAN et al. 2003 does not provide methods and data to estimate CH_4 fluxes. CH_4 emissions were assumed to be insignificant at dry sites (water table –20 to >-80 cm). They were only taken into consideration and calculated for wet sites (water table higher than –20 cm). As described in chapter 1, methane efflux is produced by anaerobic soil organisms. JUNGKUNST 2004, VON ARNOLD et al. 2005a, VON ARNOLD et al 2005c, JUNGKUNST & FIEDLER 2007 and JUNGKUNST et al. 2008 provide CH_4 flux measurements from organic forest soils (Table 10). For the estimation of the CH_4 emissions from wet sites, the mean value over the eleven values in Table 10 was calculated.

Hence, the mean emission value of 1,2 t CO_2e ha^{-1} yr^{-1} was used for CH_4 emissions on wet sites.

c) Application of CO_2 and CH_4 calculations to the forest classes

The carbon in living woody biomass, in dead organic matter and in soil organic matter was summarized. The calculated carbon amount for each forest class was transformed to t CO_2 ha^{-1} $yr^{-1}$by multiplying with the factor 44/12 (transmission factor from 1 unit carbon to CO_2). Furthermore, the calculated CH_4 efflux was transformed into CO_2e and summed with CO_2 to the total GHB_{100} for each forest class (Table 11).

Finally the GHB_{100} per ha was applied to area unit by multiplying the measured surface area of each forest type with its GHB_{100} per ha.

Table 11:Calculated GHB_{100} from CO_2 and CH_4 efflux for 20 forest classes, values rounded to 0,5, positive values indicate a net carbon efflux, negative values a net carbon uptake

Forest type	**Stand age**	GHB_{100} **(t CO_2e ha^{-1} yr^{-1})** **Dry site (-20 cm till < -80 cm)**	**Wet site (higher –20 cm)**
Picea abies	0-20	7	3
	>20	- 4	- 8
Pinus sylvestris	0-20	7,5	3
	>20	2	-2
Mixed forest	0-20	7	1,5
	>20	0	- 5,5
Natural deciduous forest	0-20	7	1,5
	>20	2	-4
Salix-shrub	0-20	7	1,5
	>20	3	-2

4.4.3 Synthesis of total CO_2 and CH_4 flux

The calculated GHB_{100} for each non-forest and forest site was shown in a map for each subarea with ArcGIS. Total GHB_{100} was calculated by summarizing the values of non-forest sites and forest sites.

5 Results

The following chapters are divided into non-forest sites and forest sites respectively, because the data collection and evaluation differed significantly. A description of the area's non-forest vegetation is given in chapter 5.1 and of forest vegetation in chapter 5.2. The GHB_{100} of the total area is presented in chapter 5.3.

5.1 Assessment of non-forest sites

In total 32 vegetation forms according to SUCCOW & JOOSTEN 2001, SUCCOW 1988, HUNDT & SUCCOW 1984 or COUWENBERG et al. 2008 plus four groups of fallow, succesion and degradation types were found. Furthermore four other, strongly anthropogenic land use types were detected in the study area. The 32 vegetation forms and four groups of fallow, succesion and degradation types were accumulated into 13 GESTs according to the water level class (COUWENBERG et al. 2008, see also chapter 5.1.1 and 6.2.1). Table 12 shows the share of the detected GESTs, the share of the land use types pasture, cropland, footpath and roads and watercourses and lakes as well as the share of forest sites in the study area.

Apart from forest (chapter 5.2), Fen and bog grassland are the largest share in the total study area amounting to 25% (Table 12). Moist tall forbs and meadows cover 13,3 % of the study area. Moist fen and bog grassland and Very moist *Calluna*-dwarf shrub heath are also noteworthy with coverages of 4,1 % and 3,8 % respectively.

For Herrgottsried, Fen and bog grassland have the largest shares in the subarea with 47% followed by Moist tall forbs and meadows (18,3%), Forest, shrub and clearcut (17,4%) and Moist fen and bog grassland (8,7%).

Gründlenried is dominated by Forest, shrub and clearcut with 69,6 % of the subarea, followed by Moist tall forbs and meadows (9,4%), Wet peat moss lawn (5,1%) and a mosaic of wet peat moss lawn and bog hollow (4,6%).

Forest, shrub and clearcut have with 46,7 % coverage the largest share in the subarea Arrisrieder Moos followed by Very moist *Calluna*-dwarf shrub heath (19,5%), Fen and bog grassland (13,2%), Moist tall forbs and meadows (8,2%) and Moist *Calluna*-dwarf shub heath (6,0%).

Table 12: Area balance for the detected GESTs in the study area shown as surface area (ha) and percentage of the total study area. Area balance for the detected GESTs in the subareas shown as surface area (ha) and percentage of the subarea.

GEST (water level class in brackets) **or land use type**	**Study area**		**Herrgottsried**		**Gründlenried**		**Arrisrieder Moos**	
	ha	**%**	ha	**%**	ha	**%**	ha	**%**
Fen and bog grassland (2-, 2+, 2~)	109,74	25,1	93,68	47,0	6,67	4,0	9,40	13,2
Moist fen and bog grassland (3+/2+; 3+)	18,07	4,1	17,34	8,7	0	0	0,73	1,0
Medium moist tall forbs and meadows (2-, 2+, 2~)	2,76	0,6	0,99	0,5	0	0	1,77	2,5
Moist tall forbs and meadows (3+)	57,85	13,3	36,38	18,3	15,60	9,4	5,87	8,2
Moist Calluna-dwarf shrub heath (3+)	4,28	1,0	0	0,0	0	0,0	4,28	6,0
Very moist Calluna-dwarf shrub heath (4+)	16,63	3,8	0	0,0	2,73	1,6	13,90	19,5
Very moist Calluna-dwarf shrub heath with organic mud (4+)	0,61	0,1	0	0,0	0	0,0	0,61	0,9
Very moist meadow, tall forbs and reeds (4+)	3,55	0,8	1,54	0,8	1,33	0,8	0,67	0,9
Wet tall sedge fen (5+)	4,68	1,1	4,34	2,2	0,35	0,2	0	0
Wet low sedge swamps and tall sedge fens and reeds with moss layer (5+)	5,17	1,2	1,03	0,5	4,14	2,5	0	0
Wet reeds (5+)	0,52	0,1	0,52	0,3	0	0	0	0
Wet peat moss lawn (5+)	8,51	1,9	0	0	8,51	5,1	0	0
Wet peat moss lawn/ bog hollow area (5+)	7,61	1,7	0	0	7,61	4,6	0	0
Pasture, Cropland, Footpath and roads, Watercourses and lakes (n.d.)	13,04	2,99	8,67	4,35	3,51	2,12	0,86	1,21
Forest, shrub & clearcut (n.d.)	183,50	42,0	34,74	17,4	115,42	69,6	33,33	46,7
TOTAL	**436,53**		**199,23**		**165,87**		**71,43**	

5.1.1 GESTs and vegetations forms in the study area

The classified GESTs and vegetation forms as basic unit of the GESTs are described in the following chapter. All mentioned relevés and vegetation forms are labeled in appendix 6, map 1-3. Ecological indicator groups are shown in detail in appendix 4. The relevés of the vegetation forms are shown in appendix 5, vegetation table 1-3.

The following paragraphs describe those vegetation forms according to SUCCOW & JOOSTEN 2001, SUCCOW 1988, HUNDT & SUCCOW 1984 or COUWENBERG et al. 2008 that were found in the study area. COUWENBERG et al. 2008 summarized vegetation forms at similar site conditions (indicated by water level class and species composition) to GESTs. However, there are sites in nature that cannot be classfied as vegetation form. Those sites also occured in the study area. Here, the corresponding GEST was estimated from the water level class and species composition of the community (see chapter 4.2.2 and 6.2.1).

Additionally, the phytosociological association (see also chapter 2.1.2) is described for every relevé in the following paragraphs.

Fen and bog grassland (water level class 2-, 2+, 2~)

a) *Taraxacum-Lolium*-grassland (Fig. 3; appendix 5: Tab.1)

Most grasslands in the study area are dominated by grass seedings (relevé H05, H18, H22, H36, H43, H44, H45). A common mixture is *Lolium perenne* or *Lolium multiflorum* with *Trifolium repens, Ranunculus repens, Plantago lanceolata* and *Taraxacum officinale*. The grass seedings are typical substitutes for medium moist *Trisetum flavescens*-meadows with high nutrient content. Sometimes, instead of *Lolium* species, *Elymus repens* is the dominating grass species. The *Taraxacum-Lolium*-grasslands show a certain variability in the species composition, whereas in all cases not more than five to ten species are present. Often *Alopecurus pratensis, Poa pratensis, Poa trivialis* and *Dactylis glomerata* and some herbaceous species contribute to the herb layer as remainders from *Trisetum flavescens*-meadows.

Fig. 3: *Taraxacum-Lolium*-grassland

In phytosociology grass seedings and intensively managed grasslands are not described as an association, but may be treated as Molinio-Arrhenatheretea-substitutes.

Moist fen and bog grassland (water level class 3+/2+; 3+)

a) Moist *Taraxacum-Lolium*-grassland (Fig. 4; appendix 5: Tab.1)

A moist variety of the *Taraxacum-Lolium*-grassland (relevé H06) is characterised by *Phalaris arundinacea* (see also COUWENBERG et al. 2008).

Fig. 4: Moist *Taraxacum-Lolium* grassland

In phytosociology grass seedings and intensively managed grasslands are not described as an association.

b) Temporarily flooded grassland (Fig. 5; appendix 5: Tab.1)

A special type of grassland develops near watercourses (relevé H17). There, a composition of meadow grasses like *Poa pratensis, Alopecurus pratensis* and *Poa trivialis* is dominated by *Glyceria fluitans*, indicating frequent flooding.

Fig. 5: Temporarily flooded grassland dominated by *Glyceria fluitans*

Taking into consideration the meadow-like appearance of the community, there is no described association in phytosociology, that resembles the given species composition.

Medium moist tall forbs and meadows (water level class 2-, 2+, 2~)

a) *Trisetum flavescens*-meadow (Rispengras-Goldhafer-wiese, HUNDT & SUCCOW 1984) (Fig. 6; appendix 5: Tab.1)

The *Trisetum flavescens*-meadow (relevé AR14) develops in submontane areas on medium moist sites with a medium nutrient content. The dominating and naming grass *Trisetum flavescens* is accompanied by other grasses like *Dactylis glomerata* and *Cynosurus cristatus*. The herb layer shows common meadow species like *Trifolium pratense, Achillea millefolium*, *Ranunculus acris* and *Plantago lanceolata*.

Fig. 6: *Trisetum flavescens*-meadow

In phytosociology relevé AR14 is characterised as Poo-Trisetetum flavescentis.

b) Community with tendency towards *Hypericum perforatum-Galium album*-community (Johanniskraut-Wiesenlabkraut-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 7; appendix 5: Tab.2)

Relevé AR34 is probably an abandoned meadow and the dominating species resemble the species composition of the *Hypericum perforatum-Galium album*-community. However, main ecological indicator groups and species like *Arrhenatherum elatius* are missing. It can be assumed, that in contrast to the typical community, the given species composition does not result from an

Fig. 7: Community with tendency towards *Hypericum perforatum-Galium album*-community

abandoned *Cirsium oleraceum-Arrhenatherum elatius*-community (Kohldistel-Glatthafer-Wiese, SUCCOW & JOOSTEN 2001) but from a more humid abandoned *Angelica sylvestris-Cirsium oleraceum*-community (Kohldistel-Wiese, SUCCOW & JOOSTEN 2001).

In phytosociology relevé AR34 can be identified as abandoned and degraded Calthion meadow, probably a degraded Angelico-Cirsietum oleracei.

c) *Phragmites australis-Aegopodium podagraria-Urtica dioica*-community (Schilf-Giersch-Brennessel-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 8; appendix 5: Tab.2)

Fig. 8:*Phragmites australis-Aegopodium podagraria-Urtica dioica*-community

The *Phragmites australis-Aegopodium podagraria-Urtica dioica*-community (relevé H15) is a species poor, eutrophic community. It is dominated by *Urtica dioica* and accompanied by *Galium aparine* and small amounts of *Phalaris arundinacea* and other grasses.

In phytosociology relevé H15 is classified as *Urtica dioica-Convolvulus (Calystegia) sepium*-community. It is typical for eutrophic, moist to wet sites.

<u>Moist tall forbs and meadows (water level class 3+)</u>

a) *Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta*-meadow (Kohldistel-Wiese, Succow & Joosten 2001) (Fig. 9; appendix 5: Tab.1)

Fig. 9: Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta meadow

The *Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta*-meadow (relevé H12, H23, H26, H27, H38, AR15, G25) is an extensively managed moist meadow which is only weakly characterised by differential species. *Cirsium oleraceum, Angelica sylvestris, Filipendula ulmaria*, *Lotus uliginosus* and *Myosotis scorpioides* indicate medium nutrient content and moist soils. They are frequent as well as *Polygonum bistorta,* that is common in subalpine areas. Furthermore meadow species like *Rumex acetosa, Ranunculus acris* and *Planatgo lanceolata* complete the community. The species composition in the community varies strongly and there are smooth transitions to the nutrient-poor *Molinia caerulea*-community, the wet *Scirpus sylvaticus*-community and - depending on the maintenance - to several fallow phases.

In phytosociology the community is classified as Angelico-Cirsietum oleracei. It is the central association in the Calthion alliance with *Cirsium oleraceum* as weak association character species and a frequent occurrence of alliance and order character species, e.g. *Angelica sylvestris*.

b) *Molinia caerulea*-meadow (Prachtnelken-Pfeifengras-Wiese, SUCCOW & JOOSTEN 2001) (Fig. 10; Fig. 11; appendix 5, Tab.1)

Fig. 10: *Molinia caerulea*-meadow

Fig. 11: *Molinia caerulea*-meadow, *Gentiana asclepiadea*-type

The *Molinia caerulea*-meadows (relevé H01, H04, H09, H11, H13, H21, AR03, AR05, AR08, AR09, AR10, AR11, AR13, AR16, AR35, G14, G20, G26) in the study area are very variable. Beneath the main element *Molinia caerulea,* the species *Potentilla erecta*, *Luzula multiflora, Carex flava* and *Carex nigra* are most frequent in the community. All species are indicating nutrient poor, but moist site conditions. The transition type to the *Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta*-meadow (AR16) shows a very low coverage of Molinia caerulea and a higher occurrence of meadow species, e.g. *Galium uliginosum, Ajuga reptans, Plantago lanceolata* and *Rumex acetosa*. Although relevé AR03 lacks *Molinia caerulea* it is classified as transition type of a *Molinia caerulea*-meadow, because of its meadow-character with *Ranunculus acris*, *Galium uliginosum, Ajuga reptans* and *Rumex acetosa* but also *Carex nigra* from the small sedge fens. Base-rich varieties (H01, H21) also have a higher occurence of species from the *Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta*-meadow, but still a high coverage of *Molinia caerulea*. Species poor varieties (H04, G26) host as main components *Molinia caerulea, Potentilla erecta* and *Carex nigra* in high coverages. A speciality of the subalpine region is a *Gentiana asclepiadea*-type (G14), where the typical species occur in low coverages and additionally *Carex panicea, Carex gracilis, Selinum carvifolia, Inula salicina, Veratrum album* and *Gentiana asclepiadea* add to the species composition. Acidic sites (AR05) are species poor and characterised by supplement of *Trichophorum alpinum* and *Calluna vulgaris*.

In phytosociology the sites are classified as Molinietum caeruleae with comparable subdivisions as explained above.

c) *Filipendula ulmaria-Urtica dioica-Polygonum bistorta*-community (Mädesüß-Wiesenknöterich-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 12; appendix 5: Tab.2)

Fig. 12: Herb layer of *Filipendula ulmaria-Urtica dioica-Polygonum bistorta*-community

The *Filipendula ulmaria-Urtica dioica-Polygonum bistorta*-community (relevé H46) is common on moist, eutrophic, nearly neutral and often calcareous soils. Common species in this unmanaged community are *Filipendula ulmaria, Scutellaria galericulata, Phragmites australis* and *Carex acutiformis*. Moreover species from moist meadows like the naming *Polygonum bistorta* or *Crepis paludosa, Lotus uliginosus* and *Cirsium oleraceum* contribute to the species composition. The typical nitrogen indicator species *Urtica dioica* and *Galium aparine* are missing in relevé H46 and are replaced by the neophytic *Impatiens glandulifera*.

In phytosociology relevé H46 would be classified as an abandoned Angelico-Cirsietum oleracei.

d) *Filipendula ulmaria*-community (Mädesüß-Hochstaudenflur, SUCCOW & HUNDT 1984) (Fig. 13; appendix 5: Tab.2)

Fig. 13: *Filipendula ulmaria*-community

The *Filipendula ulmaria*-community (relevé H08, H33, H40) mainly develops from abandoned moist meadows or in unmanaged herbaceous seams along moist meadows. *Filipendula ulmaria, Lysimachia vulgaris, Scutellaria galericulata* and *Phalaris arundinacea* belong to the common species composition. *Potentilla palustris* in relevé H08, *Carex lasiocarpa* in relevé H33 and *Epilobium palustre* in relevé H33 and H40 indicate a moist to wet and not too eutrophic variety. A special floristic element is *Thalictrum aquilegifolium* that is frequently found in communities in subalpine regions.

In phytosociology, relevé H08, H33 and H40 cannot be classified as a distinct association and have to be treated as *Filipendula ulmaria*-community.

e) *Lythrum salicaria-Urtica dioica-Phragmites australis*-community (Weiderich-Brennessel-Schilf-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 14; appendix 5: Tab.2)

Fig. 14: *Impatiens glandulifera* and *Phragmites australis* in the *Lythrum salicaria-Urtica dioica-Phragmites australis*-community

In the *Lythrum salicaria-Urtica dioica-Phragmites australis*-community (relevé H35, H37, H41, H42, H50, H51) indicators for wet soils are missing. *Filipendula ulmaria* and *Cirsium oleraceum* indicate moist conditions. The high amounts of *Phragmites australis, Carex acutiformis* and *Phalaris arundinacea* are a sign, that the sites are not or only hardly cut and probably sometimes flooded. This impression is emphasised by the herb layer, with the nutrient indicator species *Urtica dioica* and *Galium aparine*. Additionally occurs the neophytic *Impatiens glandulifera*, that is common along watercourses and also an indicator of high nutrient content.

In phytosociology, relevé H35 can be classified as the species-poor Phalaridetum arundinaceae, with its character species *Phalaris arundinaceae*. This community is typical along watercourses on eutrophic soil. Relevé H37 is a community that is close to the Phalaridetum arundinaceae, but cannot finally be classified due to the low coverages of the typical plant species and the high coverage of *Carex acutiformis* and *Impatiens glandulifera*. Relevé H41, H42 and H51 cannot clearly be classified, but identified as abandoned moist meadows. The species composition with *Cirsium oleraceum* and *Polygonum bistorta* indicates, that the sites used to belong to the Angelico-Cirsietum oleracei. Relevé H50 is a community, that is close to the *Urtica dioica- Convolvulus (Calystegia) sepium*-community. A final classification is difficult because of the untypically high *Phragmites australis* coverage.

f) Moist fallow (Fig. 15; appendix 5, Tab.2)

Relevé H39 represents a succession of moist meadows with the fallow indicators *Calamagrostis canescens* and *Phalaris arundinacea*. It develops on fallow meadows that are sometimes flooded, for example near watercourses. The reeds are accompanied by meadow species like *Polygonum bistorta* and *Angelica sylvestris*, as well as by grassland species like *Ranunculus acris* and *Rumex acetosa*. In phytosociology, H39 would be treated as unhierarchical *Calamagrostis canescens*-community.

Along moist, shady and only sparsely maintained forest edges (relevé H29) one can find a seam dominated by *Carex brizoides*. Nitrogen indicators like *Urtica dioica* are rare as well as tall forbs like *Filipendula ulmaria*. Phytosociology would classify H29 as unhierarchical community dominated by *Carex brizoides*.

Fig. 15: Moist fallow H39, H29, AR17, AR04 and H49 (from top to bottom)

Relevé AR17 is a transition between sedge fen and moist meadow. The dominance of *Carex rostrata* and *Anthoxanthum odoratum* as well as the occurrence of *Frangula alnus* and *Quercus robur* suggest, that the site is not frequently cut. The few herbaceous plant like *Galium palustre, Epilobium palustre, Carex nigra* and *Potentilla erecta* indicate wet and base- and nutrient-poor conditions. In phytosociology there is no clear classification for the community.

Relevés G19 and AR04 are possibly the result of the extensification or grazing of grasslands. *Juncus effusus* is an indicator of a site disturbance. *Festuca rubra, Holcus lanatus, Carex leporina* and *Anthoxanthum odoratum* are common on poor meadows. Companions are species of fresh meadows and indicator species for moist and poor soils. In phytosociology, relevé G19 and AR04 could be classified as a degraded Epilobio-Juncetum efusii

The fragmentary structure, the comparably high amount of *Phragmites australis* and *Calamagrostis epigejos* and the occurrence of species from moist meadows suggest, that relevé H49 is also a succesion phase of a moist meadow, but with medium nutrient content. In phytosociology relevé H49 could be classified as an abandoned Molinietum caerulea.

g) Degraded *Holcus lanatus*-meadow (Honiggras-Wiese, SUCCOW & JOOSTEN 2001) (Fig. 16; appendix 5: Tab.1)

Fig. 16: Degraded *Holcus lanatus*-meadow

Characteristic species of the *Holcus lanatus*-meadow are *Holcus lanatus* and its companions *Anthoxanthum odoratum, Deschampsia cespitosa, Lychnis flos-cuculi*, *Ranunculus repens* and *Rumex acetosa*. It is typical on lime poor, moist meadows. The communities in the study area however (relevé H14, H16, H19, H24) are at most a degraded type of the *Holcus lanatus*-meadow. Further diagnostic species like *Lotus uliginosus* or *Vicia cracca* are missing and the cover of *Holcus lanatus* is only mediate. This might be due to frequent flooding from adjacent water courses (also indicated by *Glyceria fluitans*).

In phytosociology, the community would be classified as degraded Loto uliginosi-Holcetum lanati (PASSARGE 1999).

Moist *Calluna*-dwarf-shrub heath (water level class 3+)

a) Moist *Calluna*-dwarf shrub heath (Feuchte Hochmoorheide, COUWENBERG et al. 2008) (Fig. 17; appendix 5: Tab.3)

Fig. 17: Moist *Calluna*-dwarf shrub heath dominated by *Calluna vulgaris*, *Molinia caerulea* and spontaneous colonisation by scrub.

Moist *Calluna*-dwarf shrub heath (relevé AR06, AR18, AR21, AR23, AR24, AR27, AR28, AR30) is a species poor community of degraded, drained bog, dominated by *Calluna vulgaris* and *Molinia caerulea*. It is nutrient poor and acidic. Raised bog species like *Sphagnum nemoreum, Eriophorum vaginatum, Oxycoccus palustris* and *Polytrichum strictum* are represented only sparsely in very low coverages (r-2b). *Vaccinium uliginosum* is frequent with low coverages (r-2a); *Pleurozium schreberi* indicates desiccation on some sites. Most sites show a spontaneous colonisation by scrub (*Betula pubescens, Frangula alnus, Picea abies*), which indicates comparably dry conditions.

In phytosociology relevé AR06, AR18, AR21, AR23, AR24, AR27, AR28, AR30 can be classified as degraded Sphagnetum magellanici. A tendency to the *Cladonia arbuscula*- subassociation may be assumed, but cannot be confirmed.

<u>Very moist *Calluna*-dwarf shrub heath (water level class 4+)</u>

a) Very moist *Calluna*-dwarf shrub heath (Sehr feuchte Hochmoorheide, COUWENBERG et al. 2008) (Fig. 18; Fig. 19; appendix 5: Tab.3)

Fig. 18: Slight hummock structure of the Very moist *Calluna*-dwarf shrub heath

Very moist *Calluna*-dwarf shrub heath (relevé AR07, AR12, AR19, AR20, AR22, AR26, AR31, AR32, G02) is characterised by a fragmentary *Sphagnum* cover and a high cover of dwarf shrub- or grass hummocks. Fragments of typical raised bog vegetation like *Andromeda polifolia* and *Oxycoccus palustris* are still present in small amounts and show the nutrient poor and acidic conditions. The light-demanding *Sphagnum magellanicum* retreats and is mainly replaced by *Sphagnum nemoreum*, that is additionally tolerant towards drier conditions. Futhermore *Calluna vulgaris*, *Eriophorum vaginatum* or *Molinia caerulea* reach high coverage. *Pleurozium schreberi* and *Vaccinium vitis-idaea* indicate dry to moist conditions, where fluctuating water levels are possible. The community is ecologically close to the *Cladonia-Calluna vulgaris-* community (Flechten-Heidekraut-Torfmoosrasen, SUCCOW 1988). However, as lichen were not assessed in this study, a definitive classification as *Cladonia-Calluna vulgaris*-community is not possible.

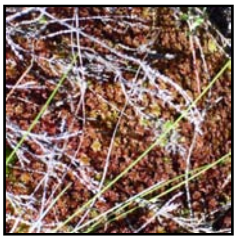


Fig. 19: Sphagnum nemoreum (red) and Calluna vulgaris (grey) in the Very moist *Calluna*-dwarf shrub heath

Phytosociology classifies relevé AR07, AR12, AR19, AR20, AR22, AR26, AR31, AR32, G02 as degraded Sphagnetum magellanici. Here as well a tendency to the *Cladonia arbuscula*- subassociation may be assumed, as the differential species *Vacciunium vitis-idaea* and *Pleurozium schreberi* are present. However, this cannot finally be postulated without assessing the lichen cover.

Very moist Calluns dwarf shrub heath with organic mud (water level class 4+)

a) Very moist *Calluna*-dwarf shrub heath with organic mud (Sehr feuchte Hochmoorheide mit Muddeflächen, COUWENBERG et al. 2008) (Fig. 20; appendix 5: Tab.3)

Fig. 20: Very moist Calluna-dwarf shrub heath with organic mud

The very moist *Calluna*-dwarf shrub heath with organic mud (relevé AR25) is a degradation of vegetation cover, mainly caused by drainage. The community is characterised by a mosaic of open organic mud, grass species and sparsely spread dwarf shrubs. Dominating species are *Rhynchospora alba* and *Molinia caerulea* indicating still moist but drier conditions than in typical bog hollow and hummock areas. The presence of *Sphagnum subnitens*, a species rather growing on topogenous mires, indicates a site disturbance.

In phytosociology relevé AR25 can be classified as a degraded Sphagnetum magellanici.

Very moist meadow, tall forbs and reeds (water level class 4+)

a) *Scirpus sylvaticus*-meadow (Waldsimsen-Wiese, SUCCOW & JOOSTEN 2001) (Fig. 21; appendix 5: Tab.1)

Fig. 21: *Scirpus sylvaticus*-meadow

The Scirpus sylvaticus-community (relevé H02, H03) resembles in its species composition the *Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta*-community, but is dominated by the bright green leaves of *Scirpus sylvaticus. Cirsium oleraceum* however is missing. The community develops in small, constantly moist to wet depressions in meadow landscapes. Transition forms to other moist meadow communities are common.

In phytosociology the communitiy is classified as Scirpetum sylvatici.

b) *Parnassia palustris-Molinia caerulea*-meadow (Herzblatt-Pfeifengras-Wiese, Succow & Joosten 2001) (Fig. 22; appendix 5: Tab.1)

Fig. 22: *Epipactis palustris* in the *Parnassia palustris-Molinia caerulea*-meadow

The *Parnassia palustris-Molinia caerulea*-meadow (relevé AR01, AR02) develops on nutrient-poor, moist to wet and calcareous sites. The community differs from the common *Molinia caerulea*-meadows by the occurrence of the lime indicating species *Parnassia palustris*, *Epipactis palustris* and *Eriophorum latifolium*. Furthermore, floristic elements from sedge fens (*Carex pulicaris*) and from moist meadows (e.g. *Angelica sylvestris*, *Crepis paludosa, Centaurea jacea*) distinguish the community. Relevé AR01 is a typical variety, while AR02 shows with a higher coverage of meadow species and a lack of *Parnassia palustris* a beginning degradation and transformation towards an *Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta*-meadow.

In phytosociology the community is classified as Parnassio-Molinietum caerulae (PASSARGE 1999).

c) *Carex nigra-Caltha palustris-Filipendula ulmaria*-community (Braunseggen-Mädesüß-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 24; appendix 5: Tab.2)

Fig. 23: Withered *Dactylorhiza incarnata* in the *Carex nigra-Caltha palustris-Filipendula ulmaria*-community

The *Carex nigra-Caltha palustris-Filipendula ulmaria*-community (relevé H25) is a type of moist fallow. It is characterised by the *Caltha palustris*- and *Galium palustre*- groups in combination with small sedges from the *Carex nigra*- and *Carex disticha*-groups and frequent moist meadow species like *Polygonum bistorta* and *Angelica sylvestris*. *Filipendula ulmaria, Juncus effusus* and *Carex acutiformis* are indicators for missing maintenance. *Dactylorhiza incarnata* is a sign of nitrogen-poor sites. This correlates well with the lack of *Lythrum salicaria* and *Lysimachia vulgaris*, that would grow on more eutrophic sites and would typically occur.

In phytosociology relevé H25 would be classified as a fallow of the Angelico- Cirsietum oleracei with species of moist meadows and the above mentioned fallow indicators.

d) *Solanum dulcamara-Galium palustre-Phragmites australis*-community (Nachtschatten-Schilf-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 24; appendix 5: Tab.2)

Fig. 24: *Solanum dulcamara-Galium palustre-Phragmites australis*-community

In relevé H34 *Phragmites australis, Carex acutiformis, Solanum dulcamara, Equisetum fluviatile* and *Filipendula ulmaria* indicate moist to wet conditions and are common in the *Solanum dulcamara-Galium palustre-Phragmites australis*-community. *Peucedanum palustre* and *Angelica sylvestris* possibly intruded from surrounding tall forb and meadow communities and support the moisture estimate.

Relevé AR29 must be treated as a special variety of the *Solanum dulcamara-Galium palustre-Phragmites australis*-community, because of its high cover with *Carex paniculata x Carex remota.* It may be assumed that the large *Carex* hummocks are relicts from former development stages and vegetation forms and that the community is still in a transition process. Although the cover of *Urtica dioica* and *Solanum dulcamara* is low, it indicates an eutrophic site, perhaps caused by nutrient input from the nearby meadows and forests. The species combination between AR29 and H34 differs probably, because AR29 is shadier.

