Mire ecosystems in Latvia

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Abstract: In Latvia mires comprise 4.9 % of the total land area. Peat deposits, i.e. peatlands bigger than 1 ha and with more than 0.3 m peat, 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.
Both minerotrophic (fens and transitional mires) and ombrotrophic (raised bogs) mires occur in Latvia. Mires are distributed throughout the country but the area covered differs among the nature regions of Latvia. Distribution of mires and diversity of mire vegetation are determined by geology of area, origin of mires and climatic differences between coastal and continental parts of Latvia.
Fens, started to develop in the early Holocene in the Preboreal 10.000 years BP in the lower areas of the lowlands and in the small glaciocarstic depressions of uplands. Later, during the Atlantic many fens transformed into transitional mires and gradually into raised bogs. About 35 % of mires have formed as a result of filling-in of basins, but others are formed in the result of land paludification. During the Boreal, when climate became warmer, the formation of mires became more extensive. In the largest mires, like Kemeri Mire, Teici Mire raised bog vegetation developed. During the Atlantic Time mire formation conditions became favourable for mire development and witnessed the most extensive mire formation in Latvia. During that time the area was significantly influenced by the Baltic Sea stage Littorina Sea, when the water level was higher about 5-6 m than at present and large coastal areas of the present Coastal Lowland were covered by water. Fluctuations and decrease of the Littorina Sea level caused the formation of shallow lagoon lake basins where lake terrestrilization took place and large areas developed into mires (Sarnate Mire, areas around Kanieris, Engure and Babite Lakes).
Mires are protected in the North Vidzeme Biosphere Reserve, National Parks (Slitere, Kemeri and Gauja), Strict Nature Reserves (Teici, Krustkalni and Grini), Nature parks and nature reserves, as well as in protected landscape areas. There are six Ramsar sites in Latvia – Kanieris Lake, Engure Lake, Teici and Pelecare Bogs, Northern Bogs, Lubana Wetland Complex and Pape Wetland Complex.
In Latvia pristine and undamaged mire complexes are still found, most of which now are state protected. In total about 12 % from the Latvian mires are under state protection. On the other hand, about half of mires are influenced by various human activities, like drainage, peat cutting, eutrophication and fire and the degradation of the mires influenced by drainage continues.

Key words: Minerogenous mires, ombotrophic mires.

Introduction

The natural conditions and biological diversity of Latvia are determined by its geographical location near the Baltic Sea (55° 40' and 58° 05' northern latitude and 20° 58' and 28° 14' eastern longitude), variable geological conditions, relief, hydrology and climate (Fig. 1) Total area of Latvia comprises 64.635 km². Geobotanically, Latvia belongs to the hemiboreal (boreo-nemoral) vegetation zone (AHTI et al. 1968) characterised by deciduous-coniferous (mixed) forests.

The climate is influenced by the Atlantic air masses and the near-by Baltic Sea. This has resulted in a high atmospheric humidity and a moderate temperature regime, which determines the mild climate. The climate becomes more continental towards the eastern part of Latvia.

Southwest, south, southeastern winds prevail, but in summer western and northwestern winds are the most frequent. Annually Latvia is crossed by an average of 120-140 cyclones. In January range of temperature varies from –2.6 °C to –6.6 °C. In July, correspondingly varies from +16.8 °C to +17.6°C. Annual precipitation is 500-800 mm per year. The vegetation period (the

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Fig. 1: Location of Latvia in Europe.

daily average temperature above +5°C) begins approximately in April 15 and last for 180-200 days (KALNINA 1995).

In Latvia mires comprise 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 peat, 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 (Fig. 2).

The degree of paludification in Latvia shows that the main factors promoting this process are geological processes, relief and characteristics of surface deposits. Most paludified areas are located in the inland lowlands with gently undulating relief of the till and glaciolimnic clay and silt. Many mires have formed as a result of terrestrialization of shallow lakes and ancient rivers or its' meanders, as well as filling-in of the former lagoons. Approximately 28% of raised bogs initially formed as a result filling-in of some basins and comprise gyttja layer in the very bottom.

The present surface topography of Latvia was mainly formed in the result of the last – Weischelian (Latvian) glacier and its' melting water processes. Then main relief macroforms – uplands and lowlands formed. Glacial deposits cover almost the entire territory of Latvia. Exception are coastal areas that were greatly changed during the Late Glacial period after the retreat of glacier and the Holocene when the area was significantly influenced by the basins of

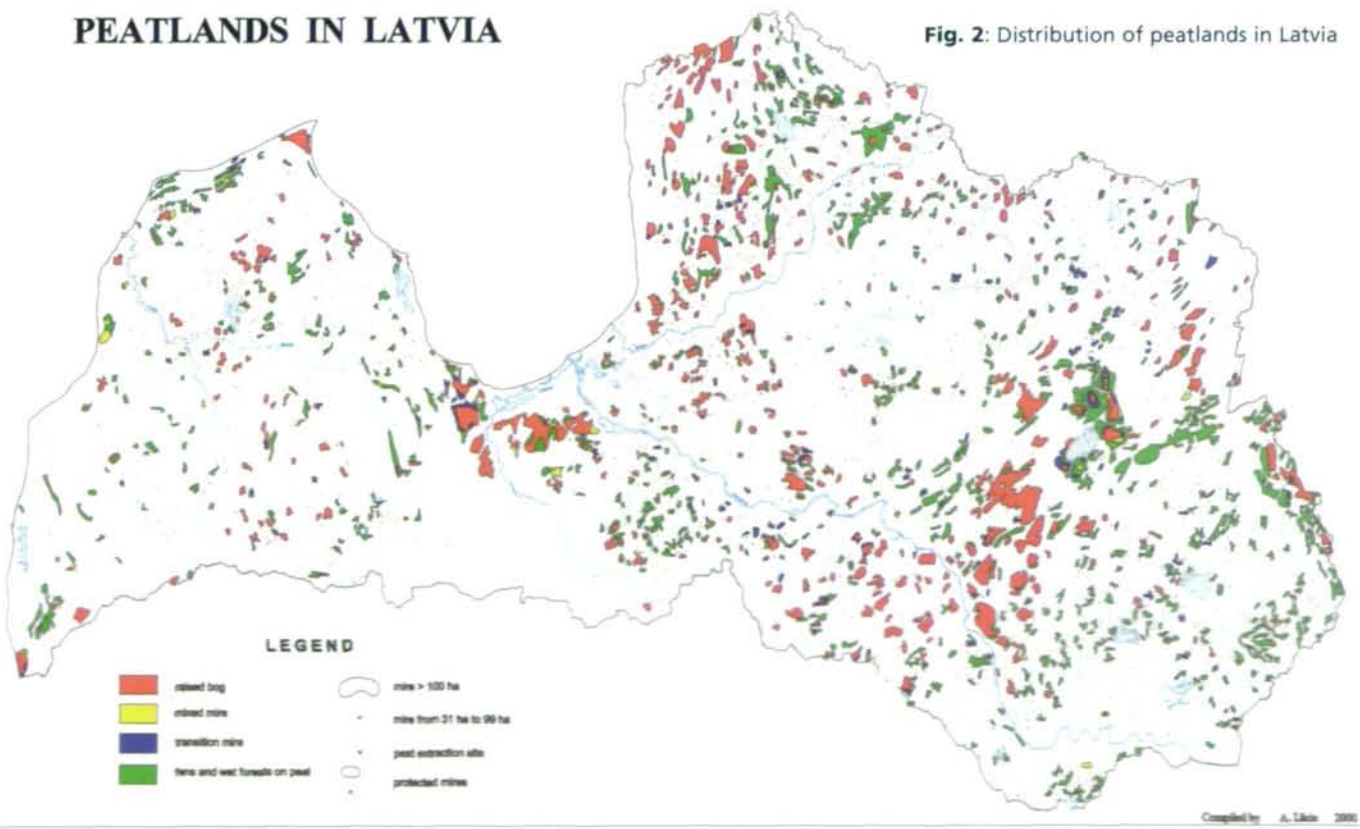


Fig. 2: Distribution of peatlands in Latvia

Baltic Sea stages, mainly the Baltic Ice Lake and the Littorina Sea. The water level of these basins was higher than at present and large coastal areas were covered by waters and influenced by its' dynamics, e.g. erosion and sedimentation. The plains were formed by Baltic Ice Lake and Littorina Sea and occupy the largest part of the Coastal Lowland, where marine sediments may be covered by eolian sands. The present relief of Latvia over several thousand years in addition to the geological processes was influenced by human activities, and has changed due to the increase of human population, more intensive use of natural resources and agriculture development.

