FIELD GUIDE

Raised Bog seminar "Sharing experience on Raised Bog Restoration" July 23-25, 2012

Rīga 2012

Field Guide

Raised bog seminar
”Sharing experience on Raised Bog Restoration”
July 23-25, 2012,
Latvia

Compiled by Dr.biol. Māra Pakalne

Contribution from:
Dr. geogr. Laimdota Kalniņa, Dr. geol. Aija Dēliņa
Dr. geogr. Agnese Priede, Dr. biol. Liene Auniņa
Dr.biol. Voldemārs Spuņģis
Valda Baroniņa, Gundega Freimane
Aivars Petriņš, Valdis Pilāts

2012
University of Latvia

Contents

INTRODUCTION **6**

MIRE FORMATION AND DEVELOPMENT IN LATVIA **7**

PEATLANDS IN LATVIA **10**

EXCURSION SITES **15**

MELNAIS LAKE MIRE NATURE RESERVE 15
ROŽU MIRE NATURE RESERVE 23
AKLAIS MIRE NATURE RESERVE 29
STIKLI MIRES NATURE RESERVE 36

RAISED BOG HABITAT MONITORING IN THE EC LIFE PROJECT "RAISED BOGS" SITES **46**

HYDROLOGY OF THE PROJECT SITES AND GROUNDWATER TABLE MONITORING **48**

„Restoration of Raised Bog Habitats in the Especially Protected Nature Areas of Latvia"
LIFE04NAT/LV/000196

SEMINAR PROGRAMM

SHARING EXPERIENCE ON RAISED BOG RESTORATION

23-25, 2012

Monday, July 23, 2012

Maritim Park Hotel Riga
1 Slokas Street
Riga, LV-1048
Tel.: +371 67069014
www.maritim.lv

July 23, 2012

9.00 – 9.10 Dr. biol. Māra Pakalne **Opening of the seminar**

9.10 – 9.30 Johannes Erik Annoby **The broad and unruly variation of obrogenous mires in West Norway and how to protect them generically by juridical descriptions**

9.30 - 9. 50 Leonas Jarašius, Dr. Romas Pakalnis, Dr. Jūrate Sendzikaite **Approaches to hydrological condition improvement in Aukstumala Raised bog and plant cover restoration in the post-mined areas**

9.50 - 10.10 Anders Lyngstad **Action Plans for Typical Raised Bogs and Oceanic Bogs in Norway**

10.10 – 10.30 Dr. biol. Olga Galanina **Spring mires in Pechory district, Pskov region (Russia).**

10.30 - 11.00 **Coffee break**

11.00 - 11.20 Jānis Ķuze **The experience of Ķemeri LIFE project**

11.20 – 11.40 Dr. geogr. Agnese Priede **Vegetation recovery in bog restoration in Ķemeri National Park**

11.40 – 12.00 Ilze Ķuze **EC LIFE Project „Hydroplan" actions**

12.00 – 12.20 Uvis Suško **The history of Aizkraukle Mire and surrounding forests in course of last 330 years**

12.20 -12.40. Dr. geogr. Laimdota Kalniņa **Raised bog development in the LIFE Project sites in Latvia**

12.40 – 13. 10 Aija Dēliņa **Raised bog hydrology and management measures in the EC LIFE Project „Raised bogs" sites in Latvia**

13.10 – 13. 30 Dr. biol. Māra Pakalne **Mire restoration and conservation experience in Latvia**

13.30 – 13.50 **Discussion**

13. 50 – 14.40 **Poster session**

15.00 – 19.00 **Excursion to Melnais Lake Mire Nature Reserve, visit of the Raised bog restoration area.** Packet lunch

Excursion guides: Dr. biol. Māra Pakalne, Dr. geogr. Laimdota Kalnina, Dr. biol. Liene Auniņa, Dr. geol. Aija Dēliņa

20.00 **Dinner**

Overnight in Maritim Park Hotel Riga

July, 24 2012

8.00 **Departure to Rožu Mire Nature Reserve**

10.30 – 13.00 **Excursion in Rožu Mire**

Excursion guides: Dr. biol. Māra Pakalne, Dr. geol. Aija Dēliņa, Uvis Suško

15.00 – 16.00 **Lunch Aizkraukle**

16.00 – 19.30 **Excursion to Aklais Mire Nature Reserve**

20.00 **Dinner in Maritim Park Hotel Riga**

Overnight in Maritim Park Hotel Riga

July, 25 2012

8.00 **Breakfast**

8.30 **Departure to Vasenieki Mire in Ventspils District**

14. 00 – 15.00 **Lunch in Ventspils**

15.00 **Departure to Riga**

18.30 **Arrival in Riga in the hotel Maritim Park Hotel Riga**

INTRODUCTION

From 2010-2013 the EC LIFE project **"Restoration of Raised bog Habitats in the Especially Protected Nature areas"** is carried out. The aim of the project is to re-establish the active raised bog habitats (7110*) in the areas influenced by drainage, restore project site hydrology and to protect the raised bog bird species of EU importance.

Active raised bog (7110*) is a priority habitat of Habitats Directive and one of the Europe's most rarest and threatened habitats.

The project includes four especially protected nature areas (Nature Reserves) that are also Natura 2000 sites: Melnais Lake Mire, Aizkraukle Mire and Forests, Aklais Mire and Rožu Mire with the total area of 4843 ha, from which 290 ha are degraded areas with critical need of restoration because they are influence from drainage and peat extraction (Fig. 1).

Fig. 1. Location of the project sites

The management plans for all the four project sites - Aklais Mire, Melnais Lake Mire, Rožu Mire (Annex 2), and in Aizkraukle Mire and Forests Nature Reserve, are completed.

In order to carry out the restoration of the active raised bog in the drained parts of the four project sites, the hydrological assessment of the sites and peat stratigraphical analysis was carried out. Impact after the change of water level to the possible risk of flooding of surrounding area was determined and is given in the management plan for each project site.

Technical designs were elaborated by the subcontractor - "Meliorprojekts" State Ltd. according to Latvian legislation. A large-scale map 1:10 000 was used for recording data and

exact number and location of the dams in all project sites. Precise number of dams is a part of the technical designs, where also their size and construction type is stated.

Peat stratigraphical analysis was carried out in all project sites. Results are summarised in the management plans for each project site.

MIRE FORMATION AND DEVELOPMENT IN LATVIA

Dr. geogr. Laimdota Kalniņa

The climate with higher precipitation over evaporation, slightly undulated relief and impermeable deposits on the bottom of many depressions in Latvia favours development of diverse mire types, like raised bogs and fens.

Mires in Latvia have been formed in the negative relief forms of ground surface, which were formed mainly as the result of the last - Weischelian (Latvian) glacier and its melting water activities. Exception are coastal areas, where relief formed during the Late Glacial after the retreat of glacier and the Holocene when the area was significantly influenced by the basins of Baltic Sea stages, mainly by the Baltic Ice Lake and the Littorina Sea. Peatlands have been formed under different geological and paleoecological conditions and time**.** They preserve a physical record of their history in the form of their 'peat archives'. Archaeological and palaeoecological data demonstrate that peat has been used already by ancient people, but extraction and utilisation for industrial purposes in Latvia**,** like in other Baltic States**,** started at the beginning of the 20th century.

Generally**,** the climate of Latvia is influenced by Atlantic air masses and location at the Baltic Sea. This has resulted in a high atmospheric humidity and a moderate temperature regime, which determines the mild climate with higher precipitation over evaporation favourable for mire development. Besides climate the important factors promoting the process of mire formation in Latvia are relief, clayey deposits at bottom of depressions and hydrological regime. Most paludified areas are located in the inland lowlands with gently undulated relief, where depressions are covered by till and glaciolimnic clay and silt.

The oldest Latvian mires date from the very Late Glacial time and beginning of the Holocene, from the Preboreal about 10 000 years ago. They have originated mainly by land paludification or filling-in in of shallow basins that were mostly remnants of glacial lakes and glaciocarst depressions. Mire formation processes both by filling-in of shallow basins and paludification, became more intensive during the Boreal Period, when climate became warmer and less humid, as well as biomass produced by mire plants increase.

During the Boreal, when climate became warmer, the formation of extensive mires commenced. The largest part of mires in Latvia has been developing since the Boreal Time. About 9000 years ago, when the Boreal climate became warmer and less humid, the groundwater level decreased. The mire vegetation gradually became fed mainly by rain water. The eutrophic plant species were gradually replaced by mesotrophic ones. For example, *Hypnum* moss was replaced by *Sphagnum* species and *Eriophorum vaginatum*. In tree layer dominate pine; alder and some broad-leaved trees became established at the mire edges. Filling-in of the lakes is proved by the layer of fen and transition peat that covers the gyttja sediments. Due to rather dry climate, lake terrestrialization was promoted by the

decrease of their water level. Part of the largest mires formed during the Boreal Period. Those fens where thick peat layer had accumulated and plants did not reach mineral ground water, gradually transformed into transition mires, and the first layers of raised bog peat started to develop. Due to an increase of water level during the Ancylus Lake stage of the Baltic Sea, the groundwater level rose in the area close to the coast. Wet conditions appeared in the depressions formed during the existence of the Baltic Ice Lake, the bottom of which was situated near to the sea water level and bog development has started.

About 7500 years ago, the climate changed and warm humid climatic conditions of the Atlantic Period commenced. In the central areas of mires, where a 2-3 m thick layer of peat had accumulated, the raised bog vegetation was fed only by precipitation. In these areas ombrogenous mire vegetation developed. When it decomposed, a raised type of peat was formed with transitional peat at the edges of the mires.

During the Atlantic Time many large fen areas transformed into raised bogs. In the mires composition of local vegetation changed. Plants in the central areas of mires could not reach the groundwater anymore. In these central parts ombrotrophic raised bog vegetation developed more rapidly. Raised bog peat was represented mainly by cotton grass *Eriophorum* and bog-moss *Sphagnum,* whereas wood remains accumulated. In those parts of bogs where humidity was lower, pine stands and pine-cotton-grass peat developed. In this time a 1- 2 m thick layer of peat formed.

During the Atlantic Time mire areas significantly increased in the coastal areas that was caused by the activity of the Littorina Sea. Transgression of the Littorina Sea that is the Baltic Sea stage basin with higher water level, with warm and salty waters took place and caused rise of level up to 2.5-5 m. Low coastal areas appeared under the sea level and formed large shallow lagoons. During the first regression of the Littorina Sea, about 6000 to 5000 years ago, due to decrease of sea water level these lagoons of the Littorina Sea were separated from the sea and basins became freshwater lakes and were filling-in at the end of the Atlantic Time or the first half of the Subboreal Time.

Nowadays, just the deepest lagoons have preserved as lakes, e.g. Kaņieris, Engure, Babīte Lake, but the shallowest have developed into mires, such as Sārnate Mire. Some of them are covered by sand and now support wet meadows or pastures.

During the Atlantic Time climatic conditions became favourable for diverse plant growth, especially for warmth demanding plants. These conditions were optimal for mire development, consequently the most extensive mire formation in Latvia commenced. The broad-leaved forests surrounded the mires. During the Atlantic Time the largest fens gradually transformed into transition mires and later into raised bogs. At the end of this period *Sphagnum* species were widely distributed and started to dominate in the raised bog vegetation.

About 4800 years ago the Subboreal Period set in. In this period, the bog vegetation was basically formed by *Sphagnum* and *Eriophorum vaginatum*. When these plants decomposed, the *Sphagnum magellanicum* peat developed. Besides, there were remnants of *Scheuchzeria* and dwarf shrubs in the peat. In this period, an intensive accumulation of peat occurred all over, followed by intensive development of raised bog domes, peat layer fracturing on the dome slopes due to gravitational instability, appearance of bog pools and the formation of hummock-hollow complexes.

At the second half of the Subboreal Period, 3500-3000 years ago, the inter-dune mire complex started to form in the north-western coastal area of Latvia, predominantly in the Slītere National Park. They developed in the narrow depressions between dune ridges and series of alternating long narrow dune ridges. The narrow depressions of the inter-dune ridge mire complex filled-in with fen peat at the beginning of the mire formation, but latter peat layers covered also dunes and raised peat started to form. Parts of these former inter-dune areas nowadays are large raised bogs, for example the Baži Mire.

During the Subatlantic Period that began about 2800 years ago, the climate became colder and more humid. In this period, *Sphagnum fuscum* peat developed, occupying the upper part of the peat deposits. In this peat, residue of *Sphagnum fuscum* composes 45-90 %. The rest of the peat consists of *Sphagnum angustifolium* and *Sphagnum magellanicum* remnants and *Eriophorum vaginatum*.

In the early stages of mire development *Phragmites* and *Carex* species dominated, e.g. *Phragmites australis*, *Carex dioica*, *C. nigra*, *C. panacea*, while trees and shrubs, such as *Betula pubescens*, *Frangula alnus*, *Pinus sylvestris*, *Myrica gale* and Salix spp. dominated in species-rich fens. When the mire development started, particularly during the Atlantic Time, many of the currently rare plant species, like *Myrica gale*, *Cladium mariscus*, *Trapa natans*, *Salix myrtilloides* and *Hammarbya paludosa* were distributed.

Development of raised bogs was associated with a rapid increase of various *Sphagnum* species in the vegetation. During the Subboreal Period, *Sphagnum fuscum, Scheuchzeria palustris* and *Eriophorum vaginatum* often dominated in the raised bog vegetation, but during the Subatlantic Period, *Sphagnum magellanicum, Andromeda polifolia* and *Calluna vulgaris* became more widespread. Micro-climate primarily determined vegetation composition in these raised bogs.

Composition of plant remains and pollen has preserved in peat sequences and was used as potential climatic and vegetation signal. It indicates that mire development in the Coastal Lowland area in general started comparatively late. Most of them originated just during the Late Atlantic or the Subboreal Time, while the oldest mires in Latvia formed already during Preboreal Time. The data obtained indicate that in paludified areas fen and transition mire vegetation remained for a short duration before fast changes of environmental conditions favoured raised bog development.

Nowadays, fens occupy smaller areas than raised bogs in Latvia, but the number of fens is greater, showing that the area of a fen is usually smaller than that of a raised bog. This is related to the fact that minerotrophic mires develop in places where ground waters and river waters are rich in nutrients, and often form in the vicinity of former lakes that have filled-in. At present, approximately one third of all mires in Latvia have originated from shallow lakes.

Ombrogenous mires can be dome-shaped or plateau type, open or wooded. Often the central part of the bog is open, but the margins are covered with pine. In many bogs the hummock-hollow complex is common and parallel oriented bog pools and lakes are found.

According to data of peat botanical composition and palynological studies and dating by ^{14}C method, it is found that in the raised bogs the largest thicknesses are characteristic of *Sphagnum* peat, which was formed during the Subatlantic Time. The mean annual thickness of *Sphagnum* peat layer formed during the Subatlantic Time reach 1.12 mm, but for some

bogs it is even three times higher. In many cases**,** it can be explained by the very low decomposition degree (3-5 %). For the Atlantic and Subboreal Time, peat layer accumulation rate was 0.61 -0.65 mm annually, however, for layers formed during the Atlantic Time it can be higher because they have been compressed by the weight of the upper layers. The highest degree of the *Sphagnum* peat decomposition (28 %) is estimated for peat accumulated in the Subboreal Time under comparatively dry climate conditions (Kalnina et al. 2008).

From the studies of mire development the following conclusions can be drawn:

Mire development usually started with fen stage that originated in the Preboreal Period, 10 000 years ago, and due to the filling-in of shallow remnant glacial water basin or glaciocarstic depressions.

Paludification of the ground in coastal areas took place at the end of the Boreal and the beginning of the Atlantic period, when the water level increased in the Baltic Sea due to transgression of the Littorina Sea and caused an increase of the groundwater level in adjacent areas.

At the end of the Boreal and during the Atlantic period, many fens were transformed into transitional mires and gradually into raised bogs. The youngest mires have developed in shallow lakes of the Littorina Sea lagoons and inter-dune depressions during the end of the Atlantic and the Subboreal (3000-5500 years ago).

PEATLANDS IN LATVIA

Dr. biol. Māra Pakalne

Peatlands are distributed in all the regions of Latvia and include various mire types. According to the type mires obtain water and nutrients, they are divided into geogenous and ombrogenous mires. Geogenous mires - fens and transition mires are fed by the waters which are in contact with the mineral soil, and in such a way obtain also minerals. Ombrogenous mires - raised bogs obtain water and minerals with the precipitation. More than a half of the mires are in a natural condition. The others have been drained or used for peat extraction. About 12 % of all the mires are under state protection.

Mire types in Latvia

Mires in Latvia comprise about 4.9 % of the total land area. Peat deposits, i.e. peatlands of more than 1 ha large and with more than 0.3 m deep peat layer, cover 10.4 % of the land and include, next to mires with thick peat layers, also some forest types, drained mires, and peat extraction sites. Mires are distributed all over the country but the covered area differs among the nature regions of Latvia (Pakalne & Kalnina, 2000). The largest raised bogs are found in the Eastern Latvia Lowland, Coastal Lowland, Middle Latvia Lowland and North Vidzeme Lowland. Large part of mires have formed as a result of filling-in of shallow lakes and ancient rivers or their meanders, as well as filling-in of former lagoons that have turned into shallow lakes after regression of the basins of the Baltic Sea stages, predominantly Littorina Sea. The degree of paludification in certain landscapes ranges from 0.1 % to 40 %.

Maximum degree of paludification is related to the lowlands with gently undulating relief, the Quaternary cover of which consists of till beds. Lowlands with glaciolimnic and lacustrine cover are considerably paludified from 10-15 % on the coast of the Gulf of Riga to 30-40 % in the Lubāns Plain.

Various human activities have influenced mires in Latvia, like drainage and peat extraction.

Ombrogenous mires: raised bogs (fed only by precipitation): Raised bogs are present all over Latvia. Two regional raised bog types are recognized, namely the western type with *Trichophorum cespitosum* and the eastern type with *Chamaedaphne calyculata*. These bogs can be dome-shaped or of the plateau-type and may be open or wooded. The central parts of the bogs are often open but the margins are wooded. The most common micro-relief feature of raised bogs is the alternation of relatively dry hummocks and ridges with wet hollows and open-water bog pools. Bog pools are mainly large and elongated.

Vegetation of ombrotrophic mires has a significant cover of dwarf shrubs with the dominance of *Sphagnum* species in the bryophyte layer. *Sphagnum magellanicum, S. rubellum, and S. fuscum* often occur on hummocks. *Calluna vulgaris*, *Empetrum nigrum*, Oxycoccus palustris, Andromeda polifolia and *Drosera rotundifolia* are prominent on hummock ridges. Between the hummocks are hollows where bryophytes, like *Sphagnum cuspidatum* and *S. tenellum* are common, while *Scheuchzeria palustris, Rhynchospora alba* and *Drosera anglica* are typical vascular plants in these micro-habitats. Also lakes occur in the raised bogs.

Communities of *Oxycocco - Sphagnetea* are well presented in the raised bogs. The *Sphagnetum magellanici* often occurs on hummocks as well as *Empetro nigri-Sphagnetum fusci.* In the eastern Latvia *Chamaedaphne - Sphagnetum magellanici* community is common, but in the western and northern part - *Eriophoro-Trichophorum cespitosi* occurs.

Protected species in raised bogs

Mammals:	*Nyctalus noctula, Vespertillo murinus, Pipistrellus nathusii, Myotis daubentoni, Eptesicus nilssonii, Lutra lutra, Ursos arctos.*
Bird species:	
On the margins of raised bogs:	*Aegolius funereus, Columba oenas, Circaetus gallicus, Dryocopus martius, Haliaetus albicilla, Aquila chrysaetos, Ciconia nigra, Caprimulgus europaeus, Pandion haliaetus.*
Nesting and feeding:	*Lagopus lagopus, Lanius collurio, L. excubitor, Pluvialis apricaria, Grus grus, Aquila chrysaetos, Gavia arctica, Numenius phaeopus*, *Circus aeruginosus*, *C. pygargus, Numenius arquata, Falco columbarius*, *Asio flammeus*, rare – *Cygnus cygnus, Limosa limosa, Tringa totanus, Larus ridibundus,* very rare – *Philomachus pugnax.*
Reptiles:	*Coronella austriaca, Lacerta agilis.*
Invertebrates:	*Vertigo ronnebyensis, Clossiana frigga, Clossiana freija, Erebia embla, Carabus menethriesi.*
Vascular plants:	*Trichophorum cespitosum*, *Drosera intermedia*, *Lycopodiella inundata, Betula nana, Salix myrtilloides.*

Bryophytes: *Calypogeia sphagnicola, Odontoschisma sphagni, Sphagnum lindbergii, Sphagnum molle, Odontoschisma denudatum, Splachnum pensylvanicym, Splachnum sphaericum.*

Geogenous mires: fens (fed by the water that has been in contact with the mineral bedrock or substrate)

Fens presently are widely distributed in Latvia, wherever waterlogged conditions are maintained, in part at least, by ground water. They range in a size from extensive fen complexes to small sites only of a few square meters.