In phytosociology H34 may be classified as *Carex acutiformis*-community, whereas AR29 cannot clearly be classified, because of its high amount of *Carex paniculata x Carex remota* and a lack of clear character species.

e) Succesion of *Carex appropinquata-Molinia caerulea*-community (Wunderseggen-Pfeifengras-Staudenflur, SUCCOW & JOOSTEN 2001) (Fig. 25; appendix 5: Tab.2)

Fig. 25: Succesion of *Carex appropinquata-Molinia caerulea*-community

Relevé G21 represents a community that is probably an abandoned moorgrass meadow. Although the ecological indicator group of *Carex appropinquata* is not present in the relevé, *Menyanthes trifoliata, Typha latifolia* and *Peucedanum palustre* indicate wet conditions. *Juncus effusus* is an indicator of disturbed habitats. Species like *Lotus uliginosus, Angelica sylvestris* and *Stellaria* *graminea* are common companion plants in moist meadows and indicate the former land use. *Rubus ideaus* and *Phragmites australis* are a sign of fallow. *Eriophorum vaginatum* and *Oxycoccus palustris* are unusual in the community and indicate, that the site is probably in a transition process and influenced by the adjacent raised bog area. Hence, the relevé cannot clearly be classified as *Carex appropinquata-Molinia caerulea*-community, because the typical species are only partly present and their succesors suggest a development away from the community.

In phytosociology relevé G21 can be identified as a fallow of the Molinietum caerulea with *Phragmites australis* and *Juncus effusus* indicating the abandonment.

f) Wet fallow (Fig. 26; appendix 5: Tab.2)

Fig. 26: Wet fallow with *Filipendula ulmaria* and *Carex vesicaria*

Relevé H54 is mainly characterised by *Filipendula ulmaria* and *Carex vesicaria*. Both species indicate moist sites with a medium to high nutrient and nitrogen content. Especially *Carex vesicaria* is a common companion in fallows of moist meadows, joined by *Phragmites australis* and *Phalaris arundinacea. Lythrum salicaria* and *Scutellaria galericulata* however, are more common in typical *Filipendula ulmaria*-communities*.* In phytosociology relevé H54 is classified as Caricetum vesicariae.

Wet tall sedge fens (water level class 5+)

a) *Calliergonella cuspidata-Menyanthes trifoliata-Carex elata*-community (Spitzmoos-Großseggen-Ried, SUCCOW & JOOSTEN 2001) (Fig. 27; appendix 5: Tab.2)

Fig. 27: Species-poor *Calliergonella cuspidata-Menyanthes trifoliata-Carex elata*-community

The *Calliergonella cuspidata-Menyanthes trifoliata-Carex elata*-community (relevé H07, H31, H48) is a mesotrophic fen dominated by sedges. Its pH ranges from slightly acidic to subneutral. The accompanying herbs *Peucedanum palustre* from the *Lysimachia thyrsiflora* group *or Galium palustre* and *Equisetum fluviatile* from the *Galium palustre* group indicate wet conditions and a mean nutrient content. In the relevés only sparsely presented, but normally typical is *Calliergonella cuspid*ata, which contributes to a fragmentary moss layer. Relevé H48 can be considered as *Carex acutiformis* facies, where the typical *Carex elata* is replaced. The meadow species in relevé H48 can either be a relict from a former development phase or invaded from adjacent moist meadows.

In phytosociology relevé H07 and H31 are classified as Caricetum elatae, as association of hydrosere succesion, that probably occurs in flooded peat cut areas. Relevé H48 is a *Carex acutiformis*-community, typically growing on eutrophic, moist soils.

b) *Valeriana dioica-Berula erecta-Carex paniculata*-community (Sumpfbaldrian-Rispenseggen-Ried, SUCCOW & JOOSTEN 2001) (Fig. 28; appendix 5: Tab.2)

Fig. 28: *Valeriana dioica-Berula erecta-Carex paniculata*-community with *Equisetum fluviatile*, *Salix*-shrub in the backgorund

The *Valeriana dioica- Berula erecta- Carex paniculata*-community (relevé H32, H52, H53, H56, H58) is characterised by a frequent high coverage with *Carex paniculata* accompanied by *Phragmites australis* and *Carex acutiformis*. Additionally, *Peucedanum palustre*, different representatives of the *Caltha palustris*- and *Lythrum salicaria* group, *Galium palustre and Equisetum fluviatile* and only sparsely spread *Filipendula ulmaria* and *Carex nigra* indicate a meso-eutophic site, that is only weakly acidic. More calcareous sites are characterised by the occurance of *Valeriana dioica* and *Dactylorrhiza incarnata*. Exceptionally humid sites contain *Typha latifolia*.

Phytosociology classifies relevé H32, H52, H53, H56, H58 as Caricetum paniculatae, with the character species *Carex paniculata*. It is typical on base-rich and sometimes calcareous sites.

Wet low sedge swamps and tall sedge fens and reeds with moss layer (water level class 5+)

a) *Sphagnum recurvum-Carex limosa*-community (Torfmoos-Schlammseggenried, SUCCOW & JOOSTEN 2001) (Fig. 29; appendix 5: Tab.2)

Fig. 29: Blossoming *Rhynchospora alba* in the *Sphagnum recurvum-Carex limosa*-community

The *Sphagnum recurvum-Carex limosa*-community (relevé G16, G18) is characterised by a more or less closed *Sphagnum* layer and dominance of *Rhynchospora alba*. *Eriophorum angustifolium* indicates the wet, nutrient- and lime-poor conditions. In G18, untypically for this community, *Sphagnum papillosum* is dominating the moss layer. This could be seen as an indication of that the peat in the topogenic mire is raised above the direct influence of the mineral soil (NEBEL & PHILIPPI 2000), and the mire is in a transition phase towards a raised bog. The occurrence of raised bog species like *Andromeda polifolia* as well as species from moorgrass meadows like *Molinia caerulea* and *Carex panicea* underline this assumption. Relevé G16 shows a more typical *Sphagnum* cover, with a mix of *Sphagnum fallax* and *Sphagnum cuspidatum*. Moreover, typical raised bog species are missing and *Menyanthes trifoliata* and *Carex lasiocarpa* are present as indicators for transition mires.

In phytosociology relevé G16 and G18 can be classified as communities with a similar species composition like the Rhynchosporetum albae. However, neither G16 nor G18 are bog hollows, which would be the typical form of a Rhynchosporetum albae. Furthermore, G16 shows clear tendencies towards the Caricion lasiocarpae alliance, hosting the alliance indicator species *Menyanthes trifoliata* and *Carex lasiocarpa*. Presumably site conditions of relevé G16 and G18 are comparable to site conditions in a bog hollow, so the vegetation development follows the same direction.

b) *Sphagnum recurvum-Eriophorum angustifolium*-community (Torfmoos-Seggen-Wollgrasried, SUCCOW & JOOSTEN 2001) (Fig. 30; appendix 5: Tab.2)

Fig. 30: *Sphagnum recurvum-Eriophorum angustifolium*-community

Relevé G23 can be classified as very species poor facies of the *Sphagnum recurvum-Eriophorum angustifolium*-community. The site is characterised by a *Sphagnum fallax* cover with *Eriophorum vaginatum* hummocks and represents an acidic and nutrient-poor site, that can be found in the lagg area.

Phytosociology classifies relevé G23 as *Eriophorum vaginatum*-community without own character species. The community is described as species poor and always weakly minerotroph (OBERDORFER 1992).

c) *Sphagnum recurvum-Juncus effusus*-community (Torfmoos-Flatterbinsen-Ried, SUCCOW & JOOSTEN 2001) (Fig. 31; appendix 5: Tab.2)

Fig. 31: *Sphagnum recurvum-Juncus effusus*-community

The *Sphagnum recurvum-Juncus effusus*-community (relevé G22, G24) is a typical, wet lagg- community (Succow 1988). A closed cover of *Sphagnum fallax* in the moss layer is accompanied by a high amount of *Carex rostrata* and *Juncus effusus* in the herb layer. Species like *Eriophorum vaginatum* and *Oxycoccus palustris* are eventually part of the community and indicate acidic sites. *Oxycoccus palustris* furthermore is a weak indicator for minerotrophic sites.

In phytosociology relevé G22 and G24 can be classified as Caricetum rostratae, a plant community of hydrosere succesion, where facies with *Sphagnum fallax* distinguish nutrient poor sites.

d) *Calliergonella cuspidata-Viola palustris-Carex appropinquata*-community (Spitzmoos-Kleinseggen-Ried, SUCCOW & JOOSTEN 2001) (Fig. 32; Fig. 33; appendix 5: Tab.2)

Fig. 32: Meagre variety of the *Calliergonella cuspidata-Viola palustris-Carex appropinquata*-community (relevé H10)

Fig. 33: Scarcely managed variety of the *Calliergonella cuspidata-Viola palustris-Carex appropinquata*-community (relevé H47)

The *Calliergonella cuspidata-Viola palustris-Carex appropinquata*-community (relevé H10, H47) is a fen with small, mainly stem-spreading sedges and a comparably species-rich herb layer. *Galium palustre*, *Equisetum fluviatile*, *Crepis paludosa* and *Equisetum palustre* are characteristical for moist to wet sites with a mean nutrient content. *Carex nigra* and *Potentilla palustris* distinguish rather acidic and nutrient poor conditions. Hence, both sites can be considered slightly mesotrophic, while *Menyanthes trifoliata, Succisa pratensis* and *Sphagnum contortum* in relevé H10 incicate a more meagre variety. Relevé H10 is characterised by the sedges *Carex lasiocarpa, Carex flava* and *Carex nigra*, whereas in relevé H47 *Carex elongata* and *Carex nigra* dominate. It can be assumed from field observation, that H47 is not frequently maintained and that scrub was only recently removed. So a higher shading might have caused the high amount of *Carex elongata*. The accompanying moss cover with *Calliergonella cuspidata* and *Climacium dendroides* (H47) is not very distinct, but characteristical. A moss cover with *Sphagnum contortum* (H10) can occur in base-rich fens or wet, extensively used pastures (NEBEL & PHILIPPI 2005).

In phytosociology relevé H10 would be classified as Caricetum lasiocarpae, with *Carex lasiocarpa* as character species of the association. Other typical species are for example *Equisetum fluviatile, Peucedanum palustre, Potentilla palustris* and *Menyanthes trifoliata*. Furthermore typical companion plants like *Lythrum salicaria, Scutellaria galericulata* and even *Sphagnum contortum* are present. Relevé H47 cannot clearly be classified as a phytosociological association. It is probably a transition phase. Considering the species composition one could assume, that the community used to be close to the Caricetum lasiocarpae (hosting several of its companion plants) and is developping towards carr with *Carex elongata* as character species. However, this assumption cannot finally be confirmed.

e) *Primula farinosa-Schoenus ferrugineus*-community (Mehlprimel-Kopfbinsen-Ried, SUCCOW & JOOSTEN 2001) (Fig. 34; appendix 5: Tab.2)

Fig. 34: *Primula farinosa-Schoenus ferrugineus*-community with brownish *Eriophorum latifolium* hummocks

The *Primula farinosa-Schoenus ferrugineus*-community (relevé G15) consists of low sedges, herbs and a compact moss layer. It is characteristical for calcareous, mesotrophic sites, where *Carex hostiana, Parnassia palustris, Juncus alpino-articus, Eriophorum latifolium, Pinguicula vulgaris, Dactylorrhiza incarnata* and *Schoenus ferrugineus* distinguish the community from other calcareous swamp communities. Additionally *Carex davalliana* occurs in low coverage. Characterising mosses are among others *Dicranum bonjeanii, Campylium stellatum* and *Bryum pseudotriquetum.*

In phytosociology, the community is characterised as Primulo-Schoenetum ferruginei, that is close to the Caricetum davallianae, but confines by the occurrence of *Schoenus ferrugineus*.

f) Succesion of *Sphagnum recurvum-Juncus acutiflorus*-community (Torfmoos-Waldbinsen-Braunseggen-Ried, SUCCOW & JOOSTEN 2001) (Fig. 35; appendix 5: Tab.2)

Fig. 35: Succesion of *Sphagnum recurvum-Juncus acutiflorus*-community

Relevé G17 resembles in its species composition *a Sphagnum recurvum- Juncus acutiflorus*- community. This mesotrophic and acidic community ist typical for percolated areas or spring-water bogs. Relevé G17 is probably a succesion phase of the community, because it is situated near the "spring", where the water, that infiltrates in the bog area of Gründlenried, is set free again (see chapter 3.6). Furthermore it still hosts typical species like *Oxycoccus palustris, Carex lasiocarpa, Viola palustris* and *Carex echinata.* However, the comparably high coverage with *Molinia caerulea* and *Phragmites australis* and *Juncus effusus* suggest a disturbance and a succesion process.

In phytosocioloy the community may be treated as a succession phase of a Caricetum lasiocarpae.

g) Fragmentary tall sedge fen (Fig. 36; appendix 5: Tab.2)

Fig. 36: Fragmentary tall sedge fen

Relevé H28 is situated on a forest edge. Field observation shows, that trees were cut and removed. The site has a poor drainage, what enhances an development of *Carex acutiformis*, *Carex rostrata*, *Sphagnum palustre* and *Sphagnum teres*. Among others *Calluna vulgaris* and *Potentilla erecta* indicate base-poor conditions. *Dryopteris carthusiana* and *Polytrichum formosum* are presumably relicts of a former forest stand indicate as well soil acidity. In phytosociology relevé H28 could be classified as a disturbed, fragmentary Caricetum rostratae.

<u>Wet reeds (water level class 5+)</u>

a) Wet reed (Fig. 37; appendix 5: Tab.2)

Fig. 37: Wet reed with *Typha latifolia*.

The species composition of relevé H57 indicates with *Typha latifolia, Equisetum fluviatile* and *Phalaris arundinacea* generally wet site with fluctuating water level. *Filipendula ulmaria, Lysimachia vulgaris, Lythrum salicaria, Valeriana officinalis* and *Impatiens noli-tangere* are common on nutrient rich, moist to wet sites.

In phytosociology relevé H57 cannot clearly be classified.

<u>Wet peat moss lawn (water level class 5+)</u>

a) *Sphagnum magellanicum*-community (Bunter Torfmoosrasen, SUCCOW & JOOSTEN 2001) (Fig. 38; Fig. 39; appendix 5: Tab.3)

Fig. 38: *Sphagnum magellanicum*-community as typical raised bog vegetation

The *Sphagnum magellanicum*-community (relevé G01, G03, G05, G07, G09) is the typical hummock community in nutrient-poor and acidic raised bogs, which consists of *Sphagnum* mosses like *Sphagnum magellanicum* and *Sphagnum nemoreum* and raised bog species like *Eriophorum vaginatum, Andromeda polifolia, Oxycoccus* *palustris* and *Polytrichum strictum*. *Calluna vulgaris* is typical on the drier top of the hummocks, whereas *Sphagnum fallax* is present on the wet edges near the bog hollows. Also *Rhynchospora alba* and *Scheuchzeria palustris* can be found sparsely on moist spots. *Drosera rotundifolia* however is a common companion. In the given relevés *Andromeda polifolia* plays a minor role, probably because of the shading by *Calluna vulgaris*.

Fig. 39: *Drosera rotundifolia* on *Sphagnum nemoreum* and *Sphagnum magellanicum*.

In phytosociology relevé G05 can be classified as typical Sphagnetum magellanici. Relevè G01 is seen as a Sphagnetum magellanici subassociation with *Scheuchzeria palustris*, whereas relevés G03, G07 and G09 are a Sphagnetum magellanici subassociation with *Rhynchospora alba.*

b) *Eriophorum vaginatum-Sphagnum recurvum*-community (Grüner Wollgras-Torfmoos-Rasen, SUCCOW & JOOSTEN 2001) (Fig. 40; appendix 5: Tab.3)

Fig. 40: *Eriophorum vaginatum-Sphagnum recurvum*-community

Beneath the naming *Eriophorum vaginatum*- and *Sphagnum recurvum* group also the *Sphagnum magellanicum*- and *Vaccinium oxycoccus* group dominate the *Eriophorum vaginatum-Sphagnum recurvum*-community (relevé G04, G11, G13). The ecological indicator groups indicate nutrient poor and acidic conditions, that are typical for raised bogs. The community, that still consists of flat *Sphagnum*-hummocks, is more humid than the *Sphagnum magellanicum*-community which is represented by the high amount of *Sphagnum fallax* or *Sphagnum cuspidatum* on the one hand, and the total lack of *Calluna vulgaris* on the other hand. A frequent companion plant in the given relevés is *Melampyrum pratense*.

In phytosociology, relevé G11 can be classified as typical Sphagnetum magellanici because of the presence of the typical character species *Sphagnum magellanicum* and *Eriophorum vaginatum* and the absence of the differential species *Rhynchospora alba* or *Scheuchzeria palustris*. However it can be stated, that the high amount of

Sphagnum fallax and the absence of *Calluna vulgaris* indicate a moist variety of the Sphagnetum magellanici. Relevés G04 and G13 belong to the Sphagnetum magellanici subassociation of *Scheuchzeria palustris*, that is found in wet, in winter eventually flooded parts near bog hollows.

<u>Wet bog hollow (water level class 5+)</u>

a) *Sphagnum cuspidatum-Carex limosa*-community (Grüne Torfmoos-Schlenke SUCCOW & JOOSTEN 2001) (Fig. 41; Fig. 42; appendix 5: Tab.3)

Fig. 41: *Sphagnum cuspidatum-Carex limosa*-community

The *Sphagnum cuspidatum-Carex limosa*-community (relevé G06, G08, G12) is found in nutrient-poor, acidic, wet bog hollows. In contrast to the hummock-communities, the *Sphagnum magellanicum* group is abscent in the wet bog hollows and the *Eriophorum vaginatum*- and the *Vaccinium oxycoccus* group show low frequencies. However, the *Rhynchospora alba* group with *Rhynchospora alba* and *Scheuchzeria palustris* shows higher frequencies. Furthermore the community is characterised by the *Carex limosa* group with *Carex limosa* and *Drosera longifolia,* which indicate the wet conditions. In the given relevés, the for the community typical *Sphagnum cuspidatum* is replaced and represented by *Sphagnum fallax* (see "Taxonomy of critical species", appendix 2).

Fig. 42: Sphagnum fallax in the *Sphagnum cuspidatum-Carex limosa*-community

In phytosociology relevés G06, G08 and G12 are all classified as bog hollow-communities. Relevés G06 and G12 can be characterised as typical Caricetum limosae, which can be found on nutrient-poor and lime-poor, wet sites. Relevé G08 however lacks *Carex limosa* and belongs to the Rhynchosporetum albae.

Besides the above described GESTs, the following other land use types were detected, where no water level class could be determined.

Pastures

In the subareas Herrgottsried and Gründlenried grassland areas with a total of 3,8 ha were fenced and used as pastures. Livestock in Gründlenried was cattle. In Herrgottsried, no livestock was present at the time of data collection. Vegetation on the pastures was not mapped, but soil disturbance by livestock grazing was visible.

Cropland

Cropland was very rare in the study area. Only in Herrgottsried, there was an arable field (0,15 ha) used for vegetable gardening.

Footpaths and roads

Footpaths and roads accounted for 4,3 ha of the study area. In the subarea Herrgottsried, two tarmac roads cross the area whereas most of the other roads were graveled farm tracks. The graveled farm track that crossed the raised bog core of Arrisrieder Moos was overgrown by vegetation, but the mineral material was still present.

Watercourses and lakes

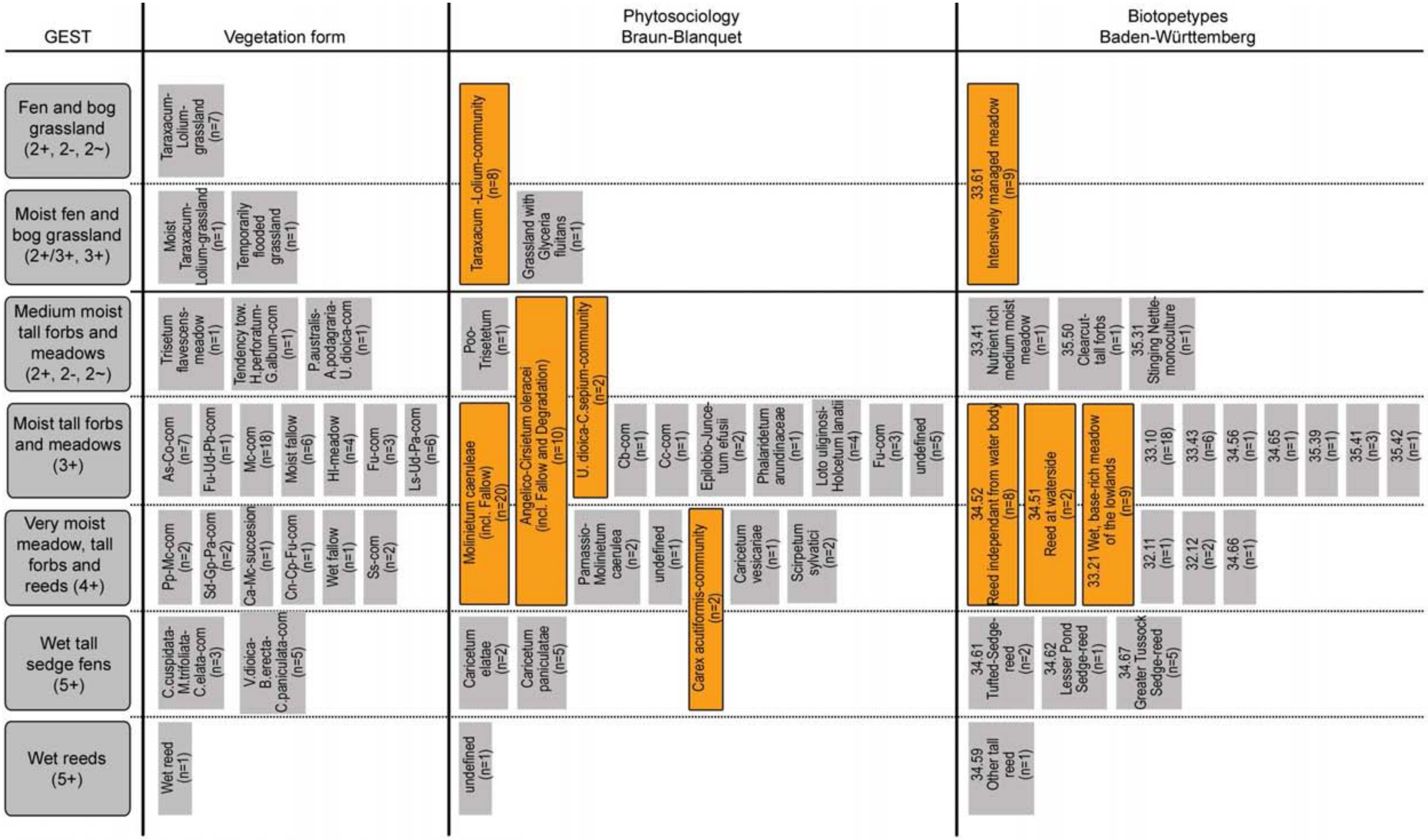
In Herrgottsried, the watercourses Wurzacher Ach, Vögelesgraben and Gospoldshofener Bach cross the subarea and accounted for 4,72 ha. In Arrisrieder Moos there was a small lake in the eastern part of the subarea (0,04 ha).

5.1.2 Identified GESTs in relation to other classification systems

GESTs and vegetation forms overlapped to different extent with the internationally accepted and applied phytosociology after Braun-Blanquet (see also chapter 2.1.2) and the regionally applied Biotope types of Baden-Württemberg (see also chapter 2.1.3). Fig. 43 and Fig. 44 show the overlap between the classification systems vegetation form, phytosociology according to Braun-Blanquet and Biotope types of Baden-Württemberg and their relation to the GESTs.

For phytosociology it is visible in Fig. 43, that in the sample sites in the study area the units *Taraxacum-Lolium*-community, Molinietum caeruleae, Angelico-Cirsietum oleracei, *Urtica dioica-Calistegia sepium*-community and *Carex acutiformis*-community were not limited to one certain water level class, but had a broader range of possible habitats. Sphagnetum magellanici in Fig. 44 covered broad ranges of the moisture gradient. Rhynchosporetum albae only represented water level class 5+ but covered two different GESTs. The differences in the classification systems resulted in a total of only seven phytosociological units, whereas the vegetation form concept provided 14 units.

In the classification system Biotope types of Baden-Württemberg, clear inconsistencies with the vegetation forms and GESTs were visible for the habitats 33.61-Intensively managed meadow, 34.52-Reed independent from waterbody, 34.51-Reed at waterside and 33.21-Wet, base-rich meadow of the lowlands (Fig. 43). Fig. 44 indicates that the two habitats 31.11-Natural raised bog and 31.32-Heather phase of a raised bog in the study area corresponded to six vegetation forms. 31.32-Heather phase of a raised bog covered three different GESTs and 31.11-Natural raised bog covered two GESTs.



<u>Abbreviations:</u> **com** = community; n = number of associated relevés
Vegetation forms: **Pp-Mc-com** = *Parnassia palustris-Molinia caerulea*-meadow; **Sd-Gp-Pa-com** = *Solanum dulcamara-Galium palustre-Phragmites australis*-community; **Ca-Mc-succesion** = Succesion of *Carex appropinquata-Molinia caerulea*-community; **Cn-Cp-Fu-com** = *Carex nigra-Caltha palustris-Filipendula ulmaria*-community; **Ss-com** = *Scirpus sylvaticus-meadow*; **As-Co-com** = *Angelica sylvestris-Cirsium oleraceum*-meadow; **Fu-Ud-Pb-com** = *Filipendula ulmaria-Urtica dioica-Polygonum bistorta*-community; **Mc-com** = *Molinia caerulea*-meadow; **Hl-meadow** = Degraded *Holcus lanatus*-meadow; **Fu-com** = *Filipendula ulmaria*-community; **Ls-Ud-Pa-com** =*Lythrum salicaria-Urtica dioica-Phragmites australis*-community
Phytosociology: **Cb-com** = *Carex brizoides*-community; **Cc-com** = *Carex canescens*-community; **Fu-com** = *Filipendula ulmaria*-community
Biotopetypes of Baden-Württemberg: **32.11** = Common sedge-reed; **32.12** = Grass of Parnassus-Common sedge-reed; **34.66** = Bladder sedge-reed; **33.10** = Moor Grass-meadow; **33.43** = poor grassland; **34.56** = Reed Canary Grass-reed; **35.39** = other monoculture; **35.41** = Tall forbs on boggy soil; **35.42** = Tall forbs along watercourses

Fig. 43: Relationship between GESTs, vegetation forms, phytosociological plant communities according to Braun-Blanquet and Biotope types of Baden-Württemberg; derived from 115 plant relevés in the study area, inconsistencies between the classification systems are shown in orange

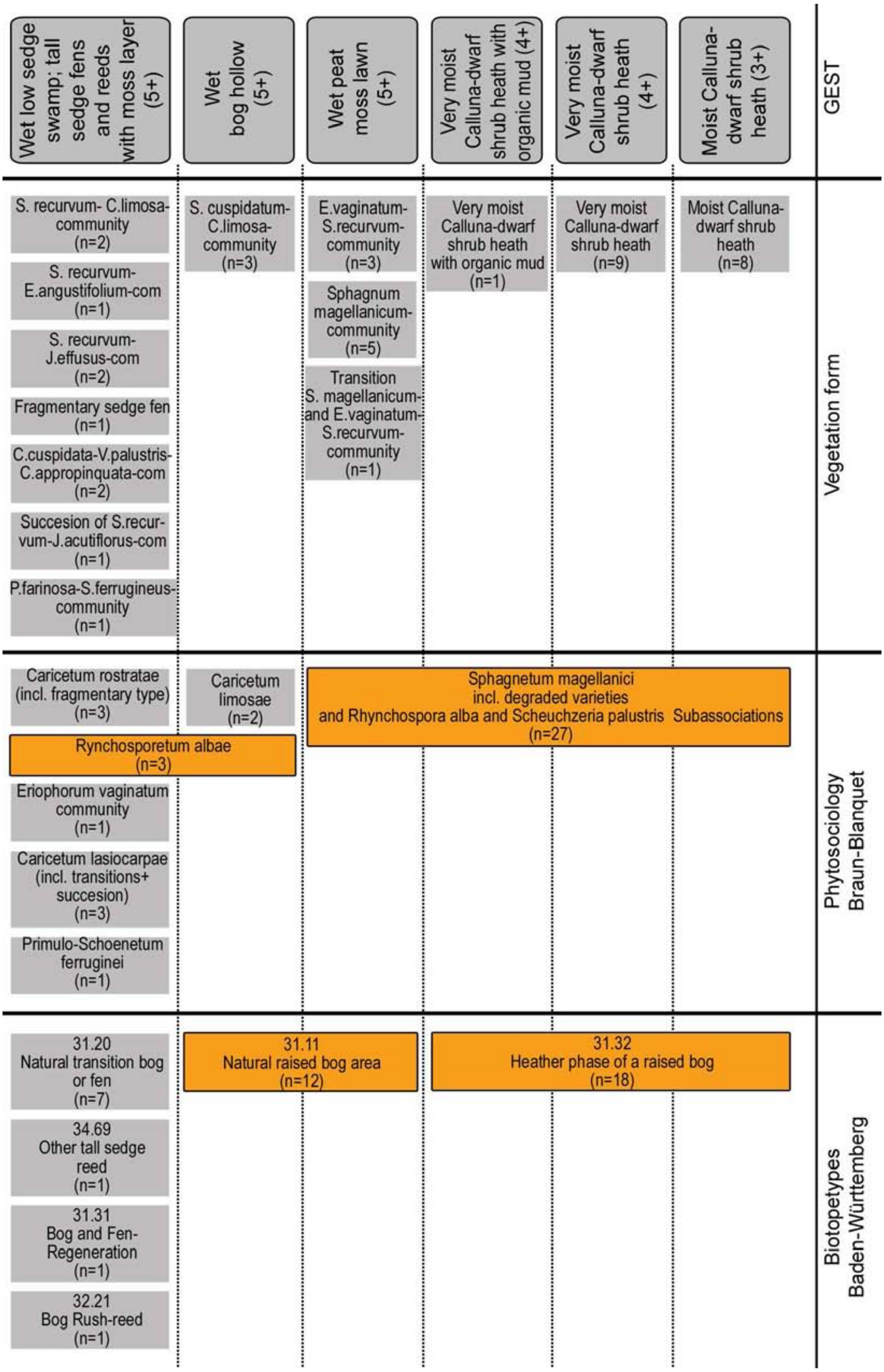


Fig. 44: Relationship between GESTs, vegetation forms, phytosociological plant communities according to Braun-Blanquet and Biotope types of Baden-Württemberg; derived from 115 plant relevés in the study area, inconsistencies between the classification systems are shown in orange

5.2 Assessment of forest sites

In the study area, 17 different forest types were detected. Additionally two small clearcut sites were found.

Table 13 shows, that wet, mature (stand age older than 20 years) *Pinus* forests had the largest share in the study area. They were followed by dry Mixed forests with a stand age older than 20 years. Mature *Picea abies* forests on drained sites played a significant role.

Table 13: Area balance for the detected forest types in the study area shown as surface area (ha) and percentage of the total study area. Area balance for the detected forest types in the subareas shown as surface area (ha) and percentage of the subarea. The surface area of non-forest sites is shown for information.