Mires are distributed throughout the country but the area covered differs among the nature regions of Latvia (PAKALNE & KALNINA 2000). The largest raised bogs occur in the East and Middle Latvia Lowland and North Vidzeme Lowland, as well as in Tireli Plain, central part of Latvia. Raised bogs are most widespread, although fens occur as well.

The oldest mires in Latvia were fens that formed in the lower areas about 10.000 years ago, during the Preboreal. During that time fens originated also in many small glaciokarstic depressions in the uplands due to filling-in of small basins.

During the Boreal, when climate became warmer, the formation of extensive mires commenced. Largest part of mires in Latvia has been developing since the Boreal Time. During the Atlantic Time climatic conditions became favourable for for mire development and witnessed the most extensive mire formation in Latvia. The broad-leaved forests surrounded mires.

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

During the Atlantic Timefens gradually transformed into transitional mires and later into raised bogs. Development of raised bogs was associated with a rapid increase of various *Sphagnum* species in mire vegetation. During the Subboreal *Sphagnum fuscum*, *Scheuchzeria palustris* and *Eriophorum vaginatum* often dominated in raised bog vegetation, but during the Subatlantic *Sphagnum magellanicum*, *Andromeda polifolia* and *Calluna vulgaris* became more widespread. Microclimate primarily determined species composition in these raised bogs (KALNINA 1998).

Mires in geobotanic districts of Latvia

According to the differences in geological development, vegetation and soil features Latvia is divided into eight geobotanical districts (KABUCIS 1995). Differences in mire types, distribution, floristic peculiarities and representation are observed among the geobotanical districts.

The **Coastal Lowland** is situated along the coast of the Baltic Sea and Gulf of Riga. Here mire vegetation covers quite large areas and includes raised bogs as well as poor and rich fens. Rich fens have developed near coastal Littorina Sea lagoon lakes, like Kanieris and Engure Lakes, situated in this area. In similar location is located also area of Sarnate Mire, where Littorina Sea lagoonal lakes were formed during the final stage of this sea.

Raised bogs of the Coastal Lowland belong to the western type, where *Trichophorum cespitosum* occurs. Raised bogs can be dome-shaped and plateau-type bogs with a level centre, but occasionally with steep slopes (developed from shallow ancient lagoon lakes). Mire types, characteristic for the Coastal Lowland are calcareous fens and inter-dune mires. Sulphur springs with *Cladium mariscus* and *Schoenus ferrugineus* occur in the mires of the Kemeri National Park. Also Slitere National Park and Engure Nature Park including valuable mire vegetation are located in the Coastal Lowland.

The **North Vidzeme** is characterised by a high presence of mires and the dominance of vast raised bogs. In the western part of

this district there is the border of distribution of *Chamaedaphne calyculata*. This border is considered to split raised bogs of western and eastern type. Also fens occur in the region. Tall-sedge fens with *Carex appropinquata*, C. *caespitosa*, C. *diandra*, C. *lasiocarpa* are most widespread. Also small-sedge fens with *Carex nigra*, C. *panicea* and C. *flava* occur there. There are also fens with *Salix lapponum*, S. *rosmarinifolia*, S. *myrsinifolia* and S. *cinerea* in the shrub layer and mires with *Betula humilis* and *Betula nana*. *Betula nana* occurs mainly in the raised bogs located in the northern Latvia.

The North Vidzeme Biosphere reserve is situated in this area and is especially rich in raised bogs.

The Central Vidzeme, Zemgale and Central Latvia geobotanic districts are much poorer in mires than other regions of Latvia. In Central Vidzeme mires cover small areas. During the latest decades they have been drained and used for agricultural purposes. Raised bogs are rare. Fens and transition mires occur near lakes and include mire communities with *Carex rostrata*, C. *diandra*, C. *elata*, C. *lasiocarpa* and C. *acutiformis*. In such mires *Salix myrtilloides* and several rare orchids like *Corallorhiza trifida*, *Hammarbya paludosa*, *Liparis loeselii*, *Epipactis palustris* occur. Communities with *Carex appropinquata* are typical in river valley mires.

In Central Vidzeme, mires cover small areas. Raised bogs are very rare. Fens dominate and occur mainly near lakes in the eastern part of the district. The common species of fens include *Carex rostrata*, C. *diandra*, C. *elata*, C. *lasiocarpa*. In the fens and transition mires rare species, like *Salix myrtilloides*, *Corallorhiza trifida*, *Hammarbya paludosa*, *Liparis loeselii*, *Epipactis palustris* occur.. Wooded mires and mires with very dense shrub layer occur in this region as well.

In Central Latvia fens and transition mires dominate and appear mainly near the lakes as have developed as a result of lake terrestrialization. They include sedge vegetation with C. *acutiformis*, C. *acuta*, C. *rostrata*, C. *riparia*, C. *vesicaria*. Suda Mire including raised bog vegetation occurs in this district within the area of the Gauja National Park.

The **West Latvia** geobotanical district is not rich in mires. The minerotrophic mires that do occur in the in the depression between morainic hills and hillocks and may include lakes as well. Fens on calcareous soils comprise plant communities with *Myrica gale*, *Schoenus ferrugineus*, *Liparis loeselii* and *Carex hostiana*. Abava Nature Park and Stikli Mires Nature Reserve are located in this district.

Most common species in fens are *Carex diandra*, C. *appropinquata*, C. *caespitosa* and C. *vesicaria*. There are also fens with a shrub layer consisting of *Salix cinerea*, S. *rosmarinifolia*, S. *lapponum* and *Betula humilis*. In raised bogs *Trichophorum cespitosum* occurs.

The **East Latvia** is one of the richest in mires areas in Latvia. Both ombrotrophic and minerotrophic mires occur there. Raised bogs belong to the eastern type with *Chamaedaphne calyculata* in the shrub layer. The largest mire in Latvia – Teici Mire with the total area of 16.000 ha is situated in the Jersika Plain and has developed both in the result of lake terrestralizarion and soil paludification (BAMBE 1993). Raised bogs are mostly covered with pine, more rarely they are of open type. Lubana Wetland Complex that is a Ramsar site is located in this area.

In the **South-East Latvia** geobotanic district mires are situated between hills near the lakes. These mires have developed as a result of the filling-in of lakes. Ombrotrophic mires do occur in this district, although minerotrophic mire vegetation dominates.

In the fen vegetation with *Carex rostrata* and C. *lasiocarpa* dominates and may be accopmnied by *Menyanthes trifoliata* and *Comarum palustre*. Some of the mires of the area characterise by tall sedges – *Carex appropinquata* and C. *elata*. In some sites *Salix rosmarinifolia*, S. *cinerea and Betula humilis* occur, as well as *Betula pubescens* and *Alnus glutinosa*. Also *Betula nana* is found in this district. Several rare moss species – *Moerckia hibernica*, *Bryum neodamense* and *Meesia triquetra* are distinguished in the mires. In the South-East Latvia transition mires with *Oxycoccus palustris* and *Sphagnum teres* and S. *warnstorfii* occur. *Liparis loeselii* is the protected orchid growing there.