Fens frequently occur as a zone of variable extent around lakes, in waterlogged hollows and raised bog margins, and in river floodplains and are typically dominated by sedges, like *Carex lasiocarpa* and *C. rostrata*. Other associated plant species include *Menyanthes trifoliata, Comarum palustre, Eriophorum angustifolium, Lysimachia vulgaris, Peucedanum palustre* and *Succisa pratensis*. Fen vegetation is rich in bryophytes, e.g *Campylium stellatum, Calliergonella cuspidata, Fissidens adianthoides, Bryum pseudotriquetrum, Drepanocladus revolvens* and *Scorpidium scorpioides*. One can distinguish between rich and poor fens. The *Scheuchzerio-Caricetea fuscae* communities often occupy these fens, like *Caricetum rostratae, C. lasiocapae* and *C. diandrae*.

Where fens have developed on a limestone substrate, rich fens have developed. One of the most distinct features of calcareous fens is that they are very rich in plant species, from these many are rare and protected species. *Schoenus ferrugineus* is a characteristic species of calcareous fens and can be accompanied by a range of plants, including *Primula farinosa, Parnassia palustris, Pinguicula vulgaris, Carex hostiana, and Sesleria caerulea* (Pakalne, 1995). Orchids, like *Dactylorhiza incarnata* and *Epipactis palustris* are well represented in calcareous fens. Another rich fen community includes *Carex davalliana* that may occur also in spring mires near the flushes.

Vegetation of fens can be open or covered with shrubs, like *Betula pubescens* and *Salix cinerea*. Sedge species such as *Carex lasiocarpa, C. rostrata, C. panicea* are characteristic for minerotrophic mires. Other associated species are *Menyanthes trifoliata, Comarum palustre, Eriophorum polystachion, E. latifolium, Lysimachia vulgaris, Peucedanum palustre* and *Succisa pratensis*.

Reed swamps and tall-sedge communities, e.g. *Phragmitetum australis* and *Caricetum elatae* often occur near lakes. The dominant species here include *Phragmites australis* associated with *Scirpus lacustris* and *Typha latifolia*.

When peat accumulates above the mineral groundwater, it becomes increasingly isolated from this nutrient source. In transition mires the influence of groundwater has strongly diminished and precipitation water starts to prevail. In transition mires *Sphagnum* species dominate in the bryophyte layer. Common species in transition mires are *Carex limosa, Carex rostrata, C. lasiocarpa* and *Rhynchospora alba* that are accompanied by *Eriophorum polystachion, Scheuchzeria palustris* and *Andromeda polifolia*. In the bryophyte layer *Sphagnum teres*, *S. warnstorfii*, and *S. flexuosum* are amongst the dominants. The *Rhynchosporetum albae* and *Caricetum limosae* communities occur there.

Protected species in fens

Mammals: *Lutra lutra*

Invertebrates: *Acicula polita, Pupilla muscorum*, *Hirundo officinalis, Papilio machaon, Dolomedes plantarius, Catocala adultera, Vertigo alpestris, Vertigo angustior, Vertigo genesii, Carabus menethriesi, Carcharodus flocciferus,*

Vascular plants: *Carex davalliana, Carex heleonastes*, *Carex scandinavica, Cladium mariscus, Eriophorum gracile*, *Juncus stygius,, Schoenus ferrugineus, Carex buxbaumii, Saussurea esthonica, Utricularia ochroleuca, Hydrocotile vulgaris, Primula farinosa*, *Dactylorhiza cruenta, D. baltica, D. fuchsii, D. maculata, D. russowii, D. incarnata, Gymnadenia conopsea, Liparis loselii, Ophrys insectifera, Pinguicula vulgaris*, *Hammarbya paludosa, Malaxis monophyllos, Saxifraga hirculus.*

Bryophytes: *Moerckia hibernica, Riccardia multifida, Riccardia incurvata, Riccardia chamaedryfolia, Cinclidium stygium, Bryum neodamense, Trichocolea tomentella, Hamatocaulis vernicosus, Calliergon trifarium, Paludella squarrosa, Drepanocladus lycopodioides, Meesia hexasticha, Meesia triquetra*..

Protected species in transition mires

Vascular plants: *Hammarbya paludosa, Dactylorhiza maculata, Drosera intermedia, Saxifraga hirculus*, *Carex paupercula, Rhynchospora fusca, Salix myrtilloides.*

Bryophytes: *Calliergon trifarium, Lophozia rutheana, Splachnum rubrum, Sphagnum pulchrum, S. obtusum*.

According to the Latvian legislation mires are protected in a wide range of protected nature areas, like Teiči and Krustkalni Nature Reserves, Slītere, Ķemeri, and Gauja National Parks, North Vidzeme Biosphere Reserve, nature reserves, nature parks (Engure Nature Park, Abava Nature Park), and protected landscape areas. These sites include raised bogs, fens and lakes.

At present six Ramsar sites are established in Latvia: Teiči and Pelečāre Mires, Engure Lake, Kaņieris Lake, the Lubāna Wetland Complex, Northern Bogs, and Pape Wetland Complex.

In Latvia, there are 336 Natura 2000 sites that include a wide diversity of forest, freshwater, coastal, grassland habitats, in addition to all the mire types of Latvia.

There are protected habitats of Europe (according to Habitats Directive) that occur in the mires of Latvia:

- Active raised bogs,
- Degraded raised bogs still capable of natural regeneration,
- Transitional mires and quaking bogs,

- Fennoscandian mineral-rich springs and spring fens,
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae,*
- Petrifying springs with tufa formation *(Cratoneurion),*
- Natural dystrophic lakes and ponds,
- Bog woodland.

According to the legislation of Latvia, protected mire habitats in Latvia include:

- Mineral rich springs and spring fens,
- Petrifying springs with tufa formation,
- Sulphur springs,
- Calcareous fens with *Carex davalliana,*
- Calcareous fens with *Schoenus ferrugineus,*
- Fens with *Juncus subnodulosus,*
- Calcareous fens with *Cladium mariscus,*
- Transition mires with *Rhynchospora fusca.*

EXCURSION SITES

MELNAIS LAKE MIRE NATURE RESERVE

Melnais Lake Mire is one of the four sites of the EC financed LIFE project "Restoration of Raised Bog Habitats in the Especially Protected Nature Areas of Latvia". The other sites include Aizkraukle Mire and Forests, Aklais Mire and Rožu Mire.

The nature reserve was established in 2004. Total area comprises 317 ha. It is an especially protected nature area in Latvia – Nature Reserve and is included in European network of protected territories Natura 2000. The site is located in Olaine Municipality of the Olaine District.

The site is surrounded by peat extraction fields. Peat extraction has started in 1930s. Melnais Lake Mire is part of the larger Cena Mire, which is the second largest raised bog in Latvia, covering the area of 8983 ha.

Drainage has caused the groundwater level lowering, favoured forest growth and separated the bog area from the agricultural lands. In the drained areas, especially in the area close to the ditches pine forest stands have established. There are deep ditches as well as smaller ones.

In the marginal areas, the ditches had caused peat compaction that does not allow the further growth of mire.

In 2011 the Management plan was elaborated for Melnais Lake Mire Nature Reserve that includes the management actions, like building of dams on the drainage ditches, building of nature trail and watching tower, as well as monitoring of site hydrology and habitats.

The management plan includes also information about the site flora, fauna, habitats, as well as maps with the management actions.

The main nature values

- Raised bog with hummock-bog pool complex (36 %),
- Dystrophic lake (6 %),
- Permanent shallow lakes that have developed in place of the previous peat fields and are important for birds (12 %),
- In total, 17 especially protected bird species,
- Especially protected habitats cover 84 % of the nature reserve.

Negative threats

- Drainage of mire and its surrounding area,
- Peat extraction close to the border of the nature reserve,
- Lowering of the water level in Melnais Lake and raised bog pools,
- Repeated fires in the mire due to the drainage.

The main management activities in the territory

Building of dams on drainage ditches to improve the hydrological condition and to prevent the impact of desiccation

Mire development and the history of the area

Melnais Lake Mire has developed in a relief depression of the Baltic Ice Lake accumulation plain, which has formed by activities of the Baltic Ice Lake more than 12 000 years ago.

However, depression was dry for long time and only due to humid and warm climate as well as high groundwater level that followed to Littorina Sea transgression, the climatic optimum resulted as very wet conditions. Conditions in the depression were favourable for wet demanding plant species, like *Carex* and *Phragmites*. Decomposition of these plants resulted as start to fen type peat accumulation. Due to peat growth, the influence of the groundwater diminished and the mire was fed mostly by nutrients obtained from the precipitation. As a result oligotrophic plants appeared, represented mainly by different *Sphagnum* species and *Eriophorum vaginatum*. Low decomposed *Sphagnum* peat has been accumulating during last 3000 years, with accumulation rate about 1.3 mm per year. Nowadays, in the largest part of mire the peat layer is 4-4.5 m deep with low peat formatting plant diversity mainly by *Sphagnum* mosses, cotton grass and Rannoch-rush (Fig. 2, Fig. 3).

During thousands of years, the mire has gone through all the phases of mire development – from fen till raised bog. Remains of plants in the peat indicate to the development course of the mire:

- At the end of the warm and humid Atlantic Period, about 5000–6000 years ago, the accumulation of peat sediments started to develop in the depression of the Plain of the Baltic Ice Lake. As a result, after the land paludificated, fen vegetation began to develop on decayed parts of plants;
- Since the Sub-boreal Period, appr. 4500 years ago, due to the climate change, raised bog vegetation started to dominate in the mire, and the peat layer slightly exceeds 5 m nowadays.

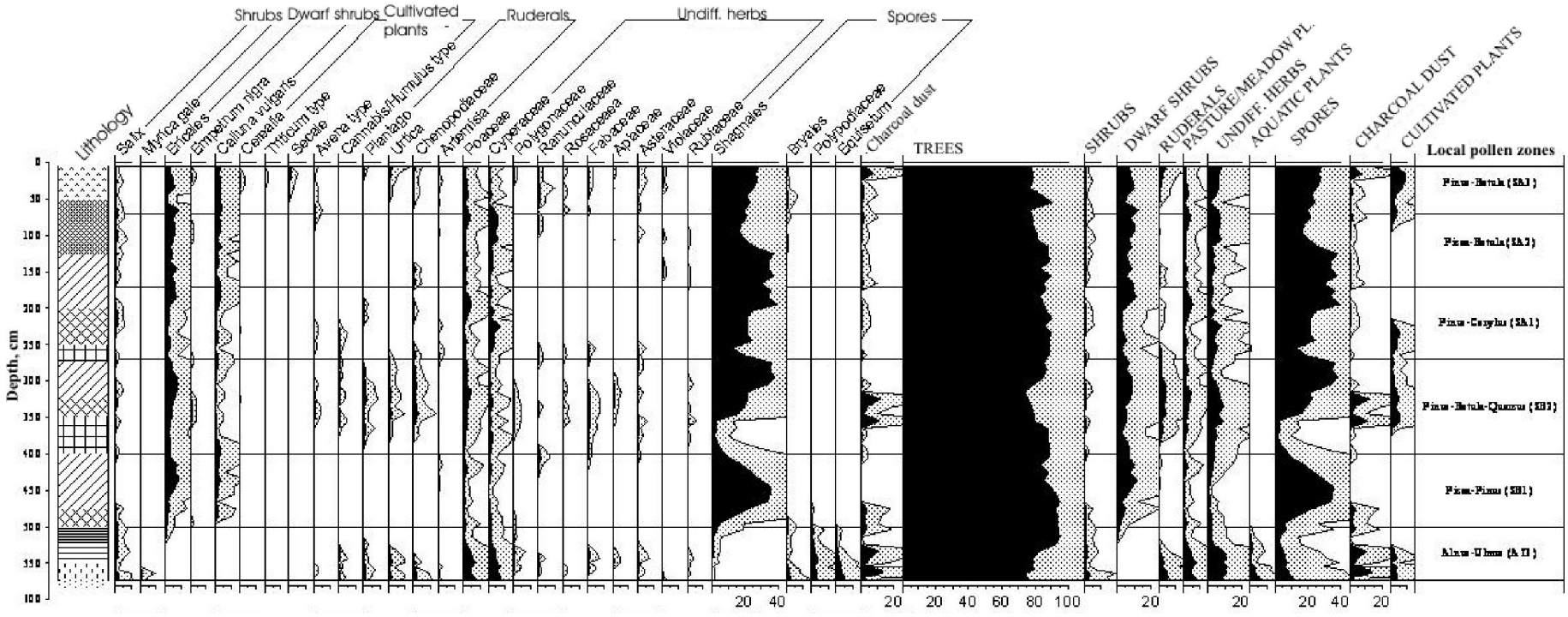


Fig. 2. Spore-pollen diagram of vascular plants and sporophytes in Melnais Lake Mire

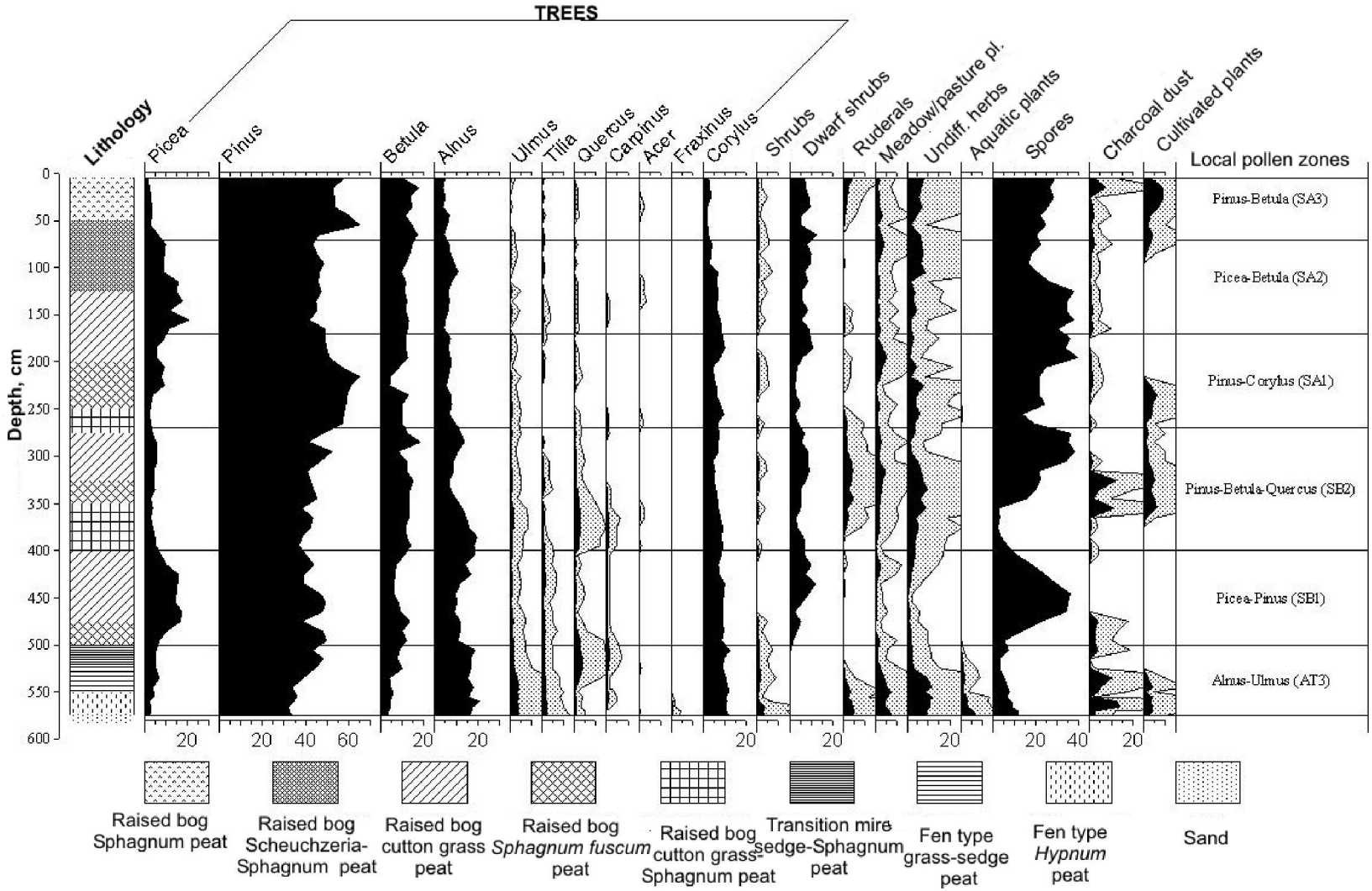


Fig. 3. Spore-pollen diagram of trees and shrubs from Melnais Lake Mire

Mire vegetation

Melnais Lake Mire includes both ombrogenous and geogenous mire vegetation. In the deepest places peat depth reaches almost 6 m, but average peat depth is 3 m.

Vegetation studies reveal that Melnais Lake Mire includes raised bog vegetation of the Classes *Oxycocco-Sphagnetea* and fen vegetation of the *Scheuchzerio-Caricetea fuscae*. The vegetation of the intact part of Melnais Lake Mire has a typical hummock-hollow complex and includes labyrinths of bog pools and ridges. Melnais Lake Mire is surrounded by bog woodland and pine forests.

There are hummocks and lawns dominated by *Sphagnum magellanicum*. On the raised bog margins there are hummocks with *Sphagnum fuscum*, *S. rubellum* accompanied by *Calluna vulgaris*, *Andromeda polifolia*, *Eriophorum vaginatum*, *Oxycoccus microcarpus*, *O. palustris*, *Drosera rotundifolia*, *Rubus chamaemorus* and *Empetrum nigrum*.

In the hollows the most common species are *Rhynchospora alba*, *Scheuchzeria palustris* and *Sphagnum flexuosum*, *S. cuspidatum*, *S. tenellum* accompanied by *Scheuchzeria palustris*, *Andromeda polifolia*, *Drosera anglica*, *D. rotundifolia*, *Oxycoccus palustris*, *O. microcarpus*, *Eriophorum vaginatum*, *Cladopodiella fluitans* and *Calypogeia sphagnicola*.

On the margins of the labyrinths of raised bog pools *Carex limosa*, *Rhynchospora alba*, *Warnstorfia fluitans* and *Sphagnum cuspidatum* occur.

The typical raised bog communities include *Sphagnetum magellanici*, *Rhynchosporetum albae*, as well as fen vegetation of *Caricetum rostratae* and *Caricetum lasiocarpae*.

The mire vegetation differs in areas with the influence from drainage, peat extraction or fire. Growth of the whole range of the typical bog bryophytes is restricted and results as their extinction and replacement by others less typical species of bog habitats. Cover of *Sphagnum* species has decreased comparing to the natural part of mire. Dense cover of *Calluna vulgaris* is observed occasionally, as well invasion of pine and birch. Nearby the ditches, the natural variation of hummocks and hollows has disappeared and there are fewer bog pools.

Melnais Lake Mire has preserved as a small nature 'oasis' within an intensively managed area. Most probably, the small territory around the lake remained intact among the vast fields of peat extraction due to its richness in water and many pools.

Approximately 60 % of the territory is covered with three especially protected mire habitats of European importance that bear the human influence of different extent:

Intact raised bog (7110*) occupies 35 % of the Nature Reserve. Raised bog vegetation dominates in the part that is less influenced by drainage. Despite various negative influences, the mire is rich in water in some parts, and several lakes and pools occur there.

Transition mire and quacking bogs (7140*)* have developed in small areas near the lakes and pools. In places, this habitat has developed due to the lowering of water level of the lakes; as a result the lake has filled-in with *Sphagnum* mosses and sedges.

Degraded raised bogs, where natural regeneration is possible or takes place (7120*),* covers 25 % of the territory of the Nature Reserve. Due to drainage, the mire has become dry and fire-hazardous – several fires have occurred in the territory, degrading the vegetation

furthermore. In many European states almost no intact mires have remained. With the help of special management activities, the influence of drainage can be diminished and restoration of the mire favoured, therefore this habitat is especially protected in the European Union.

Forests and lakes

Young forests dominate in the areas that have developed due to overgrowing of the mire or old peat fields. Biologically valuable forests cover only a little more than 10 % of the territory, two priority (*) protected forest habitats of the European importance can be found in the nature reserve:

Bog woodland (91D0*) occur mostly around the lakes and are included in the raised bog pool-ridge complex of the mire. Slowly growing and dwarf pine, ridged micro-relief and the vegetation of dwarf shrubs is characteristic of this habitat.