Forest type	Stand age (yr)	Water level	Study area ha	Study area %	Herrgottsried ha	Herrgottsried %	Gründlenried ha	Gründlenried %	Arrisrieder Moos ha	Arrisrieder Moos %
Picea abies forest	0-20	dry	1,69	0,4	0,25	0,1	1,15	0,7	0,29	0,4
Picea abies forest	>20	dry	31,54	7,2	8,67	4,4	7,15	4,3	15,72	22,0
Picea abies forest		wet	3,56	0,8	0,01	0	3,55	2,1	0	0
Pinus forest	>20	dry	1,36	0,3	0	0	1,36	0,8	0	0
Pinus forest		wet	78,64	18,0	0	0	77,41	46,7	1,23	1,7
Mixed forest	0-20	dry	5,14	1,2	0,45	0,2	4,27	2,6	0,41	0,6
Mixed forest		wet	4,05	0,9	2,03	1,0	2,02	1,2	0,00	0
Mixed forest	>20	dry	32,59	7,5	10,29	5,2	15,13	9,1	7,17	10,0
Mixed forest		wet	8,67	2,0	0	0	1,79	1,1	6,88	9,6
Natural deciduous forest	0-20	dry	3,45	0,8	2,13	1,1	0,51	0,3	0,81	1,1
Natural deciduous forest		wet	0,22	0,1	0	0	0,22	0,1	0	0
Natural deciduous forest	>20	dry	7,85	1,8	6,43	3,2	0,64	0,4	0,79	1,1
Natural deciduous forest		wet	0,99	0,2	0,95	0,5	0,04	0	0	0
Salix shrub	0-20	dry	0,40	0,1	0,33	0,2	0,07	0	0	0
Salix shrub		wet	0,49	0,1	0,49	0,2	0	0	0	0
Salix shrub	>20	dry	1,75	0,4	1,75	0,9	0	0	0	0
Salix shrub		wet	0,96	0,2	0,96	0,5	0	0	0	0
clearcut	-	-	0,12	0	0	0	0,10	0,1	0,02	0
non-forest habitats	-	-	253,04	58,0	164,49	82,6	50,46	30,4	38,09	53,3
TOTAL			**436,54**		**199,23**		**165,88**		**71,42**	

Mature, dry Mixed forests were the major forest type in the subarea Herrgottsried with 10,29 ha. Also *Picea abies* forests older than 20 years growing on dry sites (8,67 ha) and mature, dry Natural deciduous forests (6,43 ha) are worth mentioning.

Gründlenried hosted the largest forest areas in the study area with 77,41 ha wet and mature *Pinus* forests on the raised bog core. The area of mature, dry Mixed forests was significantly smaller (15,13 ha), but occured frequently in the lagg areas. Mature, dry *Picea abies* forests were found on drained sites in the northerwestern and southwestern subarea totalling 7,15 ha.

Dry, mature *Picea abies* forests dominated the woodlands in Arrisrieder Moos on an area of 15,72 ha. Mature Mixed forests on dry sites (7,17 ha) and on wet sites (6,88ha) were common in the peat cut areas around the raised bog core. A small, fragmentary *Pinus* forest (1,23 ha) could be found on the raised bog core.

5.2.1 Forests in the study area

a) *Picea abies* forests and plantations

Picea abies forests in the study area were often *Picea abies* monocultures without or with sparsely developed herb layer (Fig. 45, left). They were often strongly managed especially on drained sites. A thick floor tissue consisting of *Sphagnum* mosses (Fig. 45, right) developed on sites, where former drainage ditches collapsed and the water level was higher. However, young *Picea abies* forests were rare in the study area as a whole.

Fig. 45: Mature *Picea abies* forest on dry sites (left) and Mature *Picea abies* forest on wet sites (right), Source: IAF Nürtingen.

b) *Pinus* forests

Pinus forests in the study area can be found as part of the typical raised bog vegetation in Southern Germany. In the study area dwarfish *Pinus sylvestris* or *Pinus mugo* dominated the tree layer. The forest floor consisted of *Sphagnum* mosses as well as of dwarf shrubs like *Vaccinium uliginosum* and *Calluna vulgaris* or grasses like *Eriophorum vaginatum* (Fig. 46).

Fig. 46: Wet mature *Pinus* forest in Gründlenried.

c) Mixed forests (Fig. 47)

Mixed forests with deciduous trees like *Betula pendula, Betula pubescens, Salix* spec., *Alnus glutinosa* and coniferous trees like *Picea abies* and *Pinus sylvestris* were common in the fens. *Frangula alnus* was found in the shrub layer. Mixed forests on dry sites were partly relicts from former coniferous plantations, where collapsing drainage ditches and increasing soil moisture thus enabled deciduous tree species to develop. Typical carr occured in former peat cut areas, where *Betula pendula, Betula pubenscens* and *Picea abi*es prefer oligo- to mesotrophic sites. *Salix* spec. and *Alnus glutionosa* grow preferedly on meso- to eutrophic sites (DIERSSEN & DIERSSEN 2001).

Fig. 47: Mature Mixed forest on dry sites, Source: IAF Nürtingen

d) Natural deciduous forest (Fig. 48)

Natural deciduous forest in the study area was mainly carr consisting of *Betula pendula, Betula pubescens, Salix* spec., *Alnus glutinosa* and *Frangula alnus.* These forests occur mainly in the meso- to eutrophic fens and host often a high amount of deadwood. Additionally, young natural deciduous forests colonized fallows of all moisture levels.

Fig. 48: Natural deciduous forest on wet sites (left and middle) and on dry sites (right) in the study area, Source: IAF Nürtingen

e) *Salix* shrub (Fig. 49)

Salix shrub was common on meso- to eutrophic fens in the study area. It colonizes fallows as well as sedge fens and can develop to carr. The main occurrence of *Salix* shrub in the study area was in the subarea Herrgottsried.

Fig. 49: Salix shrub on wet sites in Herrgottsried

f) Clearcut

Marginal clearcut areas, where there was not yet any succesion were found in Arrisrieder Moos and Gründlenried. In Gründlenried, the area was used as timber store.

5.3 Estimation of CO_2 and CH_4 flux

5.3.1 Non-forest sites

As shown in Table 14, the calculated total GHB_{100} for non-forest sites on an area of 240 ha (pasture, cropland, footpaths and roads, watercourses and lakes excluded) is 4352,57 t CO_2e yr^{-1} for CO_2 and CH_4 efflux. Fen and bog grasslands contributed with 2633,79 t CO_2e yr^{-1} (60,5 %) the largest share to total GHB_{100} of non-forest sites, followed by Moist tall forbs and meadows with 954,48 t CO_2e yr^{-1} (21,9 %) and Moist fen and bog grassland with 271,06 t CO_2e yr^{-1} (6,2 %).

Table 14: GHB_{100} for CO_2 and CH_4 efflux from non-forest sites in the total study area, shown in t CO_2e yr^{-1} and as percentage of the GHB_{100} in the total study area

GEST (Water level class in brackets)	**GHB_{100} per ha** tCO$_2$e ha^{-1} yr^{-1}	**GHB_{100} Total study area** t CO$_2$e yr^{-1}	**%**
Fen and bog grassland (2-, 2+, 2~)	24,00	2633,79	60,5
Moist fen and bog grassland (3+/2+; 3+)	15,00	271,06	6,2
Medium moist tall forbs and meadows (2-, 2+, 2~)	24,00	66,25	1,5
Moist tall forbs and meadows (3+)	16,50	954,48	21,9
Moist Calluna-dwarf shrub heath (3+)	13,00	55,63	1,3
Very moist Calluna-dwarf shrub heath (4+)	9,50	158,02	3,6
Very moist Calluna-dwarf shrub heath with organic mud (4+)	7,00	4,30	0,1
Very moist meadow, tall forbs and reeds (4+)	11,00	39,04	0,9
Wet tall sedge fen (5+)	7,00	32,79	0,8
Wet low sedge swamps and tall sedge fens and reeds with moss layer (5+)	12,50	64,64	1,5
Wet reeds (5+)	10,00	5,17	0,1
Wet peat moss lawn (5+)	3,00	25,54	0,6
Wet peat moss lawn/ bog hollow area (5+)	5,50	41,86	1,0
Pasture, Cropland, Footpath and roads, Watercourses and lakes (n.d.)	n.d.	n.d.	n.d.
Total		**4352,57**	

The calculated GHB_{100} for the subarea Herrgottsried (156 ha without pasture, cropland, footpaths and roads, watercourses and lakes) was 3197,75 t CO_2e yr^{-1} for CO_2 and CH_4 efflux. Gründlenried revealed on an area of 47 ha a GHB_{100} of 579,70 t CO_2e yr^{-1}. Arrisrieder Moos had a GHB_{100} of 575,12 t CO_2e yr^{-1} on an area of 37 ha (Table 15).

Table 15: GHB_{100} for CO_2 and CH_4 efflux from non-forest sites in the subareas Herrgottsried, Gründlenried and Arrisrieder Moos, shown in t CO_2e yr^{-1} and as percentage of the GHB_{100} in each subarea

GEST (Water level class in brackets)	**GHB_{100} per ha** (tCO_2e ha^{-1} yr^{-1})	**GHB_{100} Herrgottsried** t CO_2e yr^{-1}	**%**	**GHB_{100} Gründlenried** t CO_2e yr^{-1}	**%**	**GHB_{100} Arrisrieder Moos** t CO_2e yr^{-1}	**%**
Fen and bog grassland (2-, 2+, 2~)	24,00	2248,21	70,3	160,09	27,6	225,49	39,2
Moist fen and bog grassland (3+/2+; 3+)	15,00	260,05	8,1	-	-	11,01	1,9
Medium moist tall forbs and meadows (2-, 2+, 2~)	24,00	23,85	0,7	-	-	42,41	7,4
Moist tall forbs and meadows (3+)	16,50	600,24	18,8	257,44	44,4	96,81	16,8
Moist Calluna-dwarf shrub heath (3+)	13,00	-	-	-	-	55,63	9,7
Very moist Calluna-dwarf shrub heath (4+)	9,50	-	-	25,96	4,5	132,06	23,0
Very moist Calluna-dwarf shrub heath with organic mud (4+)	7,00	-	-	-	-	4,30	0,7
Very moist meadow, tall forbs and reeds (4+)	11,00	16,94	0,5	14,68	2,5	7,41	1,3
Wet tall sedge fen (5+)	7,00	30,37	0,9	2,42	0,4	-	-
Wet low sedge swamps and tall sedge fens and reeds with moss layer (5+)	12,50	12,93	0,4	51,71	8,9	-	-
Wet reeds (5+)	10,00	5,17	0,2	-	-	-	-
Wet peat moss lawn (5+)	3,00	-	-	25,54	4,4	-	-
Wet peat moss lawn/ bog hollow area (5+)	5,50	-	-	41,86	7,2	-	-
Pasture, Cropland, Footpath and roads, Watercourses and lakes (n.d.)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Total		**3197,75**		**579,70**		**575,12**	

In the total study area the mean GHB_{100} per ha non-forest sites (240 ha without pasture, cropland, footpaths and roads, watercourses and lakes) was 18,1 t CO_2e ha^{-1} yr^{-1} (Fig. 50).

Herrgottsried's mean GHB_{100} was with 20,5 t CO_2e ha^{-1} yr^{-1} higher than the study area mean, Gründlenried's with 12,3 t CO_2e ha^{-1} yr^{-1} remarkably lower. Arrisrieder Moos (15,4 t CO_2e ha^{-1} yr^{-1}) was still lower than the study area mean and Herrgottsried's GHB_{100}, but higher than Gründlenried's GHB_{100} (Fig. 50).

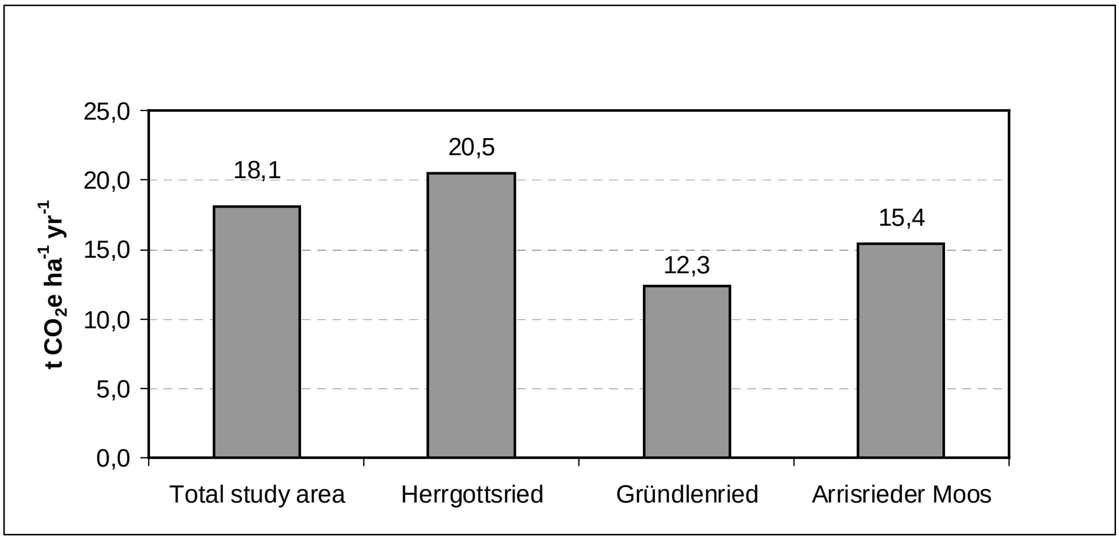


Fig. 50: GHB_{100} per ha on non-forested area compared to the mean GHB_{100} per ha non-forested subarea of Herrgottsried, Gründlenried and Arrisrieder Moos

5.3.2 Forest sites

Table 16 shows that forest sites in the total study area (without clearcut areas) had a carbon uptake from CO_2 and CH_4 of -259,91 t CO_2e yr^{-1}. Wet, mature *Pinus* forests (-157,28 t CO_2e yr^{-1}), dry, mature *Picea abies* forests (-126,17 t CO_2e yr^{-1}) and wet, mature Mixed forests (-47,70 t CO_2e yr^{-1}) had the largest carbon uptake. Dry, young Mixed forests (35,95 t CO_2e yr^{-1}) and dry, young Natural deciduous forests (24,16 t CO_2e yr^{-1}) had the largest efflux.

The forest sites in Herrgottsried had with an estimated efflux of 3,56 t CO_2e yr^{-1} (Table 17) a nearly neutral carbon balance indicated on an area of 34,74 ha. The highest efflux was found in young, dry Natural deciduous forests (14,92 t CO_2e yr^{-1}) and mature, dry Natural deciduous forests (12,85 t CO_2e yr^{-1}). *Picea abies* forests had the highest carbon uptake (-34,68 t CO_2e yr^{-1}).

Gründlenried showed a net carbon uptake of -172,45 t CO_2e yr^{-1} (Table 17). The main uptake occurred in wet, mature *Pinus* forests (-154,82 t CO_2e yr^{-1}) and mature, dry and wet *Picea abies* forests (-28,59 t CO_2e yr^{-1} and -28,40 t CO_2e yr^{-1} respectively). Efflux mainly came from dry, young Mixed forest (29,92 t CO_2e yr^{-1}) and dry, young *Picea abies* forest (8,02 t CO_2e yr^{-1}).

Table 16: GHB_{100} for CO_2 and CH_4 efflux (positive value) and uptake (negative value) from forest sites in the total study area, shown in t CO_2e yr^{-1} and as percentage of the GHB_{100} in the total study area

Forest type	Stand age (yr)	Water level	GHB_{100} **per ha** t CO_2e ha^{-1} yr^{-1}	GHB_{100} **total study area** t CO_2e yr^{-1}	**%**
Picea abies forest	0-20	dry	7,0	11,86	-4,6
Picea abies forest	>20	dry	-4,0	-126,17	48,5
Picea abies forest		wet	-8,0	-28,47	11,0
Pinus-forest	>20	dry	2,0	2,73	-1,1
Pinus-forest		wet	-2,0	-157,28	60,5
Mixed forest	0-20	dry	7,0	35,95	-13,8
Mixed forest		wet	1,5	6,07	-2,3
Mixed forest	>20	dry	0,0	0,00	0,0
Mixed forest		wet	-5,5	-47,70	18,4
Natural deciduous forest	0-20	dry	7,0	24,16	-9,3
Natural deciduous forest		wet	1,5	0,34	-0,1
Natural deciduous forest	>20	dry	2,0	15,71	-6,0
Natural deciduous forest		wet	-4,0	-3,97	1,5
Salix shrub	0-20	dry	7,0	2,81	-1,1
Salix shrub		wet	1,5	0,74	-0,3
Salix shrub	>20	dry	3,0	5,24	-2,0
Salix shrub		wet	-2,0	-1,93	0,7
clearcut	-	-	n.d.	n.d	-
TOTAL				**-259,91**	

Table 17 also shows that the forested area of Arrisrieder Moos had a net carbon uptake of -91,02 t CO_2e yr^{-1}. Dry, mature *Picea abies* forests had the largest share in the GHB_{100} of the subarea (-62,90 t CO_2e yr^{-1}) followed by wet, mature Mixed forests (-37,85 t CO_2e yr^{-1}). Efflux was mainly caused by dry, young Natural deciduous forest (5,66 t CO_2e yr^{-1}), dry young Mixed forest (2,89 t CO_2e yr^{-1}) and dry, young *Picea abies* forest (2,05 t CO_2e yr^{-1}).

The forest sites in the total study area had a mean uptake of –1,4 t CO_2e ha^{-1} yr^{-1}. Herrgottsried showed with a GHB_{100} of 0,1 t CO_2e ha^{-1} yr^{-1} a nearly equalized carbon balance. Gründlenried's carbon uptake was with -1,5 t CO_2e ha^{-1} yr^{-1} similar to the total study area's GHB_{100} and Arrisrieder Moos showed with –2,7 t CO_2e ha^{-1} yr^{-1} a higher uptake than the study area mean (Fig. 51).

Table 17: GHB_{100} for CO_2 and CH_4 efflux (positive value) and uptake (negative value) from forest sites in the subareas Herrgottsried, Gründlenried and Arrisrieder Moos, shown in t CO_2e yr^{-1} and as percentage of the GHB_{100} in each subarea

Forest type	Stand age (yr)	Water level	GHB_{100} **per ha** t CO_2 ha^{-1} yr^{-1}	GHB_{100} **Herrgottsried** t CO_2 yr^{-1}	%	GHB_{100} **Gründlenried** t CO_2 yr^{-1}	%	GHB_{100} **Arrisrieder Moos** t CO_2 yr^{-1}	%
Picea abies forest	0-20	dry	7,0	1,78	49,9	8,02	-4,7	2,05	-2,3
Picea abies forest	>20	dry	-4,0	-34,68	-973,7	-28,59	16,6	-62,90	69,1
Picea abies forest		wet	-8,0	-0,07	-1,9	-28,40	16,5	0	0
Pinus-forest	>20	dry	2,0	0	0	2,73	-1,6	0	0
Pinus-forest		wet	-2,0	0	0	-154,82	89,8	-2,45	2,7
Mixed forest	0-20	dry	7,0	3,15	88,3	29,92	-17,4	2,89	-3,2
Mixed forest		wet	1,5	3,04	85,3	3,03	-1,8	0	0
Mixed forest	>20	dry	0	0	0	0	0	0	0
Mixed forest		wet	-5,5	0	0	-9,86	5,7	-37,85	41,6
Natural deciduous forest	0-20	dry	7,0	14,92	418,9	3,58	-2,1	5,66	-6,2
Natural deciduous forest		wet	1,5	0	0	0,34	-0,2	0	0
Natural deciduous forest	>20	dry	2,0	12,85	360,8	1,27	-0,7	1,59	-1,7
Natural deciduous forest		wet	-4,0	-3,81	-107,1	-0,16	0,1	0	0
Salix shrub	0-20	dry	7,0	2,34	65,7	0,47	-0,3	0	0
Salix shrub		wet	1,5	0,74	20,8	0	0	0	0
Salix shrub	>20	dry	3,0	5,24	147,2	0	0	0	0
Salix shrub		wet	-2,0	-1,93	-54,1	0	0	0	0
clearcut			n.d.	n.d		n.d		n.d	
TOTAL				**3,56**		**-172,45**		**-91,02**	

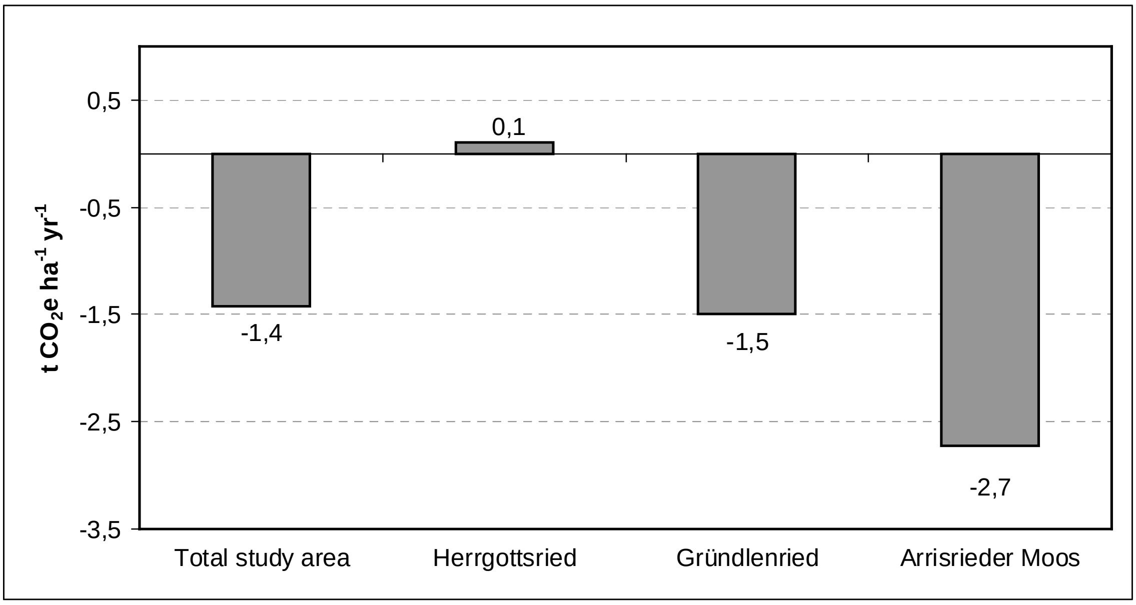


Fig. 51: GHB_{100} per ha forested site area compared to the mean GHB_{100} in the forested subareas Herrgottsried, Gründlenried and Arrisrieder Moos. Positive values indicate a net carbon efflux, negative values a net carbon sequestration.

5.3.3 Synthesis of total CO_2 and CH_4 flux

Fig. 52 shows that the summarized GHB_{100} from non-forest sites (240 ha, Fig. 53) and forest sites (183,5 ha; Fig. 53) in the total study area was 4092,66 t CO_2e yr^{-1}. The total carbon efflux of 4352,57 t CO_2e yr^{-1} was only slightly reduced by the carbon sequestration of forest sites (-259,91 t CO_2e yr^{-1}).

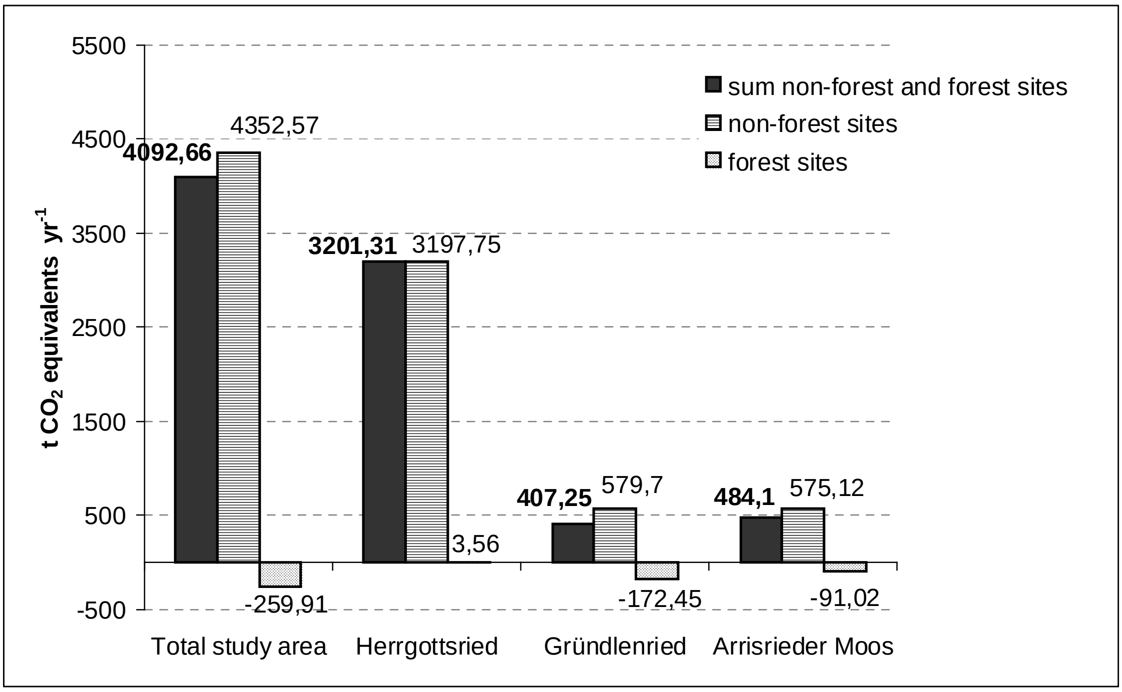


Fig. 52: GHB_{100} (t CO_2e yr^{-1} for CO_2 and CH_4 fluxes) of totals, non-forested and forested sites as well as comparisons of the subareas Herrgottsried, Gründlenried and Arrisrieder Moos. Positive values indicate a net carbon efflux, negative values indicate a net carbon sequestration.

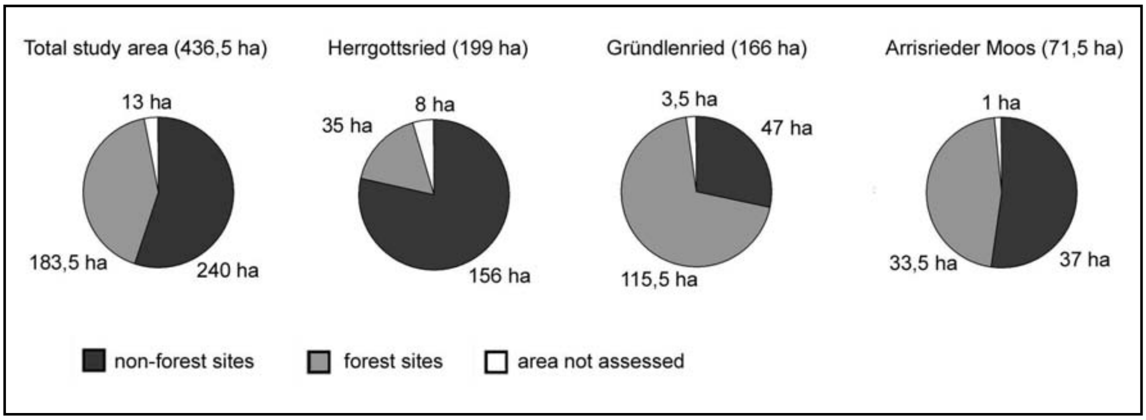


Fig. 53: Share of non-forest sites, forest sites and area not assessed (ha) in the total study area as well as in the subareas Herrgottsried, Gründlenried and Arrisrieder Moos.

The subarea Herrgottsried contributed with 3201,31 t CO_2e yr^{-1} the largest share to the total study area's GHB_{100} (Fig. 52). Forests (34,74 ha, Fig. 53) however only added a marginal share (3,56 t CO_2e yr^{-1}) to Herrgottsried's

GHB_{100}. Herrgottsried's GHB_{100} was approximately eight times higher than Gründlenried's GHB_{100} (407,25 t CO_2e yr^{-1}, Fig. 52) but Herrgottsried's surface area was only 1,2 times higher. Compared to Arrisrieder Moos (484,1 t CO_2e yr^{-1}, Fig. 52), Herrgottsried's GHB_{100} was approximately 6,5 times higher, but its surface area was 2,8 times higher (Fig. 53).

The mean GHB_{100} per ha was 9,7 t CO_2e ha^{-1} yr^{-1} in the total study area. In the subareas, Herrgottsried had the highest GHB_{100} per ha (16,8 t CO_2e ha^{-1} yr^{-1}), followed by Arrisrieder Moos (6,9 t CO_2e ha^{-1} yr^{-1}) and Gründlenried (2,5 t CO_2e ha^{-1} yr^{-1}).

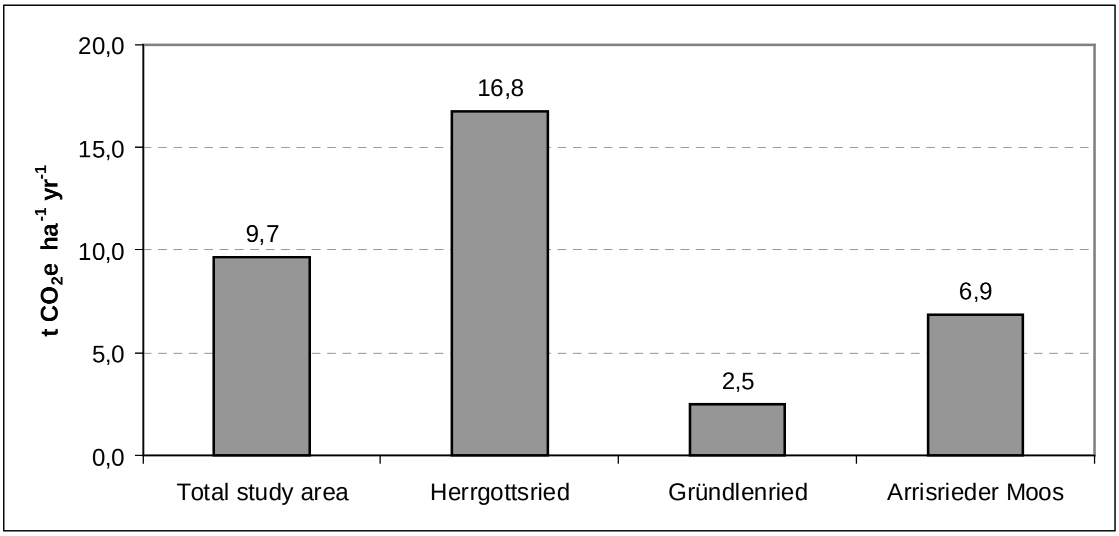


Fig. 54: GHB_{100} per ha area compared to the mean GHB_{100} in the subareas Herrgottsried, Gründlenried and Arrisrieder Moos.

Fig. 55 shows that large parts of Herrgottsried showed a carbon efflux of 20 to 25 t CO_2e yr^{-1}. Only small areas in the western subarea sequestered carbon to a maximum magnitude of –4,9 to –0,1 t CO_2e yr^{-1}.

Large parts in the raised bog area of Gründlenried sequestered carbon amounts of between –4,9 to –0,1 t CO_2e yr^{-1} and some areas sequestered even –8,0 to –5,0 t CO_2e yr^{-1} (Fig. 56). Fringe areas had a carbon efflux between 20 and 25 t CO_2e yr^{-1}.