State of the art and history of investigations, mappings, usage and conservation

In Latvia the most important peatland studies started in the 1926 by Mire and Peat Research Laboratory of the University of Latvia under the supervision of Professor P. NOMALS. As a result, 6.763 peat deposits were recorded. Studies dealing mainly with mire distribution, structure, peat properties (botanical composition, ferrum, ash content, decomposition degree, etc.) and mire water chemical characteristics were carried out in mires throughout Latvia. P. NOMALS published results of the studies in a number of books that contain summary reports on mire characteristics and evaluation for peat extraction. Since that time mire research by means of pollen compostion, mire stratigraphy and development was carried out by P. GALENIEKS and M. LININA-GALENIEKS. Laboratory for Peat Studies was established at the University of Latvia. Group for mires worked also at the Ministry of Agriculture. Later, mire studies were devoted mainly to mire geology, flora in a scope of overall investigation of flora in Latvia. Mires have been often the study areas for ornithologists as for professionals, as well as for amateurs.

A number of organisations and researchers (geologists, geographers, botanists, ecologists, ornithologists, hydrologists, etc.) are involved in mire research of Latvia. Most valuable peatlands of Latvia are identified, also those of international importance and meeting Ramsar Convention criteria. The value of the studied mires was detected and their conservation status evaluated (PAKALNE et al. 2004).

Mire studies in protected areas are performed by its staff or by other scientists. Since the establishment of the Teici Strict Nature Reserve in 1992 mire studies are carried out there that includes research of flora, vegetation, birds, insects and mammals, geological development. Plankton communities have been investigated in bog lakes by a group of hydrobiologists (DRUVIETIS et al. 1998)

In the Slitere, Kemeri, Gauja National Parks, North Vidzeme Biosphere Reserve and Gauja National Park, Engure Nature Park mire researchers from University of Latvia have studied mire vegetation.

A number of mire related studies are carried out – study of metal concentration in moss species and peat, paleobotanical peat analysis, studies of mire insects, study of bryophyte flora in the mires, evaluation of plankton communities in mire lakes, study of mammals. Plant species monitoring including mire habitats is performed in the Slitere National Park.

Research in Latvia has been carried out mostly in the protected mires of Latvia. Still new localities of protected plant species are being discovered, like the habitats with *Schoenus ferrugineus*, *Carex davalliana* and *Saxifraga hirculus*.

In 2004 *Swertia perennis* was found in a spring mire, close to the border of the Gauja National Park. This is a plant species that has not been found in Latvia for the last 50 years. In the same area also another very rare species in Latvia *Ligularia sibirica* was discovered.

Mire terminology and classification systems

Mires in Latvia include minerotrophic mires (fens and transition mires) and ombrotrophic mires (raised bogs).

Minerogenous (minerotrophic) mires: fens

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 metres.

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 Scheuchze-

Fig. 3: Fen vegetation in Bedne Mire.

rio-Caricetea fuscae communities often occupy these fens, like, Caricetum rostratae, C. lasiocapae and C. diandrae.

Where fens have developed over 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, a number of which are rare and protected. *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*. Orchids, like *Dactylorhiza incarnata* and *Epipactis palustris* are well represented in calcareous fens. Rich fens are characterised by high species diversity. 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* (PAKALNE 1998). Sedge species such as *Carex lasiocarpa*, *C. rostrata*, *C. paniced* are characteristic for minerotrophic mires. Other associated species are *Menyanthes trifoliata*, *Comarum palustre*, *Eriophorum polystachion*, *E. latifolium*, *Lysimachia vulgaris*, *Peucedanum palustre* and *Succisa pratensis*.

Reedswamps 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. Transition mires are marked by the appearance of *Sphagnum* species that make up most of the moss layer. In transition mires common species include *Carex limosa*, *Carex rostrata*, *C. lasiocarpa* and *Rhynchospora alba* that are accompanied by *Eriophorum polystachion*, *Scheuchzeria palustris*, *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*, *Carabanus 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*, *Dactylorhyza cruenta*, *D. baltica*, *D. fuchsii*, *D. maculata*, *D. russowii*, *D. incarnata*, *Gymnadenia conopsea*, *Liparis loselii*, *Ophrys insectifera*, *Pinguicula vulgaris*, *Hammarbya paludosa*, *Malaxis monophyllos*, *Pinguicula vulgaris*, *Saxifraga hirculus*

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

Ombrogenous (ombrotrophic) mires: raised bogs

Raised bogs are present all over Latvia (Fig. 4). Two regional raised bog types are recognised, 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 microrelief 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 microhabitats. 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, Lutra lutra, Eptesicus nilssonii, Ursos arctos*

Bird species

On the margins of raised bogs: *Aegolius funereus, Columba oenas, Circaetu gallicus, Dryocopus martius, Haliaetus albicilla, Aquila chrysaetos, Ciconia nigra, Caprimulgus europaeus, Pandion haliatus*

Nesting and feeding: *Lagopus lagopus, Lanius collurio, L. excubitor, Circaetu gallicus, 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 – Gugatnis Philomachus pugnax*

Reptiles: *Coronella austriaca, Lacerta agilis*

Invertebrates: *Vertigo ronnebyensis, Clossiana frigga, Clossiana freija, Erebia embla, Carabanus menethriesi*

Vascular plants: *Trichophorum caespitosum, Drosera intermedia, Lycopodiella inundata, Betula nana, Salix myrtilloides*

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

Fig. 4: Raised bog vegetation in Janisu–Dainu Mire in the North Vidzeme Biosphere Reserve.

Mire protection in Latvia

According to the Latvian legislation mires are protected in a wide range of protected nature areas, like Teiči and Krustkalni Nature Reserves, Slitere, Kemeri, 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 presently 6 Ramsar sites are designated in Latvia: Teici un Pelecare Mires, Engure Lake, Kanieris Lake, the Lubana Wetland Complex, Northern Bogs, and Pape Wetland Complex.

There are 336 prospective Natura 2000 sites that include a wide diversity of forest, freswater, 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 of Latvia are distinguished:

- 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*

Mires in specially protected nature areas

Mires in the Gauja National Park

Mires in the Gauja National Park include raised bogs, fens, transition mires. Suda Mire is the largest mire in the Gauja National Park with the total area of 2.575 ha from which 2.339 ha includes raised bog vegetation, 188 ha transition mire vegetation and 48 ha fen vegetation.

Suda Mire has developed as a result of ground paludification during the second part of the Preboreal (aproximately before 9200-9400 years), when reed-wooden-cotton grass peat has formed in the area under the wet climatic conditions. Paleobotanical studies reveal that upwards in peat botanical sequence increases the number of *Sphagnales*. Gradually fen and transitional peat layers are covered by raised bog peat. During the first half of the Atlantic Time the largest part of Suda Mire has developed into raised bog.

Nowadays Suda Mire is a typical raised bog with a number of bog lakes and pools. There are open bog areas as well as wooded ones. There are a lot of smaller and larger lakes in the mire. In the southern part sulphur springs occur, as well as several mineral islands.

Transition mire vegetation with *Carex rostrata* and *C. lasiocarpa* occurs on the mire margins and near some of the bog lakes. Rare species include *Sphagnum balticum* and *Salix myrtilloides*. Typical species of hummocks are *Empetrum nigrum*, *Calluna vulgaris*, *Eriophorum vaginatum*, *Rubus chamaemorus*, *Polytrichum juniperinum* but in hollows and near bog pools *Rhynchospora alba* and *Scheuchzeria palustris* are accompanied by the bryophytes, like *Sphagnum cuspidatum*, *S. tenellum*, *Cladopodiella fluitans* and *Calypogeia sphagnicola*.

The presence of mineral islands with different types of forest adds to the species richness of the mire. The mire supports a peculiar species composition, having together species of western and eastern distribution in Latvia, such as *Trichophorum cespitosum* and *Chamaedaphne calyculata*.