Western taiga (9010*) can be found only around Melnais Lake. The forest once developed on peat soil, but after the drainage peat has mineralized and the quality of vegetation has changed. The main value of the habitat is the slowly growing 140 year-old pines. The forests on the lake shores have experienced several fires.

Lakes are the value of the small Nature Reserve. The largest is Melnais Lake (6 ha), but at least nine more lakes with area more than 0.3 ha are located here. Many smaller lakes can be found in the mire ecosystem as a part of bog pool complex.

All mire lakes in the Nature Reserve are especially protected habitat in the European Union and Latvia – **Dystrophic lakes** (3160*).

There are areas in the Nature Reserve where peat extraction was completed several decades ago. At present permanent shallow lakes suitable for birds have developed there or paludification process has started naturally and a fen vegetation is developing.

Plants

Mire flora is very specific – mostly here occur species, which are fully adapted to the wet habitat. There are no special rarities in the flora of the territory; however, species characteristic to mire occur in the more natural part of the Reserve.

Birds

More detailed bird studies in Melnais Lake Mire during the recent years are partly related to the close location to the airport for which birds can imply some danger. In the territory of the Nature Reserve, 17 bird species are recorded, which are included in the EU Bird Directive, e.g. *Botaurus stellaris, Cygnus cygnus, Mergus albellus, Pandion haliaetus, Milvus migrans, Circus aeruginosus, Grus grus, Porzana porzana, Tetrao tetrix, Tringa glareola, Philomachus pugnax, Bubo bubo, Caprimulgus europaea, Dryocopus martius.*

The number of species varies through the years, because most of the bird species nest here irregularly, they have small populations or are observed only during the migration. However,

the total diversity of especially protected bird species in such a small territory is comparatively high and very important for the neighbourhood of Riga.

The most significant group of birds constantly nesting in the territory are the raised bog bird species. One of the priority protected bird species in the nature reserve is *Tringa glareola* (4–8 couples) for which the open part of the mire with pools and lakes is its most suitable nesting place. The previous peat fields, where permanent, shallow lakes partly filled-in with vegetation have formed, are suitable for waterfowl. The species, like *Botaurus stellaris*, *Circus aeruginosus*, *Cygnus Cygnus*, *Porzana porzana* and *Porzana parva* were observed. *Caprimulgus europaeus* (1–3 couples) and permanently in the territory nesting *Bubo bubo* (1 couple) represent the forest birds. Taking into account that the total number of Eagle Owls in Latvia is about 50 couples, the small territory of the nature reserve is very important for this species in the scale of Latvia.

Invertebrates

There is a great diversity of invertebrate species in the territory of the Nature Reserve, however, disturbance created by drainage increase the number of both typical and non-typical species of the mire and in its surroundings, as well as the number of transitory species.

Mire butterfly species often occur throughout the mire – *Clossiana selene* and *Colias palaeno*. From especially protected insect species, only predatory insect species can occur in the mire, for instance, dragonflies. *Leucorrhini pectoralis* and *L. albifrons* favour the shallow lakes of the previous peat extraction fields and almost cannot be found around Melnais Lake. Both species are protected both in Latvia and the European Union.

Mammals

The fauna of mammals is poor in the Nature Reserve because the territory is small and comparatively monotonous. Melnais Lake ensures some diversity, where several bat species can be observed, for instance, *Myotis daubentoni* and *Eptesicus nilssoni*.

The territory of the Nature Reserve is a favourite dwelling place for *Artiodactyla* species. They can find shelter here from the surrounding territories, which are intensively managed and populated. Roes *Capreolus capreolus* and moose *Alces alces* reside here, but elks *Cervus elaphus* and wild boars *Sus scrofa* use the mire as a transition corridor from one to another region. Wolves cross the mire comparatively often as well.

Sometimes in the mire one can see the footprints of *Lynx lynx.* For the *Canis lupus* and *Lynx lynx* the mire is an important area as it is a biological corridor along which the migration of animals can take place from one region to another.

Humans with their economic activities have favoured the presence of some animals in Melnais Lake Mire. In the intact part of the raised bog one can not find *Castor fiber*, but when the ditches are made on the margins of Melnais Lake Mire, beavers find their living area soon. If there are ditches, there are also conditions suitable for the beaver: water in the ditch and food in the drained part of the mire, like broad-leaved trees and herbaceous plants. Previously, beavers were hunted by humans, while nowadays they are hunted by

Vulpes vulpes and especially *Canis lupus*. Ditches as a habitat is good also for some other mammal species, like *Neomys fodiens, Microtus arvalis* (if there are grassy habitats).

Drainage influence

The shape of Melnais Lake Mire is not even, it has a dome that has formed from peat accumulation during thousands of years. Melnais Lake is situated in the centre of the dome. It gathers water from the nearest surrounding, but in the previous century a ditch was dug from the lake to the drainage system. Similarly, the water level was lowered in several raised bog pools and smaller lakes – as a result, the water reservoirs have almost completely filled-in with vegetation.

In total, the hydrological conditions of the Melnais Lake Mire were substantially changed by human activities, 84 % of the territory are surrounded by drainage ditches. Peat extraction in the surroundings of the Nature Reserve that was started in 1930-ties, continues up to present.

Management actions

After peat extraction, it is impossible to restore the natural raised bog vegetation completely. However, the impact of drainage can be diminished and the hydrological condition can be stabilized. It is possible to raise the level of groundwater and to reduce the seasonal fluctuations by building dams on the ditches. Therefore, such dams were built in Melnais Lake Mire, where the degraded bog occupies ¼ of the territory. Similar management activities were carried out in the nearby Cena Mire Nature Reserve, and the results are successful:

- The groundwater level of the mire has increased;
- The fluctuations of the groundwater level are not high;
- Regeneration of the characteristic mire vegetation takes place.

The hydrological and vegetation monitoring was started in Melnais Lake Mire in order to observe the change in the hydrological condition and the influence of dam building to the mire habitats and their restoration process.

ROZU MIRE NATURE RESERVE

Rožu Mire Nature Reserve was established in 1987. The total area of Reserve comprises 1010 ha. The goal of establishing the Nature Reserve was to protect the unchanged natural ecosystems and distinctive landscapes of the mire. The site is located in Sala and Sēlpils Municipalities of the Sala District. The mire has started to develop about 10 000 years ago. Maximum depth of peat layer reaches 8 m.

Habitats

- Mires 63 %
- Forests 35 %

The main nature values

- Intact raised bog
- Degraded raised bog with possible natural regeneration
- Bog woodland
- Old and natural Western taiga
- Mineral-rich springs
- About 98 % of the Nature Reserve are especially protected habitats
- In total 30 especially protected plant and animal species

Negative influence - Drainage of the mire

The main management activities in the territory - Building dams on drainage ditches in the mire to prevent the impact of desiccation

The Nature Reserve presents valuable combination of bog habitats including elements of transition mires and bog woodland. The central part of the Nature Reserve presents an excellent quality of active raised bog with swamp lakes, raised bog pools and hollows. Peripheral part is formed by different forest stands – mainly the bog woodland, which has developed because of both natural conditions and anthropogenic influence. The Reserve also includes black alder swamp, old boreal forests with springs and iron rich spring seepage areas.

Geology

Within the frame of the project LIFE+ project “Restoration of Raised Bog Habitats in the Especially Protected Nature Areas of Latvia”, a number of geological borings were carried out in order to analyze the mire sediments of spore-pollen examples.

Pollen diagram reflects the character of local and regional vegetation and the changes since the beginning of Preboreal Period (more than 10 000 years ago) until nowadays.

Intensive accumulation of peat took place during the Atlantic Period (7500-4500 years ago), when the most widespread plant species forming peat was *Sphagnum*, Cotton-grass and Rannoch-rush.

Nowadays Rožu Mire sediment consists of ~ 6 m raised bog peat, mainly created by *Sphagnum* – cotton-grass peat. The average depth of the peat layer is 4.3 m, the maximum – 8 m (Fig. 4, Fig. 5).

Mire development

Rožu Mire Nature Reserve is located on East-Latvia lowland, Sēlija monticule, in Daugava drainage area, Saka basin. The territory of the Reserve is a part of a larger mire-forest complex, which was historically called "Pliksne Mire" and its total acreage reached 1428 ha. The mire is surrounded by hillocks from three sides and it has two discrete domes of peat reaching the height of 85.4 meters above the sea level. At the beginning of the mire development it was formed by three separate mires and, by gradually flowing together, they created single mire.

Those three parts historically had each its own place-name. The inland dune was called "The End of the World".

Rožu Mire was formed as a result of wet mineral soil paludification in bog depression. Palaeobotanical studies and ^{14}C dating show that Rožu Mire started to develop about 11 000 – 10 000 years ago, when climate amelioration took place. At that time started distribution of birch-pine forests, which gradually were replaced by dense pine forests. During this time in the Rožu Mire depression fen peat started to form due to intensive soil and vegetation development. Comparatively dry climate conditions were favourable also for peat decomposition. As a result well decomposed (> 40 %) fen and transition mire peat with lowest accumulation rate were deposited before 8000 – 7000 years. The most intensive peat accumulation started before 2000 years, when peat formatting plants predominantly were *Sphagnum* mosses, cotton grass and Rannoch-rush.

Mire habitats

The mire habitats cover totally 624 ha of the Reserve. The largest area of mire is ombrotrophic or raised bog – 573 ha, while minerotrophic mire-transition mire reaches 69 ha. The Nature Reserve includes five especially protected mire habitats of the European importance:

Active raised bogs (code 7110*) occur in 428 ha area of the Reserve territory. The exposed area of mire is formatted by mosaic of raised bog hummocks, hollows and bog pools, surrounded by peat areas. Part of mire is overgrown by fine pine, but depressions are covered by white Beak-sedge *Rhynchospora alba.*

Depressions on peat substrates of the Rhynchosporian (7150) are open peat areas, often without vegetation which normally forms on the slopes of the domes in active raised bogs. Mire depressions can be observed in the central part of the mire in 46 ha wide territory. The presence of this habitat indicates to the active formation of raised bog micro landscape – hummocks, pools, ridges and hollows.

Degraded raised bogs still capable of natural regeneration (7120) are mainly located on the southern part of the Riestu Mire. The total area of this habitat covers 147 ha of the Reserve.

Transition mires and quaking bogs (7140) occupy 69 ha of the Nature Reserve. They are wet, swampy and are fed by precipitation, above water flows and groundwater. The transition mire is dominated by such species as White Beak-sedge *Rhychosphora alba*, Bog sedge *Carex limosa*, Rannoch-rash *Scheuchzeria palustris.*

Fennoscandian mineral-rich springs and springfens (7160)**.** The total area of this habitat is about 260 m^2. The habitat consists of seepage areas with vegetation and poor water flow in some places.

Forests

The Nature Reserve includes four especially protected forest habitats of the European importance:

Bog woodland (code 91D0*) covers 339 ha of the Nature Reserve. Bog woodland mostly occurs in the peripheries of the Reserve. In the older areas of mire slow growing Scots pine *Pinus sylvestris* and downy birch *Betula pubescens* can be observed, land is covered by bog-moss *Sphagnum spp.* Yet, most of the bog woodland habitats are rather young and have formed as a result of mire drainage.

Western taiga (9010*) cover 7 ha of the Nature Reserve. These forests are characterized by mixed timber forest, basically made up by Norway spruce *Picea abies*, aspen *Populus tremula* and downy birch *Betula pubescens*, but in the shrub-layer grow hazel *Corylus avelana* and rowan *Sorbus aucuparia*.

The forests show common natural forest habitat structures: forest stands of various age, openings in tree layer, dead-wood on different decomposition stages, many old hazels and trees with hollows.

Fennoscandian hemi boreal natural old broad-leaved deciduous forests rich in epiphytes (9020*) cover 0.3 ha. The forest stand consists of aspen *Populus tremula*, alder *Alnus glutinosa* and small-leaved lime *Tilia cordata*.

Fennoscandian deciduous swamp woods (9080*) cover 4.8 ha. The tree layer is dominated by such species as alder *Alnus glutinosa,* admixture of downy birch *Betula pubescens* and Norway spruce *Picea abies.*

Plants

In the Nature Reserve four especially protected vascular plant species have been found - *Dactylorhiza incarnata*, *Dactylorhiza maculata, Euonymus verrucosa*, *Platanthera bifolia,* as well as moss *Neckera pennata* and lichen *Arthonia byssacea.*

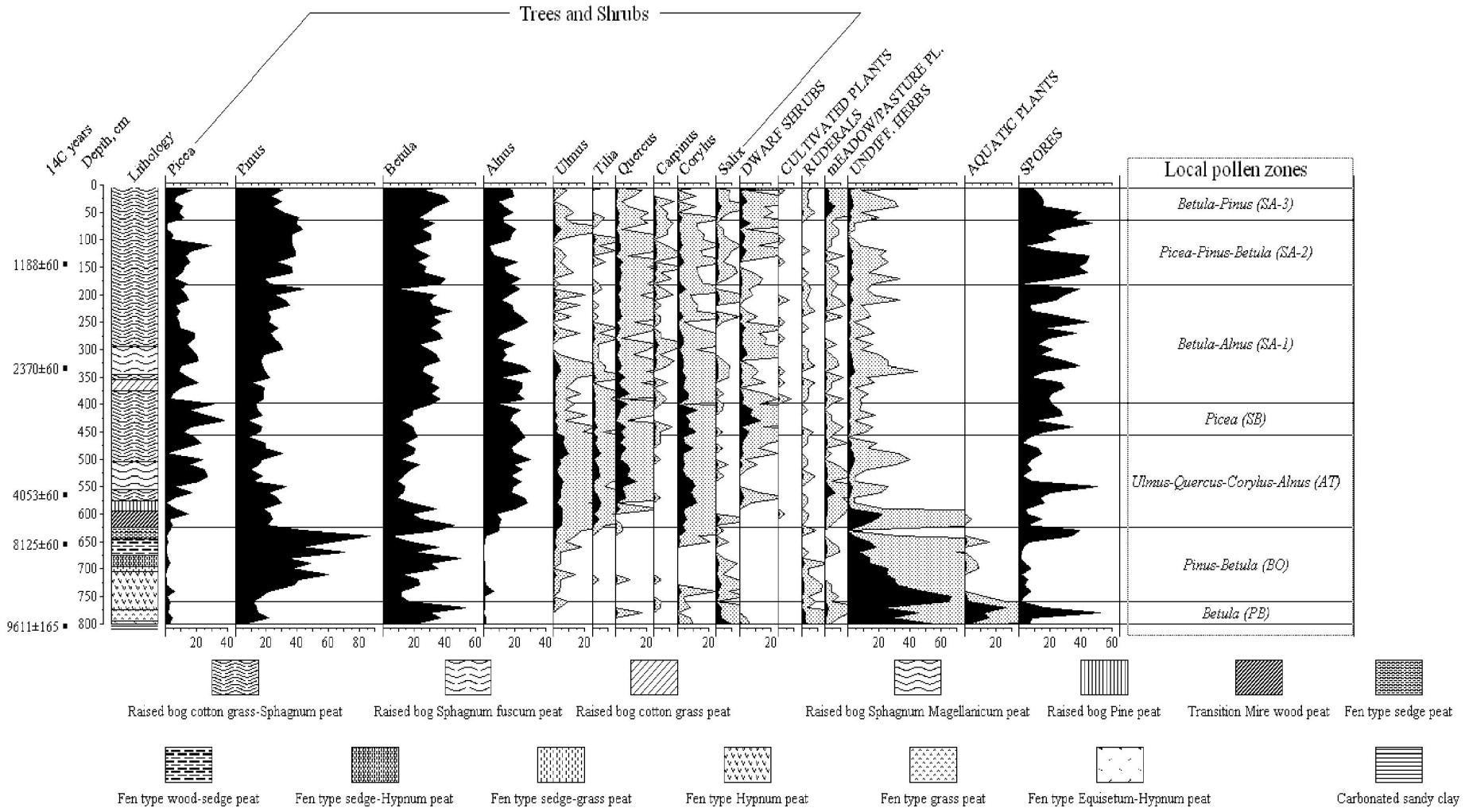


Fig. 4. Spore-pollen diagram of trees and shrubs in the peat deposit in Rožu Mire

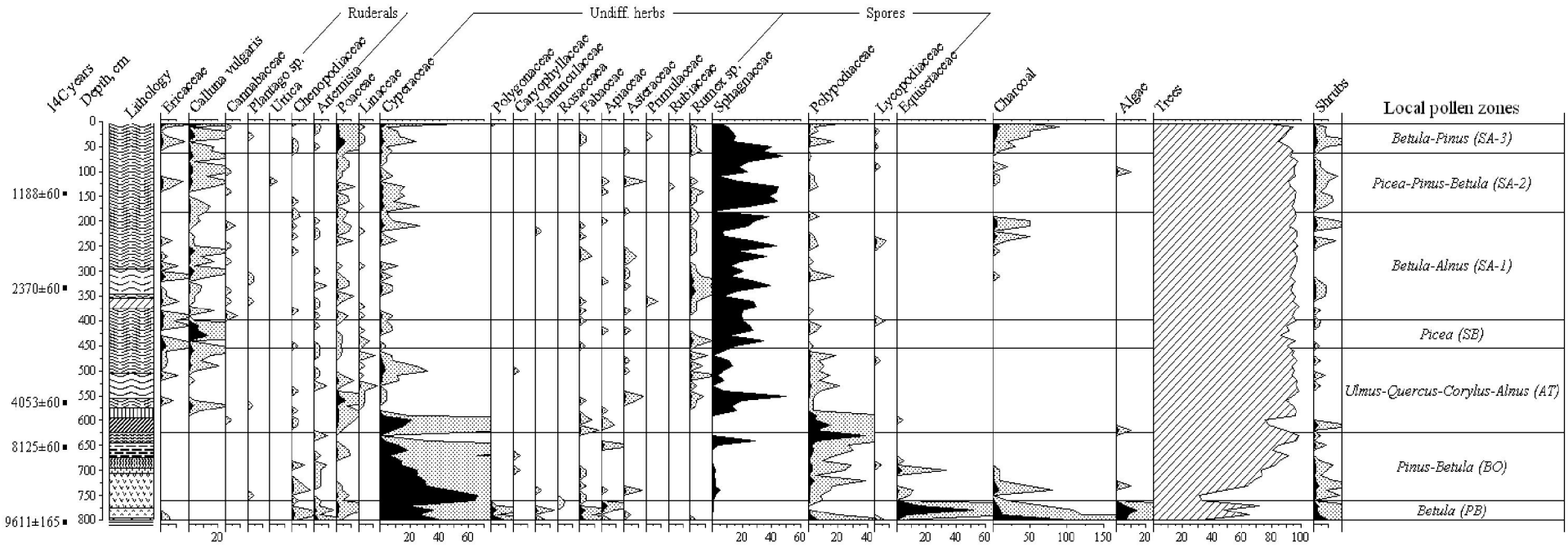


Fig. 5. Spore-pollen diagram of vascular plants and sporophytes in the peat deposit in Rožu Mire

Birds

Altogether 15 especially protected bird species of European importance were recorded in the Nature Reserve. Natural and undisturbed forests give an essential shelter, feeding and nesting place for rare wildfowl – *Ciconia nigra*, *Tetrao urogallus*, *Bonasa bonasia* and *Dryocopus martius*. One couple of *Aquila pomarina* was seen flying over the old forest stands. There are several artificial nests with *Pandion haliaetus* families.

Pluvialis apricaria and *Tringa glareola* are highly rare bird species, which only nest in the raised bog and transition mires. Several *Tetrao tetrix* males have been observed spending their rutting period in the Rožu mire.

Invertebrates

Whithin Rožu Mire 70 invertebrate species were observed, including four especially protected species. Different species of dragonflies can be found in the bog pool complex, among them – especially protected *Leucorrhinia albifrons* and *L. pectoralis*. Also grasshopper *Mecosthetus grossus* is living in the transition mire.

Mammals

The forests surrounding the mire and its small water courses ensure that the fauna of mammals is diverse and rather rich. In the Nature Reserve 31 species were found, which makes a half of all mammal species occurring in Latvia. Eight of these species are especially protected: *Lynx lynx, Canis lupus, Castor fiber, Martes martes, Lepus timidus, Eptesicus nilssonii, Plecotus auritus* and *Muscardinus avellanarius.*

Nature Reserve is part of the overall geographic distribution area of Common Dormouse. The southern part of the Nature Reserve provides this species with appropriate habitat - forest crop with hazels. 16 bird cages were put out in this area on July 2010.

Negative influence

The drainage which started at the second half of the last century can be considered as the main factor negatively affecting the mire. This drainage system is still functioning and it keeps draining the mire. Habitat degradation features were observed in Rožu Mire on different levels, yet the mire habitats located next to the ditches are especially degraded and these areas slowly cover with bog woodland. After the increase of forested area, also the transpiration of plants is rising, therefore gaining the loss of water. Raised bog on the margins of the Reserve has lost its previous quality.