In Arrisrieder Moos the highest carbon efflux (20 to 25 t CO_2e yr^{-1}) was found in the southern fringe areas. The highest carbon sequestration (-8,0 to –5,0 t CO_2e yr^{-1}) was situated in areas around the raised bog core (Fig. 57).

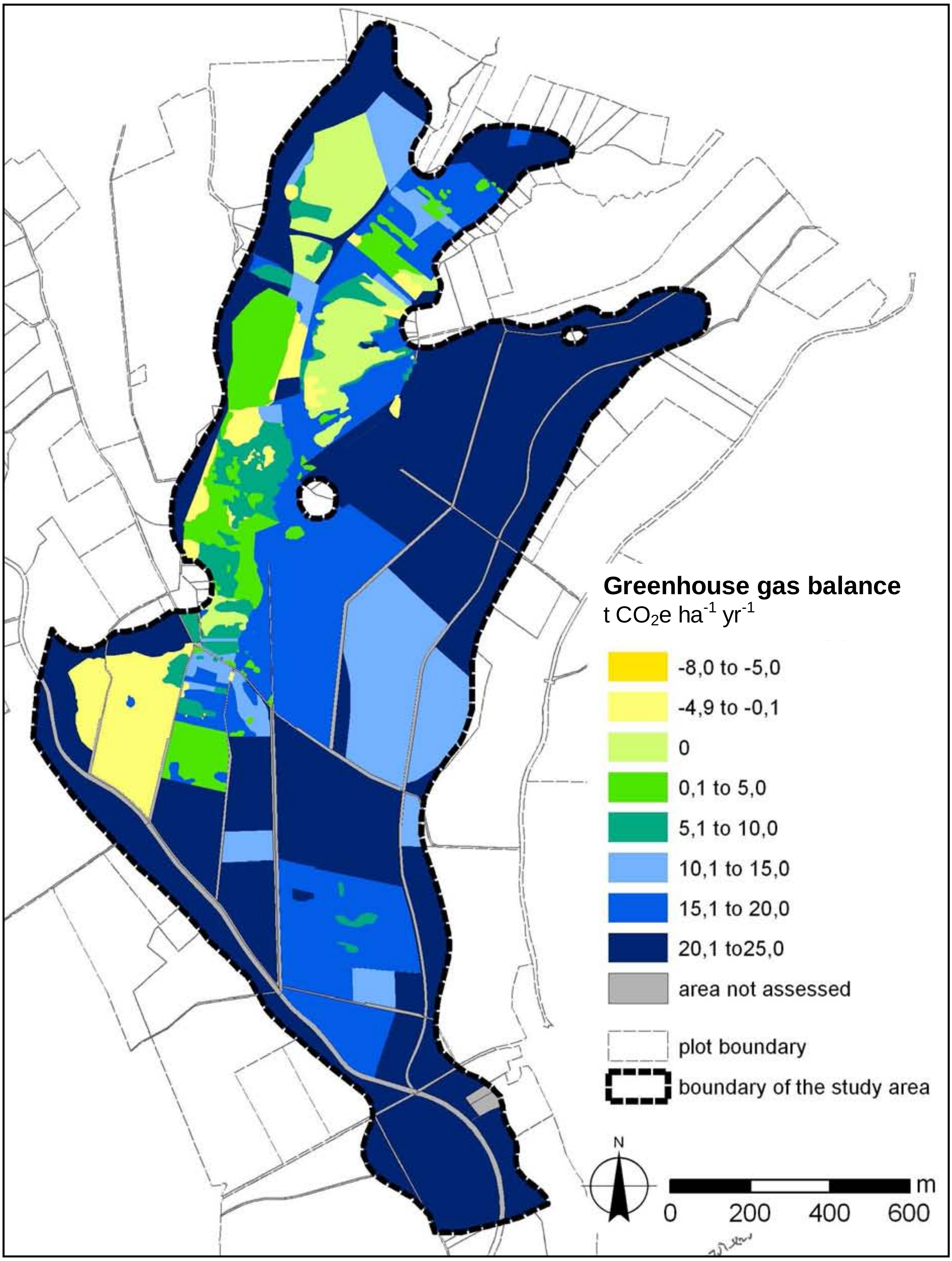


Fig. 55: GHB_{100} per ha (t CO_2e ha^{-1} yr^{-1}) in the subarea Herrgottsried, scale 1:15.000, base map: © Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/11

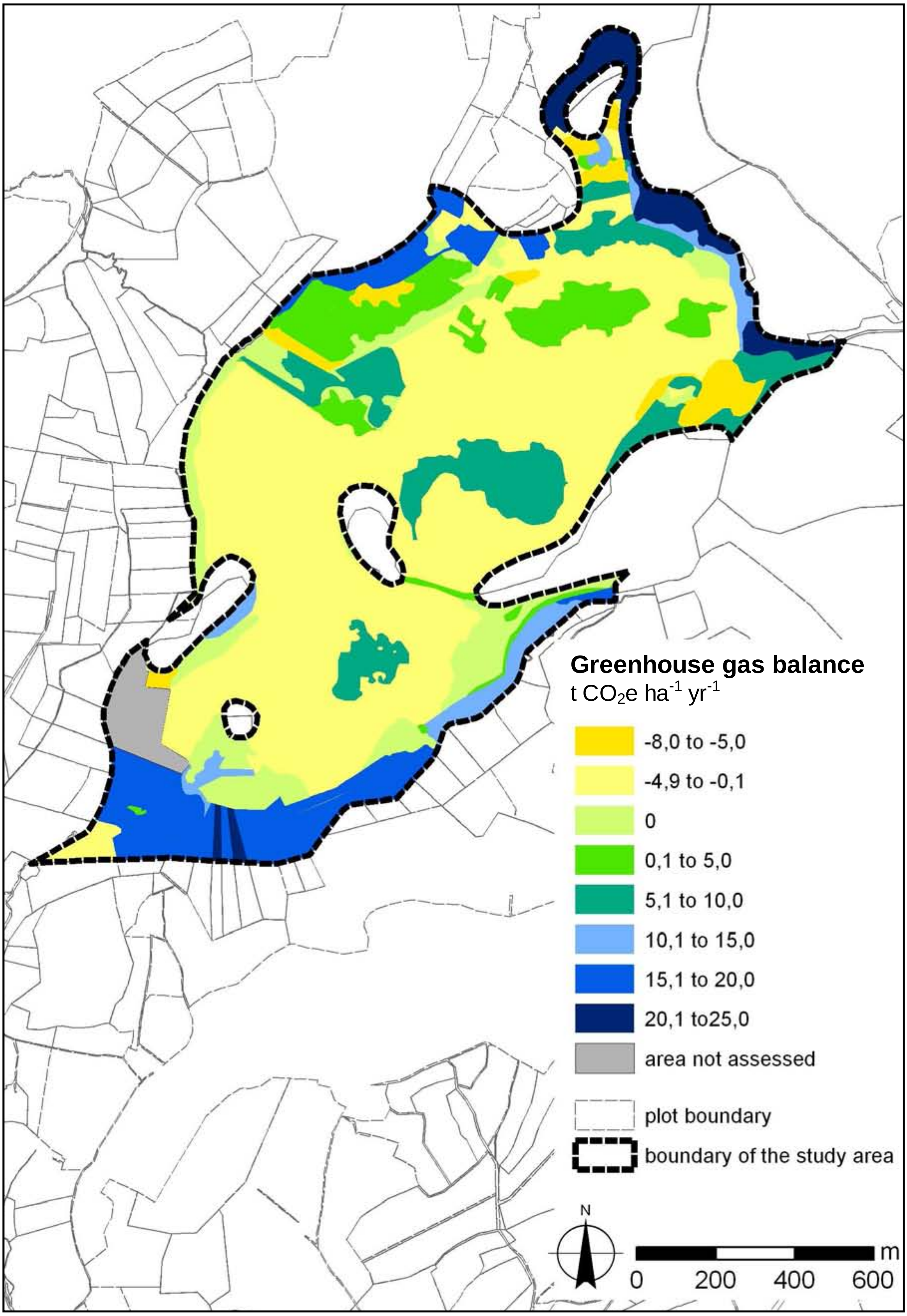


Fig. 56: GHB_{100} per ha (t CO_2e ha^{-1} yr^{-1}) in the subarea Gründlenried, scale 1:15.000, base map: © Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/112851.9-1/11

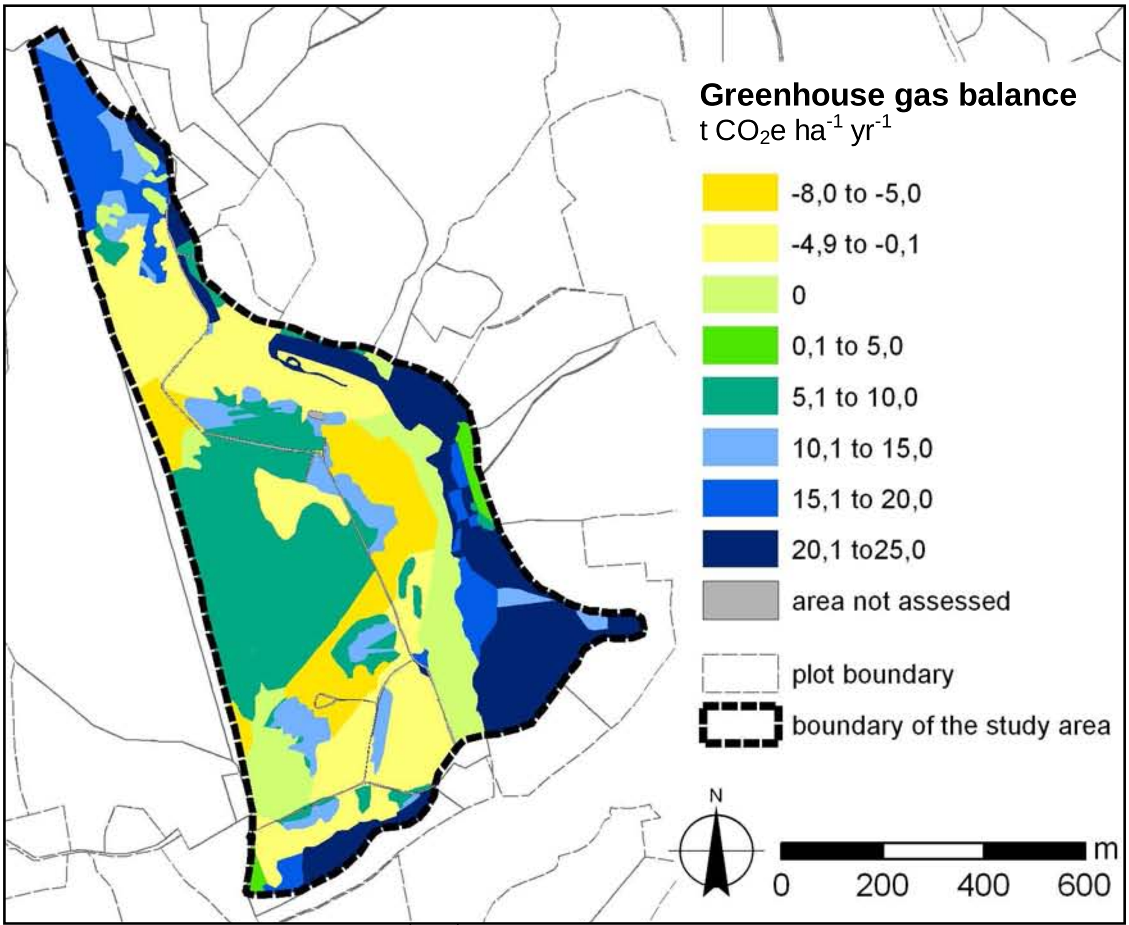


Fig. 57: GHB_{100} per ha (t CO_2e ha^{-1} yr^{-1}) in the subarea Arrisrieder Moos, scale 1:15.000, base map: © Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/11

6 Discussion

6.1 Methodology

The following chapter deals with the methods applied and encounters of obstacles and limitations during the working process. They partly exemplify problems that could occur in a statewide application of the methods used here. The encountered obstacles and limitations should be considered if a statewide system would be aspired. Furthermore, the knowledge on methodological limitations is necessary to judge on the credibility of the resulting flux estimates.

6.1.1 Data collection and evaluation of non-forest sites

For data collection, vegetation relevés as well as an areawide vegetation survey were performed. Normally, vegetation relevés are mapped and evaluated in a first step. The areawide vegetation survey is subsequently performed according to a mapping key produced from the vegetation relevés. In contrast to the common procedure, vegetation relevés and area-wide vegetation survey had to be mapped simultaneously in this study, due to the set time limit. Although it might be argued that the common procedure represents the vegetation more accurate, the used method was considered to be sufficient, as indicator species presented by COUWENBERG et al. 2008 were used in the mapping or vegetation types could be identified due to species lists.

GESTs are derived from vegetation forms (COUWENBERG et al. 2008). However, vegetation forms are mainly applied in eastern Germany (KOSKA et al. 2004) and there is only a limited amount of literature adressing wetland vegetation forms. Insufficient descriptions of vegetation forms that might cause a deficient classification could possibly be a source of mistakes in the data evaluation. SUCCOW & JOOSTEN 2001 state that all vegetation samples can be classified as vegetation form using their ecological indicator groups. The practical work in this thesis showed that this was not possible due to lack of detailed vegetation form description for Southern Germany. Many relevés hosted only few ecological indicator groups that were common in several different vegetation forms. Hence, water level class and GEST were estimated according to the given species composition and to mean quantitative Ellenberg indicator values. The assignment of water level classes and GESTs was a possible error source in the data evaluation, because a published relation between Ellenberg indicator values and water level classes could not be found.

Thus, the insufficient description of vegetation forms for Southern Germany made an adaptation of the mapping process problematic.

6.1.2 Data collection and evaluation of forest sites

Mapping data provided by IAF Nürtingen was classified into forest types. Important factors influencing CO_2 and CH_4 fluxes in organic soils under stands of forest are soil temperature (e.g. VON ARNOLD et al. 2005b, DINSMORE et al. 2009, KECHAVARZI et al 2010), peat type (KECHAVARZI et al. 2010), water table depth (e.g. MARTIKAINEN et al. 1995, JUNGKUNST et al. 2008) and stand age (e.g. ZERVA & MENCUCCINI 2005, BALL et al. 2007, SAIZ et al. 2006).

Opinions contradict, whether tree species is an important determinant for CO_2 and CH_4 efflux. BERGER et al. 2010 support this assumption, whereas VON ARNOLD et al. 2005a were not able to detect an influence of tree species on CO_2 efflux. However, DINSMORE et al. 2009 stated that plant community composition and structure are a main control on soil carbon. Tree species was therefore considered to be an important factor in this study.

Water table is important, because it controls the oxygen in the soil and therefore acts on inputs and outputs of CO_2 and outputs of CH_4 (see chapter 1). JUNGKUNST et al. 2008 talk about an „on-off-switch" for CH_4 emissions. JUNGKUNST & FIEDLER 2007 report that CH_4 emissions are only noteable if the water table is higher than –10 cm. ROULET et al. 1992 indicate that CH_4 emissions are neglectable, if the water table is below –20 to –30 cm. Therefore, the mean value of –20 cm was used as the critical threshold. Forests with a median annual water table from –20 cm and higher were considered 'wet' and sites with a median annual water table from –20 to > -80 cm were considered 'dry'. Thus, this classification was in accordance with the GEST water levels for non-forest sites.

As shown in KECHAVARZI et al. 2010 the factors peat type, temperature and soil water content are interacting, as soil water content and temperature determine peat accumulation. Therefore peat type was not considered seperately in this study. Temperature was assumed to be homogenous in the study area.

Hence, the classification of forest types was limited to the parameters water table depth, stand age and tree species, where age and species composition were used as indicators for tree productivity.

6.1.3 Estimation of CO_2 and CH_4 flux for non-forest sites

The GHB_{100} according to COUWENBERG et al. 2008 was applied to 55 % of the total study area. A general discussion of the GEST concept is out of scope of this thesis and its suggested emission estimates are accepted. In the following sections only those parts are discussed, where uncertainties are considered to be especially noteworthy.

Emission estimates for Fen and bog grassland

COUWENBERG et al. 2008 published GHB_{100} for Fen and bog grassland according to the water level class and indicator species. As opposed to that, HARGITA & MEIßNER 2010 argue that there is no relationship between waterlevel class and vegetation for Fen and bog grassland. They suggest an estimate of the water level class according to adjacent natural sites. This thesis follows COUWENBERG et al. 2008 assuming that the water level of a site is reflected in vegetation because management of grassland depends among others on the water level class (e.g. the trafficability with agricultural machines depends on the soil stability that is among others controlled by soil moisture). In turn, the vegetation in grassland ecosystems depends to a large extent on the prevailing management. Therefore, a relation between grassland vegetation and waterlevel class was considered to be reasonable.

Emission estimate for footpaths and roads, watercourses and lakes, pastures and cropland

As mentioned in chapter 4.4.1, footpaths and roads, watercourses and lakes, pastures and cropland were excluded from the estimation of CO_2 and CH_4 emissions for non-forest sites.

At footpaths and roads the original peat soil was either sealed or removed and replaced by mineral soil or gravel. Therefore, these areas were not considered, because the GEST estimate is limited to peat soils.

Nearly all riverbeds in the study area consisted of mineral soil layers. Therefore they were excluded from the estimate. CH_4 fluxes from ditch water and from saturated peat soil bordering ditches (HENDRIKS et al. 2007) were considered to be unpredictable in the study area. For lakes, no adequate default emission values could be detected in literature.

Pastures were not included in the estimation of CO_2 and CH_4 emissions, because NIEVEEN et al. 2005 has reported a clear effct of grazing on the CO_2 emissions from peat pasture. They point out, that the exchange of CO_2 is strongly influenced by grazing management. Moreover it is generally not clear, if carbon emissions from ruminants on pastures should be included in the estimate (e.g. in NIEVEEN et al. 2005) or if they should be omitted (e.g. LANGEVELD et al. 1997).

The estimation of CO_2 and CH_4 fluxes from cropland is very site specific and depends on various factors. COUWENBERG et al. 2008 provide emission values for cropland according to the water level class. Furthermore carbon fluxes depend on the crop type (e.g. BERGLUND & BERGLUND 2010, KASIMIR-KLEMEDTSSON et al. 1997). KASIMIR-KLEMEDTSSON et al.1997 estimate net flux rates ranging from 8 to 115 t CO_2 ha^{-1} yr^{-1}. Cropland was not included in the emission estimate in this study, because (1) it was not possible to detect the water level class of cropland, (2) the crop type was not mapped, (3) cropland area played a minor role in the study area and (4) because of the large variability of the provided GHB_{100} for cropland.

6.1.4 Estimation of CO_2 and CH_4 flux for forest sites

Carbon in living biomass

A key factor for the estimate of CO_2 fluxes in forest sites is forest productivity. Productivity for forest stands older than 20 years was gathered by the evaluation of the forest management plans for Herrgottsried and Arrisrieder Moos (LANDRATSAMT RAVENSBURG 2010a, 2010b). For *Pinus* forests the net increment of ‘Pine’ was used, where there was no information if ‘Pine’ relates to *Pinus sylvestris* or *Pinus mugo*. Hence, it is possible that the net increment of *Pinus* forests was overestimated on sites where *Pinus mugo* dominates, because *Pinus mugo* often grows relatively slow. Furthermore, a reduced net increment due to soil humidity on wet sites was not taken into consideration due to lack of suitable data. Therefore, net increments should be verified and refined in future works.

Carbon in dead organic matter

The carbon output from deadwood was calculated based on the dead wood input (equation 6), because the magnitude of the dead wood carbon stock was not known in the study area. Hence, the multiplication of the decay rate and dead wood input provided a minimum value for the carbon output from deadwood. It may be assumed that the actual carbon output is higher than the estimated value. The carbon emission would have been higher, if the total dead wood carbon stock would have been taken into consideration. If dead wood carbon stocks are known, equation 6 may not be used, because in this case the decay rate has to be multiplied by the total carbon stock.

Carbon in soil organic matter

VON ARNOLD et al. 2005c estimated mean emissions of *“3.0 t CO_2-C ha^{-1} $year^{-1}$ (range 2.49 - 3.51) for the well drained sites and 1.9 t CO_2-C ha^{-1} $year^{-1}$ (range 1.45 - 2.35) for the poorly drained sites*” in temperate forests. Their estimates are supported e.g. by the measurements of O’CONNELL et al. 2003, who detected CO_2 emissions from boreal forests soils of 5,64 t C ha^{-1} yr^{-1} and 3,19 t C ha^{-1} yr^{-1} for moderately and poorly drained soils respectively. These values are higher than the PENMAN et al. 2003 default values. Both authors indicate that CO_2 emissions from wet soils are smaller than CO_2 emissions from dry soils (see also chapter 1). VON ARNOLD et al. 2005c defined ‘poorly drained sites’ as sites with a water table higher than –50 cm and ‘well drained sites’ as sites with water table lower than –50 cm. However, water tables in this thesis are classified as ‘wet’, if the mean annual water table is higher than 20 cm under soil surface and as dry, if the mean annual water table is –20 cm to > -80 cm. Hence, it was assumed that carbon flux values in this thesis have to be lower than VON ARNOLD et al. 2005c’s mean values. Therefore, an efflux value of 2,5 t C ha^{-1} yr^{-1} was applied for dry sites, corresponding to the lower range of VON ARNOLD et al. 2005c’s estimate for well drained sites. In the consideration of sites with a mean annual water table higher than -20 cm, the interaction of the magnitude of CO_2 and CH_4 emissions has to be taken into consideration. As explained in chapter 1, CH_4 is mainly produced under anaerobic conditions and CO_2 under aerobic conditions. Water tables higher than -20 cm are subject to CH_4 emissions (JUNGKUNST & FIEDLER 2007, JUNGKUNST et al. 2008, ROULET et al. 1992). Hence, as soon as CH_4 emissions occur, it may be assumed that CO_2 emissions decrease or cease under anaerobic conditions. Therefore, CO_2 flux values in this thesis have to be significantly lower than VON ARNOLD et al. 2005c’s mean values for poorly drained sites. In this case the significantly lower PENMAN et al. 2003 default value of 0,68 t C ha^{-1} yr^{-1} (range 0,41 – 1,91 t C ha^{-1} yr^{-1}) is used.

CH_4 fluxes

For CH_4 emissions on sites having a mean annual water table higher than –20 cm, the mean value of 1,2 t CO_2e ha^{-1} yr^{-1} (range 0,099 – 7,93 t CO_2e ha^{-1} yr^{-1}) was used. Table 10 shows, that JUNGKUNST 2004 suggests exeptionally high efflux values compared to VON ARNOLD et al. 2005a, VON ARNOLD et al. 2005 c, JUNGKUNST & FIEDLER 2007 and JUNGKUNST et al. 2008. It may be discussed, if this outlier should not have been deleted. It was included here, because it was the only measurement of *Picea abies* forest on organic soils performed over a period of two years found in literature. It was not possible by the means of the given references to detect the most reliable value for CH_4 fluxes in Southern German forests. Therefore the mean over all values was used.

Application of CO_2 and CH_4 calculations to the forest types

The calculated GHB_{100} in Table 11 reflects the role of forests in the carbon cycle. Atmospheric carbon is assimilated by trees and subsequently transferred to organic carbon in living plant tissue. The tree productivity depending on tree species and tree age determines the rate of carbon uptake. Soil organisms decomposing litter from trees and other plants subsequently cause carbon emission.

Hence, young forests on dry sites with a mean annual water table of –20 cm to >-80 cm have a net carbon efflux. As long as the total plant productivity is low, soil organisms will decompose more carbon than young trees can assimilate in their biomass. Mature *Picea abies* forests on dry sites have the highest productivity value in the study area (LANDRATSAMT RAVENSBURG 2010a, 2010b). Their carbon assimilation rate is higher than the decomposition rate of the soil organisms. Therefore there is a net carbon uptake. Mature *Pinus sylvestris* forests, Mixed forests, Natural deciduous forests and Salix-shrub are less productive (LANDRATSAMT RAVENSBURG 2010a, 2010b) than *Picea abies*. They show a net carbon efflux on dry sites, because decomposition by soil organisms is higher than carbon assimilation by trees.

On wet sites with water tables higher than –20 cm young forest stands still have a net carbon efflux. All mature forests on the wet sites assimilate more carbon into tree biomass than soil organisms release, thus sequestering carbon in the ecosystem.

The opinions in the literature on the magnitude of carbon fluxes from forests are divergent. AUGUSTIN in SUCCOW & JOOSTEN 2001 suggests carbon fluxes of 0,49 t CO_2e ha^{-1} yr^{-1} for undisturbed carr and 5,81 t CO_2e ha^{-1} yr^{-1} for drained carr. HÖPER 2007 advises 1,3 t CO_2e ha^{-1} yr^{-1} for bog forest and 4,6 t CO_2e ha^{-1} yr^{-1} for fen forest. These results are incorporated into the estimates of BYRNE et al. 2004, who suggest 0,04 t CO_2e ha^{-1} yr^{-1} for drained forest on bog and -0,2 t CO_2e ha^{-1} yr^{-1} for drained forest on minerotrophic fen. SAATHOFF 2008 summarizes actual carbon flux measurements and suggests carbon uptakes of -41 to –7 t CO_2e ha^{-1} yr^{-1} for forests. These results show, that carbon fluxes from forests are probably highly site specific and related to productivity factors not considered here. The estimated emission factors in this thesis (Table 11) are inbetween the published flux ranges or with 7 t CO_2e ha^{-1} yr^{-1} for dry, young forests only marginally higher.

However, the emission factors for forests presented here have limitations. Timber harvest is not considered in the calculation, as well as decreasing tree productivity with rising water table. Furthermore, N_2O fluxes are not included in the emission factor.

6.1.5 Synthesis of total CO_2 and CH_4 flux

As the synthesis combines different estimation methods for non-forest sites and for forest sites, the results should not be interpreted as definite quantities, but rather as relations between the carbon fluxes on different sites. Hence, the emission factors in Fig. 55, Fig. 56 and Fig. 57 are classified by similar intervals. Generally, the magnitude of the calculated emission factors corresponds to BYRNE et al. 2004. The aforementioned suggested, that carbon emission from forests < mire < grassland < crops. This relation was represented by the emission factors used in this thesis.

6.2 Assessment of non-forest sites

6.2.1 Greenhouse Gas Emission Site Types and vegetations forms in the study area

As described above, some relevés could not clearly be identified as described vegetation form due to the mentioned reasons. For those, the water level class had to be identified according to the present species and/or mean quantitative Ellenberg indicator values. The following section discusses this identification and thus the description as GEST. Only those vegetation types are mentioned, where there is no explicit reference to water level class in the literature.

<u>Fen and bog grassland (water level class 2-, 2+, 2~)</u>

b) *Taraxacum-Lolium*-grassland (appendix 5: Tab.1)

The species-poor *Taraxacum-Lolium*-grasslands were intensively managed (3-5 cuts per year and organic fertilisation) and drained areas and were therefore generally handled as Fen and bog grassland. Ellenberg indicator values for moisture were between 4,2 and 5,5 and were comparable to those of a *Trisetum flavenscens*-meadow (Ellenberg indicator value here: 5,6). Therefore *Taraxacum-Lolium*-grasslands were considered to be substitute communities for *Trisetum flavenscens*-meadows belonging to the same water level class 2- (HUNDT & SUCCOW 1984).

Moist fen and bog grassland (water level class 3+/2+; 3+)

a) Moist *Taraxacum-Lolium*-grassland and Temporarily flooded grassland (appendix 5: Tab.1)

The species composition of the Moist fen and bog grassland was very similar to the Fen and bog grassland, but also hosted moisture indicators. Both differentiating species *Phalaris arundinacea* and *Glyceria fluitans* grow on sites prone to flooding. COUWENBERG et al. 2008 suggested water level class 4+ for *Phalaris arundinacea*-fen and bog monoculture. Taking the given species composition with *Ranunculus repens, Poa trivialis* and *Alopecurus prate*nsis into consideration, median annual water levels of 0 till -20 cm under soil surface seemed overestimated, whereas median annual water levels between –20 to -45 cm under soil surface were reasonable. Therefore water level class 3+ was chosen.

Medium moist tall forbs and meadows (water level class 2-, 2+, 2~)

a) Community with tendency towards *Hypericum perforatum-Galium album*-community (appendix 5: Tab.2)

The given community hosted only a few moisture indicators like *Cirsium oleraceum, Deschampsia cespitosa* and *Phalaris arundinacea*, but the larger amount of species belonged to the medium moist to dry meadows. Perhaps, the site had initially been an *Angelica sylvestris-Cirsium oleraceum*-community, but the actual mean quantitative Ellenberg indicator value for moisture of 4,9 showed medium moist conditions. The occurrence of ecological indicator groups from the *Hypericum perforatum-Galium album*-community justified the classification as medium moist tall forbs.

Moist tall forbs and meadows (water level class 3+)

a) *Filipendula ulmaria*-community (appendix 5: Tab.2)

Filipendula ulmaria-communities belong either to water level class 4+ or 3+. (SUCCOW & JOOSTEN 2001). As the differentiating ecological indicator groups *Galium palustre* group, *Caltha palustris* group and *Lysimachia thyrsiflora* group for water level class 4+ were not or only sparsely represented, the given *Filipendula ulmaria*-communitites were specified as water level class 3+.

b) Moist fallow AR17 (appendix 5: Tab.2)

Moist fallow AR17 hosted *Carex rostrata*, that indicates water level class 4+. However, *Anthoxantum odoratum* and various other plants from low sedge swamps, e.g. *Carex nigra,* that rather tend towards water level class 3+, predominated. Therefore water level class 3+ was chosen.

c) Moist fallow G19, AR04 (appendix 5: Tab.2)

The high amount of *Festuca rubra* indicated that the site was not very moist, although *Carex rostrata* was present. *Holcus lanatus* is also typical on moist sites, therefore water level class 3+ was chosen.

d) Moist fallow H49 (appendix 5: Tab.2)

The species composition of relevé H49 suggested that it was a succesion from a *Molinia caerulea*-meadow, caused by missing maintenance. Thus, the water level class was assumed to equal the *Molinia caerulea*-meadow (3+).

e) Moist fallow H39 (appendix 5: Tab.2)

Species composition and adjacent land use suggested that H39 was an abandoned *Angelica sylvestris-Cirsium oleraceum*-meadow and should therefore be treated in water level class 3+. The high mean quantitative Ellenberg indicator value was caused by the high occurrence of *Phalaris arundinacea* and *Calamagrostis epigejos*. It may be assumed that these species were overestimated, because most other species in the community indicated a lower value.

f) Moist fallow H29 (appendix 5: Tab.2)

Water level class 3+ was chosen, because the species composition indicated only moist conditions as no wetness indicators were present.

g) Degraded *Holcus lanatus*-meadow (appendix 5: Tab.1)

SUCCOW & JOOSTEN 2001 published water level class 3+ or 4+ for *Holcus lanatus*-meadows. As the species composition resembled to large parts the *Angelica sylvestris-Cirsium oleraceum*-community and did not host any wetness indicators, water level class 3+ seemed to be appropriate in this case.