Sphagnetum magellanici and Empetro nigri – Sphagnetum fusci characterise the bog hummocks, but Rhynchosporetum albae, Caricetum limosae and Scheuchzerio–Sphagnetum cuspidati are found in the hollows. *Sphagnum magellanicum* lawns with *Trichophorum cespitosum* occur also. Suda Mire includes a rare mire community in Latvia the Eriophoro-Trichophoretum cespitosi.

In the Gauja National Park communities of the Class Montio-Cardaminetea are widespread and occur near springs and along flushes. Springs that have developed at the foots of river ravines, like on the left bank of Amata River or near Perlupe River.

Springs in the Gauja National Park occur on the river ravine slopes. When the slo-

pes are steep the sites are characterised by the dominance of *Cratonoeron filicinum*, *Palustriella commutata*, *Plagiomnium ellipticum*, *Fissidens adianthoides*, *Bryum pseudotriquetrum*, *Pellia endivifolia* and *Conocephalum conicum*. At the foot of river ravines slopes and in forest springs with *Cratonoeron filicinum*, *Palustriella commutata*, *Plagiomnium ellipticum* and other plants species like *Cirsium oleraceum*, *Caltha palustris*, *Chrysosplenium alternifolium*, *Myosotis palustris*, *Galium palustre*, *Crepis paludosa Cardamine amara*, *Veronica beccabunga*, *Myosoton aquaticum*, *Chrysosplenium alternifolium*, *Geum rivale*, *Crepis paludosa*, *Plagiomnium undulatum*, *P. elatum*, *Plagiochila asplenoides* occur. Some sites include also protected bryophyte species *Trichocolea tomentella*.

Davida Springs are located on the left bank of Vaive River. It is a place where from the Plavinu Formation deposits 34 springs run out (SKRUPSKELE 1994). Small waterfalls are located on the steep slopes. From the spring water iron hydroxides are deposited. It is a complex including Montio-Cardaminetea communities on the steep slopes, Phragmito-Magnocaricetea and fragments of Scheuchzerio-Caricetea fuscae mire vegetation. Here springs, streams, fen communities occur near the flushes.

Characteristic species include *Cirsium oleraceum*, *Deschampsia cespitosa*, *Veronica beccabunga*, *Myosoton aquaticum Equisetum palustre*, *Chrososplenium alternifolium*, *Caltha palustris*, *Cratonoeron filicinum*, *Conocephalum conicum*, *Plagiomnium ellipticum* and *Bryum pseudotriquetrum*.

In the area of Davida springs on the slopes with springs and streams, spring mire vegetation has developed. The characteristic species in the fen vegetation are *Carex hostiana*, *C. panicea* and *Epipactis palustris*. In separate places in the fen springs reach the surface and include other species like *Cirsium oleraceum* and *Cratonoeron filicinum*.

The steep slopes of the Kazu Ravine include springs, streams and flushes. In the Kazu Ravine mire vegetation has developed and includes also springs. Spring vegetation is a part of mire that is characterised by Scheuchzerio-Caricetea fuscae vegetation (Caricetum rostratae). On the ravine slopes there are rheocrenes (gushing springs) the water spurts out of a horizontal or down sloping strata and immediately races down into the valley. There are also limnocrenes (spring basins) the water wells up from below. In the ravine itself helocrenes (seepages or spring fen) has developed where the water seeps up through the ground. The margins lead to the mire vegetation.

In Kazu Ravine rich fen vegetation is characterised by Caricetum rostratate and includes *Carex rostrata*, *C. panicea*, *Epipactis palustris*, *Dactylorhyza incarnata*, *Cirsium oleraceum*, *Galium palustre*, *Equisetum palustre*, *Primula farinosa* and mosses *Bryum pseudotriquetrum*, *Calliergonella cuspidata*, *Calliergon giganteum*, *Fissidens adianthoides*, *Campylium stellatum* and *Plagiomnium ellipticum*. Springs in Kazu Ravine are rich in calcium.

In addition to the common spring species, also other bryophytes like *Thuidium pfiliberti*, *Rhytididelphus subpinatus*, *Cirriphillum piliferum* and *Eurhynchium pulchellum* occur. There is also an ecotone zone that leads to the spring fen vegetation. This marginal zone between the spring vegetation and mire vegetation includes both typical spring species, like *Cirsium oleraceum*, and *Pellia endivifolia* and fen species, like *C. lepidocarpa*, *Cirsium palustre* and *Equisetum palustre*.

From the all the above mentioned sites differs the spring mire located near Suda River not far from Suda Mire (PAKALNE & CAKARE 2001). It is a complex of springs that includes mire vegetation. The spring area is characterized by *Cirsium oleraceum*, *Poa palustris*, *Menyanthes trifoliata*, *Chrysosplenium alternifolium*, *Caltha palustris*, *Poa palustris*, *Crepis paludosa*, *Galium palustre*, *Menyanthes trifoliata*, *Cirsium palustre* and *Myosotis palustris* associated with *Calliergonella cuspidata* and *Bryum pseudotriquetrum*. It borders with vegetation that passes into transition mire vegetation with *Betula humilis*, *B. pubescens*, *Salix rosmarinifolia* and *Frangula alnus* in the schrub layer, but *Eriophorum vaginatum*, *Comarum palustre*, *Equisetum palustre* and *Potentilla erecta* occur in the herb layer. *Sphagnum teres* and *S. squarrosum* grow in the moss layer and appear together with *Aulacomnium palustre* and *Calliergon stramineum*. In this case the

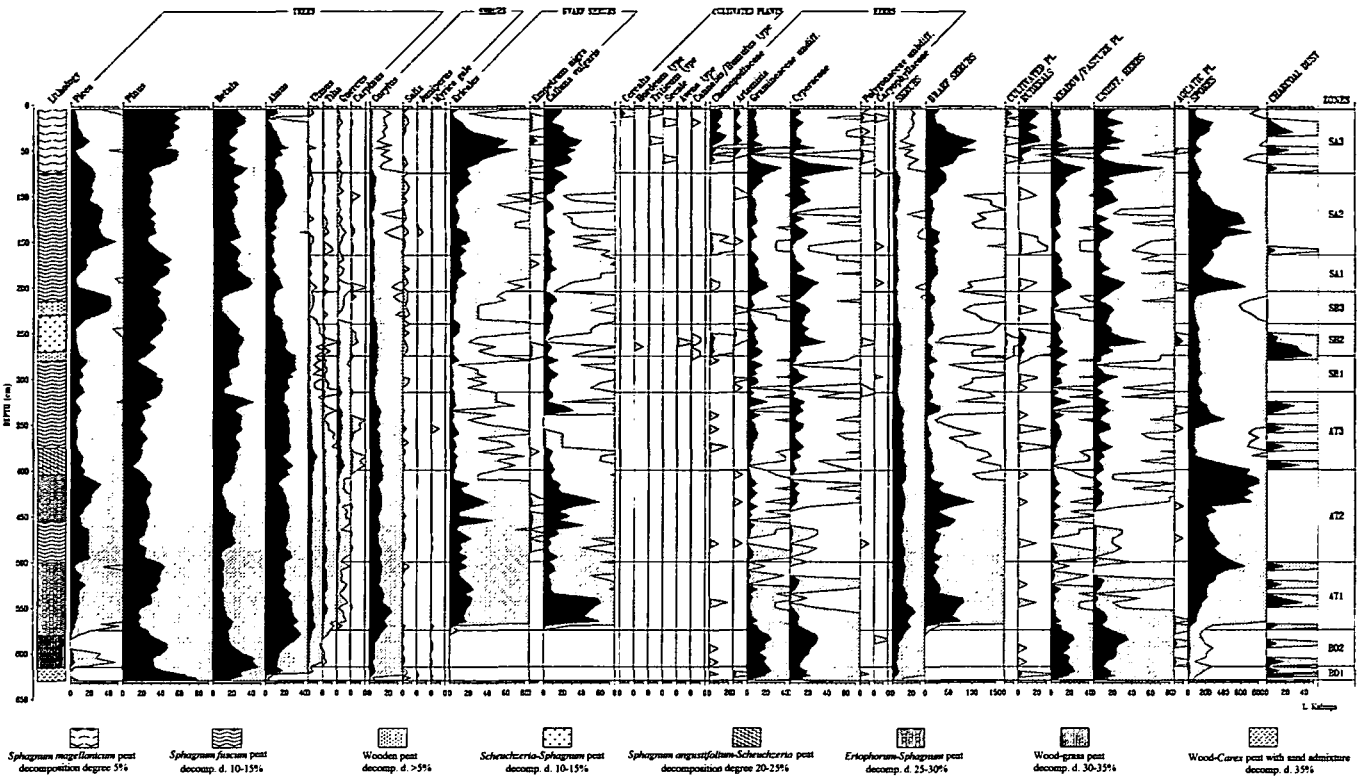


Fig. 5: Pollen diagram from Lielais Kemeri Tirelis Mire,

mire vegetation development is clearly observed in this spring area and there is not a sharp boundary between the springs and adjacent mire vegetation.