The management and monitoring

In order to restore the natural hydrological conditions of mire, restoration works will be carried out: 59 peat dams will be built to restore the mire habitats across 138 ha territory. Building of the dams should increase the level of water near to each dam by 10 cm, therefore the average water level of Rožu Mire will be raised without flooding the entire territory. Changes of the hydrological level of the mire should occur in the area of 235 ha.

AKLAIS MIRE NATURE RESERVE

Aklais Mire Nature Reserve was established in 1999. The area is 2003 ha. The site is located in Daudzese Municipality of the Jaunjelgava District. The mire has started to develop about 9000 years ago. Maximum thickness of peat layer is 9.3 m, the average thickness – 4 m

Habitats

- Forests 60 %
- Mires 38 %
- Lakes 1.3 %

The main nature values

- Intact raised bog with hummock-hollow micro-relief,
- Bog woodland,
- Diverse natural forest habitats,
- Scenic dystrophic bog lakes,
- Especially protected habitats of Latvian and European importance cover 81 % of the Nature Reserve,
- In total, 63 especially protected plant and animal species of Latvian and European importance.

Negative influence - Drainage of the mire

Management activities:

- Building of dams on drainage ditches in mire to prevent the impact of desiccation and to restore the natural hydrology of the mire,
- Restoration of the open part of the mire by cutting the undesirable pines,
- Elimination of spruce in dry boreal pine forests.

Mire development

Aklais Mire Nature Reserve is located in the Taurkalne Plain of the Middle Latvian Lowland. The mire has developed by land paludification and filling-in of shallow depressions. Shallow inlets of Znotiņu Lake located in the central part of the mire have grown over and created good conditions for forming of the mire. It is tested by the presence of gyttja layer found below the peat layer in the central part of the mire.

There are two domes in the mire reaching the height of 3-4 m above the surrounding territory. Znotiņu Lake is located between both domes while six other smaller lakes have preserved at the slope of the western dome.

Part of the lakes are of glacial origin, while some of them are bog pools originated during the long formation period as the result of pressure caused cracks in the peat layer.

Aklais Mire has developed due to fill-in of small shallow basins in the Aklais Mire depression. As a result of climate amelioration before 9000 years, shallow basins including small lakes become fill-in by gyttja. It was covered by peats of fen and transitional mire. *Sphagnum*-sedge, Rannoch rush-cotton grass, as well as, in some areas also *Hypnum* peat layers were deposited. Since the climatic optimum before 7000-5000 years peat layers developed both

vertically and horizontally and occupied larges and larger areas, where raised bog cotton grass-*Sphagnum fuscum* and *Sphagnum fuscum* peat layers were deposited (Fig. 6, Fig. 7).

Lakes

In total, 12 natural lakes can be found within the Nature Reserve covering 25 ha or 1.3 % of the territory. All these lakes represent the especially protected habitat **Dystrophic lakes** (3160*). The largest of them are Znotiņu Lake, Ģirupes Lake and Mazais Ģirupes Lake. Banks of lakes are low and swampy, covered by pine swamp forests, raised bogs and transition mires. Drainage ditches in the mire have significantly affected Znotiņu Lake.

The raised dry and peaty bank along the waterline of Znotiņu Lake indicates the lowering of the water level. In Znotiņu Lake 13 different habitat types are known. The coastal quagmire of the western part of the lake is the species richest mire where three moss and 17 vascular plant species occur.

Banks of the lake are dominated by *Molinia caerulea*, other frequent species are *Agrostis stolonifera, Calamagrostis neglecta*, *Comarum palustre*, and bog-mosses *Sphagnum spp*. Around lakes occasionally occur *Carex acuta, Calla palustris* and *Peucedanum palustre*.

Mires

Mires cover 502 ha or 25 % of the Nature Reserve. The raised bog is the most common type taking 97 % of the mire area. Transition mires are rare in the Reserve and their total area comprises 17 ha. Although being not intense, a certain drainage impact has been still affecting the mire during longer period of time. As a result negative changes were observed in the natural development of the bog – great part of the originally open area of Aklais Mire has gradually overgrown with pine swamp forests.

The raised bog covering the area of 480 ha represents the European especially protected habitat type ***Active raised bogs*** (7110*). The most typical active raised bog occurs in the central open parts of the mire around both domes, while their edges have overgrown with small pines. Aklais Mire is characterized by hummock-hollow micro-relief and small pine trees, *Calluna vulgaris*, *Ledum palustre*, *Vaccinium uliginosum*, *Rubus chamaemorus*, *Eriophorum vaginatum*, *Andromeda polifolia*, *Oxycoccus palustris*, *Drosera rotundifolia* and raised bog mosses.

Transition mires are characterized by scattered small pine trees and downy birches as well as by *Carex lasiocarpa, Menyanthes trifoliata* and bog-mosses *Sphagnum* spp. One of the most important nature values of Aklais Mire is rich stands of rare and protected *Salix myrtilloides.*

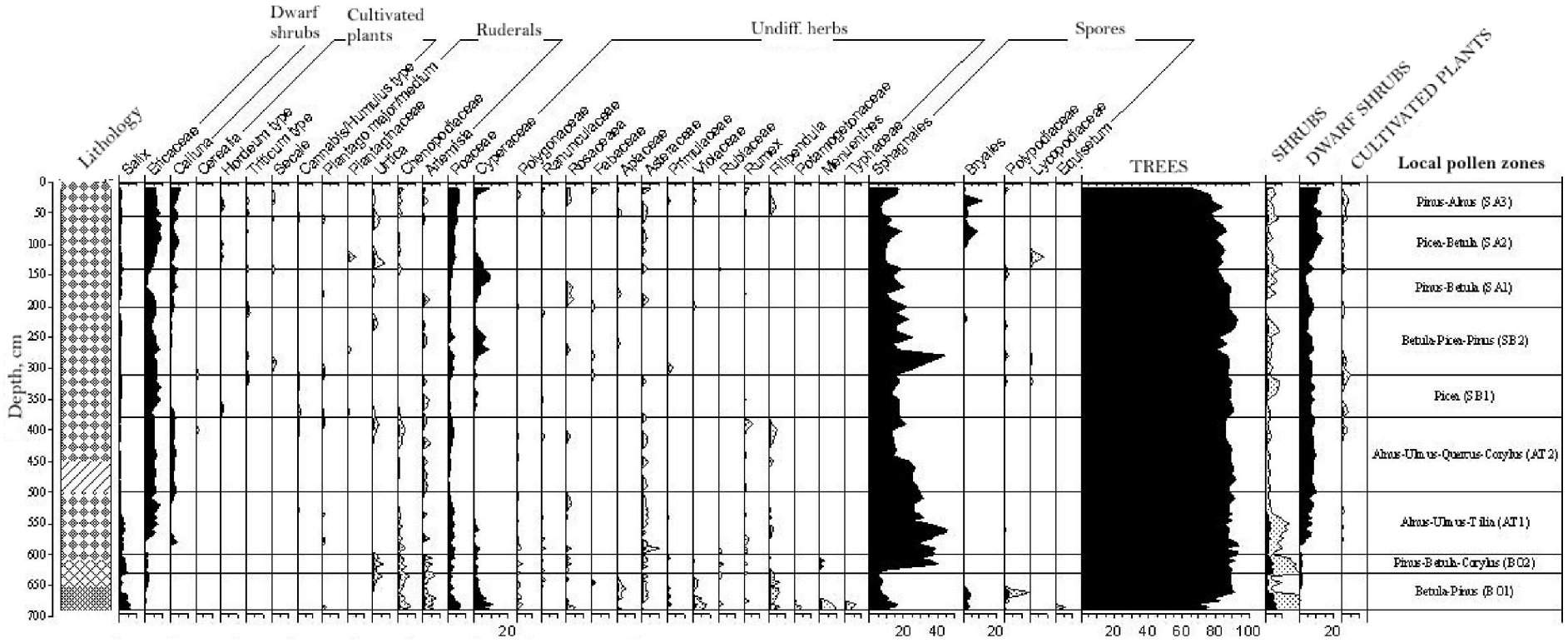


Fig. 6. Spore-pollen diagram of trees and shrubs in the peat deposit in Aklais Mire Nature Reserve

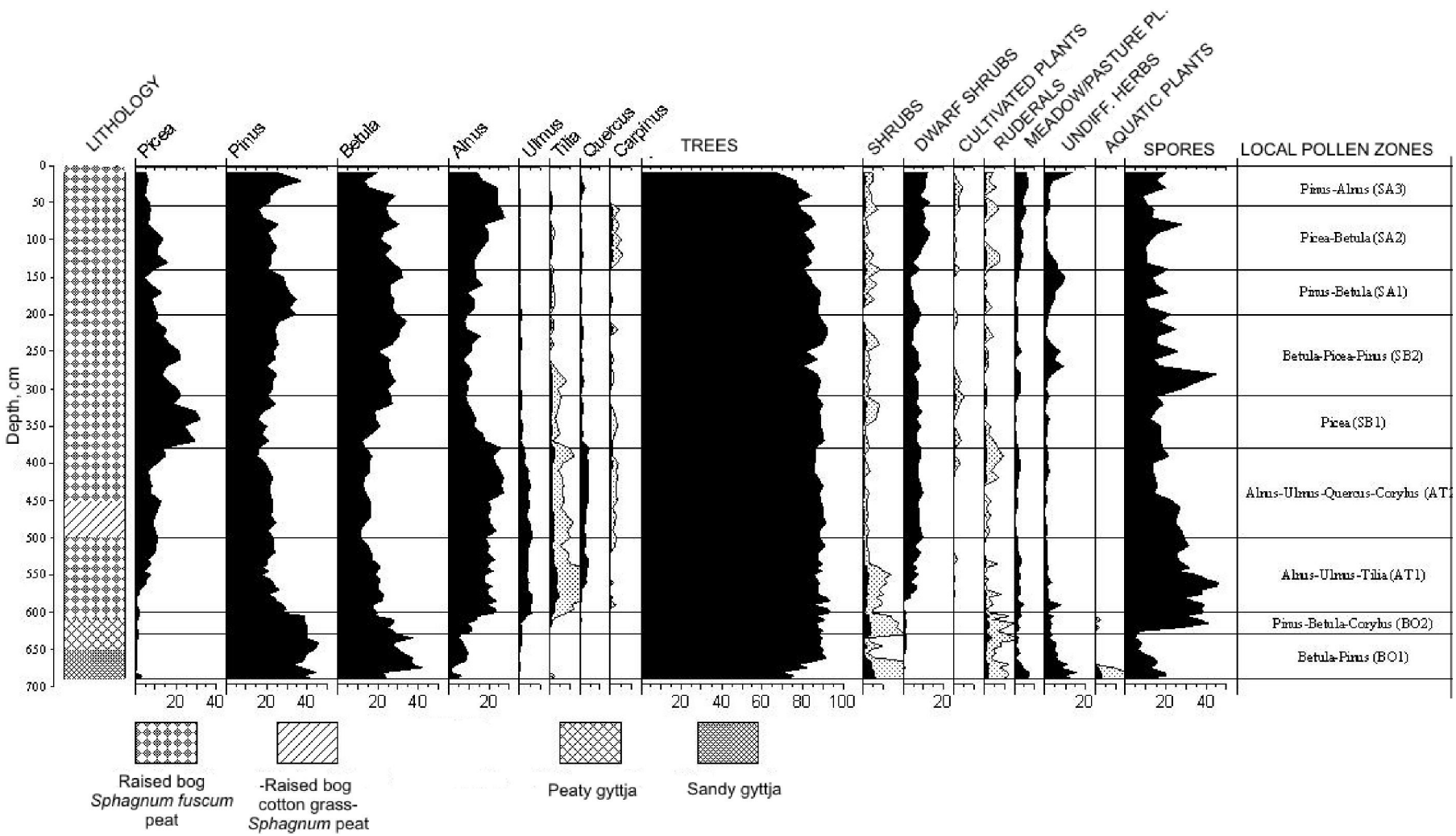


Fig. 7. Spore-pollen diagram of trees and shrubs in Aklais Mire Nature Reserve

Forests

Rare and valuable natural boreal coniferous forests dominate in Aklais Mire Nature Reserve. Swamp forests cover the largest part of forested area, while black alder swamps as well as small pieces of broad-leaved forests can be found in several places. Many of these forests are considered as outstanding in terms of biodiversity. Forests of the Reserve include four especially protected forest habitat types of the European importance, covering 1080 ha or 73% of all forests and 54% of the total Reserve territory:

Bog woodland (code 91D0*) covers 890 ha and includes wet pine and birch forests, wet spruce forests and bogged-up black alder swamps.
Western taiga (9010*) covers 102 ha and is widespread in almost the whole territory of the Reserve.
Fennoscandian hemi boreal natural old broad-leaved deciduous forests rich in epiphytes (9020*) are very rare and cover 4.3 ha of the Nature Reserve.

As a result of drainage, gradual changes of the natural environment characterized by an increasing growth of forest took place in rather many places of the Reserve.

Plants

In Aklais Mire Nature Reserve 17 especially protected vascular plants species as well as eight moss and one lichen species are recorded. Most of these species can be observed only in natural old-growth forests and in undisturbed wet mires. Rare species of mires are represented by *Carex paupercula, Dactylorhiza incarnata*, *Dactylorhiza maculata, Hammarbya paludosa, Malaxis monophyllos*, *Poa remota* and *Salix myrtilloides*.

The Luminous Moss *Schistostega pennata* - a rare specialist species of natural forest habitats was discovered in the old-growth forests of the Reserve. It is just 5 mm long and forms small patches on open sandy soil.

Protonema of the Luminous Moss appears luminescent in twilight rays of the setting sun or flashlight that is a very unusual natural phenomenon. Only several such moss species are known in the world, the other ones occurring in tropics and subtropics as well as in Australia.

Birds

Altogether 23 especially protected bird species of European importance were discovered in the Nature Reserve.

The greatest value of the Reserve is eagle *Haliaeetus albicilla* that is nesting already for many years close to the Reserve. Several pairs of osprey *Pandion haliaetus* are constantly dwelling in the Reserve since 1965. The greatest number of osprey, five pairs, was recorded in 1990.

The very rare black-throated diver *Gavia arctica* was recorded in the Reserve. Its population is estimated just up to five pairs in the whole country.

Tengmalm's owl *Aegolius funereus* lives in the tree holes made by black woodpecker *Dryocopus martius* in undisturbed forests. The habitat of rare hole-nesting bird species is undisturbed old forests with large dimension trees that have preserved in the Reserve.

Tetrao tetrix, *Grus grus*, *Pluvialis aplicaria* live in open area of the mire, while *Bonasia bonasia*, *Strix uralensis*, and *Picoides tridactylus* are inhabitants of forests. In the Nature Reserve three mating-places of *Tetrao urogallus* are known.

The drainage impact of the last century is still affecting the mire habitats of the Reserve. Protected mire bird species – cranes and especially European Golden Plover *Pluvialis aplicaria* nest mostly in open areas of natural mires with water bodies. Therefore the main negative factors on these species are the drainage of mire, increased tree growth and afforestation of mire.

Mammals

The Nature Reserve includes diverse habitats – open and forested mires in its centre, mosaic of untouched forests in its periphery, as well as lakes and water courses that provide generous dwelling sites for animals.

In the nature reserve 29 mammal species were recorded, which makes almost a half of all mammal species occurring in Latvia. Seven of these species are especially protected: *Lynx lynx, Canis lupus, Castor fiber, Martes martes, Lepus timidus, Eptesicus nilssonii* and *Pipistrellus nathusii*.

At least one lynx and several wolves regularly dwell in the Nature Reserve. As the size of the area inhabited by individual lynx and wolves depends on forage resources and may reach even several hundreds km^2, these animals dwell in forest tracts both of the Nature Reserve and its surrounding areas.

A bear has been observed in Aklais Mire during berry-picking time in autumn. Nevertheless, it is not a regular dweller here but rather an occasionally migrating species.

There is a great number of game animals in the Reserve. Roes, deer, elks and wild boars are resting and hiding in the Reserve but go for feeding to the nearby rural territories.

Beaver activities can be observed in almost all drainage ditches as well as in Znotiņu Lake. By damming up drainage ditches beavers reduce water run-off from the mire.

Invertebrates

In Aklais Mire Nature Reserve 61 invertebrate species were observed and include eight especially protected species, e.g. *Leucorrhinia pectoralis*, *Dolomedes plantarius*, *Sphingonotus caerulans, Cucujus haematodes*, *Lycaena dispar.*

Mire restoration activities

Aim of sustainable protection and management of the territory was to preserve the habitat complex of raised bog with restored, optimal hydrology and to ensure the common ecological functionality of the Nature Reserve. It is also important to preserve the favourable conditions for the Latvian and European level protected species.

Overall, the negative influence of the drainage is comparatively small and intensive water flow can be observed only in particular places in the mire. However, taking into consideration the history of hydrological changes of the mire, the influence has a long-term character. The drainage system mainly consists of small hand-dug ditches arranged in the 1st half of the 20th century.

The main management activity is building of 16 peat dams on drainage ditches in order to restore natural hydrological conditions of the mire. This should result in a restoration of mire habitats of an area of 60 ha in close vicinity of drainage ditches. The negative influence of drainage should be decreased within the territory of the whole catchment area of the mire whose area is 623 ha.

References:

1. **Dabas aizsardzības mājas lapa, elektroniskais resurss: http://www.daba.gov.lv/public/**
2. Baronina V. (ed.) 2011: Management plan for Melnais Lake Mire Nature Reserve. Latvian Fund for Nature (in Latvian).
3. Baronina V. (ed.) 2011: Management plan for Aizkraukle Mire and Forests Nature Reserve. Latvian Fund for Nature (in Latvian).
4. Freimane G. 2011. Management plan for Rožu Mire Nature Reserve.
5. Reihmanis J. 2011. Management plan for Aklais Mire Nature Reserve
6. Pakalne M., Kalnina L. 2000: Mires in Latvia. *Suo,* 51(4): 213-226.
7. Pakalne M., Salmina L., Seglins V. 2004: Vegetation diversity of valuable peatlands in Latvia.- International Peat Journal*,* 12: 99-112.
8. Pakalne M., Kalnina L. 2005: Mire ecosystems in Latvia. In: G.M. Steiner (ed.). Moore-von Sibirien bis Feuerland / Mires – from Siberia to Tierra del Fuego. Biol. Zentrum der OeO_Landesregierung. Pp. 147-174.

STIKLI MIRES NATURE RESERVE

Stikli Mires Nature Reserve was established in 1977. Total area comprises 6636 ha. It is an especially protected nature area in Latvia – nature reserve and Natura 2000 site, Internationally Important Bird area. It is located in Puze and Usma Municipalities, Ventspils District.

Habitats

- Mires (28 %)
- Forests (34 %)

The main nature values

- Raised bog habitats with diverse micro-relief structures, including pools and hollows
- Open transition mire habitats
- Mineral-soil islands in the mire
- Diverse forest habitats
- In total, eigth especially protected habitats of EU importance and two of Latvia
- In total, 109 especially protected plant and animal species of the European Union and Latvia

Negative threats

- Drainage of mire and forests
- Peat extraction close to the border of the Nature Reserve

The main management activities in the territory – Re-establishing site hydrology in Vasenieki Mire

Stikli Mires are especially protected nature area, established in 1977 with the total area of 6636 ha. The mires are located in Ventspils District. Stikli Mires Nature Reserve is the largest raised bog complex in the Western Latvia. It includes five raised bogs, seven lakes and large forest areas. The total area of Stikli Dižpurvs Mire reaches 724 ha. The other mires are Vasenieki Mire (497 ha), Vanagu Mire (354 ha), Zvaguļu Mire (244 ha), Pumpuru Mire (283 ha).

More detailed studies were carried out in Vasenieki Mire. The central part of Vasenieki Mire includes also intact raised bog vegetation. The round-shaped raised bog ecosystem in its intact area is highly water saturated; especially wet is the northern part of the raised bog. The highest dome is placed in the central part of the raised bog. The medium size and smaller pools are distributed in circle around the dome. The peat layer thickness in average varies between 2 and 3 m. Under the peat layer, at the bottom of the raised bog there is sand, loamy sand and clay. Therefore, certain possibilities for water movement via the border horizon between mineral and peat layers exist, as it was observed in the drainage ditches. The natural water flow follows the west direction. There is also forested depression with a natural rivulet. The flow in drainage systems also follows the west direction. Beaver, which role for bog hydrology is still not fully studied, mostly blocks drainage ditches.

During the 1970-ties and 1980-ties, the western and northern part of the Vasenieki Mire was intensively drained for the planned peat extraction. It was stopped in 1977 when there was established an especially protected nature area. In Vasenieki Mire the drainage ditches are deeper than in the other sites, even up to 2-3 m.