<u>Moist Calluna dwarf-shrub heath (water level class 3+)</u>

COUWENBERG et al. 2008 classify *Calluna*-dwarf shrub heath up to water level class 3+. Possible drier sites are not considered. Hence, mistakes in the carbon flux estimation might occur, if drier sites that might have higher carbon efflux due to a higher peat mineralisation are classified as water level class 3+. However, as there is no mean provided by COUWENBERG et al. 2008 to distinguish *Calluna*-dwarf shrub heath with water level class 3+ from drier sites, the possible source of error was accepted here.

Very moist tall forbs and meadows (water level class 4+)

a) Succesion of *Carex appropinquata-Molinia caerulea*-community (appendix 5, Tab.2)

The given succesion from *Carex appropinquata-Molinia caerulea*-community hosted wetness indicators as well as meadow species and it was probable, that the site used to be a moorgras-meadow. The species composition suggested a transition phase from a *Molinia caerulea*-meadow (water level class 3+) to a wet reed (water level class 5+), where the current state seemed to be inbetween. Therefore water level class 4+ was chosen.

b) Wet fallow (appendix 5: Tab.2)

The high amount of *Carex vesicaria* indicated a wet variety of a *Filipendula ulmaria*-community and the community was therefore classified as wet fallow with water level class 4+.

Wet tall sedge fens (water level class 5+)

Taking into consideration the specific plant species composition in the relevés, it may be discussed, if the *Calliergonella cuspidata-Menyanthes trifoliata-Carex elata*-community might not be more humid and the *Valeriana dioica-Berula erecta-Carex paniculata*-community might not be drier than water level class 5+. However, the mean quantitative Ellenberg indicator values did not support this opinion. Moreover, the vegetation form concept and its findings were not part of this thesis and the vegetation forms and dedicated water level classes were not to be questioned in this thesis. However it should be mentioned that regional differences in the water level classes of the vegetation forms generally cannot be excluded, but cannot be treated here.

Wet low sedge fens and tall sedge fens and reeds with moss layer (water level class 5+)

a) *Primula farinosa-Schoenus ferrugineus*-community

It might be argued that due to the species composition, the *Primula farinosa-Schoenus ferrugineus*-community could be slightly drier (water level class 4+/5+) than estimated. However, it was out of scope of this thesis to question the vegetation form concept itself and its estimates of water level classes. Therefore water level class 5+ for the *Primula farinosa-Schoenus ferrugineus*-community was accpeted here. It might generally be possible that regional differences in the water level classes of vegetation forms might occur, but there are currently no studies available on this subject.

b) Succesion from *Sphagnum recurvum-Juncus acutiflorus* community (appendix 5: Tab.2)

The comparably high cover of *Sphagnum* mosses and the reed-like structure of the site in combination with the wetness indicator species justified the classification.

c) Fragmentary sedge fen (appendix 5: Tab.2)

Taking into consideration the physiognomy of the site, the occurrence of different *Carex*-species in combination with a *Sphagnum*-layer justified the perception as tall sedge fen with moss layer, although uncommon species like *Calluna vulgaris* and *Molinia caerulea* were present.

Wet reed

The community was clearly classified as Wet reed in the water level class 5+, because the community did not have a distinct moss layer and the main components were the wetness indicators *Typha latifolia, Equisetum fluviatile* and *Phragmites australis*. Furthermore there was no permanent flooding.

6.2.2 Identified GESTs in relation to other classification systems

GEST and Phytosociology according to Braun-Blanquet

As Fig. 43 shows, the phytosociological plant communities according to Braun-Blanquet used here are classified in broader categories than the vegetation forms. Hence, different GESTs are covered by only one phytosociological plant community.

The Molinietum caerulea for example covers 20 samples that are distributed to the GESTs Moist tall forbs and meadows (water level class 3+) and Very moist meadows, tall forbs and reeds (water level class 4+). Interferences are even more visible for the Angelico-Cirsietum oleracei (10 samples), that covers Medium moist tall forbs and meadows (water level class 2+, 2-, 2~), Moist tall forbs and meadows (water level class 3+) and Very moist meadows, tall forbs and reeds (water level class 4+). These inconsistencies occur, because the phytosociological plant communities include fallow phases and degradation phases of the original communities, although the environmental settings might already have changed. In the vegetation form concept, these developments are described by own classes, taking into consideration the actual water and nutrient balance of the site.

The findings for the *Carex acutiformis*-community and the *Urtica dioica-Calistegia sepium*-community (Fig. 44) are considered to have a low informative value, because there are only two samples for each plant community. No general conclusion should be drawn from them.

The *Taraxacum-Lolium* community is not described as a definite phytosociological plant community but is a substitute for more natural grasslands from the Molinio-Arrhenatheretea. Here as well the explanatory power is too low, due to the lack of definition.

The Sphagnetum magellanici is with 27 relevés a frequent plant community in the study area. It covers various phases of raised bog vegetation that are all accumulated in the community. The Sphagnetum magellanici is not distinguished according to water level. Described subassociations do not correlate with vegetation forms in the sampled sites. This results in an overlap where the Sphagnetum magellanici covers six different vegetation forms and four GESTs, ranging from water level class 3+ till 5+.

The Rhynchosporetum albae covers two GESTs in water level class 5+ (Fig. 44). It relates to the GESTs 'Wet bog hollows' as well as to 'Wet low sedge swamps and tall sedge fens and reeds with moss layer' and to the vegetation forms *Sphagnum cuspidatum-Carex limosa*-community (n=1) and *Sphagnum recurvum-Carex limosa*-community (n=2) respectively. The vegetation form concept distinguishes here strongly between fen and bog vegetation, whereas this exact differentiation is not given for phytosociological plant communities.

GEST and Biotope types of Baden-Württemberg

Fig. 43 shows that especially the meadow and reed Biotope types cover more than one distinct GEST. Biotope type 33.61, intensively managed meadow (n=9) covers as well the GESTs Fen and bog grass land (water level class 2+, 2-, 2~, n=7) as Moist fen and bog grassland (water level class 2+/3+, 3+, n=2). This is because there is no clear division between water level classes in grassland biotopes in the Biotope types of Baden-Württemberg. Only a division according to nutrient level and management intensity and only sometimes in combination with site humidity can be found.

Although Biotope type 33.21 'Wet base-rich meadow of the lowlands' (n=9) as well as Biotope type 34.51 'Reed at water side' (n=2) cover two different GESTs with the water level classes 3+ and 4+, the relations between the systems could be handled by the adaption of additional mapping parameters for the Biotope types. In contrast, Biotope type 34.52 'Reed independent from water body' (n=8) covers various types of *Phragmites australis*-dominated sites. It corresponds to five different vegetation forms and extends over the GESTs Moist tall forbs and meadows (n=6) and Very moist meadow, tall forbs and reeds (n=2) respectively. Here, the classification systems are very inconsistent and adaption is considered to be difficult.

Fig. 44 shows that the Biotope types of Baden-Württemberg classifiy typical raised bog vegetation in two broad categories, where the chosen divisions are in accordance with GESTs divisions. Inconsistencies with GEST are smaller than between phytosociology and GEST. Here a chance may be seen to synchronise Biotope types and GESTs in a future revision of Biotope types.

Relevance of the result and future recommandations

As described in chapter 2.1.2, plant communities in phytosociology were developed to describe regular, recurrent plant combinations that can be distinguished from each other by character species (DIERSCHKE 1994). However, the communities are not static (see chapter 2.1.2). Furthermore 62 of the 115 relevés in this thesis belong to phytosociological plant communities that are inconsistant with the GESTs (Fig. 43 and Fig. 44). Hence, phytosociology according to Braun-Blanquet does not seem to be suitable for carbon flux estimates.

The Biotope types of Baden-Württemberg were developed as standard tool for statewide or regional surveys on the state of nature and landscape, including information on species and their dispersion as well as on land use type and intensity (LUBW 2009, see also chapter 2.1.3). In total 58 of the 115 relevés belong to Biotope types, that are not consistent with the GESTs. However, for the 30 relevés of raised bog vegetation (Fig. 44), a further delineation in compliance with the GESTs generally seems to be possible, because the overlaps are very clear and simple. Also for the 18 meadow-relevés (Fig. 43: Wet, base-rich meadow of the lowlands and Intensively managed meadow) the creation of subtypes according to the GEST seems to be manageable. One weakness of the Biotope types of Baden-Württemberg concerning a possible carbon flux estimate are Reeds (Fig. 43: Biotope types 34.51 and 34.52). Here, many different vegetation forms (that are the basis for the GESTs) are accumulated and therefore these classes are very inhomogenous.

However, as a major planning tool in the federal state of Baden-Württemberg, it would be desirable, if the Biotope types of Baden-Württemberg would provide information on the potential carbon fluxes of fen and bog sites as far as possible. Although the results presented in chapter 5.1.2 are only an example and were not statistically evaluated, they show that further studies on the subject could be worthwhile. More knowledge on the relation between GESTs (vegetation forms) and the Biotope types of Baden-Württemberg is needed to use them as estimator of carbon flux from fen and bog soils.

6.3 Estimation of CO_2 and CH_4 flux

6.3.1 Non-forest sites

Fen and bog grassland was the largest carbon emitter for non-forest sites in the total study area. This is due to the fact, that it stretched over 25% of the total study area (Table 14) and had the highest annual GHB_{100} per ha (24 t CO_2e ha^{-1} $yr^{-1)}$. Fen and bog grassland as well as Moist tall forbs and meadows were the main CO_2e emitters in all subareas (Table 15). It is remarkable that in the subarea Herrgottsried 90 % of the subarea's non-forest GHB_{100} was caused by those two GESTs on 65,8 % of the subarea.

The calculated GHB_{100} for non-forest sites in the total study area (Table 14) was 4352,57 t CO_2 yr^{-1}, where 73,5 % efflux was produced in Herrgottsried, 13,3 % in Gründlenried and 13,2 % in Arrisrieder Moos. This can be explained by the fact that nearly half of the subarea Herrgottsried has been drained for grassland use. The drainage caused high carbon efflux. Furthermore the non-forest sites of Herrgottsried were three to four times larger than the non-forest sites of Gründlenried and Arrisrieder Moos (Fig. 53). The area of Gründlenried was more than twice as large as the area of Arrisrieder Moos. However, both areas showed the same magnitude of GHB_{100}. Gründlenried consisted to large parts of undrained raised bog area with a low carbon efflux. In contrast, drained raised bog areas of Arrisrieder Moos had a comparably high carbon efflux on a comparably small area.

The mean GHB_{100} per ha reflected land use pattern and showed the relationship between human impact (drainage) and GHB_{100} (Fig. 50). Herrgottsried with a high actual human impact on non-forest sites (47 % fen and bog grassland) had the highest annual GHB_{100} per ha (20,5 t CO_2e ha^{-1} yr^{-1}). Arrisrieder Moos showed human impact on non-forest sites in the boundary areas (13,2 % fen and bog grassland) but the raised bog core regenerated from former drainage. Thus, Arrisrieder Moos had a moderate annual GHB_{100} per ha (15,4 t CO_2e ha^{-1} yr^{-1}). Gründlenried consisted to large parts of nearly untouched raised bog area with peat mosses and only marginal human impact in the boundary areas (4% fen and bog grassland). Hence, it had a low annual GHB_{100} per ha (12,3 t CO_2e ha^{-1} yr^{-1}). It is likely that the mean annual GHB_{100}

per ha would have differed, if the study area had been delineated differently (e.g. larger boundary areas for Arrisrieder Moos and Gründlenried).

6.3.2 Forest sites

Wet, mature *Pinus* forests had the highest carbon uptake in the study area (–157,28 t CO_2e yr^{-1}), followed by dry, mature *Picea abies* forests (–126,17 CO_2e yr^{-1}). Hence, both had a similar estimated magnitude of carbon sequestration in the study area. However, wet, mature *Pinus* forests covered more than twice as much surface of the study area than dry, mature *Picea abies* forests. The similar magnitude can be explained by the higher productivity of *Picea abies* forests compared to *Pinus* forests. However, all estimates have to be considered under the limitations mentioned in chapter 6.1.4.

Gründlenried had the highest rate of carbon uptake in forest sites among the subareas due to the size of the forest-sites and the high sequestration in wet, mature *Pinus* forests. Arrisrieder Moos showed a carbon uptake, while Herrgottsried was releasing carbon, although both areas had a similar magnitude of forest cover. This can be explained by the difference in forest type composition. The carbon uptake in Arrisrieder Moos was mainly caused by dry, mature *Picea abies* forest with a high productivity. The carbon efflux in Herrgottsried however, was mainly caused by low productive, dry Natural deciduous forest, where CO_2 efflux from soil was high.

The low mean annual GHB_{100} per ha forestland (Fig. 51) was in accordance with the findings of BYRNE et al. 2004, who estimated an efflux of 0,04 t CO_2e ha^{-1} yr^{-1} for drained forest on bog and an uptake of -0,2 t CO_2e ha^{-1} yr^{-1} for drained forest on minerotrophic fen.

6.3.3 Synthesis of total CO_2 and CH_4 flux

The synthesis of total CO_2 and CH_4 fluxes showed that the high carbon emission from non-forest sites cannot be compensated by the comparably low carbon uptakes of forest sites in the study area. The highest potential for climate change mitigation can be found on non-forest sites in the study area, because they produce high carbon emissions compared to their surface area. Hence, potential areas for mitigation measures are projected in Fig. 55, Fig. 56 and Fig. 57 that show the GHB_{100} relation between different land uses (see also BYRNE et al. 2004).

The calculated annual per capita CO_2 and CH_4 emission in Baden-Württemberg is approximately 8 t CO_2e yr^{-1} (STATISTISCHES LANDESAMT BADEN-WÜRTTEMBERG 2009). The evaluated study area's mean GHB_{100} per ha is 9,7 t CO_2e ha^{-1} yr^{-1}. Thus, the total study area's mean GHB_{100} per ha is marginally higher than the annual per capita emission.

The annual carbon emission of CO_2 and CH_4 from industrial processing and energy in the federal state of Baden-Württemberg is 78.695.000 t CO_2e yr^{-1}. (STATISTISCHES LANDESAMT BADEN-WÜRTTEMBERG 2010). The annual total carbon emission of CO_2 and CH_4 in the study area is 4092,66 t CO_2e yr^{-1}. Hence, the annual total carbon emission in the study area may considered to be low compared to the total carbon emission in the federal state of Baden-Württemberg (0,005%). However, it corresponds to the CO_2e emissions of approximately 512 inhabitants of Baden-Württemberg.

7 Conclusion

The following obstacles and limitations were detected during the estimate of source and sink function. The described CO_2e consisted of CO_2 emissions and CH_4 emissions. N_2O emissions were not included in the estimate. Possible inaccuracies in the total estimates may be caused by inaccuracies during the mapping process and data processing in ArcGIS as well as during interpretation and classification of external data. Pastures, cropland, footpaths and roads, water courses and lakes as well as clearcut areas were not included. The examined vegetation classification systems were only partly compatible with each other. The application of a vegetation-based greenhouse gas emission estimate with the GEST concept in the federal state of Baden-Württemberg was not fully compatible. Familiarisation with the GEST mapping system was problematic due to insufficient description for Southern Germany. Biotope types of Baden-Württemberg could be a possible tool to be used in the federal state of Baden-Württemberg. Hence, GHB_{100} of peatlands should be considered in a future revision of the Biotope types.

The combined emission estimates for non-forest and forest sites in the study area were in close agreement with BYRNE et al. 2004. Forests were estimated to have low emissions or even a carbon uptake. Mire sites were estimated to have low carbon emissions and grasslands had the highest emissions. Hence, the highest carbon mitigation potential was seen for grasslands. Further research could focus on verifying the estimated emission factors in the study area. For a statewide application of vegetation-based greenhouse gas estimates from peatlands, parameters must be verified and emission factors have to be refined.

The greenhouse gas emission estimate showed on one hand that the total carbon efflux from the study area was small compared to the total carbon efflux from anthropogenic sources in Baden-Württemberg. On the other hand the results here have emphasized that carbon estimates in peatlands in Baden-Württemberg should not focus on finding new strategies to sequester large amounts of carbon that are emitted elsewhere by anthropogenic sources. Carbon estimates should be used as a tool to find the best possible way to maintain the carbon pool in peatlands and to avoid additional emissions. A quantification of emissions is needed to be able to intervene where it is most useful. A vegetation-based approach is generally feasible, but has to be refined for a statewide application.

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Author’s declaration

I hereby declare that I have written this thesis without any help from others and without the use of sources and support materials other than those stated above.

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APPENDIX

Appendix 1 – List of vascular plants and list of mosses

Abbreviations

Red List

D	Red List of protected plant species Germany
BW	Red List of protected plant species Baden-Württemberg
AV	Red List of protected plant species Alpenvorland region
N	neophyte

Red List categories

1	critically andangered
2	endangered
3	vulnerable
G	threatened
V	regionally threatened
R	rare
-	species not endangered
d	data deficient
n.d.	not defined

List of vascular plants

Species	Family	English name	Red List			N
			D	BW	AV	
A						
Achillea millefolium L.	Asteraceae	Common Yarrow	-	-	-	
Aegopodium podagraria L.	Apiaceae	Bishop's weed	-	-	-	
Agrostis canina L.	Poaceae	Bent Grass	-	-	-	
Agrostis capillaris L.	Poaceae	Common Bent	-	-	-	
Agrostis gigantea ROTH	Poaceae	Black Bent	-	-	-	
Agrostis stolonifera L.	Poaceae	Creeping Bent	-	-	-	
Ajuga reptans L.	Lamiaceae	Bugle	-	-	-	
Alchemilla vulgaris agg.	Rosaceae	Lady's Mantle	n.d.	n.d.	n.d.	
Alopecurus geniculatus L.	Poaceae	Marsh Foxtail	-	-	-	
Alopecurus pratensis L.	Poaceae	Meadow Foxtail	-	-	-	
Andromeda polifolia L.	Ericaceae	Common Bog Rosemary	3	3	3	
Angelica sylvestris L.	Apiaceae	Archangel	-	-	-	
Anthoxanthum odoratum L.	Poaceae	Scented Vernal Grass	-	-	-	
Arrhenatherum elatius (L.) BEAUV. EX. J. PRESL ET C. PRESL	Poaceae	False Oat Grass	-	-	-	
Avenella flexuosa (L.) DREJER	Poaceae	Wavy Hair Grass	-	-	-	
B						
Bellis perennis L.	Asteraceae	Daisy	-	-	-	
Betula pendula ROTH	Betulaceae	European White Birch	-	-	-	
Betula pubescens EHRH.	Betulaceae	Downy Birch	-	-	-	
Briza media L.	Poaceae	Common Quaking Grass	-	-	V	
Bromus hordeaceus L.	Poaceae	Soft Brome	-	-	-	
C						
Calamagrostis canescens (WEBER) ROTH	Poaceae	Purple Small Reed	-	-	-	
Calamagrostis epigejos (L.) ROTH	Poaceae	Bush Grass	-	-	-	
Calluna vulgaris (L.) HULL	Ericaceae	Scots Heather	-	-	-	
Caltha palustris L.	Ranunculaceae	Kingcup	-	-	-	
Campanula patula L.	Campanulaceae	Spreading Bellflower	-	-	V	
Campanula rotundifolia L.	Campanulaceae	Harebell	-	-	-	

Species	Family	English name	Red List			N
			D	BW	AV	
Cardamine pratensis L.	Brassicaceae	Cuckoo Flower	-	-	-	
Carex acuta L.	Cyperaceae	Slender Tufted-sedge	-	-	-	
Carex acutiformis EHRHART	Cyperaceae	Lesser Pond-Sedge	-	-	-	
Carex appropinquata SCHUMACHER	Cyperaceae	Fibrous Tussock-Sedge	2	3	V	
Carex brizoides L.	Cyperaceae	-	-	-	-	
Carex davalliana SMITH	Cyperaceae	-	3	3	3	
Carex demissa HORNEMANN	Cyperaceae	Common Yellow-Sedge	n.d.	-	-	
Carex diandra SCHRANK	Cyperaceae	Lesser Tussock-sedge	2	2	3	
Carex disticha HUDSON	Cyperaceae	Brown Sedge	-	-	-	
Carex echinata MURRAY	Cyperaceae	Star Sedge	-	V	V	
Carex elata ALLIONI	Cyperaceae	Tufted-Sedge	-	-	-	
Carex elongata L.	Cyperaceae	Elongated Sedge	-	V	-	
Carex flava agg.	Cyperaceae	Large Yellow-Sedge	-	V	-	
Carex hirta L.	Cyperaceae	Hairy Sedge	-	-	-	
Carex hostiana DC.	Cyperaceae	Tawny Sedge	2	2	3	
Carex lasiocarpa EHRHART	Cyperaceae	Slender Sedge	3	3	3	
Carex limosa L.	Cyperaceae	Bog-sedge	2	2	2	
Carex nigra (L.) REICHARD	Cyperaceae	Common Sedge	-	V	-	
Carex ovalis GOOD.	Cyperaceae	Oval Sedge	-	-	-	
Carex pallescens L.	Cyperaceae	Pale Sedge	-	-	-	
Carex panicea L.	Cyperaceae	Carnation Sedge	-	-	-	
Carex paniculata L.	Cyperaceae	Greater Tussock-sedge	-	-	-	
Carex paniculata x remota	Cyperaceae	-	n.d.	n.d.	n.d.	
Carex pilulifera L.	Cyperaceae	Pill Sedge	-	-	-	
Carex pulicaris L.	Cyperaceae	Flea Sedge	2	2	3	
Carex rostrata STOKES IN WITHERING	Cyperaceae	Bottle Sedge	-	-	-	
Carex vesicaria L.	Cyperaceae	Bladder Sedge	-	-	-	
Carum carvi L.	Apiaceae	Caraway	-	-	-	
Centaurea jacea L.	Asteraceae	Brown Knapweed	-	-	-	
Cerastium fontanum BAUMGARTEN	Caryophyllaceae	Mouse Ear	-	-	-	
Cerastium glomeratum THUILLIER	Caryophyllaceae	Mouse Ear	-	-	-	
Chaerophyllum aureum L.	Apiaceae	Chervil	-	-	-	
Circaea lutetiana L.	Onagraceae	Paris Nightshade	-	-	-	

Species	Family	English name	Red List			N
			D	BW	AV	
Cirsium arvense (L.) SCOP.	Asteraceae	Creeoung Thistle	-	-	-	
Cirsium oleraceum (L.) SCOP.	Asteraceae	Cabbage Thistle	-	-	-	
Cirsium palustre (L.) SCOP.	Asteraceae	Marsh Thistle	-	-	-	
Cirsium rivulare (JACQ.) ALL.	Asteraceae	Brook Thistle	-	V	V	
Cirsium vulgare (SAVI) TEN.	Asteraceae	Bull Thistle	-	-	-	
Crepis paludosa (L.) MOENCH	Asteraceae	Hawk's Beard	-	-	-	
Cynosurus cristatus L.	Poaceae	Crested Dog's Tail	-	-	-	
D						
Dactylis glomerata L.	Poaceae	Cocksfoot	-	-	-	
Dactylorhiza incarnata (L.) SOÓ	Orchidaceae	Early Marsh Orchid	2	3	3	
Deschampsia cespitosa (L.) BEAUV.	Poaceae	Tufted Hairgrass	-	-	-	
Drosera anglica HUDSON	Droseraceae	Great Sundew	2	2	2	
Drosera rotundifolia L.	Droseraceae	Round Leaved Sundew	3	3	3	
Dryopteris carthusiana (VILL.) H.P.FUCHS	Athyriaceae	Charterhouse Shield Fern	-	-	-	
Dryopteris dilatata (F.G. HOFMANN) ASA GRAY	Athyriaceae	Broad Buckler Fern	-	-	-	
E						
Elymus caninus (L.) L.	Poaceae	Bearded Couch	-	-	-	
Elymus repens (L.) GOULD	Poaceae	Couch Grass	-	-	-	
Epilobium palustre L.	Onagraceae	Willowherb	-	V	-	
Epilobium parviflorum SCHREB.	Onagraceae	Willowherb	-	-	-	
Epipactis palustris (L.) CRANTZ	Orchidaceae	Marsh Helleborine	3	3	V	
Equisetum fluviatile L.	Equisetaceae	Horsetail	-	-	-	
Equisetum palustre L.	Equisetaceae	Marsh Horsetail	-	-	-	
Eriophorum angustifolium HONCKENY	Cyperaceae	Common Cotton Grass	-	3	V	
Eriophorum latifolium HOPPE	Cyperaceae	Broad Leaved Cotton Grass	3	3	V	
Eriophorum vaginatum L.	Cyperaceae	Tussock Cotton Grass	-	V	V	
Eupatorium cannabinum L.	Asteraceae	Hemp Agrimony	-	-	-	
Euphrasia rostkoviana HAYNE	Scrophulariaceae	Eyebright	-	-	-	
F						
Festuca ovina L.	Poaceae	Blue Fescue	-	d	d	
Festuca pratensis HUDSON	Poaceae	Meadow Fescue	-	-	-	
Festuca rubra L.	Poaceae	Red Fescue	-	-	-	

Species	Family	English name	Red List			N
			D	BW	AV	
Filipendula ulmaria (L.) MAXIM.	Rosaceae	Meadow Sweet	-	-	-	
Fragaria vesca L.	Rosaceae	Wild Strawberry	-	-	-	
Frangula alnus MILLER	Rhamnaceae	Alder Buckthorn	-	-	-	
G						
Galeopsis tetrahit L.	Lamiaceae	Common Hemp Nettle	-	-	-	
Galium aparine L.	Rubiaceae	Cleavers	-	-	-	
Galium mollugo L.	Rubiaceae	False Baby's Breath	-	-	-	
Galium palustre L.	Rubiaceae	Bedstraw	-	-	-	
Galium uliginosum L.	Rubiaceae	Bedstraw	-	-	-	
Gentiana asclepiadea L.	Gentianaceae	Willow Gentian	3	3	3	
Geranium pratense L.	Geraniaceae	Crane's Bill	-	-	-	
Geum rivale L.	Rosaceae	Indian Chocolate Root	-	-	-	
Glyceria fluitans (L.) R. BR.	Poaceae	Sweet Grass	-	-	-	
H						
Helictotrichon pubescens (HUDSON) PILGER	Poaceae	Downy Oat	-	-	-	
Heracleum sphondylium L.	Apiaceae	Hogweed	-	-	-	
Holcus lanatus L.	Poaceae	Yorkshire Fog	-	-	-	
Hydrocharis morsus-ranae L.	Hydrocharitaceae	Frogbit	3	3	3	
Hypericum montanum L.	Hypericaceae	John's Wort	-	-	-	
Hypericum perforatum L.	Hypericaceae	St. John's Wort	-	-	-	
I						
Impatiens glandulifera ROYLE	Balsaminaceae	Himalayan Balsam	-	-	-	x
Impatiens noli-tangere L.	Balsaminaceae	Touch-me-not	-	-	-	
Inula salicina L.	Asteraceae	Fleabane	-	-	-	
Iris pseudacorus L.	Iridaceae	Flag Iris	-	-	-	
J						
Juncus alpinoarticulatus CHAIX	Juncaceae	Rush	3	V	V	
Juncus articulatus L.	Juncaceae	Joint Leaf Rush	-	-	-	
Juncus compressus N.J. VON JACQUIN	Juncaceae	Round-fruited Rush	-	-	-	
Juncus effusus L.	Juncaceae	Common Rush	-	-	-	
L						
Lathyrus pratensis L.	Fabaceae	Meadow Vetchling	-	-	-	

Species	Family	English name	Red List			N
			D	BW	AV	
Leontodon autumnalis L.	Asteraceae	Hawkbit	-	-	-	
Linaria vulgaris MILLER	Scrophulariaceae	Butter-and-eggs	-	-	-	
Linum catharticum L.	Linaceae	White Flax	-	-	-	
Lolium multiflorum LAMARCK	Poaceae	Common Ryegrass	-	-	-	x
Lolium perenne L.	Poaceae	Rye Grass	-	-	-	
Lotus corniculatus L.	Fabaceae	Bird's Foot Trefoil	-	-	-	
Lotus uliginosus SCHKUHR	Fabaceae	Greater Bird's Foot Trefoil	-	-	-	
Luzula campestris (L.) A.P. DE CANDOLLE	Juncaceae	Field Wood Rush	-	-	-	
Luzula multiflora (J.F. EHRHART) LEJEUNE	Juncaceae	Many-flowered Wood Rush	-	-	-	
Lychnis flos-cuculi L.	Caryophyllaceae	Ragged Robin	-	-	-	
Lycopus europaeus L.	Lamiaceae	Gipsywort	-	-	-	
Lysimachia thyrsiflora L.	Primulaceae	Tufted Loosestrife	3	3	3	
Lysimachia vulgaris L.	Primulaceae	Loosestrife	-	-	-	
Lythrum salicaria L.	Lythraceae	Purple Loosestrife	-	-	-	
M						
Melampyrum pratense L.	Scrophulariaceae	Cow Wheat	-	-	-	
Mentha aquatica L.	Lamiaceae	Horsemint	-	-	-	
Mentha arvensis L.	Lamiaceae	Corn Mint	-	-	-	
Mentha longifolia (L.) HUDSON	Lamiaceae	Biblical Mint	-	d	d	
Menyanthes trifoliata L.	Menyanthaceae	Bogbean	3	3	3	
Molinia caerulea (L.) MOENCH	Poaceae	Purple Moor Grass	-	-	-	
Myosotis scorpioides agg.	Boraginaceae	Water forget-me-not	-	-	-	
O						
Oxycoccus palustris PERS.	Ericaceae	Wild Cranberry	3	3	3	
P						
Parnassia palustris L.	Parnassiaceae	Grass of Parnassus	3	3	V	
Peucedanum palustre (L.) MOENCH	Apiaceae	Milk Parsley	-	3	V	
Phalaris arundinacea L.	Poaceae	Reed Canary Grass	-	-	-	
Phleum pratense L.	Poaceae	Cat's Tail	-	-	-	
Phragmites australis (CAV.) TRIN. EX STEUDEL	Poaceae	Common Reed	-	-	-	
Picea abies (L.) KARSTEN	Pinaceae	Common Spruce	-	-	-	
Pimpinella major (L.) HUDS.	Apiaceae	Greater Burnet Saxifrage	-	-	-	
Pinguicula vulgaris L.	Lentibulariaceae	Bog Violet	3	3	3	

Species	Family	English name	Red List			N
			D	BW	AV	
Pinus mugo TURRA	Pinaceae	Dwarf Mountain Pine	-	n.d.	n.d.	
Pinus sylvestris L.	Pinaceae	Scots Pine	-	-	-	
Plantago lanceolata L.	Plantaginaceae	English Plantain	-	-	-	
Poa annua L.	Poaceae	Annual Blue Grass	-	-	-	
Poa palustris L.	Poaceae	Marsh Meadow Grass	-	-	-	
Poa pratensis L.	Poaceae	Meadow Grass	-	-	-	
Poa trivialis L.	Poaceae	Rough Meadow Grass	-	-	-	
Polygala amara L.	Polygalaceae	Milkwort	-	n.d.	n.d.	
Polygonum amphibium L.	Polygonaceae	Water Smartweed	-	-	-	
Polygonum bistorta L.	Polygonaceae	Adderwort	-	-	-	
Populus tremula L.	Salicaceae	Aspen	-	-	-	
Potentilla erecta (L.) RÄUSCHEL	Rosaceae	Bloodroot	-	-	-	
Potentilla palustris (L.) SCOP.	Rosaceae	Marsh Cinquefoil	-	3	3	
Prunella vulgaris L.	Lamiaceae	Self Heal	-	-	-	
Q						
Quercus robur L.	Fagaceae	English Oak	-	-	-	
R						
Ranunculus acris L.	Ranunculaceae	Buttercup	-	-	-	
Ranunculus flammula L.	Ranunculaceae	Lesser Spearwort	-	-	-	
Ranunculus repens L.	Ranunculaceae	Creeping Buttercup	-	-	-	
Rhinanthus alectorolophus (SCOP.) POLLICH	Scrophulariaceae	Yellow Rattle	-	-	-	
Rhinanthus glacialis PERSONN.	Scrophulariaceae	Yellow Rattle	3	G	G	
Rhinanthus minor L.	Scrophulariaceae	Yellow Rattle	-	-	-	
Rhynchospora alba (L.) VAHL	Cyperaceae	Beak Sedge	3	3	3	
Rubus fruticosus agg. L.	Rosaceae	Bramble	-	-	-	
Rubus idaeus L.	Rosaceae	Raspberry	-	-	-	
Rumex acetosa L.	Polygonaceae	Garden Sorrel	-	-	-	
Rumex acetosella L.	Polygonaceae	Sheep Sorrel	-	-	-	
Rumex crispus L.	Polygonaceae	Curly Dock	-	-	-	
Rumex obtusifolius L.	Polygonaceae	Bitter Dock	-	-	-	
Rumex sanguineus L.	Polygonaceae	Dock	-	-	-	
S						
Salix aurita L.	Salicaceae	Eared Willow	-	-	-	
Salix cinerea L.	Salicaceae	Grey Willow	-	-	-	
Salix cinerea x aurita	Salicaceae	Willow	n.d.	n.d.	n.d.	