Springs and spring mires in Latvia are associated with rare and protected plant species, such as *Ligularia sibirica*, *Swertia perennis*, *Saxifraga hirculus*, *Liparis loeselii*, *Malaxis monophyllos*, *Primula farinosa*, *Epipactis palustris*, *Schoenus ferrugienus*, *Carex davalliana*, *Cladium mariscus*, *Dactylorhiza incarnata*, *D. ochroleuca*, *Malaxis onophyllos* and *Epipactis palustris* as well as bryophytes, like *Hamatocaulis vernicosus*, *Paludella squarrosa*, *Trichocolea tomentella*, *Helodium blandowii* and *Bryum weigelii*.

Mires in the Kemeri National Park

The Kemeri National Park is rich in mires and includes three raised bogs. The largest is Lielais Kemeri Tirelis Mire with the total area of 6.192 ha (GALENIEKS & KRAUKLIS 1995). Zalais Mire (1.586 ha) (NUSBAUMS 1998) and Raganu Mire (1.129 ha) (KRAUKLIS 1997) are smaller. Mire vegetation occurs also near Kudraine, Dunu and Kanieris Lakes.

Lielais Kemeru tirelis Mire

Lielais Kemeru tirelis Mire is one of the largest raised bogs in Latvia. Since 1977 the largest part of the mire (5.762 ha) is a protected nature area, but since 1997 is included in the Kemeri National Park. Lielais Kemeru tirelis Mire is the one that orinated before the other mires of the Kemeri National Park and has been developing since the Boreal Time. It has formed mainly as the result of ground paludification. Before 8500-7500 B.P fen vegetation started to develop and fen peat accumulated except some areas where small lakes were located, which became terretrialized.

Lielais Kemeri Tirelis Mire has developed in the area that was covered by the Baltic Ice Lake (NIKODEMUS et al. 1997). After the retreat of the Baltic Ice Lake, fine sand deposits formed the surface of the area. Gradually, climate became milder and more humid and paludication processes of mineral sediments started in large areas of gently sloping and undulated plain, because of non permiable dolostone formations close to the surface, as well as ancient dunes have stopped water flow to the Gulf of Riga. Peat sedimentation started during the Boreal about 8500 years ago. Sedges, reeds and

grasses grew in the flat area declined to the north, but pine forests dominated in vicinity. The sedge, wooden sedge and pine-sphagnum peat has been formed, which nowadays has level of decomposition varied from 30 to 50 % (KALNINA 1998).

During the Atlantic Time the climate became favourable for more intense mire development. As a result, mesotrophic plants were replaced by eutrophic ones and *Eriophorum-Sphagnum*, *Sphagnum angustifolium-Scheuchzeria* peat deposited, degree of decomposition varied from 20 to 40%. During the Subboreal and Subatlantic less intensively decomposed (~20%) *Sphagnum fuscum* and *Sphagnum magellanicum* peat formed.

A pollen diagram shows that since the Atlantic Time there is a very rapid increase in *Sphagnum* spores, but pollen composition indicates about the broad-leaved forest maximum distribution in the surrounding (Fig. 5). Pollen, spore and botanical composition of *Sphagnum fuscum* peat formed in the middle of the Atlantic Time (about 6000-5000 years BP) and testifies that already at that time there was a raised bog vegetation in the Lielais Kemeri Tirelis Mire that has not significantly changed until present. In the Atlantic the hummock-hollow complex developed.

During the Atlantic Time Due to the humid and warm climate the raised bog developed rapidly and the thickest peat layers (2.5 – 3.0 m) were formed. A second very intensive period of peat formation was the Subatlantic (since 2500 years BP), when *Sphagnum fuscum* and later *Spagnum magellanicum* peat formed (~2 m) under humid and cool climatic conditions.

Paleobotanical studies of the Lielais Kemeri Tirelis Mire peat sequence proves that vegetation was original from the very initial – fen phase, when *Myrica gale* and *Trichophorum cespitosum* pollen and plant remains are found since the end of the Boreal Time. The insignificant presence of the anthropogenic indicator and *Cereales* pollen suggest weak influence of ancient human activities and natural change of vegetation composition (KALNINA 1998). However, at the level of 60-70 cm, together with the increase of pollen of ruderal plants and *ereales* pollen the increase in concentration of heavy metals is observed.

Fig. 6: Sulphur springs in Raganu Mire.

At present, the largest part of this mire includes raised bog vegetation and only the northern and western bog margins there is transitional mire vegetation. The mire is characterised by a hummock-hollow complex and lakes. Ancient dune formations separate the Lielais Kemeri tirelis Mire from the Gulf of Riga (ZELCA et al. 1990).

Raganu Mire

Raised bog vegetation dominates in Raganu Mire. In the northern part fen vegetation appears fed by ground waters rich in nutrients. Peculiar feature of the mire are sulphur springs surrounded by raised bog vegetation but still including fragments of earlier rich fen vegetation with *Schoenus ferrugineus*. *Cladium mariscus* is observed near sulphur springs growing together with *Phragmites australis*, *Myrica gale*, *Menyanthes trifoliata*, *Comarum palustre* (Fig. 6). In the bryophyte layer *Calliergonella cuspidata*, *Scorpidium scorpioides*, *Sphagnum warnstorfii*, *Calliergon stramineum*, *Cladopodiella fluitans*, *Bryum pseudotriquetrum* occur. Also protected plant species, like *Saxifraga hirculus*, *Schoenus ferrugineus*, *Primula farinosa* and *Paludella squarrosa* occur there as well.

Sulphur springs and rich fens appear also near Dunieris Lake where large growths of *Cladium mariscus* are known. The schrub layer is characterised by *Pinus sylvestris*, *Betula pubescens*, *Myrica gale*, but the herb layer includes *Phragmites australis*, *Sesleria caerulea*, *Schoenus ferrugineus*, *Primula farinosa*, *Pinguicula vulgaris*, *Triglochin palustris*, *Potentilla erecta*, *Molinia caerulea*, *Succisa pratensis*, *Cladium mariscus*, *Oxycoccus palustris*, *Calluna vulgaris*, *Potentilla erecta* and *Drosera rotundifolia*.

Fig. 7: Inter-dune mire complex in the Slitere National Park.

Mires in the Slitere National Park

The Slitere National Park is located in the far north of the western part of Latvia and it stretches along the coast of the Baltic Sea. All main types of forests and mires of Latvia are represented there (SEILE & RERIHA 1983).

Most peculiar is the zone of Littorina Sea Plain accumulation, represented by series of alternating long narrow walls (beach barriers with cover of eolian deposits) and narrow depressions between ridges (usually occupied by mires and lakes). This forms the bottom of the inter-dune mire complex. In some cases, when depressions have been filled- in up to to top of ridges, mire has contined to grow and has covered also the ridges, and converged with other interdune mires creating an continous raised bog cover, like Bazi Mire.