Drainage ditches in Vasenieki Mire damaged the mire hydrological regime as the water level has been lowered. The situation has now improved after building dams on the ditches.

Stikli Mires includes raised bogs that are located close to each other and, in fact, they occupy different depressions of one large depression formed during the Baltic Ice Lake. Nowadays depressions of the Baltic Ice Lake shallow water zone at the Kursa Lowland are occupied by large bog massifs, including Stikli Mires.

These and also other mires, which have formed in the depressions of the former Baltic Ice Lake bay, are located on the uneven accumulation plain area. The small lakes – relicts have been formed in the deepest depression of this former lake bay due to decrease of the Baltic Ice Lake water level at the end of the Late Glacial.

Geological vegetation history of the Vasenieki Mire

The total area of Vasenieki Mire, according the Peat Fund information (Kūdras Fonds, 1980) is 497 ha, the largest thickness of peat reaches 6.0 m, medium 3.8 m. The uppermost part of Vasenieki Mire peat consists of low decomposed raised bog type peat that becomes medium and well decomposed below the depth of 3 m.

The general characteristics of peat are as follow (Kūdras fonds, 1980):

Decomposition degree 5 – 45 %,

Moisture 96.1 – 96.0 %,

Ash content 0.9 – 14.0 %.

Vasenieki Mire has formed mainly due to land paludification in the depression formed at the coastal area of the former Baltic Ice Lake. Nowadays it is large raised bog which is almost in pristine conditions in the largest part of it. Vasenieku Mire is very wet with large number of open bog pools, particularly at the northern margin. Bottom of the mire depression has formed by water impermeable deposits – sand cemented by iron, dense morainic sandy clay.

Peat and sand contains groundwater that is fed by precipitation and therefore, fluctuation of groundwater level depends on the values of precipitation and evaporation. Groundwater level is located close to the ground surface (approximately 0.2 m). Bog micro-relief can be dividend into two zones:

- The central zone where relief is comparatively plain with small hillocks usually covered by heath, cotton grass, marsh tea and *Sphagnum*;
- Slope zone, where are to 0.4 m high *Sphagnum* hillocks, as well as heath, marsh tea, bilberry, cranberry and cotton grass.

Raised bog peat prevails in the Vasenieku Mire, but transitional mire occurs as well. Fen peat has formed mainly at the mire margins. Peat accumulate in the result of paludification of clayey deposits (clay, till), as well as of gravel in some places.

Surface of the bog is plain with decline to the margins. The central part of the bog is up to 4 m higher in comparison with southern margin, 2.5 m – with western part, 2.0 m – with eastern part and 1.0 m – with northern part.

Geology and geomorphology

According to geomorphologic division, Vasenieki Mire is located in the northern part of the Venta – Usma depression, where glaciolimnic sediments prevail. Relief of mire vicinity is plain to slightly undulate. Elevation of bog surface is in range of 37.9 m to 40.8 m above sea level (a.s.l.). The relief of surrounding area surface has formed by the last glacier activity and its' melting water basins, which coastal formations, ancient estuaries, inland dunes and local elevations of the bedrock are visible in the contemporary relief. These uplifts were islands in the Baltic Ice Lake with elevation 30-40 m a.s.l., and include depressions (20-30 m a.s.l.).

The upper part of geological section in the Vasenieki Mire area is formed by 10 to 30 m thick Quaternary deposit strata, which cover Devonian sedimentary rocks – sandstone Middle Devonian Burtnieku Formation (D_2*brt*). The very upper part of section is represented by 2.2 m to 5.5 m thick peat deposits (bQ_4) layer, which have been formed during last 6000 to 5000 years (Fig. 8). Well decomposed transitional type sedge – *Sphagnum* peat with sand admixture has been found on the bottom of mire in the studied site V-1 by pollen analysis (Table 1, Fig. 10, Fig. 11) and well decomposed raised bog *Sphagnum* – cotton grass peat in studied site V-3, which is located in the northern part of mire (Fig. 9)

Table 1.
Characteristics of peat strata in the northern part of Vasenieku Mire, site V-1.

Depth of peat layer	***Characteristics of peat layer***
0.00 – 2.50 m	Low to medium decomposed raised bog *Sphagnum fuscum* peat
2.50 – 3.00 m	Medium decomposed raised bog *Sphagnum magellanicum* peat
3.00 – 4.10 m	Medium to well decomposed raised bog *Sphagnum – Eriophorum vaginatum* peat
4.10 – 5.00 m	Well decomposed transitional type sedge – *Sphagnum* peat with sand admixture

Vegetation history and climate changes

Results of numerous investigations prove that pollen reflect local mire vegetation as well as regional vegetation composition, which allows to suggest about vegetation development and climate changes during the course of mire development. Analysing various plant species pollen found in the surface layer peat deposits, past climate may be determined. By identifying the pollen grains in the sediment, the real picture of the past environment can be obtained as well as give possibility to estimate age of deposits.

Pollen data in the studied sites V-1 and VP3 reflect mire development and vegetation changes since the middle part of the Atlantic Time up to nowadays (Fig. 10, Fig. 11).

The lower part of peat is represented by well decomposed transitional type sedge – *Sphagnum* peat with sand admixture, which has been originated on the Baltic Ice Lake sand. Pollen data indicate about the peat accumulation during the middle part of the Atlantic Time. These data point to the gap in sediment sequence between Baltic Ice Lake (11 000-10 000 years) and the middle of the Atlantic Time (6000-5000 years). Similar situation has been found in the other investigated site V3, where also the lowest peat layer has formed on the Baltic Ice Lake sediments.

Pollen data (pollen zone AT2) reflect broad leaved (oak, linden, elm) forest distribution in the surroundings of the mire during formation of the first peat layers in the mire depression. Peat layer contains charcoal dust, cultivated land pollen (*Cerealia)* and pollen of plants anthropogenic indicators like *Plantago, Urtica*, *Chenopodiaceae*. These data point on the Stone Age human existence nearby mire during the Atlantic and also the Subboreal Time, when raised bog *Sphagnum magellanicum* peat accumulated.

Comparison of pollen diagrams allows suggesting that Vasenieki Mire has started to form during the middle part of the Atlantic Time when warm and humid climate possibly promoted the raise of groundwater level in the depressions of the former Baltic Ice Lake. Moisture and temperature higher than nowadays were favourable conditions for mire vegetation development. Large biomass promotes intensive peat accumulation, but warm conditions developed decomposition process. Approximately 1.5 m thick sedge-*Sphagnum* and *Sphagnum-Eriophorum vaginatum* peat layer accumulated during the Atlantic Time. During that time, mire development was intense and peat layer soon became thick and plants could not reach mineral groundwater. Mires were fed only by precipitation that promoted the change of vegetation composition. In the mires raised bog type peat started to accumulate.

Paleobotanical studies of peat allow concluding that:

- Pollen diagrams reflect vegetation development since middle part of the Atlantic Time, when in the mire depression occurred favourable conditions for mire vegetation development and peat formation. During that time formation of sedge-*Sphagnum* peat started. Latter during ending part of the Atlantic Time and the Subboreal, it was covered by *Sphagnum-Eriophorum vaginatum* peat, during the Subatlantic Time – by *Sphagnum magellanicum* and *Sphagnum fuscum* peat;
- Mire deposits in the northern part are represented by different raised bog peat types, mainly by *Sphagnum* peat. In the central part of mire, where peat layer thickness is larger, in the bottom part of section also transitional type sedge-*Sphagnum* peat was found;
- *Carex-Sphagnum* peat has been formed during middle of the Atlantic Time, *Sphagnum*-cotton grass peat at the end of the Atlantic Time (AT3) and the Subboreal Time. *Sphagnum magellanicum* peat has formed during the middle of the Subboreal Time, and *Sphagnum fuscum* and *Sphagnum m*agellanicum low decomposed peat during the Subatlantic Time.

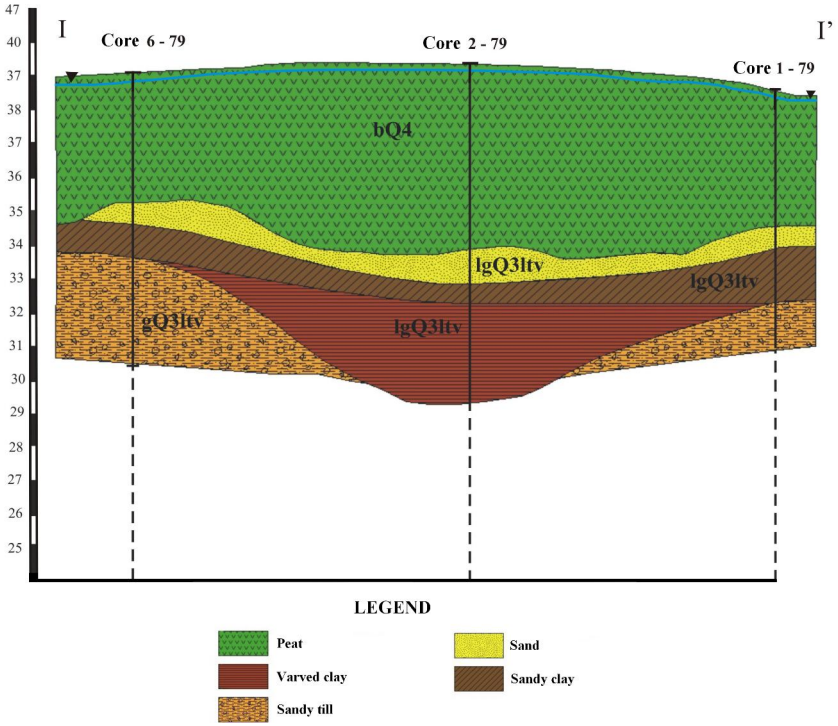


Fig. 8. Geological cross-section of the north eastern part of the Vasenieku Mire (According to Nusbaums & Zvingēvics 1979 drawn by A. Jansone)

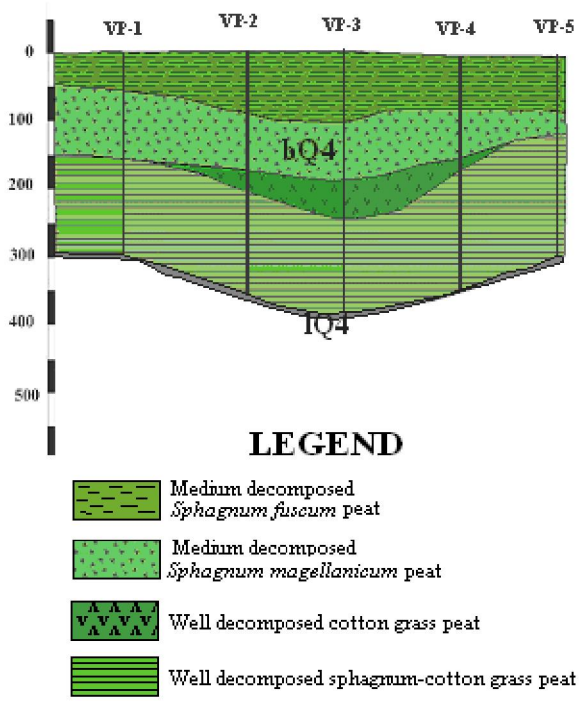


Fig. 9. Geological cross-section at the northern part of Vasenieku Mire (by A. Jansone)

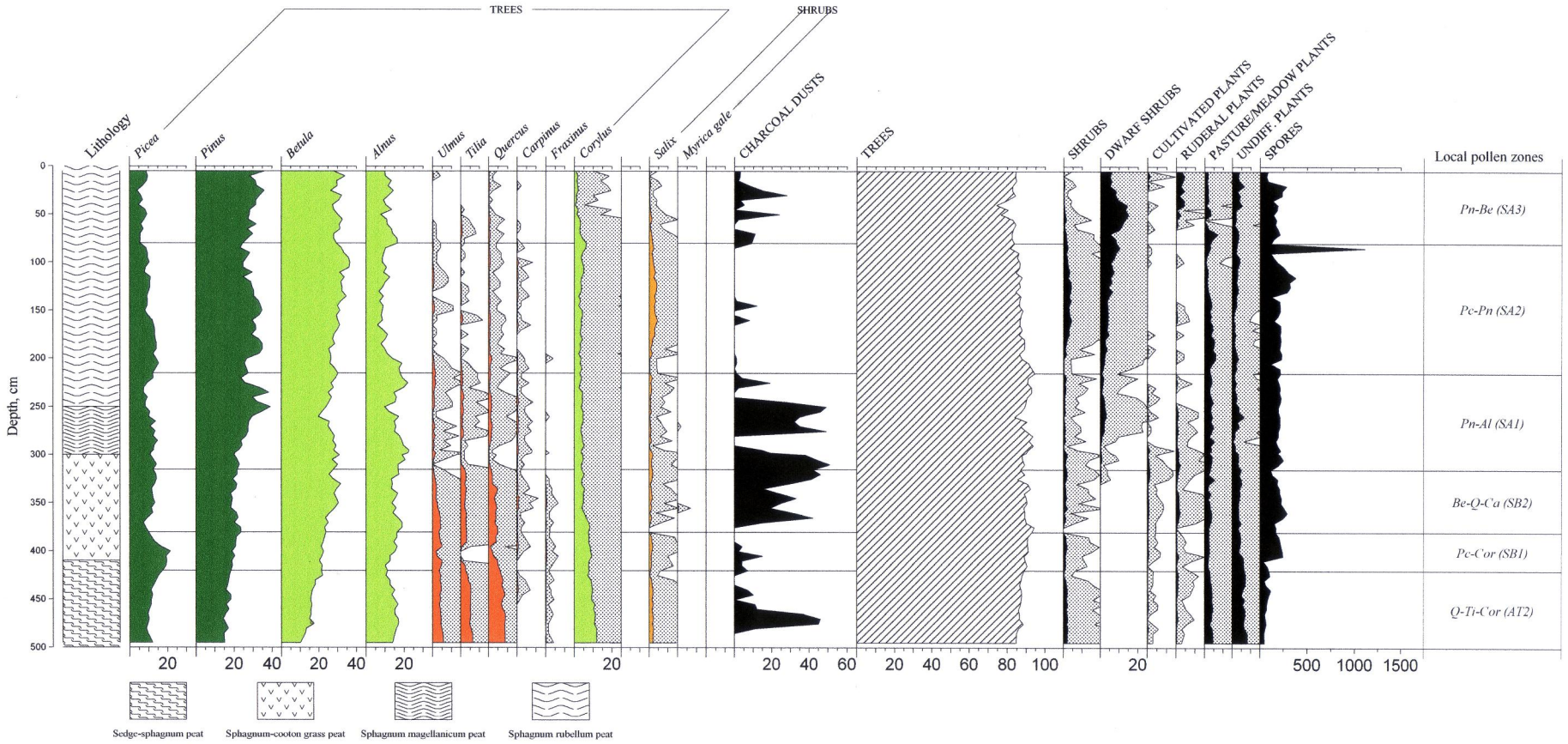


Fig. 10. Tree and general pollen composition percentage diagram from Vasenieki Mire

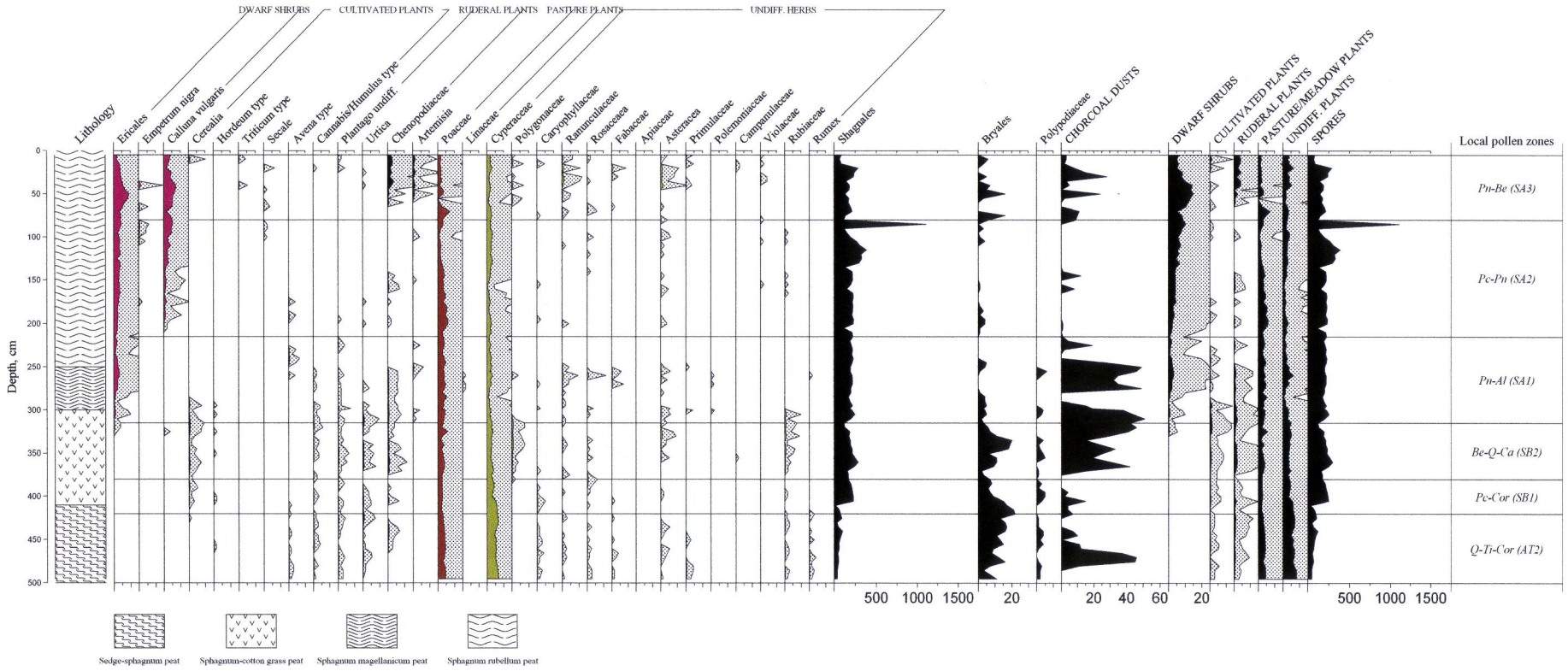


Fig. 11. Herb pollen and spores percentage diagram from Vasenieki Mire

Mire vegetation

The Nature Reserve includes five raised bogs that have a typical hummock-hollow complex and the bog pool labyrinth as well as transition mire vegetation.

Mires are mostly open with sparse pine belts on the margins. The mosaic of mires with small lakes in their centre, surrounded by wet forests, has produced a large diversity of mire communities and species. The characteristic species of western bog types, *Trichophorum cespitosum,* occur there. Bog hummocks are characterised by *Empetro nigri–Sphagnetum fusci* and *Sphagnetum magellanici* communities. In bog hollows communities with *Rhynchosporetum albae* and *Caricetum limosae* occur. Transition mire vegetation covering rather significant areas in the marginal parts of Stikli Mires includes *Caricetum rostratae*. Small fen fragments with *Caricetum lasiocarpae* occur also on mire margins. In bog hollows communities with *Rhynchosporetum albae* and *Caricetum limosae* occur (Pakalne & Kalnina 2005). The rare bryophytes *Bryum cyclophyllum* and *Sphagnum lindbergii* grow in Stikli Mires.

The raised bog habitats belong to the vegetation Class *Oxycocco-Sphagnetea* but fen habitats to the *Scheuchzerio-Caricetea fuscae*. Forests include the habitats of the Class of the boreal coniferous forests *Vaccinio-Picetea*.

Stikli Mires Nature Reserve comprises ten habitats of EC Habitats Directive including four priority habitats - active raised bog 7110*, bog woodland 91D0*, Western taiga 9010*, Alluvial forests with *Alnus glutnosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)* (9140*). The other habitats of EU importance include degraded raised bogs still capable of natural regeneration (7120), transition mires and quaking bogs (7140), depressions on peat substrates of the *Rhynchosporion* (7150), oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoëto-Nanojuncetea* (3130), natural eutrophic lakes with *Magnopotamion* or *Hydrochariton* – type vegetation (3150), natural dystrophic lakes and ponds (3160).

Stikli Mires Nature Reserve includes raised bogs and small lakes that are the habitats for protected vascular plant species of Latvia, such as *Lycopodiella inundata, Trichophorum cespitosum* and bryophytes - *Sphagnum lindbergii, S. papillosum* and *Calypogeia sphagnicola.*

Mires occupy almost 1/3 of the total area of the nature reserve – about 1870 ha. All types of mire are represented here - raised bogs (28 % of the total area), transition mires (0.4 %) and fens (0.8 %).