Species	Family	English name	Red List			N
			D	BW	AV	
Salix repens L.	Salicaceae	Creeping Willow	-	n.d.	n.d.	
Salix spec.	Salicaceae	Willow	n.d.	n.d.	n.d.	
Scheuchzeria palustris L.	Scheuchzeriaceae	Rannoch Rush	2	2	2	
Schoenus ferrugineus L.	Cyperaceae	Bog Rush	3	3	3	
Scirpus sylvaticus L.	Cyperaceae	Wood Club Rush	-	-	-	
Scutellaria galericulata L.	Lamiaceae	Helmet Flower	-	-	-	
Selinum carvifolia L.	Apiaceae	Milk Parsley	-	3	3	
Senecio aquaticus HILL	Asteraceae	Ragwort	-	-	-	
Solanum dulcamara L.	Solanaceae	Bittersweet Nightshade	-	-	-	
Stellaria graminea L.	Caryophyllaceae	Common Stitchwort	-	-	-	
Stellaria media (L.) VILLARS	Caryophyllaceae	Common Chickweed	-	-	-	
Succisa pratensis MOENCH	Dipsacaceae	Devil's Bit Scabious	-	-	V	
T						
Taraxacum agg. WIGGERS	Asteraceae	Dandelion	-	-	-	
Thalictrum aquilegiifolium L.	Ranunculaceae	Columbine Meadow Rue	-	V	-	
Thelypteris palustris SCHOTT	Polypodiaceae	Eastern Marsh Fern	3	3	3	
Thymus pulegioides L.	Lamiaceae	Lemon Thyme	-	-	-	
Trichophorum alpinum (L.) PERS.	Cyperaceae	Deergrass	3	2	2	
Trifolium campestre SCHREB.	Fabaceae	Hop Clover	-	-	-	
Trifolium hybridum L.	Fabaceae	Hybrid Clover	-	-	-	
Trifolium pratense L.	Fabaceae	Red Clover	-	-	-	
Trifolium repens L.	Fabaceae	White Clover	-	-	-	
Trifolium spec.	Fabaceae	Clover	n.d.	n.d.	n.d.	
Trisetum flavescens (L.) BEAUV.	Poaceae	Yellow Oat Grass	-	-	-	
Typha latifolia L.	Typhaceae	Bulrush	-	-	-	
U						
Urtica dioica L.	Urticaceae	Stinging Nettle	-	-	-	
V						
Vaccinium myrtillus L.	Ericaceae	Blueberry	-	-	-	
Vaccinium uliginosum L.	Ericaceae	Bog Bilberry	-	V	3	
Vaccinium vitis-idaea L.	Ericaceae	Cowberry	-	3	3	
Valeriana dioica L.	Valerianaceae	Marsh Valerian	-	-	-	
Valeriana officinalis (s.l.) L.	Valerianaceae	Common Valerian	-	n.d.	n.d.	
Veratrum album L:	Liliaceae	White Veratrum	-	n.d.	n.d.	
Veronica catenata PENELL	Scrophulariaceae	Speedwell	-	-	3	

Species	Family	English name	Red List			N
			D	BW	AV	
Veronica chamaedrys L.	Scrophulariaceae	Bird's Eye	-	-	-	
Vicia cracca L.	Fabaceae	Tufted Vetch	-	-	-	
Vicia spec.	Fabaceae	Vetch				
Vicia villosa ROTH	Fabaceae	Fodder Vetch	-	-	d	x
Viola canina L.	Violaceae	Dog Violet	-	n.d.	n.d.	
Viola palustris L.	Violaceae	Marsh Violet	-	V	-	

List of mosses

Species	Family	Red List			N
		D	BW	AV	
A					
Aulacomnium palustre (HEDW.) SCHWÄGR.	Aulacomniaceae	V	V	V	
B					
Brachythecium rutabulum (HEDW.) SCHIMP.	Brachytheciaceae	-	-	-	
Bryum pseudotriquetrum (HEDW.) P. GÄRTN., E. MEY. & SCHERB.	Bryaceae	V	-	-	
C					
Calliergonella cuspidata (HEDW.) LOESKE	Hypnaceae	-	-	-	
Campylium stellatum (HEDW.) C.E.O. JENSEN	Amblystegiaceae	n.d.	n.d.	n.d.	
Climacium dendroides (HEDW.) F. WEBER & D. MOHR	Climaciaceae	-	-	-	
D					
Dicranodontium denudatum (BRID.) E. BRITTON	Dicranaceae	V	-	-	
Dicranum bergeri BLANDOW EX HOPPE	Dicranaceae	2	3	3	
Dicranum bonjeanii DE NOT.	Dicranaceae	3	V	V	
Drepanocladus aduncus (HEDW.) WARNST.	Amblystegiaceae	d	-	-	
F					
Fissidens osmundoides HEDW.	Fissidentaceae	2	3	3	
L					
Leucobryum glaucum (HEDW.) ÅNGSTR.	Dicranaceae	V	-	-	
P					
Plagiomnium affine (BLANDOW) T.J.KOP.	Mniaceae	-	-	-	
Plagiomnium elatum (BRUCH & SCHIMP.) T.J. KOP.	Mniaceae	3	V	V	

Species	Family	Red List			N
		D	BW	AV	
Pleurozium schreberi (BRID.) MITT.	Hypnaceae	-	-	-	
Pohlia nutans (HEDW.) LINDB.	Bryaceae	-	-	-	
Polytrichum formosum HEDW.	Polytrichaceae	-	-	-	
Polytrichum longisetum BRID.	Polytrichaceae	3	2	3	
Polytrichum strictum BRID.	Polytrichaceae	3	V	V	
R					
Rhytidiadelphus squarrosus (HEDW.) WARNST.	Hypnaceae	-	-	-	
S					
Sphagnum auriculatum SCHIMP.	Sphagnaceae	V	-	-	
Sphagnum contortum SCHULTZ	Sphagnaceae	2	V	V	
Sphagnum cuspidatum EHRH. EX HOFFM.	Sphagnaceae	3	-	-	
Sphagnum fallax (H. KLINGGR) H. KLINGGR.	Sphagnaceae	-	-	-	
Sphagnum magellanicum BRID.	Sphagnaceae	3	-	-	
Sphagnum nemoreum SCOP.	Sphagnaceae	V	-	-	
Sphagnum palustre L.	Sphagnaceae	-	-	-	
Sphagnum papillosum LINDB.	Sphagnaceae	3	V	V	
Sphagnum spec.	Sphagnaceae				
Sphagnum subnitens RUSSOW & WARNST.	Sphagnaceae	3	V	V	
Sphagnum teres (SCHIMP.) ÅNGSTR.	Sphagnaceae	3	V	V	
T					
Thuidium philibertii LIMPR.	Thuidiaceae	V	-	-	
Thuidium tamariscinum (HEDW.) SCHIMP.	Thuidiaceae	-	-	-	
Tomentypnum nitens (HEDW.) LOESKE	Amblystegiaceae	2	2	V	

Appendix 2 - Taxonomy of critical species

Sphagnum fallax and Sphagnum cuspidatum

In the description of Vegetation forms (Succow 1988) *Sphagnum fallax* and *Sphagnum cuspidatum* belong to different character groups. As described in NEBEL & PHILIPPI 2005 there are a lot of different opinions how to seperate the two species and if they can be seperated from each other at all. The on the site assessment showed that *Sphagnum fallax* was growing on similar sites than *Sphagnum cuspidatum.* Submerse plants of *Sphagnum fallax* were hardly distiguishable from *Sphagnum cuspidatum* plants. Taking into consideration these given circumstances, *Sphagnum fallax* and *Sphagnum cuspidatum* were treated as exchangeable variables.

Sphangum rubellum and Sphagnum nemoreum

Sphagnum rubellum and *Sphagnum nemoreum* were treated as the same species in this work. Between taxonomists there are different opinions on the occurrence of *Sphagnum rubellum*. This work follows the opinion, that *Sphagnum rubellum* and *Sphagnum nemoreum* cannot be distinguished as separate species and only the species *Sphagnum nemoreum* was accepted.

Appendix 3 - List of described plant communities

The following list contains all described plant communities mentioned in the text. First, all vegetation forms are listed and afterwards the phytosociological plant communities in their hierarchical system.

Vegetation forms

Vegetation form	**Original name**	**Author**
Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta-meadow	Kohldistel- Wiese	SUCCOW & JOOSTEN 2001
Calliergonella cuspidata- Menyanthes trifoliata- Carex elata- community	Spitzmoos- Großseggen-Ried	SUCCOW & JOOSTEN 2001
Calliergonella cuspidata- Viola palustris-Carex appropinquata- community	Spitzmoos- Kleinseggen-Ried	SUCCOW & JOOSTEN 2001
Carex appropinquata- Molinia caerulea-community	Wunderseggen-Pfeifengras- Staudenflur	SUCCOW & JOOSTEN 2001
Carex nigra- Caltha palustris-Filipendula ulmaria- community	*Braunseggen- Mädesüß-Staudenflur*	SUCCOW & JOOSTEN 2001
Cirsium oleraceum-Arrhenatherum elatius-meadow	Kohldistel-Glatthafer-Wiese	SUCCOW & JOOSTEN 2001
Eriophorum vaginatum-Sphagnum recurvum-community	Grüner Wollgras- Torfmoos-Rasen	SUCCOW & JOOSTEN 2001
Filipendula ulmaria-community	Mädesüß- Hochstaudenflur	SUCCOW & HUNDT 1984
Filipendula ulmaria-Urtica dioica-Polygonum bistorta-community	(Mädesüß-Wiesenknöterich-Staudenflur	SUCCOW & JOOSTEN 2001
Holcus lanatus-meadow	Honiggras-Wiese	SUCCOW & JOOSTEN 2001
Hypericum perforatum-Galium album-community	Johanniskraut-Wiesenlabkraut- Staudenflur	SUCCOW & JOOSTEN 2001
Lythrum salicaria-Urtica dioica-Phragmites australis-community	Weiderich- Brennessel-Schilf- Staudenflur	SUCCOW & JOOSTEN 2001
Moist *Calluna*-dwarf shrub heath	Feuchte Hochmoorheide	COUWENBERG ET AL. 2008
Molinia caerulea-meadow	Prachtnelken-Pfeifengras-Wiese	SUCCOW & JOOSTEN 2001
Parnassia palustris-Molinia caerulea-meadow	Herzblatt-Pfeifengras-Wiese	SUCCOW & JOOSTEN 2001

Vegetation form	**Original name**	**Author**
Phragmites australis-Aegopodium podagraria-Urtica dioica community	Schilf- Giersch- Brennessel-Staudenflur	SUCCOW & JOOSTEN 2001
Primula farinosa-Schoenus ferrugineus-community	Mehlprimel-Kopfbinsen-Ried	SUCCOW & JOOSTEN 2001
Scirpus sylvaticus-meadow	Waldsimsen-Wiese	SUCCOW & JOOSTEN 2001
Solanum dulcamara-Galium palustre-Phragmites australis-community	Nachtschatten-Schilf-Staudenflur	SUCCOW & JOOSTEN 2001
Sphagnum cuspidatum-Carex limosa-community	Grüne Torfmoos- Schlenke	SUCCOW & JOOSTEN 2001
Sphagnum magellanicum-community	Bunter Torfmoosrasen	SUCCOW & JOOSTEN 2001
Sphagnum recurvum-Carex limosa-community	Torfmoos-Schlammseggenried	SUCCOW & JOOSTEN 2001
Sphagnum recurvum-Eriophorum angustifolium- community	Torfmoos-Seggen-Wollgrasried	SUCCOW & JOOSTEN 2001
Sphagnum recurvum-Juncus acutiflorus-community	Torfmoos- Waldbinsen-Braunseggen- Ried	SUCCOW & JOOSTEN 2001
Sphagnum recurvum-Juncus effusus-community	Torfmoos- Flatterbinsen-Ried	SUCCOW & JOOSTEN 2001
Trisetum flavescens-meadow	Rispengras- Goldhaferwiese	HUNDT & SUCCOW 1984
Valeriana dioica-Berula erecta-Carex paniculata- community	Sumpfbaldrian-Rispenseggen- Ried	SUCCOW & JOOSTEN 2001
Very moist *Calluna*-dwarf shrub heath	Sehr feuchte Hochmoorheide	COUWENBERG ET AL. 2008
Very moist *Calluna*-dwarf shrub heath with organic mud	Sehr feuchte Hochmoorheide mit Muddeflächen	COUWENBERG ET AL. 2008

Phytosociological plant communities

(numbering according to OBERDORFER 1992,1993)

Class: Phragmitetea TX. et PRSG. 42

1st **Order:** Phragmitetalia W. KOCH 26

2nd **Alliance:** Magnocaricion W. KOCH 26

1st Ass.: Caricetum elatae W. KOCH 26

3rd Ass.: Caricetum paniculatae WANGERIN 16

4th Ass.: Caricetum rostratae RÜBEL 12

6th Com.: Carex acutiformis-community SAUER 37

8th Ass.: Caricetum vesicariae BR.-BL. et DENIS 26

16th Ass.: Phalaridetum arundinacea (W. KOCH 26 N.N.) LIBBERT 31

Class: Scheuchzerio-Caricetea fuscae (NORDHAG. 37) TX. 37

1st **Order:** Scheuchzerietalia palustris NORDHAG. 37

1st **Alliance:** Rhynchosporion albae KOCH 26

1st Ass.: Caricetum limosae BR.-BL. 21

2nd Ass.: Rhynchosporetum albae KOCH 26

2nd **Alliance:** Caricion lasiocarpae VANDEN BERGH. apud LEBRUN et al. 49

3rd Ass.: Caricetum lasiocarpae KOCH 26

3rd **Order:** Tofieldietalia PREISG. apud OBERD. 49

1st **Alliance:** Caricion davallianae KLIKA 34

11th Ass.: Primulo-Schoenetum ferruginei (KOCH 26) OBERD. 57 em. 62

12th Ass.: Caricetum davallianae DUTOIT 24 em. GÖRS 63

Class: Oxycocco-Sphagnetea BR.-BL. et R. TX. 43

2nd **Order:** Sphagnetalia magellanici (PAWLOWSKI 28) MOORE (64) 68

1st **Alliance:** Sphagnion magellanici KÄSTNER u. FLÖßNER 33 emend.

2nd Ass.: Sphagnetum magellanici (MALCUIT 29) KÄSTNER u. FLÖßNER 33

7th Com.: Eriophorum vaginatum-community

Class: Artemisietea vulgaris LOHM., PRSG**.** et TX. in TX. 50

1st **Order:** Convolvuletalia (Calystegietalia) sepium TX. 50

2nd **Alliance:** Convolvulion (Calystegion) sepium TX. 47 em.

4th Ass.: Urtica dioica-Convolvulus (Calystegia) sepium- community LOHM. 75

Class: Molinio-Arrhenatheretea TX. 37 (em. TX. et PRSG. 51)

1st **Order:** Molinietalia caeruleae W. KOCH 26

1st **Alliance:** Filipendulion ulmariae SEGAL 66

Com.: Filipendula ulmaria- community

2nd **Alliance:** Calthion TX. 37

7th Ass.: Angelico-Cirsietum oleracei TX. 37 em. OBERD. in OBERD. et al. 67

11th Ass.: Scirpetum sylvatici MALOCH 35 em. SCHWICK. 44

13th Ass.: Epilobio-Juncetum efusii OBERD. 57

Ass.: Loto uliginosi- Holcetum lanati PASS. (64) 77 *

4th **Alliance:** Molinion caerulea W. KOCH 26

17th Ass.: Molinietum caerulea W. KOCH 26

Ass.: Parnassio-Molinietum caerulae (TX. 37) PASS. (64) 78 *

2nd **Order:** Arrhenatheretalia PAWL. 28

1st **Alliance:** Arrhenatherion elatioris W. KOCH 26

24th Ass.: Poo-Trisetetum flavescentis KNAPP 51 em.

Appendix 4: List of ecological indicator groups

According to SUCCOW & JOOSTEN 2001

Group no.	Group name	Plant species in the study area
1	Drepanocladus fluitans group	*Sphagnum cuspidatum**
11	Hydrocharis morsus-ranae group	*Hydrocharis morsus-ranae*
16	Carex limosa group	*Rhynchospora alba* *Carex limosa* *Scheuchzeria palustris* *Drosera anglica*
18	Sphagnum magellanicum group	*Sphagnum magellanicum* *Andromeda polifolia* *Sphagnum papillosum* *Sphagnum nemoreum* *Sphagnum fuscum*
19	Eriophorum vaginatum group	*Eriophorum vaginatum* *Polytrichum strictum*
20	Vaccinium oxycoccus group	*Oxycoccos palustris* *Drosera rotundifolia* *Aulacomnium palustre*
21	Sphagnum recurvum group	*Sphagnum fallax** *Pohlia nutans*
22	Carex canescens group	*Polytrichum longisetum*
24	Eriophorum angustifolium	*Eriophorum angustifolium*
25	Potentilla palustris group	*Potentilla palustris* *Menyanthes trifoliata* *Carex lasiocarpa*
26	Carex diandra group	*Carex diandra*
29	Homalothecium nitens group	*Dicranum bonjeanii*
30	Carex hostiana group	*Carex hostiana* *Parnassia palustris*
32	Eleocharis quinqueflora group	*Juncus alpino-articus*
34	Eriophorum latifolium group	*Eriophorum latifolium* *Pinguicula vulgaris*
35	Schoenus ferrugineus group	*Schoenus ferrugineus*
39	Carex elata group	*Carex elata*

Group no.	Group name	Plant species in the study area
40	Cicuta virosa group	*Carex vesicaria*
42	Typha latifolia group	*Typha latifolia*
45	Veronica catenata group	*Veronica catenata*
47	Viola palustris group	*Viola palustris* *Carex echinata*
48	Sphagnum squarrosum group	*Sphagnum palustre*
50	Sphagnum teres group	*Sphagnum teres* *Sphagnum contortum*
51	Epipactis palustris group	*Campylium stellatum*
53	Ranunculus flammula group	*Ranunculus flammula*
54	Lysimachia Thyrsiflora gruppe	*Lysimachia thyrsiflora* *Agrostis canina* *Peucedanum palustre*
55	Carex rostrata	*Carex rostrata*
56	Thelypteris palustris	*Thelypteris palustris*
58	Carex appropinquata group	*Carex appropinquata* *Valeriana dioica* *Bryum pseudotriquetum* *Dactylorhiza incarnata* *Climacium dendroides* *Salix repens*
63	Caltha palustris group	*Caltha palustris* *Mentha aquatica* *Calliergonella cuspidata* *Myosotis scorpioides* *Epilobium parviflorum* *Cirsium palustre*
64	Galium palustre group	*Galium palustre* *Equisetum fluviatile* *Equisetum palustre* *Drepanocladus aduncus*
68	Plagiomnium elatum group	*Plagiomnium elatum*
69	Ledum palustre group	*Vaccinium uliginosum*
70	Carex nigra group	*Carex nigra* *Carex panicea* *Luzula multiflora* *Juncus articulatus*
73	Carex disticha group	*Carex disticha* *Carex acuta*

Group no.	Group name	Plant species in the study area
74	Juncus effusus group	*Juncus effusus*
		Calamagrostis canescens
		Lycopus europaeus
75	Solanum dulcamara group	*Solanum dulcamara*
		Iris pseudacorus
76	Glyceria fluitans group	*Glyceria fluitans*
77	Filipendula ulmaria group	*Filipendula ulmaria*
		Galium uliginosum
		Eupatorium cannabinum
78	Lythrum salicaria group	*Lysimachia vulgaris*
		Scutellaria galericulata
		Lythrum salicaria
80	Carex paniculata group	*Carex paniculata*
		Scirpus sylvaticus
81	Calluna vulgaris group	*Calluna vulgaris*
82	Potentilla erecta group	*Potentilla erecta*
		Luzula campestris
		Succisa pratensis
83	Galium boreale group	*Briza media*
		Linum catharticum
84	Molinia caerulea	*Molinia caerulea*
85	Polygonum bistorta group	*Polygonum bistorta*
		Crepis paludosa
		Lotus uliginosus
		Angelica sylvestris
		Lychnis flos-cuculi
86	Cirsium oleraceum group	*Cirsium oleraceum*
		Valeriana officinalis
		Geum rivale
		Deschampsia cespitosa
87	Phragmites australis group	*Phragmites australis*
87	Phragmites australis group (continued)	*Carex acutiformis*
		Polygonum amphibium
		Equisetum palustre
88	Phalaris arundinacea Gr	*Phalaris arundinacea*
89	Juncus inflexus group	*Alopecurus geniculatus*
91	Ranunculus repens group	*Ranunculus repens*
		Agrostis stolonifera
		Cardamine pratensis

Group no.	Group name	Plant species in the study area
92	Alopecurus pratensis Gr	*Alopecurus pratensis* *Rumex crispus*
93	Centaurea jacae Gr	*Centaurea jacea* *Anthoxanthum odoratum* *Helictotrichon pubescens* *Rhytidiadelphus squarrosus* *Stellaria graminea*
94	Holcus lanatus group	*Holcus lanatus* *Veronica chamaedrys* *Carex hirta* *Cerastium fontanum* *Ranunculus acris* *Rumex acetosa*
95	Festuca rubra group	*Festuca rubra* *Lathyrus pratensis* *Vicia cracca* *Poa pratensis*
96	Hypericum perforatum Gr	*Hypericum perforatum*
97	Arrhenatherum elatius group	*Heracleum sphondylium* *Aegopodium podagraria*
98	Agropyron repens group	*Agropyron repens* *Phleum pratense* *Dactylis glomerata*
99	Urtica dioica Gruppe	*Urtica dioica* *Galeopsis tetrahit* *Galium aparine* *Cirsium arvense* *Poa trivialis* *Calamagrostis epigejos*

Appendix 5: Vegetation tables

Tab. 1: Meadows

Tab. 2: Reeds, sedge fens, tall forbs, fallows

Tab. 3: Bog vegetation

Tab. 1: Meadows

Parameter	Frequency	H44	H43	H36	H05	H22	H45	H18	H06	H17	AR14	AR15	H12	H38	H26	H27	G25	H23	H24	H14	H16	H19	H21	H01	AR16	AR03	G26	H04	AR13	H11	AR08	AR09	AR10	AR35	G20	AR11	H09	H13	G14	AR05	H02	H03	AR02	AR01
		Relevé number																																										
Soil type		fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	bog	bog	fen	fen	fen	fen	fen	fen	fen	bog	fen	fen	fen	fen
Area (m x m)		4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4
Area (m²)		16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Cover shrub layer [%]																																						10						
Height shrub layer [m]																																						0,6						
Cover herb layer [%]		90	100	80	100	80	100	100	100	100	100	70	100	100	60	80	90	100	95	90	100	90	100	100	80	60	80	80	100	80	50	90	80	100	40	60	60	30	100	60	100	100	80	70
Height herb layer [m]		0,4	0,25	0,6	0,80	1,00	0,8	0,8	1,00	0,8	0,6	0,8	0,85	1,1	0,8	0,70	0,8	0,35	0,9	0,6	1,00	1,00	0,45	0,35	0,8	0,5	0,9	0,35	0,8	0,90	0,6	0,6	0,7	70	0,4	0,5	0,70	0,3	1,6	0,35	0,80	0,50	0,7	0,4
Cover moss layer [%]						<1							1			<1	50	5		10			<1	20	30	40	80				50	5			70	70		60					15	15
Height moss layer [m]						0,03							0,03			0,03	0,05	0,03		0,05			0,03	0,05	0,05	0,05	0,1				0,05	0,03			0,03	0,05		0,07					0,03	0,03
Species number		9	7	5	12	17	7	12	11	7	12	18	28	26	24	24	29	13	20	12	14	13	30	17	21	15	21	12	18	26	15	21	18	15	10	24	21	10	29	7	12	11	28	25
Quantitative average Ellenberg indicator values																																												
L (light)		7,3	7,1	7	6,7	6,9	6,8	6,8	6,5	6,6	7	6,7	6,6	6,6	6,7	7,2	7,2	7,7	7,5	6,7	6,6	6,3	7,2	7,3	7	6,9	7,1	7	6,8	6,8	7	6,9	7,1	7,2	7,1	7,4	7	6,8	7,1	7,1	6,7	6,7	7,3	7,5
F (moisture)		4,5	4,2	4,8	4,7	4,7	4,9	5,5	7,1	7,6	5,6	5,1	7,2	7,3	7,4	6,2	7,7	7,8	6,6	7,1	5,8	6,6	7,4	7,2	7,9	7,3	7,4	6,7	7,7	6,6	8	7,3	7	6,7	7,4	7,7	7,3	7	8,5	7,1	6,7	7,6	8	7,8
R (reaction)		6,7	7	6,8	6,8	6,9	6,5	6,3	6,6	6	6	7,2	5,6	5,5	5,9	4,3	5,2	4,3	5,7	5,1	5,2	5,8	6	6,2	4,3	4,4	3,2	3,4	5,8	6,2	3,4	3,8	4,7	4,4	5	5,5	5,9	5	6,3	2,2	5,3	4	5,5	4,4
N (nitrogen)		6,1	6,1	6,1	6,3	5,7	6,4	6,6	7	6,8	5,2	5,8	4,1	3,6	4,3	3,9	3,5	2,2	5,2	4,1	5,2	5,4	2,3	2,8	2,8	3,8	2,3	1,5	4,5	2,2	1,8	2	2,5	2,1	2	1,7	1,9	1,2	4	1,2	4,4	4	2,9	2,1
Water level class		2+							3+/2+, 3+		2+	3+																													4+			
GEST		Fen and bog grassland							Moist or temporarily flooded fen and bog grassland		Medium moist tall forbs and meadows	Moist tall forbs and meadows																													Very moist meadow, tall forbs and reeds			
Vegetation form according to Succow & Joosten 2001 and Hundt & Succow 1984		Fen and bog grassland							Moist or temporarily flooded fen and bog grassland		Trisetum flavescens-meadow	Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta-meadow							Degraded Holcus lanatus-meadow				Molinia caerulea-meadow																		Scirpus sylvaticus-meadow		Parnassia palustris-Molinia caerulea-meadow	
																							base rich variety		Transition type		weakly characterised variety		Agrostis gigantea variety										Gentiana asclepiadea-type	acid				
Strauchschicht																																												
Betula pubescens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.
Krautschicht und Moosschicht																																												
Common species Fen and bog grassland																																												
Lolium multiflorum	6	4	4	4	3	4	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lolium perenne	3	.	.	.	.	.	.	2b	2m	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum officinale agg.	11	1	2a	2a	2a	1	1	2m	2m	.	1	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium repens	9	3	1	2b	2a	1	2b	1	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus repens	22	1	+	2b	2m	1	1	1	2a	1	.	1	.	+	1	1	1	1	.	2m	1	2a	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	+	.	.
Poa trivialis	8	.	.	.	2m	1	.	2a	2a	2b	.	1	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Alopecurus pratensis	8	.	.	.	.	.	3	3	3	2a	+	+	.	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species Moist or temporarily flooded fen and bog grassland																																												
Phalaris arundinacea	7	.	.	.	.	.	.	.	3	.	.	.	1	+	.	.	+	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Glyceria fluitans	3	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	1	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Character species Tristeum flavescens-meadow																																												
Trisetum flavescens	2	.	.	.	.	.	.	1	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium pratense	5	.	.	.	2a	.	.	.	2a	.	2b	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Dactylis glomerata	5	.	.	.	1	.	.	3	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Cynosurus cristatus	4	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea millefolium	2	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Character species Angelica sylvestris-Cirsium oleraceum-Polygonum bistorta-meadow																																												
Cirsium oleraceum	8	.	.	.	.	.	.	.	.	.	.	2a	1	+	+	.	+	.	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Myosotis scorpioides agg.	7	.	.	.	.	.	.	.	.	.	.	.	1	1	+	1	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Angelica sylvestris	12	.	.	.	.	.	.	.	.	.	.	1	+	+	.	+	1	.	.	.	.	.	r	.	.	.	.	.	.	1	.	.	2a	.	.	2a	+	.	.	.	.	.	1	+
Polygonum bistorta	10	.	.	.	.	.	.	.	.	.	.	.	2a	2a	1	1	.	+	.	.	.	.	+	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	3	1	.	.
Filipendula ulmaria	12	.	.	.	.	.	.	.	.	.	.	.	2m	2a	1	+	1	.	.	.	.	.	1	1	.	.	.	.	.	1	.	.	.	.	.	r	.	.	1	.	2a	1	.	.
Deschampsia cespitosa	12	.	.	.	.	.	.	.	.	.	.	+	3	3	1	.	.	r	.	2a	.	3	1	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	2b	3	.	.
Lotus uliginosus	12	.	.	.	.	.	.	.	.	.	.	+	1	2m	.	.	.	.	r	.	.	.	1	1	1	.	.	.	r	.	.	1	.	.	.	.	1	.	.	.	.	.	+	+
Galium mollugo	13	.	.	.	.	r	.	.	1	.	.	3	1	1	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2a	.	.	.	1	+	+	.	.	+	.	2a	.	.	.
Rumex acetosa	17	.	.	.	.	.	.	.	.	.	.	2a	1	+	+	+	.	.	+	+	+	1	+	.	+	2a	.	+	.	r	.	+	.	.	2m	.	.	.	.	.	2m	.	.	.
Ranunculus acris	14	.	.	.	.	.	.	.	.	.	1	.	1	+	+	+	1	.	+	.	1	.	+	1	.	1	.	.	.	.	.	+	.	.	.	r	.	.	.	.	.	.	+	.
Differential species Scirpus sylvaticus-meadow																																												
Scirpus sylvaticus	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	3	.	.
Poa annua	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2m	2m	.	.
Typical and differential species Holcus lanatus meadow																																												
Holcus lanatus	18	.	.	.	.	1	.	.	.	.	.	.	2m	+	1	1	.	1	1	1	3	2a	+	r	1	.	+	1	.	.	.	.	1	.	.	.	.	.	.	.	2a	.	.	+
Alopecurus geniculatus	4	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2a	2m	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lychnis flos-cuculi	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2m	1	+	+	.	+	1	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Poa pratensis	9	.	.	.	.	.	1	.	.	2b	.	.	.	+	.	2b	.	.	.	r	3	3	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Phleum pratense	9	.	.	.	+	1	.	.	+	.	.	.	.	.	.	+	1	.	+	.	2m	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Character species Molinia caerulea-meadow																																												
Molinia caerulea	21	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2a	.	.	.	.	.	4	3	+	.	3	4	2a	3	2b	2b	3	3	3	3	3	2a	1	3	.	.	2a	3
Potentilla erecta	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1	+	1	2m	2a	2m	2a	2a	1	1	.	1	1	1	1	1	.	.	2a	1
Luzula multiflora	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	.	.	.	.	1	+	+	2a	2a	2b	.	.	.	+	+	+	.	.	+	.
Carex flava agg.	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2a	3	.	.	1	.	.	.	r	r	.	.	.	2b	1	.	2a	.	.	.	.	.
Carex nigra	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	3	.	.	.	.	.	1	2b	2b	2a	+	.	.	1	2b	+	3	.	2b	.	.	.	+	.	.	2a	2a
Frangula alnus	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	1	1	2a	1	.	.	.	.	.	1	.	.	1	1
Agrostis canina	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	1	2a	.	1	.	.	.	.	.	.	.	.	.
Climacium dendroides	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	2a	.	.	.	.	+	2a	1	3	1	.	.	.	+	.	.	.	4	3	+	.	.	.	.	.	.	.
Carex panicea	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	1	.	2a	.	2a	.	.	+	.	+	.	.	.	.	.	.	2a	.	.	.	2a	2b
Differential species Molinia caerulea-meadow, Transition type																																												
Galium uliginosum	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2b	2a	.	.	.	.	.	2b	1	.	.	.	.	.	.	.	.	.	.	.
Ajuga reptans	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species Molinia caerulea-meadow, Agrostis gigantea-variety																																												
Agrostis gigantea	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species Molinia caerulea-meadow, Gentiana asclepidea-type																																												
Carex acuta	3	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	5	.	.	.	.	.
Selinum carvifolia	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Gentiana asclepiadea	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Inula salicina	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Veratrum album	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.
Differential species acid Molinia caerulea-meadow																																												
Trichophorum alpinum	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	2a	.	.	.	1
Calluna vulgaris	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	r	.	.	.	.	.	.	1	.	.	.	.
Character species Parnassia palustris-Molinia caerulea-meadow																																												
Galium palustre	13	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	1	1	.	.	.	2m	.	.	r	1	.	.	.	1	1	.	.	.	.	2m	1	+
Equisetum palustre	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2a	.	1	.	.	.	.	.	.	1	.	.	.	1	.	.	1	.	.	1	.	.	.	.	+	2a	3	2a
Calliergonella cuspidata	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	2a	2a
Briza media	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	1
Tomentypnum nitens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.
Centaurea jacea	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	1	+
Crepis paludosa	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Prunella vulgaris	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Epipactis palustris	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Carex pulicaris	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	2b
Linum catharticum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Eriophorum latifolium	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+
Parnassia palustris	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Polygala amara	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Cirsium palustre	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Juncus compressus	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.
Other vascular plants																																												
Anthoxanthum odoratum	24	.	.	.	.	1	.	.	.	.	+	.	3	1	2a	2b	.	4	3	4	3	2a	2a	2a	2a	2b	+	2m	1	.	2a	1	2a	3	.	.	.	2a	1	.	.	.	.	.
Plantago lanceolata	15	1	.	.	3	+	.	1	2a	.	1	+	.	.	1	1	.	1	+	1	.	.	1	.	1	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lysimachia vulgaris	8	.	.	.	.	.	.	.	.	.	.	.	2a	+	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	1	.	.	.	.	.	.	1	.	1	.	.	.	.	.
Rhinanthus minor	8	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1	.	.	1	.	.	.	+	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.
Lythrum salicaria	7	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	1	.	1	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Luzula campestris	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	2a	.	.	.	1	.	1	.	.	+	.	.	.	.	.	.	+
Cardamine pratensis	6	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.
Cirsium rivulare	6	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.
Lathyrus pratensis	6	.	.	.	.	.	.	.	.	.	.	.	+	+	r	.	+	.	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus flammula	6	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	1	.	2a	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2m	.	.
Thalictrum aquilegiifolium	6	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	r	.	.	.	.	.	+	.	.	.	.	+
Carex acutiformis	4	.	.	.	.	.	.	.	.	.	.	.	2a	.	2a	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Festuca rubra	4	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2b	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Juncus effusus	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Hypericum perforatum	4	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	.	.	+	.	.	.	.	.
Phragmites australis	4	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	2a	.	.	.	.	.
Rumex obtusifolius	4	+	.	.	.	.	1	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla vulgaris agg.	4	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dactylorhiza incarnata	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Chaerophyllum aureum	2	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Heracleum sphondylium	3	+	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex ovalis	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other mosses																																												
Brachythecium rutabulum	6	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.
Aulacomnium palustre	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	1	.	.	.	+	2a	.	.	.	.	.	1	.	.	.	.	.	.
Plagiomnium elatum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	+	.	.	.	.	.	.	.
Dicranum bonjeanii	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Polytrichum strictum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	3	.	.	.	.	.	.
Polytrichum formosum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Sphagnum auriculatum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphagnum palustre	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
Thuidium philibertii	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.