The above mentioned alternating relief forms a unique landscape. The complex of dunes and inter-dune mires between them were formed during the Postlitorina Baltic Sea developmment stage of the last 4700 years. Comparatively high groundwater level in the depressions between dune ridges and calcareous bedrock has resulted in formation this specific mire type – inter-dune mires which are located between the coastal formations of the Littorina Sea. (Fig. 7).

Before the mire vegetation started to develop there, there was open water between the dunes and the terrestrialisation processes started there after the regression of the Littorina Sea.

Inter-dune mires are a specific mire type that occurs only in the western part of Coastal Lowland. It is the most peculiar zone of Litorina Sea Accumulation Plain.

The inter-dune mires include fen communities from the *Scheuchzerio-Caricetea fuscae* dominated by *Carex lasiocarpa*, *Carex rostrata* (Caricetum lasiocarpae, Caricetum rostratae), and transition mire vegetation (Caricetum limosae). The communities include such species, like *Trichophorum alpinum*, *Eriophorum polystachion*, *E. gracile*, *Menyanthes trifoliata*, *Carex limosa*, *C. chordorrhiza*, *C. lepidocarpa*, *Stellaria alsine*, *S. palustre*, *Scheuchzeria palustris*, *Drosera anglica*, *D. intermedia*, *D. x obovata*, *Oxycoccus palustris*, *Utricularia intermedia*, *U. minor*, *U. vulgaris*. In the bryophyte layer *Calliergonella cuspidata*, *Scorpidium scorpioides*, *Calliergon giganteum*, *Campylium stellatum*, *Fissidens adianthoides*, *Bryum pseudotriquetrum*, are common. There are also open pools with *Nymphaea alba*, *N. candiada*, *Nuphar lutea* and in places filling-in with *Spagnum papillosum*. Also *Myricetum gale* indicating the previous minerotrophic mire conditions, but is presently already surrounded by typical *Sphagnum magellnicum* dominated bryophyte carpet.

Conservation value of the inter-dune mire complex is associated with the geological development of the area. It is connected with mire development and a high plant species diversity including a considerable assemblage of protected plant of Latvia, like, *Rhynchospora fusca* (one of four known localities in Latvia), *Malaxis monophyllos*, *Lycopodiella inundata*, *Hammarbya paludosa*, *Saxifraga hirculus*, *Carex heleonastes*, *Juncus stygius*, *Dactylorhiza incarnata*, *Liparis loeselii*, *Eriophorum gracile*, *Corallorhiza trifida*, *Dactylorhiza baltica*, *D. cruenta*, *D. fuchsii*, *D. incarnata*, *D. ochroleuca*, *D. russowii*, *Gymnadenia conopsea*, *Epipactis palustris*, and protected bryophytes, like *Moerckia hibernica* and *Cynclidium stygium*.

In the Slitere National Park there are also rich fens including mire communities

with *Schoenus ferrugineus* and other rare species, like *Carex davalliana*, *Juncus subnodulosus* (the only known locality in Latvia). The rich fen includes also springs and flushes. The other typical fen species are *Parnassia palustris*, *Pinguicula vulgaris*, *Primula farinosa*, *Carex hostiana*, *C. panicea*, *Dactylorhyza incarnata*, *D. ochroleuca*, *Gymnadenia conopsea*, *Drepanocladus revolvens*, *Campylium stellatum*, *Calliergonella cuspidata*. *Philonotis calcarea*, *Palustrella commutat*, *Cratonoeron filicinum* grow near the flushes.

Bazi Mire

Inter-dune mire complex in the Slitere National Park borders with Bazi Mire that is a raised bog of a coastal type with a total area of 1.880 ha. The largest ridge is up to 15 km long and crosses the Bazi Mire. Mires and even small lakes are located between the ridges.

Bazi Mire has formed in the area where elongated eolian sand dunes change by depressions where inter-dune mires are located. Bazi Mire has the three angle form, which depends from situation of the dunes, both in the mire bottom as well bordered dunes, which has been not covered by peat yet (Fig. 8).

This mire has formed at the very end of the Atlantic Time, when due to comparatively high groundwater level in the depressions between high ancient dunes there were wet conditions favourable for fen vegetation development.

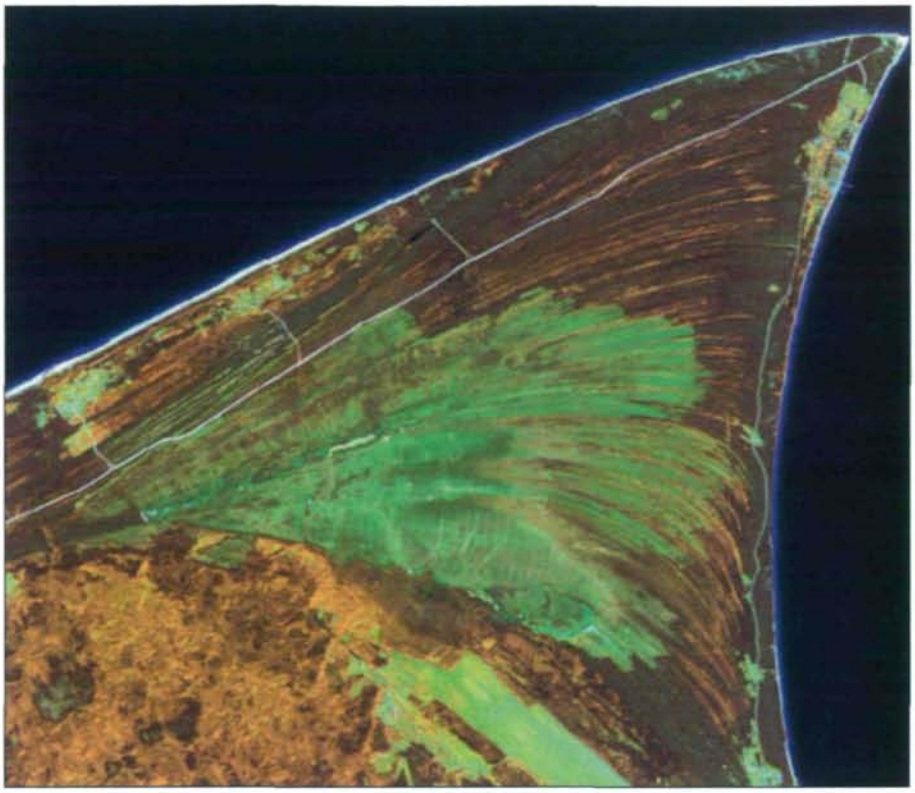
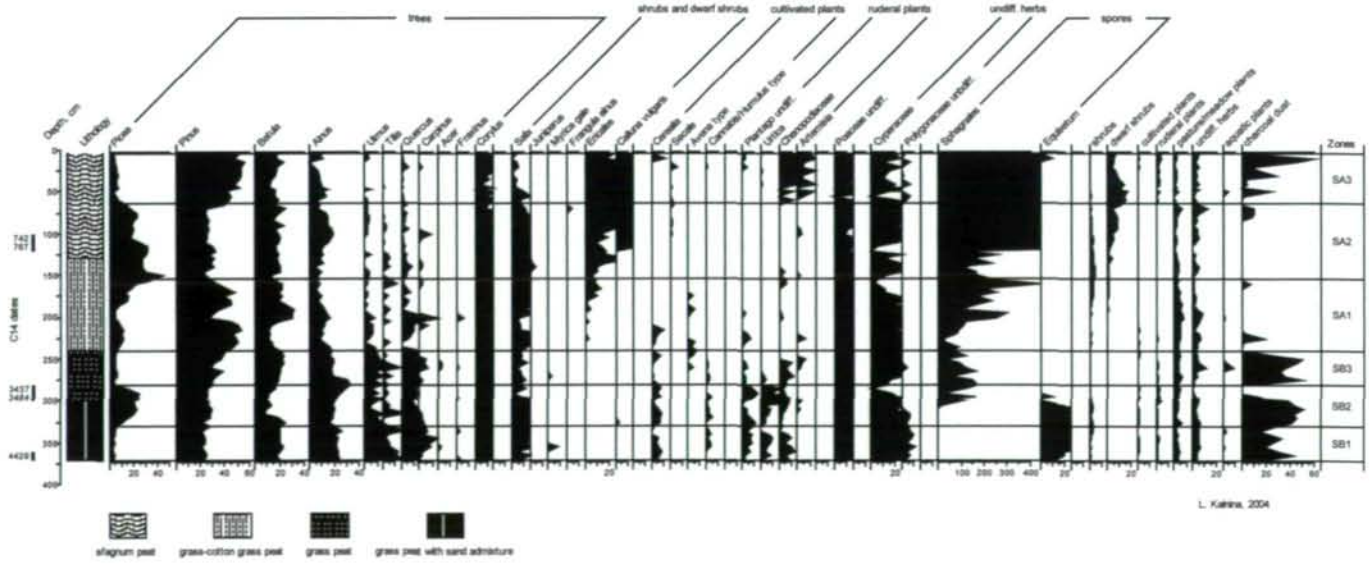


Fig. 8: Satellite image from Bazi Mire in the Slitere National Park.