Intact raised bog with its characteristic complex of hummocks and hollows has Stikli Dižpurvs Mire and the central part of Vasenieki Mire. Hummocks up to 0.5 m high and overgrown with dwarf shrubs interchange with smaller or larger raised bog pools; it is especially important for the bird species of the mire. Vasenieki Mire has the highest number of bog pools, but they are not common in Vanagu and Zvaguļu Mires.

Raised bog pools are cracks in the peat that have filled with water and are like small lakes in the mire. The depth can vary between 1 to 5 metres.

The dominance of typical bog-moss *Sphagnum* is characteristic to all raised bogs. It is the main former of peat. *Eriophorum vaginatum*, *Oxycoccus palustris*, *Andromeda polifolia*,

Rubus chamaemorus and *Ledum palustre* are characteristic species for raised bogs as well as for the Stikli Mires Nature Reserve.

Fens cover small area of the Nature Reserve; mostly they form transition zones on the mire margins and on lake shores. Sedges dominate there (*Carex elata* and *C. lasiocarpa*).

Transition mires mostly occur on the margins of the raised bogs, near the raised bog pools and on lake shores. Other *Sphagnum* species, different from those in raised bogs, occur there and are accompanied by sedges. The largest areas of transition mires have developed on the shores of Stūriņezers and Līdaku Lakes. Similar habitats can be found near other lakes in the surrounding of Stikli village.

Degraded mires developed as a result of drainage. The northern part of Vasenieki Mire from Stikli Mires Nature Reserve was drained partly, depth of the ditches reaches even 3 m. Pumpuru Mire has been drained, however the ditch system is shallow.

Plants

Flora of the Nature Reserve has been studied since 1983. In total, 486 vascular plant and 148 bryophyte species are known in the site. The territory holds 28 protected vascular plant species and 25 bryophyte species of Latvia. There are species of Habitats Directive Annex V.

Birds

Stikli Mires Nature Reserve can be considered as one of the most prominent sites for bird species in Latvia. In 2003 monitoring of bird species was started. In total in this site 28 species of European importance and protected in Latvia are known. In the forests 15 species of Bird Directive are known, especially the species of *Falconiformes (Pandion haliaeetus, Haliaeetus albicilla), Galliformes (Bonasa bonasia, Tetrao urogallus, Tetrao tetrix), Piciformes (Picoides tridactylus, Dryocopus martius)* and *Strigiformes (Glauccidium passerinum, Aegolius funereus). Tetrao urogallus* was found in the ferested area of the Nature Reserve. In the raised bogs *Pluvialis apricaria* (14 pairs), *Tringa glareola* (10 pairs), *Grus grus* (at least 15 pairs) breed as well. In the leks of *Tetrao tetrix* there are about 25 specimens.

Invertebrates

In total, 21 rare and protected species of Latvia were observed there; from them two are of Habitats Directive Annex IV - *Coenonympha hero* and *Lopinga achine*. The Annex II species was found outside the territory, but could be observed also in the territory in the places where large oaks occur.

Mammals

Many typical mammal species of Latvia are known in the territory, from them four are protected in Latvia and of European concern - *Castor fiber, Lutra lutra* and *Canis lupus*. There is also information about *Lynx lynx* in the territory.

Amphibians

From the Habitats Directive species there are known two species - *Rana lessonae* and *Rana arvalis*.

Habitats

In the mire vegetation raised bog habitats dominate (7110*), part of them are degraded after the drainage. Here occur also transition mires and quaking bogs (7140). In forests there are three habitats (9010*, 91D0*, 9080*) of Habitats Directive Annex I that are priority ones. The largest areas cover bog woodlands 91D0*. From the seven lakes, two are considered as dystrophic lakes (3160).

RAISED BOG HABITAT MONITORING IN THE EC LIFE PROJECT "RAISED BOGS" SITES

Dr. biol. Liene Auniņa, Dr. geogr. Agnese Priede

In 2010, habitat and hydrological monitoring was started in all the project sites - Melnais Lake Mire, Aklais Mire, Aizkraukle Mire and Forests, and Rožu Mire Nature Reserve and continued in 2011.

In 2010, in total 21 plots in the diameter of 4 m was set up in Rožu Mire NR, 20 in Aizkraukle Mire and Forests NR, 30 in Aklais Mire NR and 52 in Melnais Lake Mire Nature Reserve. In 2011, the 16 new monitoring plots were set up in the project sites, from them 5 plots in Aizkraukle Mire and Forests, 5 plots in Rožu Mire and 6 plots in Melnais Lake Mire to compare the degraded areas with the intact raised bog vegetation.

The size of the monitoring plots has a diameter of 4 m or 1 m. Habitat changes are monitored using on-site photographs taken in order to compare the state of habitats before and after management. Observation points for habitat and ground water level measurements are marked by GPS. In all the four project sites the habitat monitoring is aimed at assessment of the effects of mire habitat restoration at three project sites. The monitoring plots are located in transect lines perpendicularly to drainage ditches and in sites relatively less affected by drainage, five plots at each transect line. In all cases, the transect lines are parallel to transects of hydrological monitoring. The monitoring plots in the project sites were established:

- on ditches where dam building is planned ;
- in the raised bog area most likely influenced by dam building;
- in remnants of non-flooded cutover peat fields;
- on intact areas of raised bog to compare with the drainage and peat extraction influenced sites.

All habitat monitoring plots were described according to a Standard protocol, including parameters such as micro-relief, vegetation structure, cover of vascular plant, moss and lichen species (estimated in percent) and vitality of trees, shrubs and dwarf shrubs (estimated in four degrees). Each plot was attributed by an ID code. Geographical coordinates of each plot were recorded and a digital data file created. Additionally, digital photographs of all plots were taken and named according to the ID codes.

In 2011, the plots were repeatedly visited and all parameters estimated according to the Standard protocol. Photographs of each plot were repeatedly taken. As the restoration of site hydrology has not been carried yet, in comparison to 2010, in 2011 no significant changes in the plots were observed. The bog vegetation is relatively stable. Therefore, little changes in species richness and species cover was recorded that may be annual variation not related to hydrological or other changes in the habitat. Neither the cover of species, nor the vegetation structure and vitality of dwarf shrubs, shrubs and trees were significantly changed in comparison to 2010. Overall, significant impact of drainage was observed in plots

close to the drainage ditches (no or little cover of *Sphagnum* mosses, dominance of mosses of dry coniferous forests, overgrowing with pines, and well-pronounced dominance of dwarf shrubs). The cover of *Sphagnum* moss increases with increasing distance from drainage ditches, while the cover of dwarf shrubs decreases.

Number of monitoring plots in the project sites

Project sites	**Number of monitoring plots**
Melnais Lake Mire	58
Rožu Mire	26
Aizkraukle Mire and Forests	25
Aklais Mire	35
In total:	**144**

Habitat monitoring indicators are as follows - groundwater level in the project sites, plant species in the monitoring plots and bird species in the project sites. Sources of verification include – raise of groundwater table after building of dams on the drainage ditches, re-establishment of *Sphagnum* species in the drainage ditches, re-appearance of typical active raised bog species in the degraded project areas, occurrence of raised bog bird species in the open active raised bog areas.

The Monitoring Methodology for Mire Habitats was applied in the project sites.

The hydrological monitoring is carried out in the ground water monitoring wells that are located as transects in the project sites and were set up in November, 2010. In all the four project sites, the hydrological monitoring transects cross the degraded areas of raised bogs and pass also intact parts of the bogs. The groundwater level is measured in the monitoring wells twice per month. The results of both habitat and groundwater monitoring are summarised in the Monitoring Protocols for the year 2010 and 2011 and are published on the Project home page www.purvi.lv

HYDROLOGY OF THE PROJECT SITES AND GROUNDWATER TABLE MONITORING

Dr. geol. Aija Dēliņa

During the LIFE project hydrological conditions at the protected nature areas Aizkraukle Mire and Forests, Aklais Mire, Rožu Mire and Melnais Lake Mire were studied. The site inspection of the drainage ditches in these mires was carried out, assessment of the ditches' impact on water regime in mires was performed, and the stretches of ditches, where the management measures, e.g., construction of dams, should be carried out were identified. Cartographic data from different years was analysed assessing changes in hydrological regime of the mires due to the human activities. Recommendations for the groundwater level monitoring were prepared.

Project management measures include construction of dams on the selected drainage ditches in the bogs and groundwater level observations near these ditches to study the effectiveness of the taken measures. Totally 158 dams will be constructed in the bogs: 59 dams in the Rožu Mire, 54 dams in the Melnais Lake Mire, 29 dams in the Aizkraukle Mire and Forests, and 16 dams in the Aklais Mire. Groundwater level monitoring profiles were installed at some representative ditches with dams. The last well of the profile is used to observe natural groundwater table fluctuations in the bog. There are nine profiles installed in the project sites in total: two profiles in the Aklais Mire, one – in the Rožu Mire, four – in the Aizkraukle Mire and Forests and two – in the Melnais Lake Mire. The profiles are located perpendicularly to the ditches, and the wells are installed from few to several hundred meters from the ditch (well distances from the ditch: 1, 5, 10, 25, 50, 100, 250 and 500 meters). There are six to eight wells in each profile, in total 63 wells. Groundwater table is measured twice per month. The data obtained provides information on hydrological regime in the bog near the ditches and in the central, undisturbed part of the raised bog.

Aizkraukle Mire and Forests

Protected nature area (PNA) "Aizkraukle Mire and Forests" is located in the Daugava River catchment area, on the watershed between Brasla and Divaja streams and Maizite stream. The highest part of the bog is the main dome in the eastern part and the smaller dome on the west side, where the land surface altitude is 92.1-93.2 m amsl. The land surface gently slopes towards the periphery of the mire lowering to 86-87 m amsl. The natural runoff is directed to W, NW and SW from the bog, to Brasla and Maizite Streams and their tributaries. There are runoff areas bound to the natural relief as well as to the drainage management measures taken in 1930-ties on the northern part of the bog, thus causing increased surface runoff towards Brasla catchment area. Existing ditches in the western part of the bog and adjacent forests mainly drains forests neither than the mire.

The most important changes in the hydrological regime are observed in the E and SE part of the mire, where, off the limits of the PNA, peat extraction fields and drainage ditches are located. Surface runoff there is directed to north and south, and the most intensive runoff is in the south where one of the main drainage ditches is located, also reaching the PNA.

The hydrological regime of the mire was natural and semi-natural by the end of the World War II, there was only one ditch along the northern border of the mire then (TOPO 75K Latvijas laika, 2010). The first changes of hydrological regime are related to the drainage

measures in 1930-ties in the upper reaches of Brasla and Divaja streams (Meliorācijas darbi plānotie, 1939). But these changes are not significant; and almost natural regime with no new ditches is maintained in the bog at least by the beginning of 1950-ties (TOPO 25K63g PSRS, 2010). The ditches from 1920-1930 could be seen in the mire today, they are up to 1 m wide and 0.5-1 m deep.

During 1970-1980, the most important changes of the hydrological regime of the mire occured, when drainage of the SE part of the bog took place and the peat extraction were started. The ditches dug in 1980-ties are large, 3-5 m wide and about 3 m deep, cutting to the mineral soil. Currently surface water runoff via the ditches is not very fast due to the beaver dams' common on the larger ditches along the bog. Nowadays, the main changes in the hydrological regime are related to the peat extraction and drainage ditches around the peat fields.

The project management measures – construction of dams – will take place in the southern, north-western and north-eastern parts of the site, totally 29 dams will be constructed there (Fig. 12).

There are four groundwater (GW) monitoring profiles in the Aizkraukle mire (Fig. 12) – 1) at the large and 2) small ditches, where the dams will be constructed, 3) near the drainage ditch along the peat fields and 4) in the forest to control the GW table in the adjacent forest. The measured levels are provided in Annex 1.

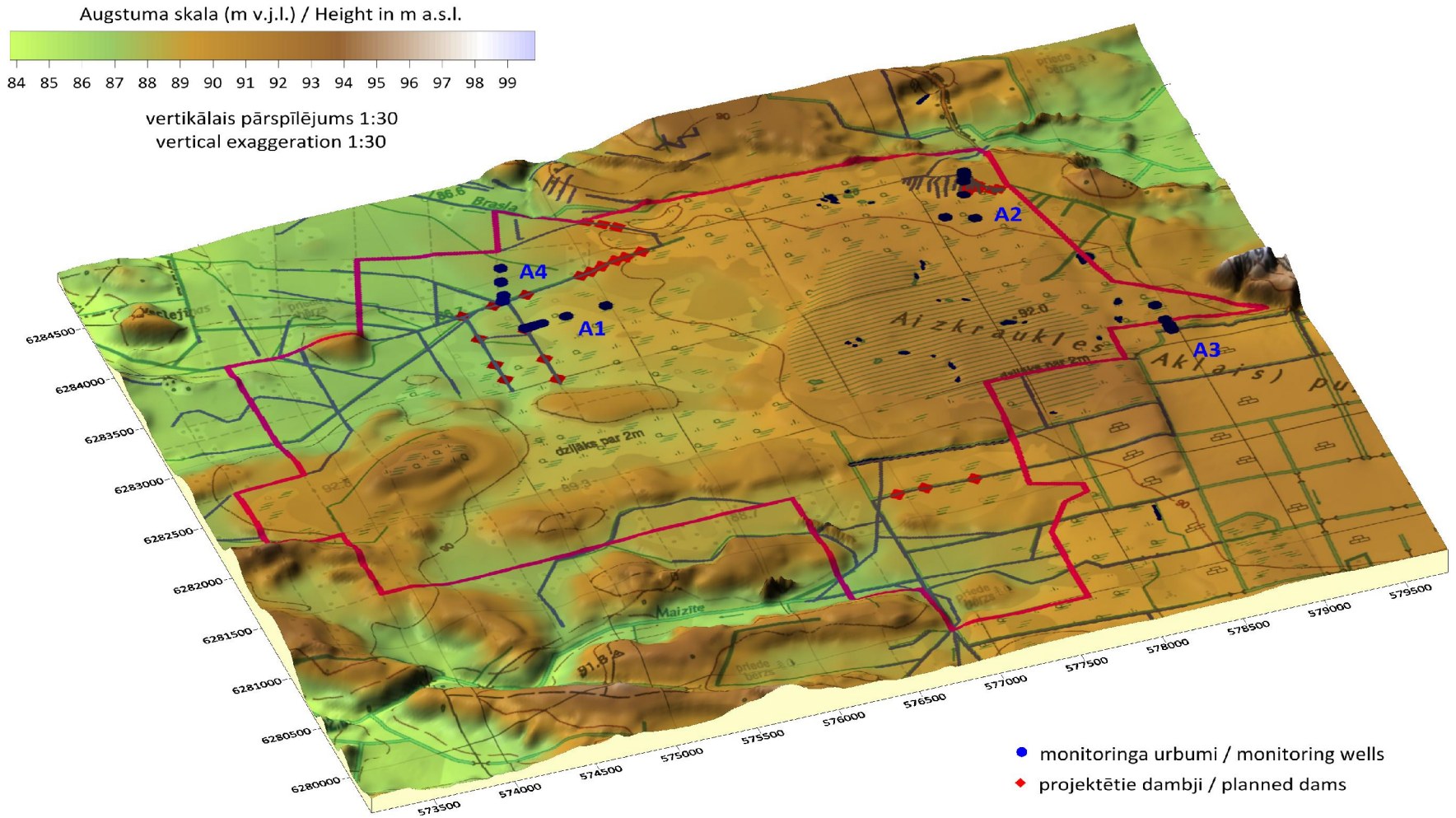


Fig. 12. Location of planned dams and groundwater monitoring profiles in the Aizkraukle Mire and Forests

Aklais Mire

Aklais Mire is located in the Lielupe River catchment area on the watershed between Iecava and Viesīte river catchments. There is a large lake – Znotiņu – in the central part of the mire; water level in the lake is about 71.5 m amsl. There is about 2-3 m wide and at least 1 m deep ditch discharging water from the Znotiņu Lake to Iecava River. The discharge of the ditch is rather low due to number of beaver dams that are constructed on the ditch. Number of smaller lakes is located on the NW part of the mire, water level in these lakes changes from 73.9 to 74.8 m amsl (TOPO 10K PSRS, 2010). These lakes are not connected with ditches, but the northernmost and largest lake discharges to Ģirupe stream via the ditch. The discharge is rather low but constant. The ditch has been dug at the end of 1930-ties, suggesting from the ditch morphology and the cartographic studies, at least in year 1951 this ditch is already mapped (TOPO 25K42g PSRS, 2010). The ditch is partially overgrown, 3-5 m wide on top and just 0.5-1 m wide at the bottom, where the water flows, total depth of the ditch varies, in the mire it is about 1-1.5 m, water depth is just 0.2-0.5 m. There are beaver dams on the ditch to the west from the mire.

The highest part of the mire lies between the Znotiņi Lake and small lakes; land surface elevation there reaches 76.8 m amsl. Surface runoff is radial from this area, but the main directions are W and SEE, to the lakes. Another mire dome is located on SE from Znotiņi Lake; the top elevation is 75.7 m amsl. Radial runoff is typical there as well, and the main directions are NW to Znotiņi Lake and to SE to the ditch discharging in the Jūgu stream south of the site. This ditch is strongly overgrown, however the water discharge at the site border could be observed easily.

The project management measures – construction of dams – will take place on all three main ditches (Fig. 13), totally 16 dams will be constructed there.

There are two groundwater (GW) monitoring profiles in the Aklais Mire (Fig. 13) – 1) at ditch discharging to Ģirupe stream, between small lakes and 2) at the overgrown ditch.

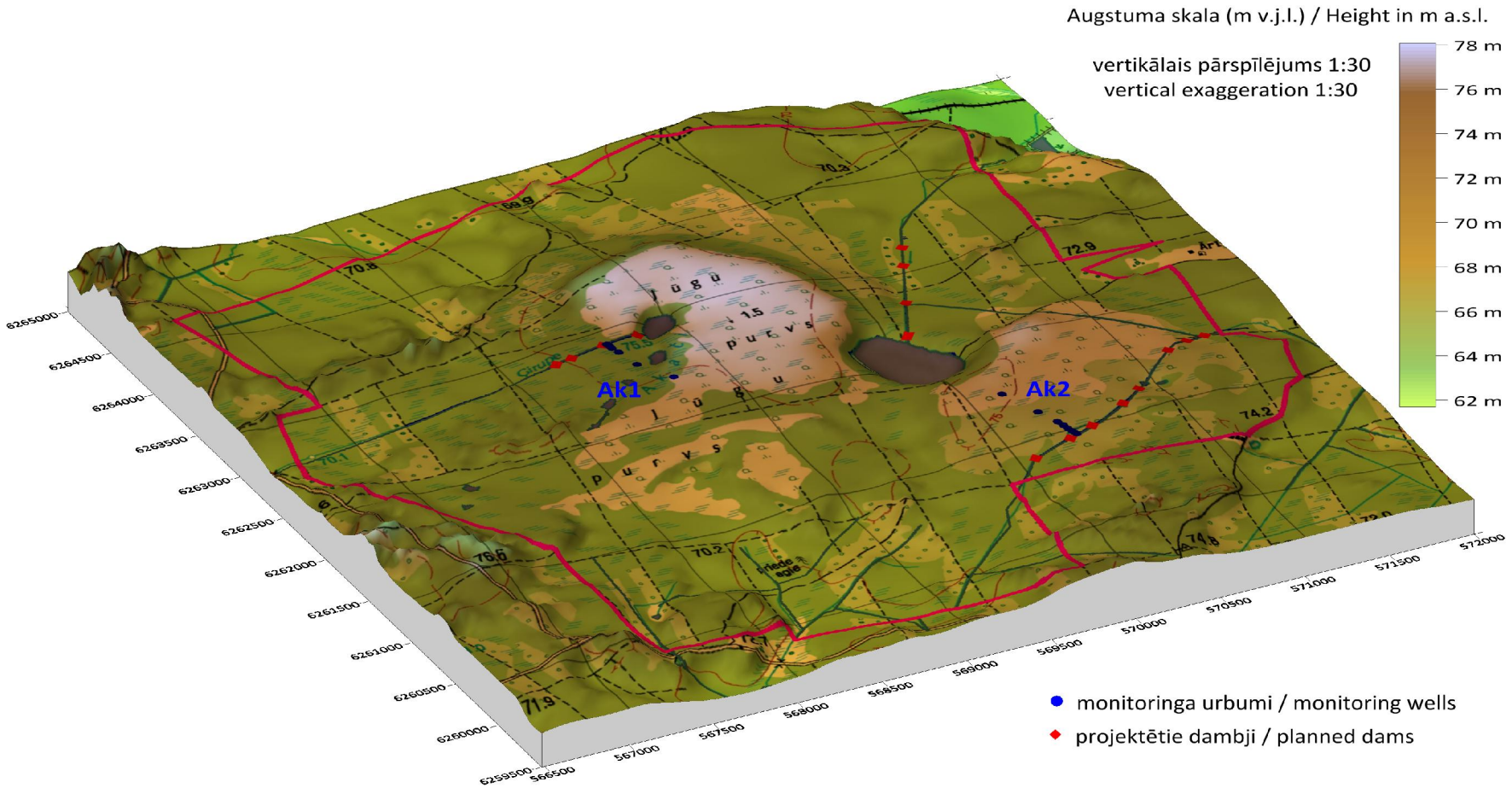


Fig. 13. Location of planned dams and groundwater monitoring profiles in the Aklais Mire

Melnais Lake Mire

Melnais Lake Mire is located in the Lielupe River catchment area on the watershed of Misa River and Babīte stream. Actually the Melnais Lake Mire is a small island of semi-natural mire that is left from the former Cenu Mire massif, surrounded by the peat extraction fields. There is Melnais (Black) Lake in the central part of the site, and number of small lakes and pools of irregular shape are scattered in the NW and SE parts of the site. Large shallow pools are located at the WNW corner of the site, where there was peat fields earlier.