Furthermore (total estimate in brackets):

AR02: Andromeda polifolia (+), Leontodon autumnalis (+), Mentha longifolia (1), Salix repens (+); **AR08:** Viola palustris (2a), Quercus robur (r); **AR09**: Cirsium vulgare (r), Mentha arvensis (1), Thymus pulegioides (+); **AR10**: Cirsium vulgare (2a), Salix aurita (r), Betula pubescens (1), Populus tremula (r); **AR11**: Agrostis stolonifera (r), Cirsium vulgare (+), Valeriana dioica (1), Lycopus europaeus (r); **AR13**: Campanula rotundifolia (r), Quercus robur (r), Stellaria graminea (+), Avenella flexuosa (2a), Rumex acetosella (1); **AR 15**: Mentha arvensis (+), Veronica chamaedrys (2b), Galeopsis tetrahit (+), Urtica dioica (1); **AR16**: Epilobium palustre; **AR35**: Campanula rotundifolia (1), Stellaria graminea (1), Agrostis capillaris (1), Poa palustris (1)

G14: Campanula rotundifolia (1), Lotus corniculatus (+), Vicia cracca (+), Euphrasia rostkoviana (1), Thymus pulegioides (+), Pimpinella major (1); **G25:** Mentha aquatica (1), Caltha palustris (1), Lotus corniculatus (1), Juncus articulatus (1); **G26:** Mentha aquatica (+), Viola palustris (2a), Lotus corniculatus (1), Juncus articulatus (1), Iris pseudacorus (+), Menyanthes trifoliata (1)

H01: Aegopodium podagraria (1), Scutellaria galericulata (+); **H02:** Veronica chamaedrys (1), Rhinanthus glacialis (1); **H03:** Agrostis stolonifera (3); **H04:** Carex rostrata (1), Festuca ovina (2a); **H05:** Stellaria media (2m), Rumex crispus (+) ; Aegopodium podagraria (+); **H06**: Stellaria media (1); **H09**: Potentilla palustris (+), Eupatorium cannabinum (1), Fragaria vesca (+), Salix spec. (+), Valeriana officinalis (+); **H11:** Equisetum fluviatile (+), Vicia cracca (+), Hypericum montanum (1), Arrhenatherum elatius (+), Carex demissa (1), Carex pallescens (1); **H12:** Equisetum fluviatile (1), Cirsium arvense (r), Galium aparine (1), Cerastium glomeratum (+), Polygonum amphibium (1), Rhinanthus alectorolophus (1), Vicia villosa (1); **H13:** Eriophorum angustifolium (r); **H14**: Trifolium spec. (2m); **H16:** Carex vesicaria (1), Galium aparine (1); **H17**: Cerastium fontanum (r); **H19**: Elymus caninus (2m); **H21:** Cirsium arvense (1), Salix aurita (r), Carex elata (2b), Salix cinerea x aurita (+), Vicia spec. (+); **H22**: Agrostis stolonifera (2a), Rumex sanguineus (r), Cerastium fontanum (1); **H23:** Caltha palustris (r), Senecio aquaticus (+); **H24**: Trifolium hybridum (1), Carex hirta (2a); **H26:** Hypericum montanum (+), Campanula patula (+), Helictotrichon pubescens (1);

H27: Bellis perennis (r), Caltha palustris (1); Trifolium repens (+), Glyceria fluitans (1); **H36:** Carum carvi (1); **H38**: Vicia cracca (+), Potentilla palustris (1), Valeriana dioica (1), Festuca pratensis (+); **H43:** Bellis perennis (r), Bromus hordeaceus (1); **H44**: Bellis perennis (r)

Tab. 2: Reeds, sedge fens, tall forbs, fallows

	Parameters	Frequency	Relevé number																																							
			G18	G16	G23	G24	G22	G17	H47	H10	G15	H28	H57	H31	H07	H48	H53	H58	H52	H56	H32	G21	H54	H25	AR29	H34	AR17	G19	AR04	H49	H39	H29	H46	H40	H33	H08	H37	H35	H41	H42	H50	H51	H15	AR34
	Soil type		fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	bog	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen	fen
	Area (m x m)		4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	2x8	4x4	4x4	4x4	4x4	4x4	4x4	4x4	2x8	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x3	2x8	4x4	4x4
	Area (m²)		16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	12	16	16	16
	Cover shrub layer [%]																															5												
	Height shrub layer [m]																															1,8												
	Cover herb layer [%]		75	80	40	90	75	100	70	60	95	60	70	80	50	70	80	70	90	80	60	100	100	70	70	60	60	100	100	80	80	90	80	70	100	75	50	100	100	60	70	70	100	100
	Height herb layer [m]		0,3	0,8	0,35	0,7	0,9	1,8	0,8	0,35	0,8	1,3	1,8	2,00	0,70	0,9	1,7	1,7	0,8	1,5	0,7	2,5	1,2	0,5	2,0	2,00	0,8	0,5	0,8	1,7	1,2	0,8	1,8	1	1,2	1	1,2	1,50	2,0	2,00	1,8	2,0	1,6	1,2
	Cover moss layer [%]		100	90	90	90	80	30	5	30	5	20			2	5					1			70	50		30		<1	5						1								
	Height moss layer [m]		0,1	0,1	0,1	0,1	0,1	0,1	0,03	0,05	0,05	0,05			0,05	0,05					0,05			0,03	0,05		0,05		0,03	0,03						0,02								
	Species number		13	9	2	5	5	16	16	23	34	19	10	7	16	23	15	11	15	13	20	25	10	37	15	7	12	13	18	24	14	10	20	15	17	16	9	9	14	20	7	11	5	17
	Quantitative average Ellenberg indicator values for the herb layer																																											
	L (light)		7,7	8	7	9	7,9	7,5	6,4	7,9	7,6	6,9	7,4	7,7	7,7	7	7	7,3	7	7,1	6,6	7,2	7	7,2	6,8	7,3	8,6	7,8	7,7	6,9	6,6	6	6,3	6,8	7,1	6,6	6	7	6,6	6,6	6,6	6,2	6,6	6,8
	F (moisture)		9	9	9	8	7,9	8,1	8,6	8,6	8,5	8,2	8,8	9	8,8	8,7	8,7	9	8,9	8,9	8,9	7,6	8,5	7,5	8	8,7	8,7	4,8	5,5	7,6	8,7	6,1	8,1	7,8	8	8,1	8,5	8,9	6,9	7,9	7	6,8	6,6	4,9
	R (reaction)		4	3,2	2	3	2,9	4,7	6,1	3,9	7,2	4,8	7	7	4,6	6,6	6,5	6,8	6,4	6,2	5,7	5,3	6,1	5,5	6,7	7	3,9	5,1	4,2	6,4	6,5	4,3	7	6,1	5,6	6,9	7	7	6,6	6,8	7	6	6,7	6
	N (nitrogen)		2,6	2,2	1	3	2,7	3,4	4,9	2,8	3,3	3,6	6,2	5,4	4,7	4,5	4,7	5,4	4,4	4,5	4,4	4,7	4,6	3,9	6,3	6	3	3,3	3,7	5,6	5,7	3,3	5,9	4,1	4,2	6,1	6	6,1	6	5,9	6,7	5,9	7,6	5,7
	water level class		5+										5+	5+								4+					3+																2+	
	GEST		Wet low sedge swamp and tall sedge fens and reeds with moss layer										Wet reeds	Wet tall sedge fens								Very moist meadow, tall forbs and reeds					Moist tall forbs and meadows																Medium moist tall forbs and meadows	
	Vegetation form according to Hundt & Succow 1984 and Succow & Joosten 2001		Sphagnum recurvum- Carex limosa- community		Sphagnum recurvum- Eriophorum angustifolium community	Sphagnum recurvum- Juncus effusus- community		Succesion from Sphagnum recurvum-Juncus acutiflorus- community	Calliergonella cuspidata- Viola palustris- Carex appropinquata community		Primula farinosa- Schoenus ferrugineus-community	Fragmentary tall sedge fen	Wet reed	Calliergonella cuspidata- Menyanthes trifoliata- Carex elata community		Carex acutiformis facies	Valeriana dioica- Berula erecta- Carex paniculata- community					Succesion of Carex appropinquata-Molinia caerulea- community	Wet fallow	Carex nigra- Caltha palustris- Filipendula ulmaria- community	Solanum dulcamara- Galium palustre- Phragmites australis- community		Moist fallows						Filipendula ulmaria- Urtica dioica- Polygonum bistorta- community	Filipendula ulmaria- community			Lythrum salicaria- Urtica dioica- Phragmites australis- community						Phragmites australis- Aegopodium podagraria- Urtica dioica- community	Community with tendency towards Hypericum perforatum- Galium album- community
No*	**Shrub layer**																																											
	Salix cinerea	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.
	Herb and moss layer																																											
1	Sphagnum cuspidatum**	1	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Hydrocharis morsus-ranae	2	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	Rhynchospora alba	3	4	4	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	Sphagnum magellanicum	2	+	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Andromeda polifolia	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sphagnum papillosum	1	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19	Eriophorum vaginatum	3	.	.	3	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	Oxycoccos palustris	4	2m	.	.	.	2b	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21	Sphagnum fallax**	6	+	3	5	5	5	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Pohlia nutans	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22	Polytrichum longisetum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24	Eriophorum angustifolium	2	1	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25	Potentilla palustris	8	.	.	.	.	.	.	1	1	.	.	.	.	2m	1	.	.	.	+	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	1	.	.	.	.
	Menyanthes trifoliata	4	.	2b	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex lasiocarpa	4	.	1	.	.	.	2b	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.
26	Carex diandra	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	Dicranum bonjeanii	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	Carex hostiana	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Parnassia palustris	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	Juncus alpinoarticulatus	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	Eriophorum latifolium	1	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Pinguicula vulgaris	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	Schoenus ferrugineus	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	Carex elata	2	.	.	.	.	.	.	.	.	.	.	.	4	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	Carex vesicaria	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
42	Typha latifolia	4	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	+	.	2a	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
45	Veronica catenata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex echinata	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
47	Viola palustris	2	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex echinata	1	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
48	Sphagnum palustre	1	.	.	.	.	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
50	Sphagnum teres	1	.	.	.	.	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sphagnum contortum	1	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
51	Campylium stellatum	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
53	Ranunculus flammula	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
54	Lysimachia thyrsiflora	1	.	.	.	.	.	.	.	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Agrostis canina	2	.	.	.	+	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peucedanum palustre	12	.	.	.	.	.	1	.	2m	.	.	.	1	+	.	1	1	1	1	2a	+	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
55	Carex rostrata	7	.	.	.	5	2b	.	.	.	.	2a	.	.	.	.	.	1	.	.	.	.	.	.	.	.	3	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
57	Thelypteris palustris	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
58	Carex appropinquata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Valeriana dioica	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bryum pseudotriquetum	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Dactylorhiza incarnata	2	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Climacium dendroides	6	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	4	2b	.	2a	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Salix repens	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
63	Caltha palustris	4	.	.	.	.	.	.	1	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
	Epilobium parviflorum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mentha aquatica	3	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Calliergonella cuspidata	10	.	.	.	.	.	.	1	.	+	.	.	.	1	1	.	.	.	.	+	.	.	1	2b	.	.	.	+	2m	.	.	.	.	.	+	.	.	.	.	.	.	.	.
	Myosotis scorpioides	5	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	1	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
	Cirsium palustre	7	.	.	.	.	.	.	.	+	.	.	.	r	.	.	1	.	+	1	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
64	Galium palustre	18	.	.	.	.	.	.	1	1	.	.	+	1	2m	1	1	1	1	1	1	.	+	+	2a	.	1	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
	Equisetum fluviatile	23	.	.	.	.	.	1	3	1	.	+	3	.	+	1	1	3	1	1	2a	.	+	1	+	2b	.	.	1	+	.	.	+	r	2a	.	.	+	.	+	.	.	.	.
	Epilobium palustre	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Drepanocladus aduncus	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
68	Plagiomnium elatum	5	.	.	.	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	.	+	.	1	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
70	Carex nigra	9	.	.	.	.	.	.	2a	2b	.	2a	.	.	.	1	.	.	1	.	1	.	.	2a	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
	Carex panicea	5	1	.	.	.	.	.	.	.	3	.	.	.	.	+	.	.	1	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Juncus articulatus	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Luzula multiflora	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
73	Carex acuta	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex disticha	2	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
74	Juncus effusus	10	.	.	.	.	3	1	.	.	.	1	.	.	.	1	.	.	.	.	.	3	.	+	.	.	.	1	2a	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.
	Lycopus europaeus	5	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	+	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Calamagrostis canescens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
75	Solanum dulcamara	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Iris pseudacorus	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
77	Filipendula ulmaria	23	.	.	.	.	.	.	2a	1	+	.	1	.	1	1	2a	.	+	1	.	.	3	1	.	1	.	.	.	+	2a	+	2b	3	4	2a	.	+	+	2a	2a	.	.	.
	Eupatorium cannabinum	3	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2a	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Galium uliginosum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
78	Lysimachia vulgaris	14	.	.	.	.	.	2a	1	.	.	1	1	.	.	1	1	1	1	.	.	1	.	.	1	.	.	.	.	1	.	.	.	2a	2a	+	.	.	.	.	.	.	.	.
	Scutellaria galericulata	12	.	.	.	.	.	1	.	.	.	.	.	1	+	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	1	+	+	+	.	.	.	+	+	.	.	.
	Lythrum salicaria	9	.	.	.	.	.	.	+	1	.	.	+	.	.	.	1	.	.	+	1	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
80	Carex paniculata	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2a	3	4	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Scirpus sylvaticus	7	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2a	.	.	.	.	.	+	.	+	.	r	.	.	.	+	.	.	.	1	.	.
81	Calluna vulgaris	1	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
82	Potentilla erecta	8	1	.	.	.	.	1	.	1	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Succisa pratensis	2	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Luzula campestris	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
83	Briza media	2	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Linum catharticum	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
84	Molinia caerulea	9	1	1	.	.	.	3	.	.	2a	2a	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	1	.	.	+	.	.	+	.	.	.	.	.	.	.	.
85	Polygonum bistorta	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2m	.	.	.	.	.	.	1	.	1	1	.	1	.	.	.	1	.	2a	.	.
	Crepis paludosa	4	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
	Lotus uliginosus	7	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.	2a	.	.	.	.	1	+	.	+	.	.	.	.	.	.	+	.	.	.	.
	Angelica sylvestris	11	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	.	+	.	.	.	.	+	+	.	+	+	1	+	.	.	.	.	.	.	.
	Lychnis flos-cuculi	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
86	Cirsium oleraceum	10	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	+	1	1	.	+	.	1
	Valeriana officinalis	3	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
	Geum rivale	4	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.
	Deschampsia cespitosa	7	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	+	1	.	.	.	.	1	.	.	.	.	1
87	Phragmites australis	16	.	+	.	.	.	.	.	.	.	.	.	2b	.	1	2a	3	+	.	.	3	1	.	3	3	.	.	.	2b	.	.	2b	.	.	.	.	.	2b	2a	4	2b	.	.
	Carex acutiformis	17	2b	.	.	.	.	.	.	.	3	2a	.	.	.	4	3	3	3	2b	.	.	.	1	.	2a	.	2a	.	.	+	.	2b	.	1	.	2b	3	2a	.	.	.	.	.
	Polygonum amphibium	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Equisetum palustre	8	.	.	.	.	.	.	1	1	+	.	.	.	1	.	+	.	.	.	.	1	.	1	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
88	Phalaris arundinacea	13	.	.	.	+	.	.	.	.	.	.	3	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	3	.	.	+	1	2b	+	3	.	2b	.	.	2b	1
91	Agrostis stolonifera	3	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Ranunculus repens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
	Cardamine pratensis	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
92	Alopecurus pratensis	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	r	.	.	+	2b	.
93	Centaurea jacea	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Anthoxanthum odoratum	6	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	3	1	2b	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Helictotrichon pubescens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
	Rhytidiadelphus squarrosus	2	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Stellaria graminea	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a
94	Holcus lanatus	4	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Veronica chamaedrys	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Carex hirta	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Ranunculus acris	4	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
	Festuca pratensis	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Rumex acetosa	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
95	Festuca rubra	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a
	Lathyrus pratensis	8	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	+	.	.	.	+	.	.	.	+	+	.	+	.	.
	Vicia cracca	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.
	Poa pratensis	4	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
96	Hypericum perforatum	4	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	2a
98	Elymus repens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Phleum pratense	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Dactylis glomerata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
99	Urtica dioica	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	+	1	2a	r	2a	2a	4	1
	Galium aparine	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	+	1	1	2a	.
	Cirsium arvense	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	2a
	Poa trivialis	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	2a	.	+	.	.	.	+	.	+	+	.	.	1	.	.	.
	Calamagrostis epigejos	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	+	.	.	.	.	.
	Galeopsis tetrahit	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Subalpine species																																											
	Thalictrum aquilegiifolium	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	2a	.	.	.	+	.	.	.	.
	Nitrogen indicators																																											
	Impatiens glandulifera	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	1	.	.	2b	.	+	2a	.	2b	.	1
	Galium mollugo	11	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	+	.	1	1	1	2m	.	.	.	1	.	1	.	2b
	Impatiens noli-tangere	4	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	2a	.	.	.
	Indicator species für poor soils																																											
	Carex ovalis	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Viola canina	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Other species																																											
	Carex elongata	4	.	.	.	.	.	.	3	.	.	2a	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex flava	7	1	.	.	.	.	.	.	1	2b	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex paniculata x remota	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carex brizoides	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	2a	.	.	2b	.	.
	Dryopteris carthusiana	2	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Rubus idaeus	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
	Polytrichum formosum	1	.	.	.	.	.	.	.	.	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

H07: Dicranodontium denudatum (+); **H08**: Cirsium vulgare (r), Salix spec. (+),Plagiomnium affine (+), Thuidium philibertii (+); **H10:** Salix spec. (+); **H15:** Glyceria fluitans (1); **H25**: Plantago lanceolata (+), Bromus hordeaceus (1), Trifolium hybridum (2m), Rhinathus glacialis (1), Trifolium campestre (1), Vicia spec. (r); **H28**: Frangula alnus (1), Salix cinerea (1), Rubus fruticosus agg. (1); Thuidium tamariscinum (1); **H32**: Plagiomnium affine (+); **H33**: Geranium pratense (r), Hypericum montanum (r); **H39**: Cirsium rivulare (+); **H40**: Cirsium rivulare (1); **H41**: Chaerophyllum aureum (1), Veratrum album (+); **H42**: Cirsium rivulare (1), Vicia villosa (1); **H46**: Mentha longifolia (1); **H53**: Salix spec. (+)

G15: Carex davalliana (1), Euphrasia rostkoviana (r), Fissidens osmundoides (+); **G17:** Sphagnum spec. (2a); **G18:** Vaccinium uliginosum (+); **G21**: Frangula alnus (2a), Salix spec. (+), Linaria vulgaris (+); **G24**: Dryopteris dilatata (+)

AR04: Plantago lanceolata (2a), Taraxacum officinale agg. (+); **AR17**: Frangula alnus (r), Quercus robur (r); **AR29**: Frangula alnus (1), Circaea lutetiana (+)

* Number of ecological indicator group: see appendix 4
** Taxonomy of critical species: see appendix 2