Large biomass of these plants after decay promoted fen peat formation. ^{14}C data for the very lower fen peat layer indicate it formation on the sandy surface before the year 4429 (Fig. 9) during the Subboreal Time.

Fen type peat sequence has formed only in the lower part of the depressions, and in some places it has sand admixture, which indicate owerblowing of the dunes. Presence of the *Equisetum* spores in the very lower peat layer indicates wet conditions. In the vicinity of the present Bazi Mire there were distributed *Pinus-Betula-Alnus* forests with

Fig. 9: Pollen diagram from Bazi Mire in the Slitere National Park.



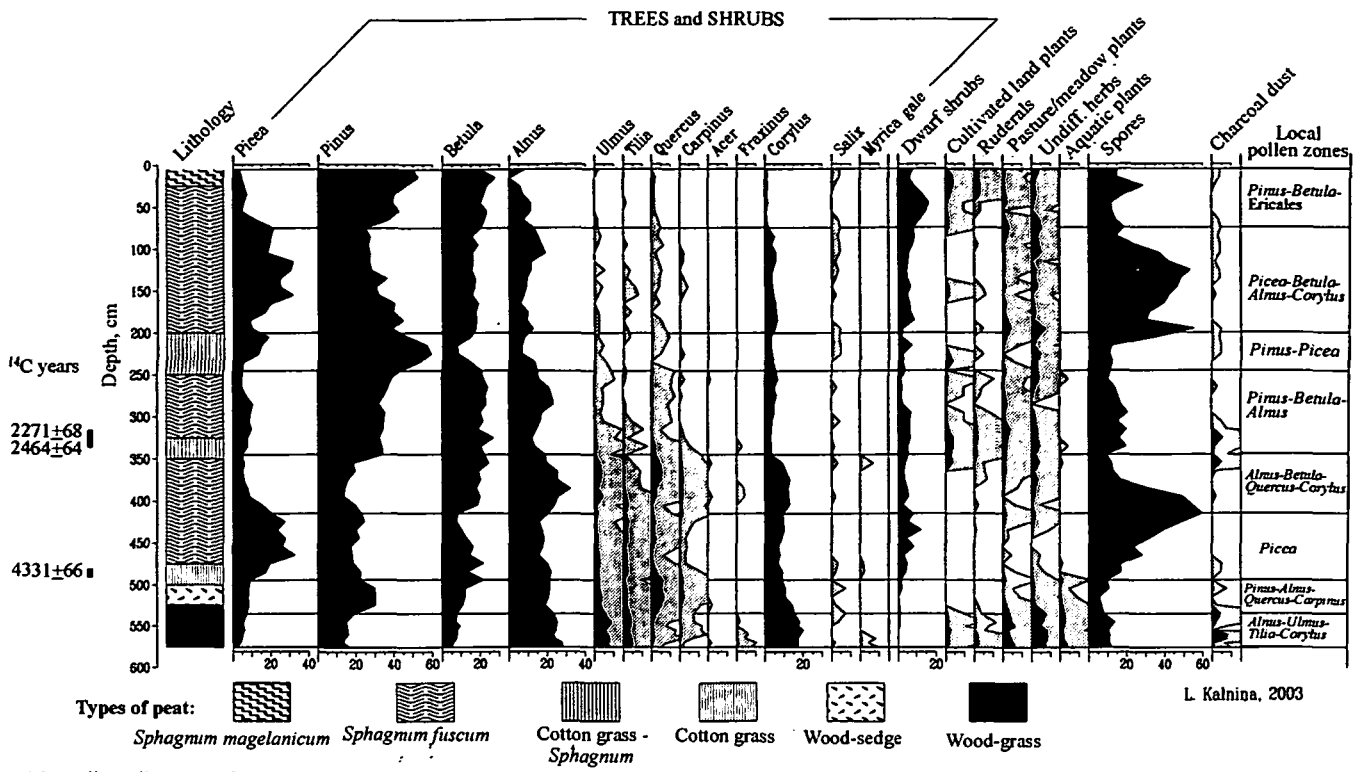


Fig. 10: Pollen diagran of the selected plants from the Cena Mire peat sequence.

some *Quercus* and and *Ulmus*. Number of *Urtica*, *Chenopodiaceae*, *Plantago* pollen and a large amount of charcoal dust particles in the lower peat layer point out to the ancient human presence in the surrounding area. Number of broad-leaved trees gradually decreased during that accumulation of the fen peat layer with sand admixture. Upward in the peat section the increase of *Picea* has been noted. When depressions were filled by peat, it covered also dunes and formed a continuous peat cover. Peat formation became more intense and gradually changed from fen and transition peat to raised bog, where *Sphagnum* and *Eriophorum vaginatum* – *Sphagnum* dominated. The very upper *Sphagnum* peat layer of 1 m thickness has been forming during 740 years or aproximately 1,3 mm per year. This layer is mainly represented by low decomposed (5%) *Sphagnum* peat. Pollen diagram indictes to a very sharp increase of *Sphagnum* spores at the same level when the start of *Sphagnum* peat development was determined. At present Bazi Mire includes the typical raised bog vegetation of coastal type with the hummock-hollow complex.

Cena Mire Nature Reserve

Cena Mire is located in the Coastal Lowland. It is specially protected nature area with the total area of 2.133 ha, an Important Bird Area (IBA) with the total area of 2.826 ha.

Geological studies reveal that Cena Mire has started to develop about 6000–6500 years ago. At present, peat thickness can reach almost 6 m, but mean layer thickness is about 3 m.

Cena Mire developed in the Holocene in the depression of the Baltic Ice Lake, where wide depression occured just 6.8 to 7.2 m above sea level, with some elevation in the borders (9.0 – 9.5 m a.s.l) (LACIS 2003). Bottom of the depression is located close to the sea level. Due to groundewater level rise, it caused water accumulation in the depression and ground paludification. Humid and warm climate, as well as high groundwater level during the Atlantic Time resulted in very wet conditions in the depression, which were favourable for fen species, like *Carex* and *Phragmites*. ^{14}C datings indicate that the very lowest wood-fen peat layer has formed before 4331±66 years. Pollen diagram shows the gradual decrease of the broad-leaved tree pollen, which indicate also to the deteoration of climate, particularly decrease of the mean year temperature (Fig. 10).

Since the origin of the mire it has been growing vertically and horizontaly and covered large areas and until first half of the 20th centuary. It became one of largest (more than 10.000 ha) raised bogs in Latvia with well- expressed humock-bog pooll microrelief and raised bog domes reaching 4-5 m height (KALNINA et al. 2005). At present a large part of Cena Mire has been degraded due to peat cutting, but the areas around all three dome are preserved and now is a specialy protected nature area.