Land surface elevation is about 13.6-13.8 m amsl at the central part, water level in Melnais Lake is about 13.1 m amsl, in the bog lakes and pools 12.1-13.4 m amsl, but in the drainage ditches surrounding and crossing the site the water level is 10.4-11.9 m amsl (TOPO 10K PSRS, 2010).

The surface runoff from the mire is directed to the north and northwest in the NW part of the site. There are number of main drainage ditches crossing the mire from SW to NE, encouraging the runoff as well as the peat extraction fields and their drainage systems surrounding the mire. Surface runoff in the central and SE part of the site is directed to the surrounding drainage ditches in the south and southeast. The Melnais Lake located in the centre of the site collects surface runoff just from the nearby area (about 0.2-0.5 m). There is a drainage ditch in the NW corner of the lake connecting the lake to the surrounding drainage system. About 100 m to the SW bank of the lake main drainage ditch is located surrounding adjacent peat fields.

Most of the bog pools in the eastern part of the mire are not directly connected to the drainage ditches, semi-natural hydrological regime is maintained there, and the gravity driven flow could be observed there.

Hydrological regime of the mire has been changed for a long time there. Already since 1930-ties drainage ditches have been dug there, reaching the NW corner of the site (TOPO 75K Latvijas laika, 2010). After the World War II the peat extraction in the Cena Mire increased and drainage system was expanded, however at the end of 1950-ties, beginning of 1960-ties the ditches do not reach the site area (TOPO 25K42g PSRS, 2010), there is just one ditch in the NE part of the site, fragments of it are present today as well. The peat extraction took place about 0.5 km NE from the site and 1-1.5 km SW from the site. Intensive peat extraction just outside the Melnais Lake Mire took place between the end of 1960-ties and 1980-ties, and to some extent there are peat extraction activities today to the E and SE from the site. Ditch network was constructed around the site and in its NW part, groundwater table was lowered there and at least 2 m of the peat were extracted. Most likely the current site area was left due to the excess moisture and a lot of pools and lakes present there that was hard or not feasible to drain.

The project management measures – construction of dams – will take place on all main ditches, totally 54 dams are constructed there.

There are two groundwater (GW) monitoring profiles in the Melnais Lake Mire (Fig. 14) – 1) at the former peat extraction fields and 2) at the ditch draining eastern part of the site.

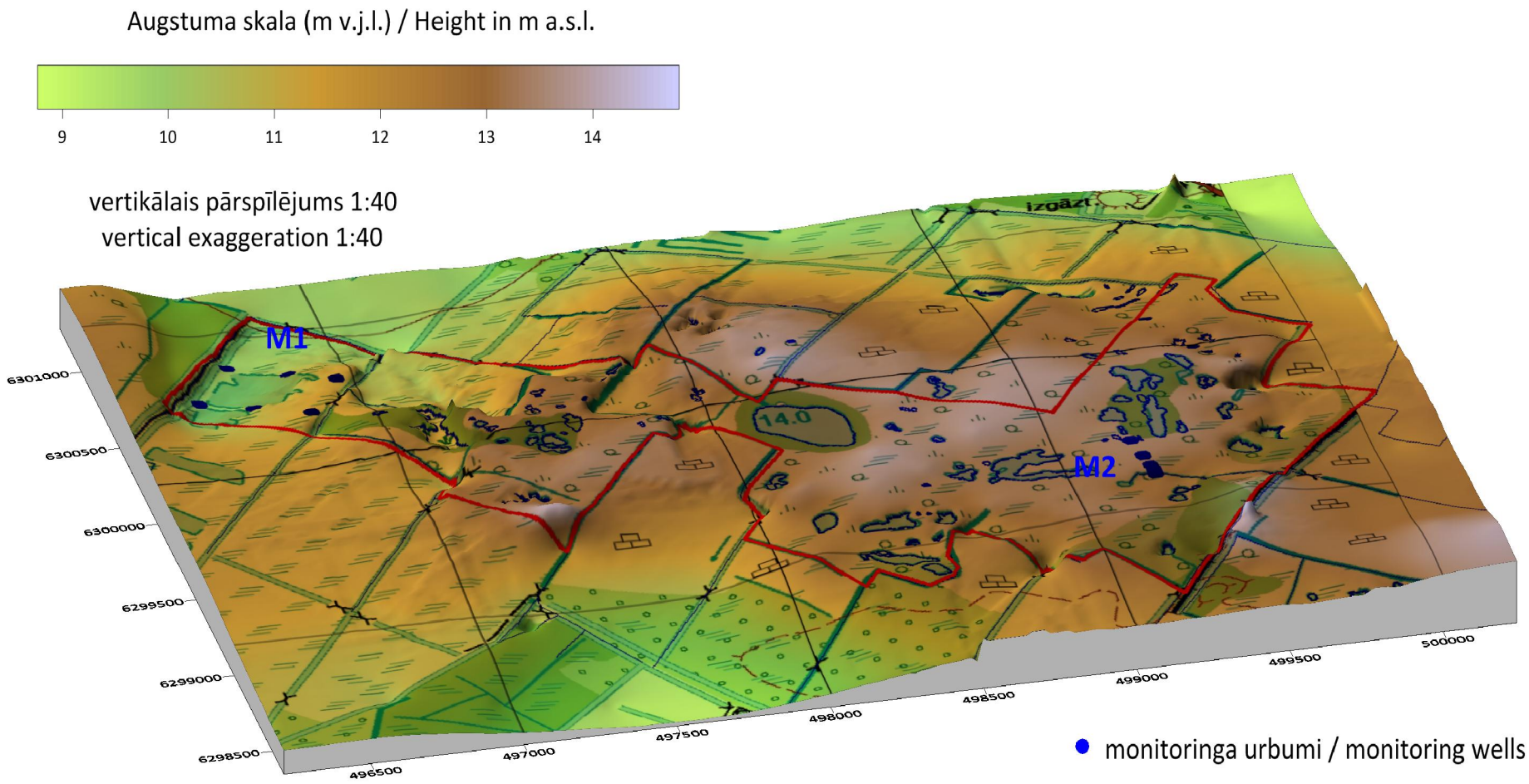


Fig. 14. Location of groundwater monitoring profiles in the Melnais Lake Mire

Rožu Mire

Rožu Mire is located in the Daugava River catchment, on the watershed among several small streams (Upju baseini 1970tie, 2010).

The mire is surrounded by esker type hills limiting surface runoff in these directions. There is elongated hill peninsula reaching from the SE and dividing the mire in two parts. The main direction of surface runoff is to NE, where the land surface is the lowest, about 85.4 m amsl. In the central part of the mire it is 87-88 m amsl and reaching up to the 89 m amsl in the SW corner (TOPO 10K PSRS, 2010). However, there is significant surface runoff to the SW as well due to the number of ditches that are dug there, thus draining the SW corner of the mire.

Hydrological regime of the mire was natural for a long time as no drainage measures were taken there before and after the World War II (TOPO 75K Latvijas laika, 2010, TOPO 25K42g PSRS, 2010). Just few ditches were dug on the periphery of the mire. In 1950-ties there was ditch running from W to E along the northern border of the site draining the forests adjacent to the mire, and it exists today. Another similar ditch runs along the southern border of the mire to the east from the peninsula. The network of ditches in the S and SW part of the mire was dug sometime in 1980-ties, and it drains this part of mire effectively.

Totally, main part of the Rožu Mire has semi-natural hydrological regime, but the S and SW parts, where it has been changed due to the drainage measures.

The project management measures – construction of dams – will take place on all main ditches, totally 59 dams will be constructed there.

There is one groundwater (GW) monitoring profile in the Rožu Mire (Fig. 15) – at the ditch network in the S part of the site.

References:

1. Upju baseini 1970tie, 2010. LPSR Upju baseinu karšu mozaīka mērogā 1:100 000. LU ĢZZF WMS. Skatīts 25.06.2010. http://kartes.geo.lu.lv
2. TOPO 10K PSRS, 2010. Bijušās PSRS armijas ģenerālštāba topogrāfisko karšu mozaīka mērogā 1:10 000. LU ĢZZF WMS. Skatīts 25.06.2010. http://kartes.geo.lu.lv
3. TOPO 25K42g PSRS, 2010 Bijušās PSRS armijas ģenerālštāba 42. gada sistēmas topogrāfisko karšu mozaīka mērogā 1:25 000. LU ĢZZF WMS. Skatīts 26.08.2010. http://kartes.geo.lu.lv
4. TOPO 75K Latvijas laika, 2010. Latvijas armijas galvenā štāba topogrāfisko karšu mozaīka mērogā 1:75 000. LU ĢZZF WMS. Skatīts 26.08.2010. http://kartes.geo.lu.lv
5. TOPO 25K63g PSRS, 2010. Bijušās PSRS armijas ģenerālštāba 63. gada sistēmas topogrāfisko karšu mozaīka mērogā 1:25 000. LU ĢZZF WMS. Skatīts 26.08.2010. http://kartes.geo.lu.lv
6. Meliorācijas darbi plānotie, 1939. Latvijas lielmeliorācijas darbu pārskata karte. Sastādījusi un izdevusi Z. M. Zemes ierīcības departamenta kultūrtehniskā daļa 1939. gadā. LU ĢZZF WMS. Skatīts 26.08.2010. http://kartes.geo.lu.lv

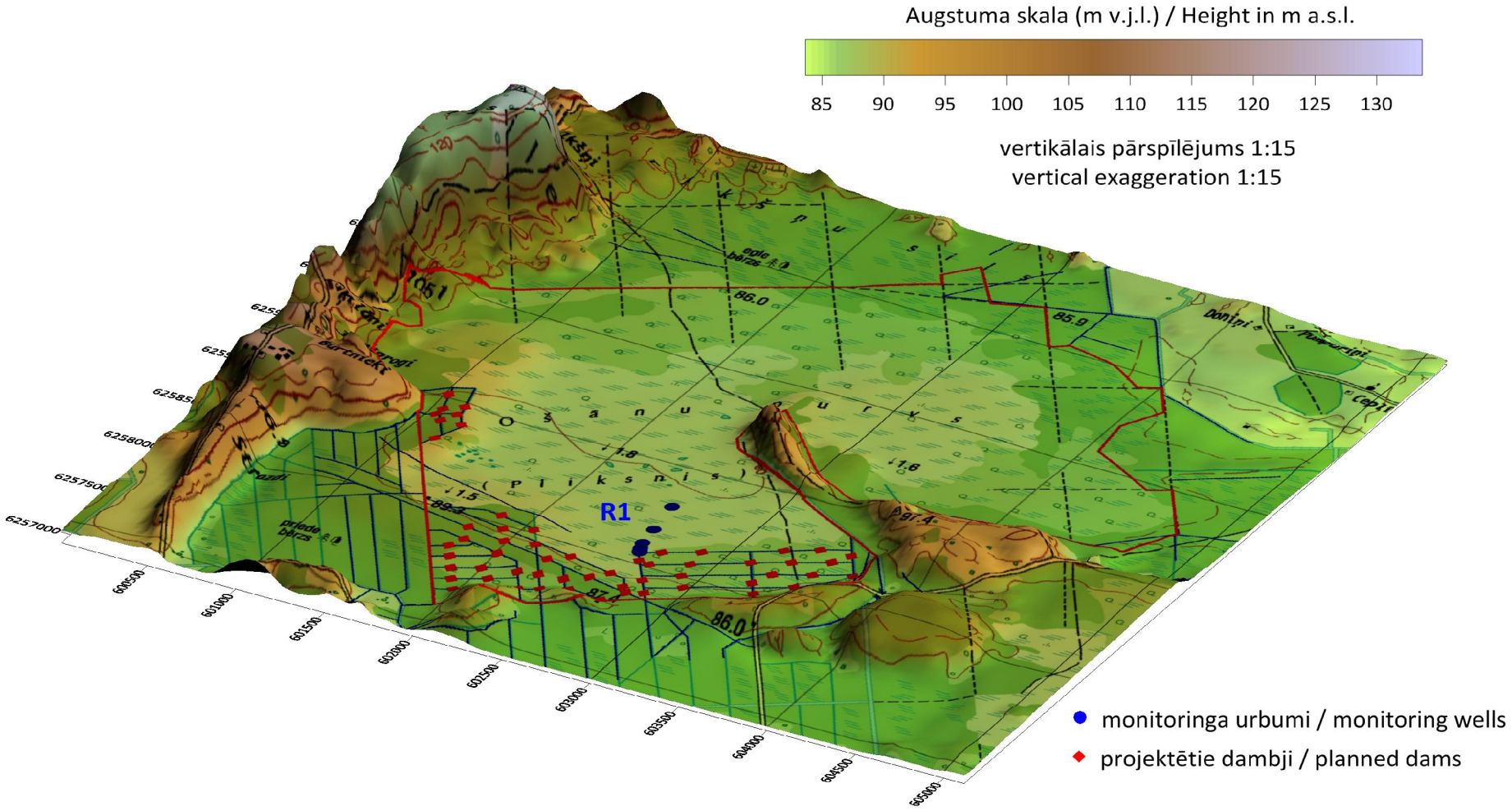
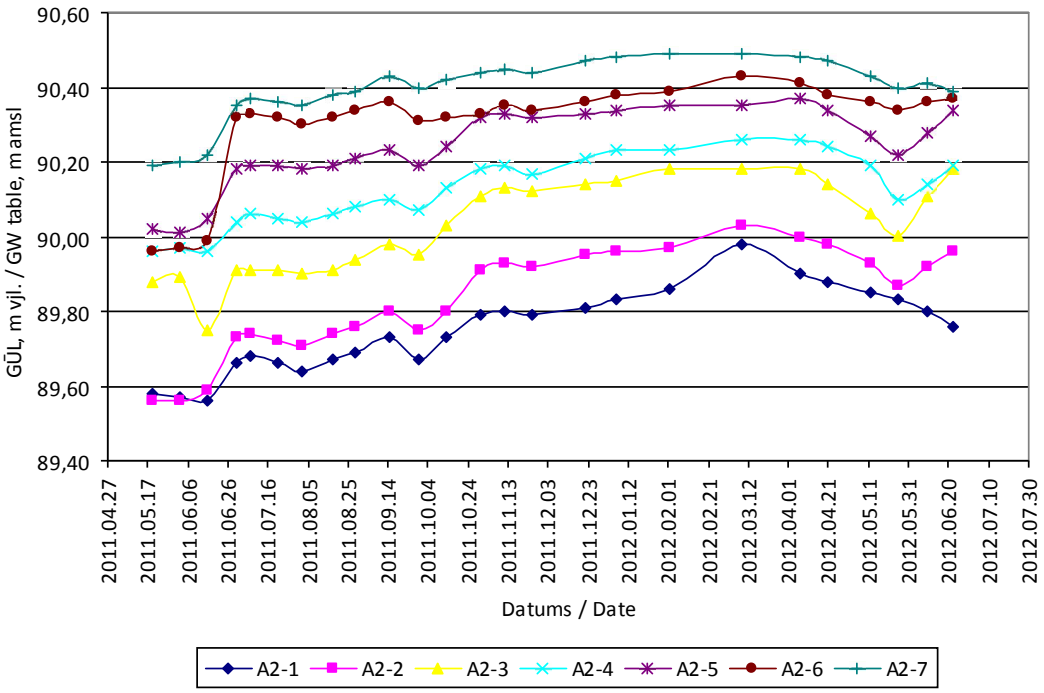


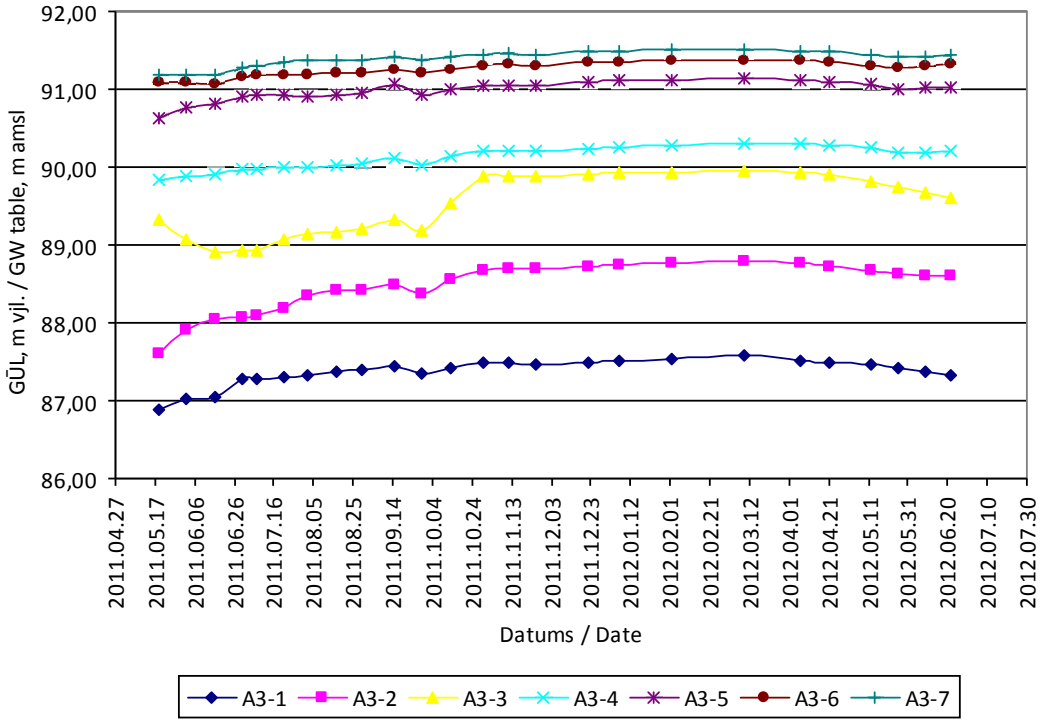
Fig. 15. Location of planned dams and groundwater monitoring profile in the Rožu Mire