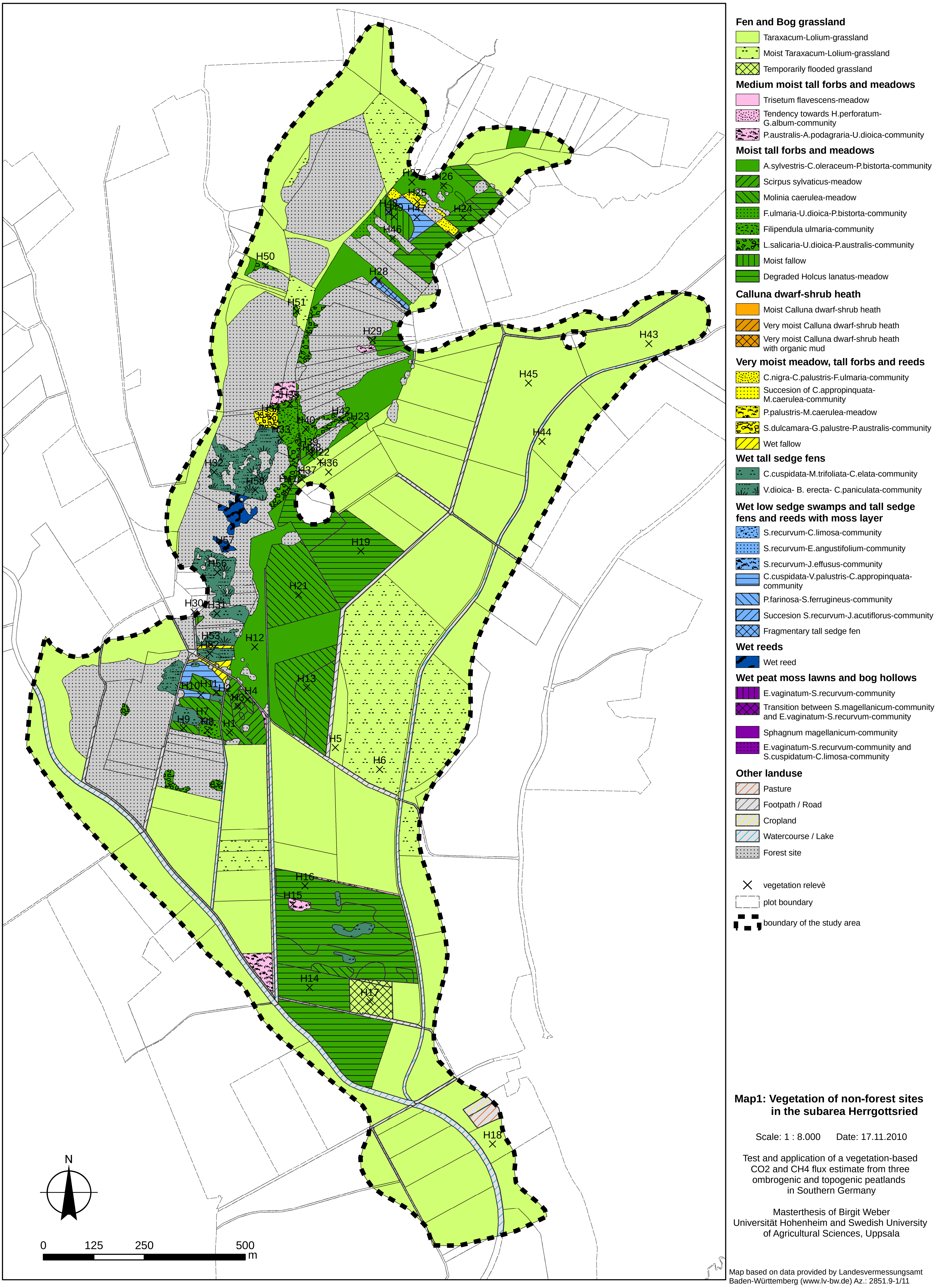
Tab. 3: Bog vegetation

No.*	Species name	Frequency	Relevé number																													
			G06	G12	G08	G04	G11	G13	G10	G03	G05	G07	G09	G01	AR25	AR19	AR20	AR31	AR32	G02	AR22	AR07	AR12	AR26	AR23	AR24	AR28	AR18	AR27	AR06	AR30	AR21
	Soil type		bog	bog	bog	fen	bog	bog	bog	fen	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	bog	fen	bog	bog	bog	bog	bog
	Area (m x m)		4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4
	Area (m²)		16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	Cover tree layer [%]																												25			
	Height tree layer [m]																												3,0			
	Cover shrub layer [%]																						20		10	25			10			3
	Height shrub layer [m]																						0,7		1,5	2,5			1,5			0,7
	Cover herb layer [%]		20	25	25	70	90	80	50	80	80	100	30	30	80	70	80	100	90	80	90	50	50	70	100	80	70	100	80	60	60	80
	Height herb layer [m]		0,35	0,3	0,3	0,4	0,5	0,5	0,45	0,35	0,4	0,4	0,35	0,4	0,3	0,4	0,5	0,6	0,3	0,35	0,5	0,4	0,6	0,6	0,4	0,7	1,00	0,7	0,6	0,4	0,6	0,5
	Cover moss layer[%]		90	100	95	100	80	100	80	90	80	90	100	100	5	90	90	15	40	80	70	40	30	50	60	20	30	<1	20			20
	Height moss layer [m]		0,1	0,15	0,1	0,2	0,1	0,1	0,1	0,1	0,15	0,1	0,1	0,15	0,05	0,15	0,1	0,1	0,1	0,1	0,1	0,05	0,05	0,1	0,05	0,05	0,1	0,05	0,1			0,05
	Species number		9	9	10	11	12	12	10	9	8	8	9	12	8	13	16	10	13	9	10	13	11	16	7	7	14	5	14	11	7	8
	Water level class		**5+**			**5+**									**4+**	**4+**									**3+**							
	GEST		Wet bog hollow			Wet peat moss lawn									Very moist Calluna- dwarf shrub heath with organic mud	Very moist Calluna- dwarf shrub heath									Moist Calluna- dwarf shrub heath							
No.*	**Vegetation form according to Succow & Joosten 2001, Succow 1988 and Couwenberg et al. 2008**		Sphagnum cuspidatum-Carex limosa-community			Eriophorum vaginatum-Sphagnum recurvum community			transition form	Sphagnum magellanicum -community					Very moist Calluna-dwarf shrub heath with organic mud	Very moist Calluna- dwarf shrub heath									Moist Calluna- dwarf shrub heath							
Tree layer																																
	Betula pubescens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.
Shrub layer																																
	Betula pendula	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.
	Betula pubescens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.
	Frangula alnus	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	1	1	.	.	2a	.	.	1
	Picea abies	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	2a	.	.	2a	.	.	.
Herb and moss layer																																
16	Carex limosa	2	2m	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Rhynchospora alba	10	2a	.	2b	.	.	2a	1	1	.	+	1	+	3	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
	Scheuchzeria palustris	5	2m	2a	2b	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Drosera anglica	2	1	.	2m	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	Sphagnum magellanicum	14	.	.	+	2a	2m	3	+	4	3	4	5	3	.	.	1	.	.	1	.	2b	2a	.	.	.	.	.	.	.	.	.
	Andromeda polifolia	15	1	1	1	.	1	2a	2a	.	.	.	2m	2m	.	2a	1	+	1	.	1	.	.	1	.	.	.	.	.	.	.	1
	Sphagnum nemoreum **	19	.	.	+	.	.	.	4	2a	2a	3	2b	4	.	4	4	2a	3	4	4	2a	2a	3	.	.	1	.	2b	.	.	2b
	Sphagnum papillosum	3	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.
19	Eriophorum vaginatum	26	+	1	1	3	5	4	3	2b	2a	1	2a	2b	1	2b	2b	.	1	2a	2a	+	2a	3	.	1	2a	.	1	r	.	2b
	Polytrichum strictum	17	.	.	.	1	2b	2a	+	1	3	2a	1	2a	.	3	2a	1	1	1	1	.	.	.	.	.	+	.	.	.	.	1
20	Oxycoccos palustris	22	1	2a	1	3	1	2b	1	1	2m	1	1	1	+	1	1	.	+	.	1	2a	.	1	.	.	1	.	1	.	.	1
	Drosera rotundifolia	16	1	2m	2m	2m	1	1	2m	1	1	1	1	2m	+	.	.	.	.	.	.	1	1	r	.	.	.	.	.	.	.	.
	Aulacomnium palustre	8	.	.	.	.	1	1	.	1	1	.	.	.	.	2a	2m	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.
21	Sphagnum fallax **	8	5	5	5	5	4	4	.	.	.	.	.	2m	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	Sphagnum cuspidatum **	1	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25	Menyanthes trifoliata	1	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
69	Vaccinium uliginosum	16	.	.	.	1	.	.	.	.	.	.	.	.	+	1	1	3	2a	1	1	1	.	1	r	.	2a	2a	2a	+	1	.
70	Carex nigra	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
	Luzula multiflora	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
81	Calluna vulgaris	23	.	.	.	.	.	.	.	4	4	5	2a	2m	2b	4	4	4	5	4	3	1	2a	2a	5	2a	3	4	2b	1	+	3
84	Molinia caerulea	14	.	.	.	1	.	.	.	.	.	.	.	.	3	.	.	.	+	.	3	2b	2b	3	+	4	3	.	4	3	4	4
	Other Sphagnum species																															
	Sphagnum subnitens	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Indicators for dry soils																															
	Pleurozium schreberi	9	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	2a	.	.	.	.	4	2b	3	1	.	.	.	.
	Vaccinium vitis-idaea	10	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	.	.	+	.	.	1	.	1	.	1	.
	Indicators for poor soils																															
	Vaccinium myrtillus	9	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	2a	+	.	.	+	.	.	.	.	1	3	+	1	.	.
	Melampyrum pratense	12	.	1	.	+	1	1	+	.	.	.	.	.	.	.	1	+	+	.	1	.	.	+	.	.	+	+	.	.	.	.
	Carex pilulifera	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
	Scrub																															
	Picea abies	9	.	.	.	+	.	r	.	.	.	.	.	.	.	r	.	+	.	.	.	+	.	+	.	.	1	.	1	.	1	.
	Betula pubescens	8	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	.	.	+	.	+	.	.	3	.	+	+	1	.
	Frangula alnus	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	1	.	+	.	.	1	.	1	1	1	.
	Quercus robur	1	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Pinus mugo	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Pinus sylvestris	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
	Salix aurita	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
	Other species																															
	Phragmites australis	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Potentilla erecta	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
	Leucobryum glaucum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.

* Number of ecological indicator group, see appendix 4

** Taxonomy of critical species, see appendix 2

Appendix 6: Maps



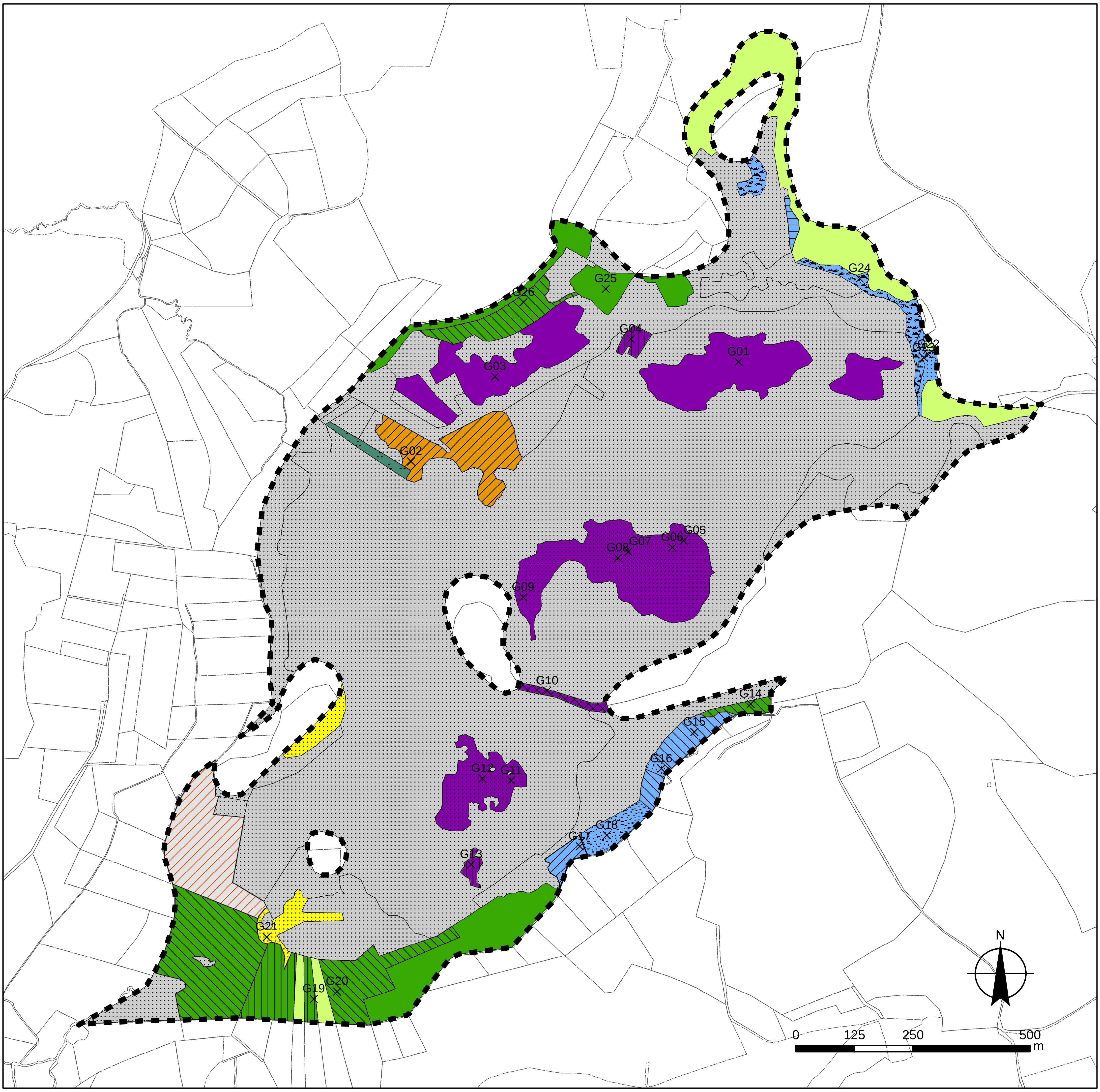
Map1: Vegetation of non-forest sites in the subarea Herrgottsried

Scale: 1 : 8.000 Date: 17.11.2010

Test and application of a vegetation-based CO2 and CH4 flux estimate from three ombrogenic and topogenic peatlands in Southern Germany

Masterthesis of Birgit Weber
Universität Hohenheim and Swedish University of Agricultural Sciences, Uppsala

Map based on data provided by Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/11



Fen and Bog grassland
- Taraxacum-Lolium-grassland
- Moist Taraxacum-Lolium-grassland
- Temporarily flooded grassland

Medium moist tall forbs and meadows
- Trisetum flavescens-meadow
- Tendency towards H.perforatum-G.album-community
- P.australis-A.podagraria-U.dioica-community

Moist tall forbs and meadows
- A.sylvestris-C.oleraceum-P.bistorta-community
- Scirpus sylvaticus-meadow
- Molinia caerulea-meadow
- F.ulmaria-U.dioica-P.bistorta-community
- Filipendula ulmaria-community
- L.salicaria-U.dioica-P.australis-community
- Moist fallow
- Degraded Holcus lanatus-meadow

Calluna dwarf-shrub heath
- Moist Calluna dwarf-shrub heath
- Very moist Calluna dwarf-shrub heath
- Very moist Calluna dwarf-shrub heath with organic mud

Very moist meadow, tall forbs and reeds
- C.nigra-C.palustris-F.ulmaria-community
- Succesion of C.appropinquata-M.caerulea-community
- P.palustris-M.caerulea-meadow
- S.dulcamara-G.palustre-P.australis-community
- Wet fallow

Wet tall sedge fens
- C.cuspidata-M.trifoliata-C.elata-community
- V.dioica- B. erecta- C.paniculata-community

Wet low sedge swamps and tall sedge fens and reeds with moss layer
- S.recurvum-C.limosa-community
- S.recurvum-E.angustifolium-community
- S.recurvum-J.effusus-community
- C.cuspidata-V.palustris-C.appropinquata-community
- P.farinosa-S.ferrugineus-community
- Succesion S.recurvum-J.acutiflorus-community
- Fragmentary tall sedge fen

Wet reeds
- Wet reed

Wet peat moss lawns and bog hollows
- E.vaginatum-S.recurvum-community
- Transition between S.magellanicum-community and E.vaginatum-S.recurvum-community
- Sphagnum magellanicum-community
- E.vaginatum-S.recurvum-community and S.cuspidatum-C.limosa-community

Other landuse
- Pasture
- Footpath / Road
- Cropland
- Watercourse / Lake
- Forest site

- vegetation relevè
- plot boundary
- boundary of the study area

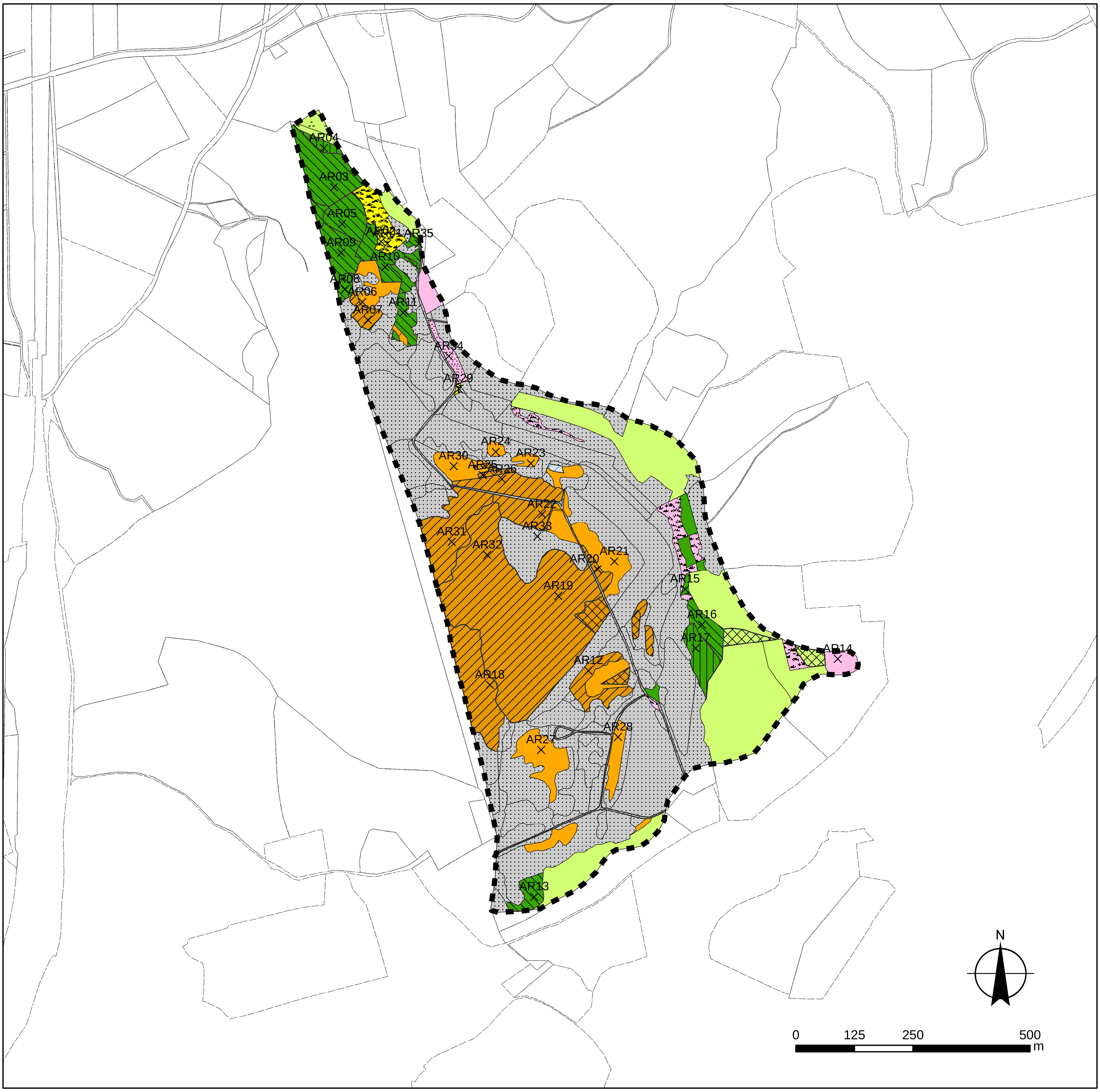
Map2: Vegetation of non-forest sites in the subarea Gründlenried

Scale: 1 : 8.000 Date: 17.11.2010

Test and application of a vegetation-based CO2 and CH4 flux estimate from three ombrogenic and topogenic peatlands in Southern Germany

Masterthesis of Birgit Weber
Universität Hohenheim and Swedish University of Agricultural Sciences, Uppsala

Map based on data provided by Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/11



Fen and Bog grassland
- Taraxacum-Lolium-grassland
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Medium moist tall forbs and meadows
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Moist tall forbs and meadows
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- Scirpus sylvaticus-meadow
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Calluna dwarf-shrub heath
- Moist Calluna dwarf-shrub heath
- Very moist Calluna dwarf-shrub heath
- Very moist Calluna dwarf-shrub heath with organic mud

Very moist meadow, tall forbs and reeds
- C.nigra-C.palustris-F.ulmaria-community
- Succesion of C.appropinquata-M.caerulea-community
- P.palustris-M.caerulea-meadow
- S.dulcamara-G.palustre-P.australis-community
- Wet fallow

Wet tall sedge fens
- C.cuspidata-M.trifoliata-C.elata-community
- V.dioica- B. erecta- C.paniculata-community

Wet low sedge swamps and tall sedge fens and reeds with moss layer
- S.recurvum-C.limosa-community
- S.recurvum-E.angustifolium-community
- S.recurvum-J.effusus-community
- C.cuspidata-V.palustris-C.appropinquata-community
- P.farinosa-S.ferrugineus-community
- Succesion S.recurvum-J.acutiflorus-community
- Fragmentary tall sedge fen

Wet reeds
- Wet reed

Wet peat moss lawns and bog hollows
- E.vaginatum-S.recurvum-community
- Transition between S.magellanicum-community and E.vaginatum-S.recurvum-community
- Sphagnum magellanicum-community
- E.vaginatum-S.recurvum-community and S.cuspidatum-C.limosa-community

Other landuse
- Pasture
- Footpath / Road
- Cropland
- Watercourse / Lake
- Forest site

- vegetation relevè
- plot boundary
- boundary of the study area

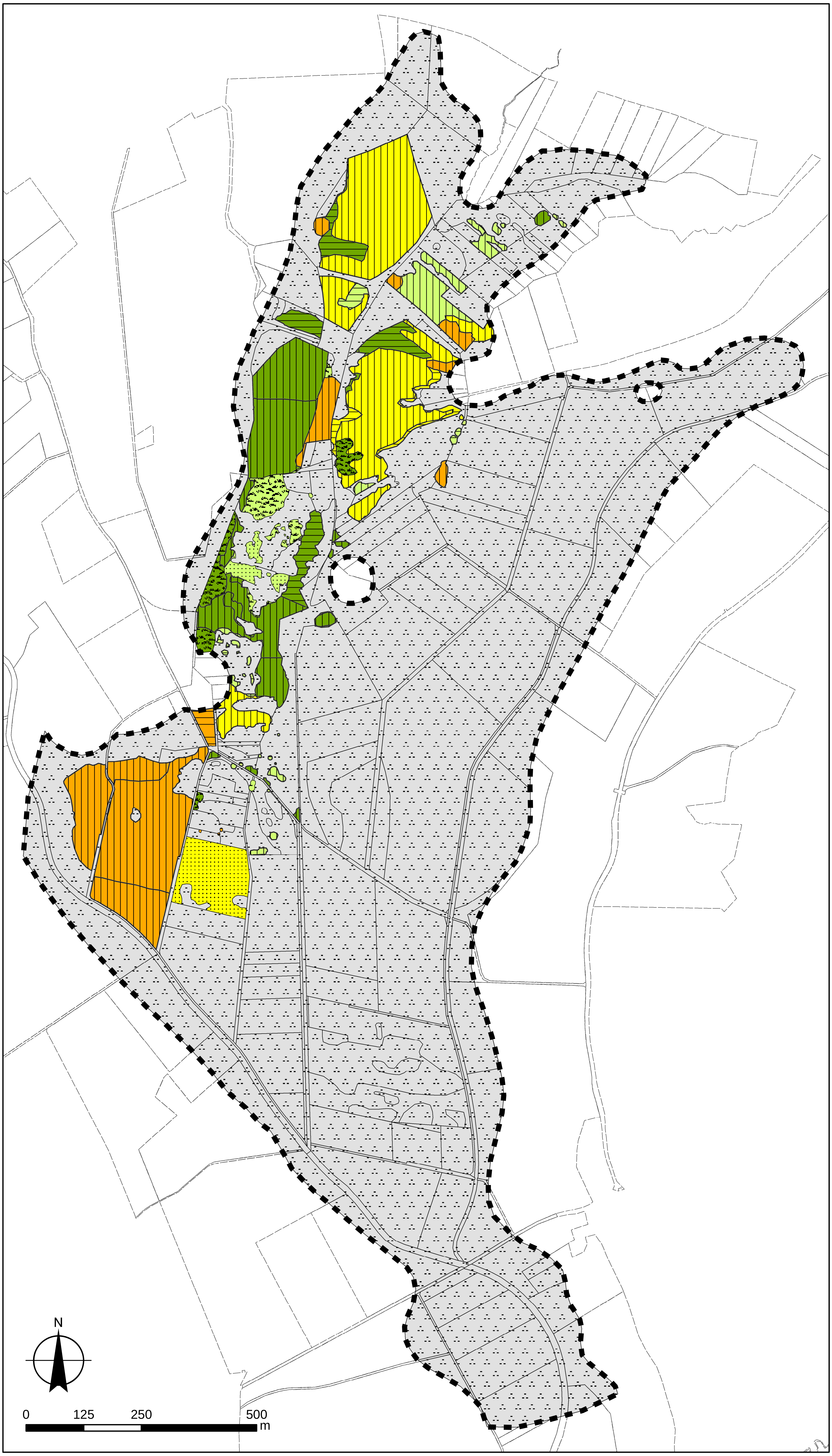
Map3: Vegetation of non-forest sites in the subarea Arrisrieder Moos

Scale: 1 : 8.000 Date: 17.11.2010

Test and application of a vegetation-based CO2 and CH4 flux estimate from three ombrogenic and topogenic peatlands in Southern Germany

Masterthesis of Birgit Weber
Universität Hohenheim and Swedish University of Agricultural Sciences, Uppsala

Map based on data provided by Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/11



Picea abies forest
- 0-20 years; dry
- 20-100 years; dry
- 20-100 years; wet

Pinus forest
- 20-100 years; dry
- 20-100 years; wet

Mixed forest
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Natural deciduous forest
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Salix shrub
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Other landuse
- clearcut
- non-forest sites

- plot boundary
- boundary of the study area

All forest in the study area were divided into two age classes 0-20 and 20-100 years. Those are distinguished into
- wet sites (annual median water level higher than -20 cm) and
- dry sites (annual median water level of -20 cm to > -80 cm)

Map4: Vegetation of forest sites in the subarea Herrgottsried

Scale: 1 : 8.000 Date: 17.11.2010

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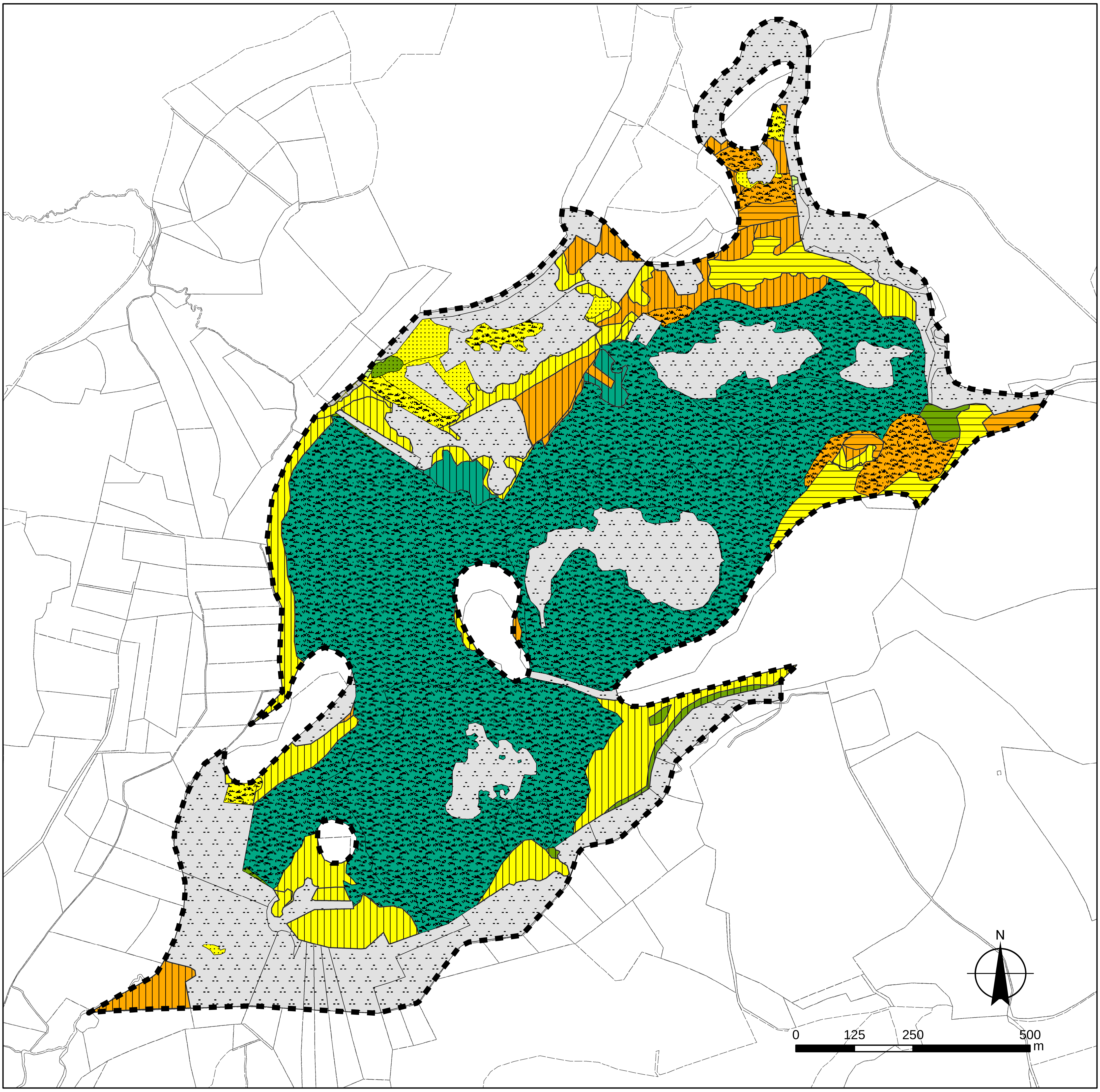

Picea abies forest
- 0-20 years; dry
- 20-100 years; dry
- 20-100 years; wet

Pinus forest
- 20-100 years; dry
- 20-100 years; wet

Mixed forest
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Natural deciduous forest
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Salix shrub
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Other landuse
- clearcut
- non-forest sites

- plot boundary
- boundary of the study area

All forest in the study area were divided into two age classes 0-20 and 20-100 years. Those are distinguished into
- wet sites (annual median water level higher than -20 cm) and
- dry sites (annual median water level of -20 cm to > -80 cm)

Map5: Vegetation of forest sites in the subarea Gründlenried

Scale: 1 : 8.000 Date: 17.11.2010

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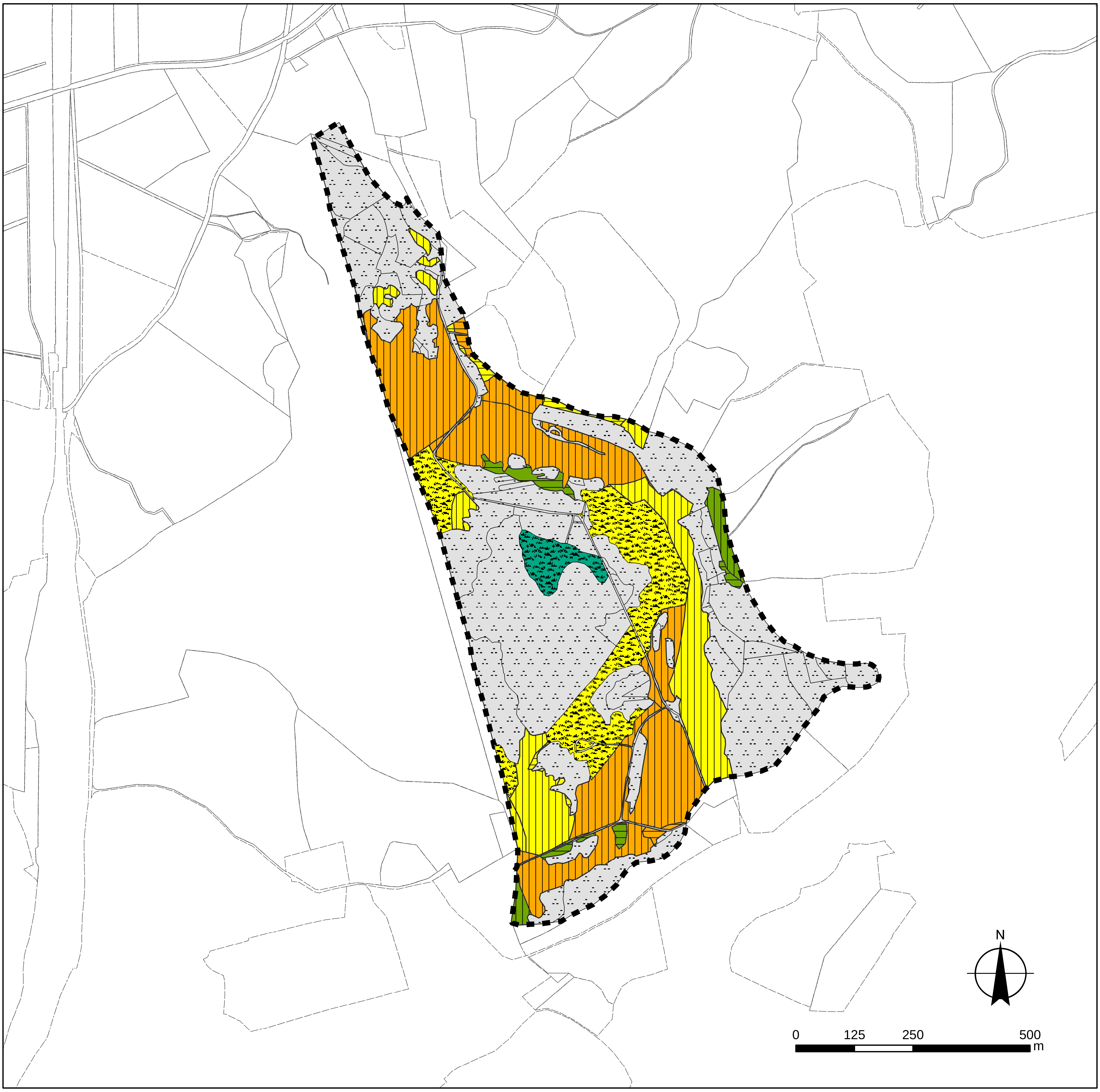

Picea abies forest
- 0-20 years; dry
- 20-100 years; dry
- 20-100 years; wet

Pinus forest
- 20-100 years; dry
- 20-100 years; wet

Mixed forest
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Natural deciduous forest
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Salix shrub
- 0-20 years; dry
- 0-20 years; wet
- 20-100 years; dry
- 20-100 years; wet

Other landuse
- clearcut
- non-forest sites

- plot boundary
- boundary of the study area

All forest in the study area were divided into two age classes 0-20 and 20-100 years. Those are distinguished into
- wet sites (annual median water level higher than -20 cm) and
- dry sites (annual median water level of -20 cm to > -80 cm)

Map6: Vegetation of forest sites in the subarea Arrisrieder Moos

Scale: 1 : 8.000 Date: 17.11.2010

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Map based on data provided by Landesvermessungsamt Baden-Württemberg (www.lv-bw.de) Az.: 2851.9-1/11