Annex 1. Groundwater table observation results

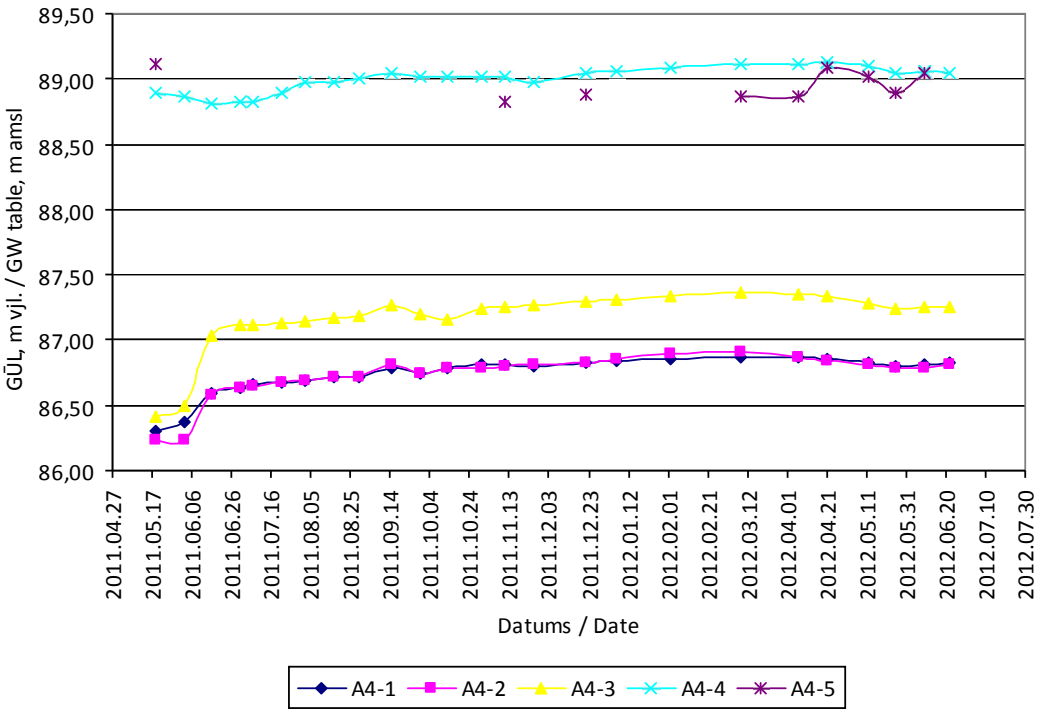
Aizkraukle Mire and Forests, profile 2



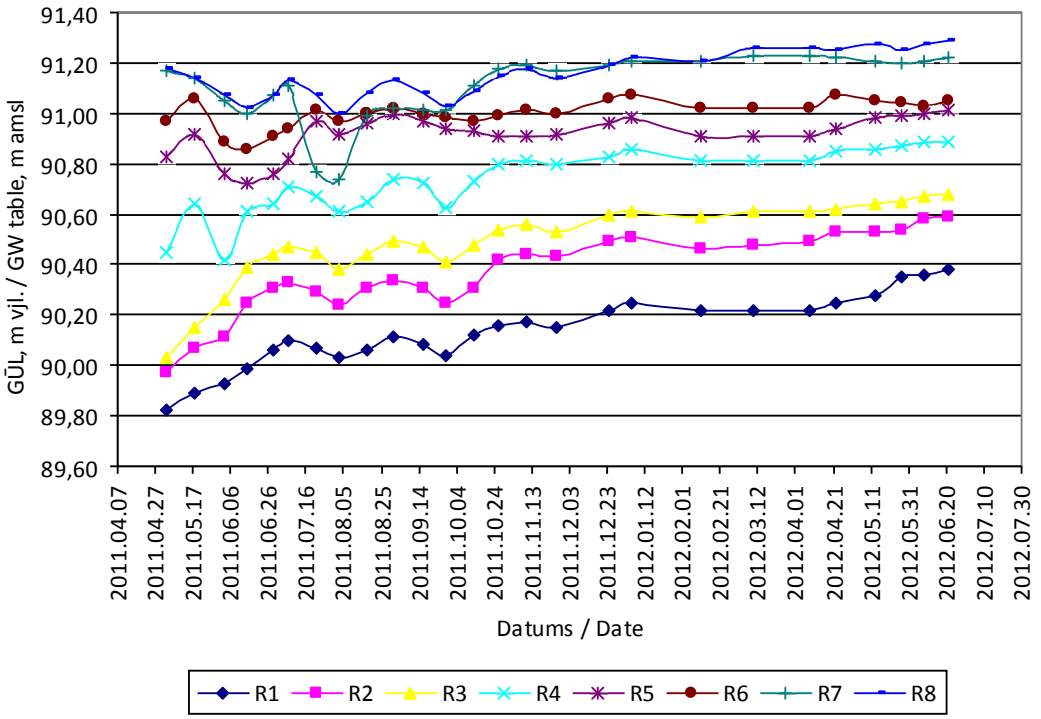
Aizkraukle Mire and Forests, profile 3



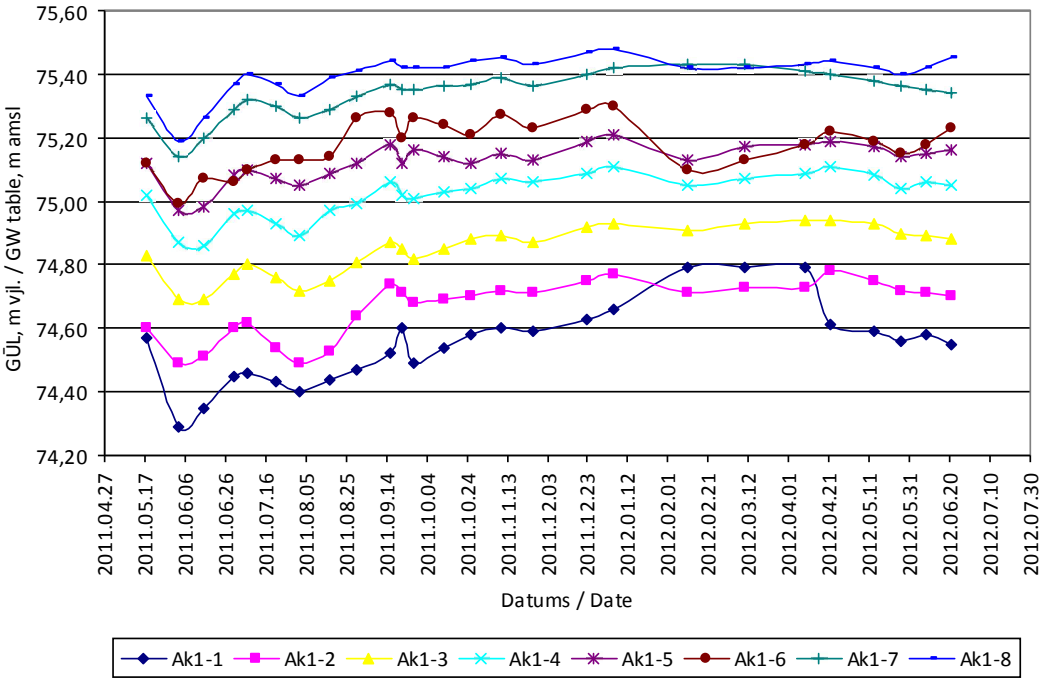
Aizkraukle Mire and Forests, profile 4



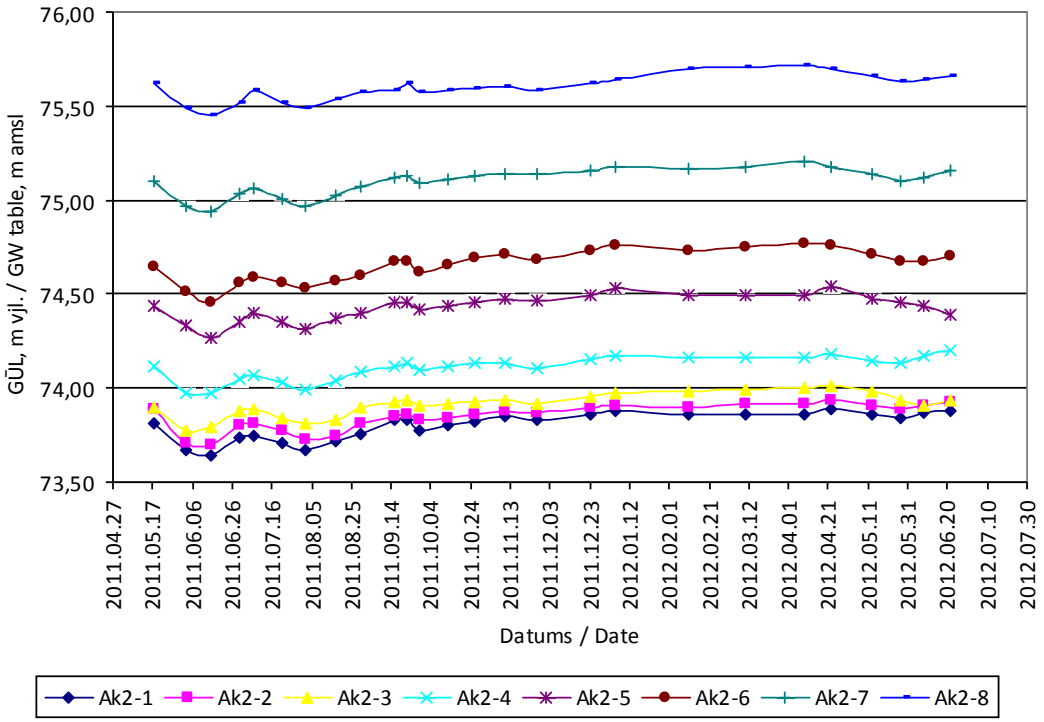
Rožu Mire, profile 1



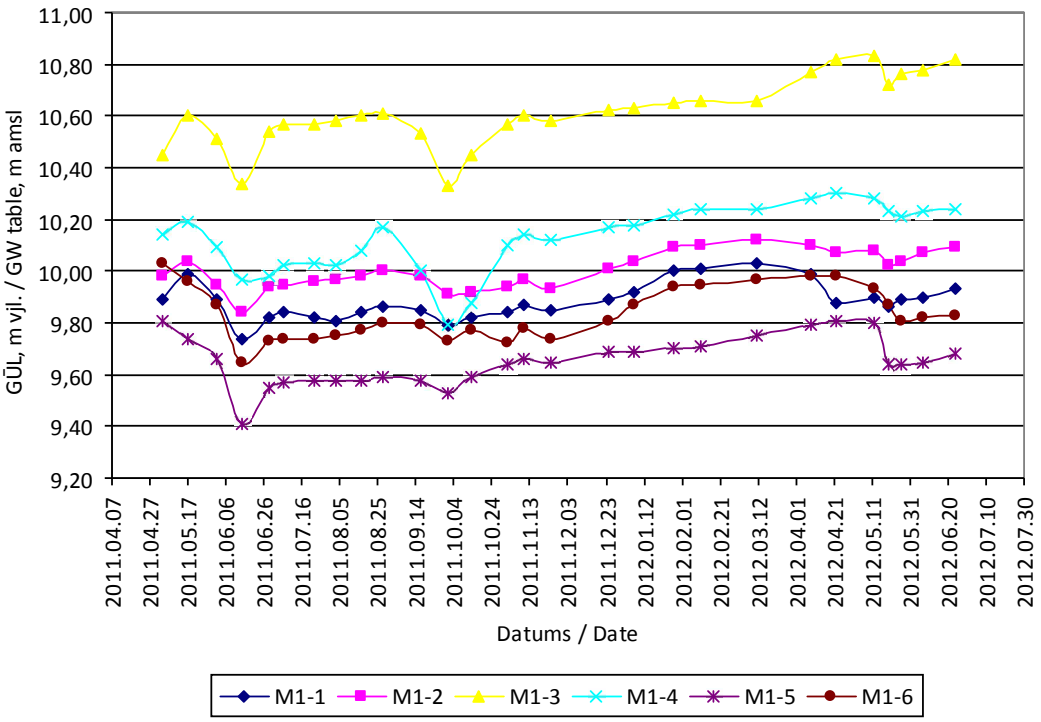
Aklais Mire, profile 1



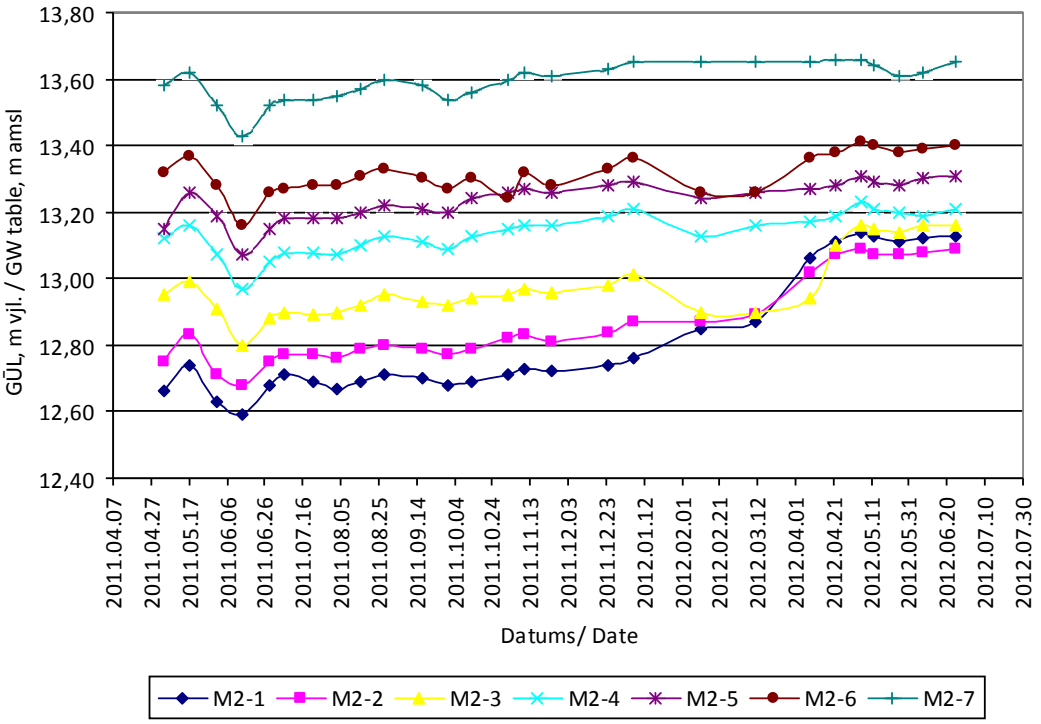
Aklais Mire, profile 2



Melnais Lake Mire, profile 1

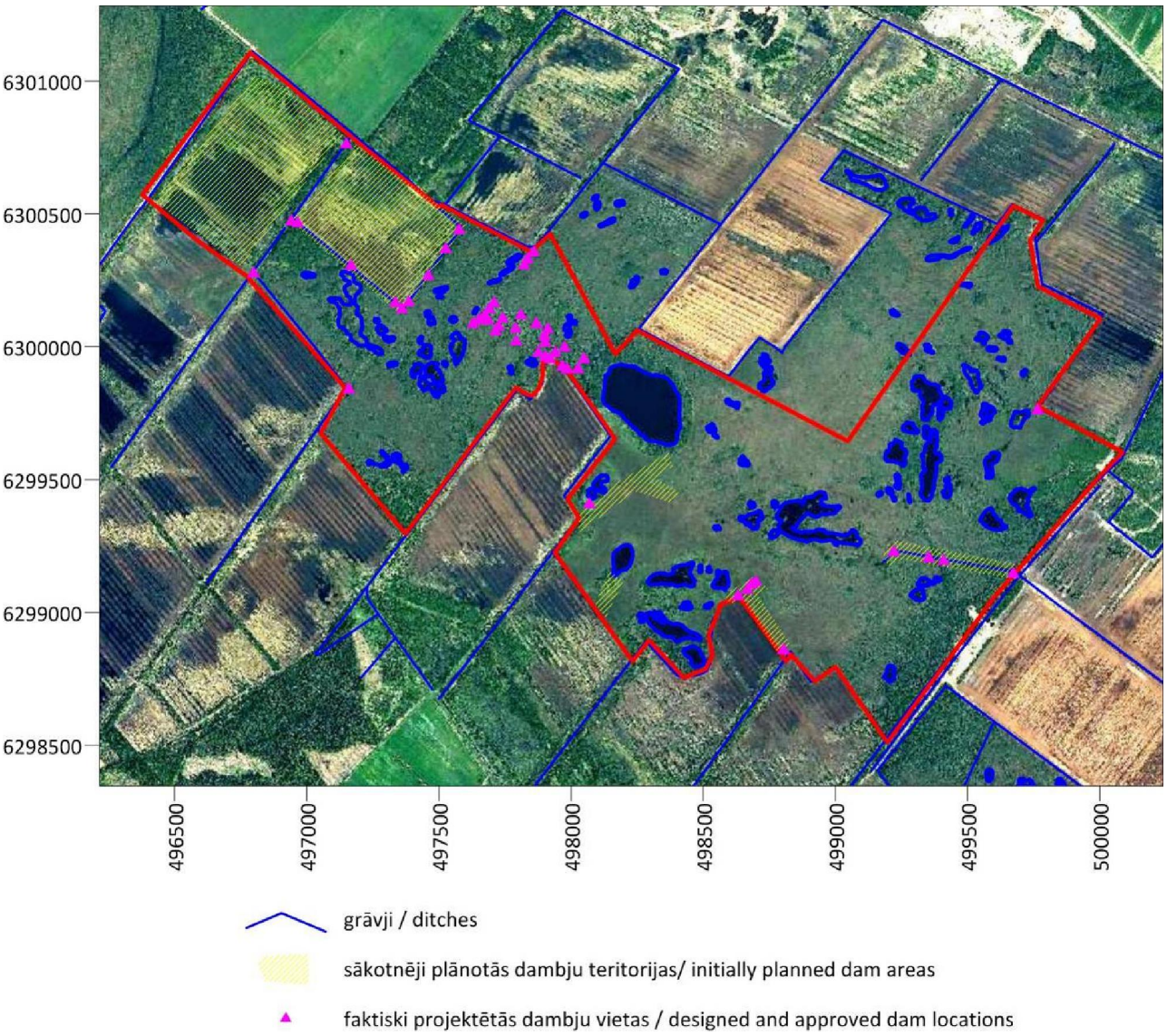


Melnais Lake Mire, profile 2

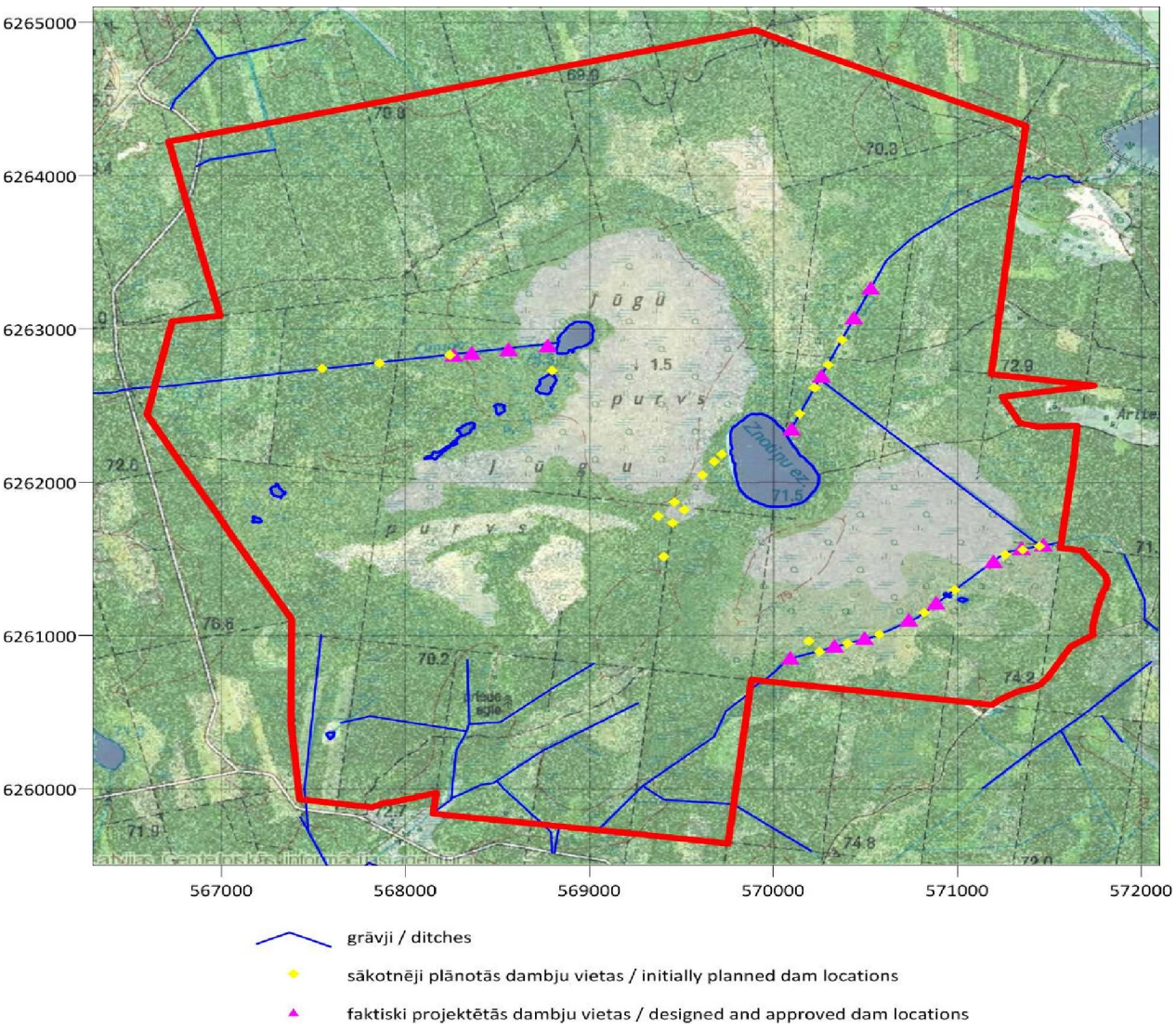


Annex 2. Management actions in Project Sites

Management actions in Melnais Lake Mire Nature Reserve



Management actions in Aklais Mire Nature Reserve



Management actions in Rožu Mire