Due to the peat growth the influence of the groundwater diminished and the mire was fed mostly by nutrients obtained from the precipitation. It caused changes also in the vegetation composition – sedge, reed and tree species decreased and oligotrophic plants appeared, represented by different *Sphagnum* species and *Eriophorum vaginatum*. Decomposition of the *Shpagnum* peat is low and rarely exceeds 15%. According ^{14}C dates raised bog peat has been accumulating at least since before 2464±64. Rate of raised bog peat accumulation reached 1,3 mm per year in the Cena Mire.

Paleobotanical studies indicate that during the late Atlantic Time in the area of Cena Mire due to rising of groundwater level there were favourable conditions fen plant growths and afterwards wood-fen peat formation (KALNINA 2003). Conditions were also favourable for the broad-leaved forest disribution in the surrounding of Cena Mire area at the begining of mire formation, which promoted large grass biomass formation in this area and decomposition processes. The climatic changes during middle part of the Subboreal (SB2) caused replacement of the fen and transition mire vegetation by the raised bog vegetation and the main peat forming plant during that time is *Sphagnum fuscum*, except some intervals where importance of the *Sphagnum angustifolium* and *Eriophorum vaginatum* increased. The initial changes appear in the very upper peat layer, where in the peat composition *Sphagnum magellanicum* is dominating. Pollen composition and ^{14}C datings indicate human activity traces during three separate time spans: the Neolithic Age, Iron Age and since Medieval Time untill nowadays.

At present Cena 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 Cena Mire has a typical hummock – hollow complex and includes labyrinths of bog pools and ridges. Bog pools have a concentric pattern and are located on both sides of the soak area that comprises transition mire vegetation (Fig. 11). Cena Mire is surrounded by bog woodland and pine forests.

Fig. 11: Raised bog vegetation in Cena Mire.

Cena Mire is a unique bog because it is one of the few raised bogs of Latvia that possess the features of the coastal raised bog type as includes *Trichophorum cespitosum*, and also the features of the eastern bog type as is the habitat for *Chamadaphne calyculata*. Cena Mire comprises the typical raised bog communities, like Sphagnetum magellanici, Rhynchosporetum albae, as well as fen vegetation of Caricetum rostratae, Caricetum lasiocarpae.

Cena Mire is the habitat for three protected vascular plant species of Latvia – *Betula nana*, *Dactylorhiza maculata* and *Trichophorum cespitosum* and two bryophyte species – *Calypogeia sphagnicola* and *Sphagnum pulchrum*. Still, the main value of the site are raised bog habitats that are highly important for 19 protected bird species of Latvia – *Aquila pomarina*, *Pandion haliaetus*, *Haliaetus albicilla*, *Circaetus gallicus*, *Circus aeruginosus*, *Tetrao tetrix*, *Numenius arquata*, *N. phaeopus*, *Pluvialis apricaria*, *Ciconia nigra*, *C. ciconia*, *Tringa glareola*, *Dryocopus mar-*

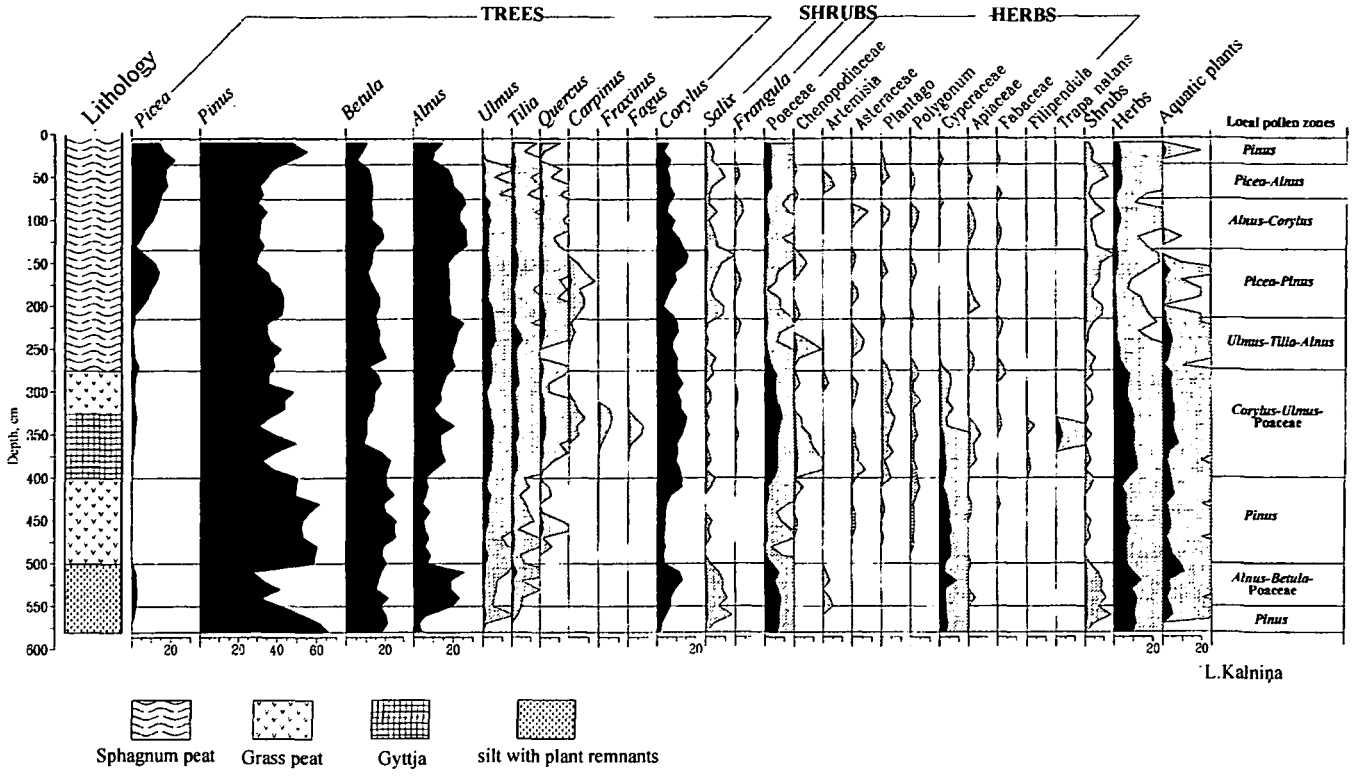


Fig. 12: Pollen diagram from Sarnate Mire.

tius, *Grus grus*, *Crex crex*, *Tringa totanus*, *Larus ridibundus*, *Lanius excubitor* and *L. collurio*. Cena Mire is an important overnight area for *Anser fabalis* and *A. albifrons* and is one of the best nesting areas of *Grus grus* in Latvia .

Sarnate Mire Nature Reserve

Sarnate Mire is located in the western part of Castal Lowland, western part of Latvia. At present, about 2.5 km wide mainland belt, that has been a former coastal bar occurs between Sarnate Mire and the Baltic Sea. The protected area of the mire reaches 2.368 ha.

In the Younger Dryas, with the fall in the level of the Baltic Ice Lake, silt and silty sand with a small amount of organic matter was laid down in the area of the present-day Sarnate Mire. In the Preboreal this area was in the coastal zone of the Yoldia Sea (MURNIECE et al. 1999). The 20-30 cm thick *Hypnum* peat layer immediately overlies the sandy clay in the large part of present mire area, while in the northern part silt with plant remains were deposited. The sediments described have pollen spectra (*Betula* maximum) characteristic of the Preboreal, which is confirmed by the date of 8900+-90 (LE-901, DOLUKHANOV 1977).

The level of the Ancylus Lake was about 4-5 m higher than the present sea level, and the area contained one or more shallow coastal lakes which were cut off from the open water of the lake on the western side by a narrow (0.3-0.5 km wide) spit of land. The upper layer of freshwater lime evidently accumulated during the time of the Ancylus Lake in larger part of area, except northern part, where gyttja overlay fen peat. The pollen spectra show the *Pinus* maximum (Fig. 12).

The northern part of Sarnate Mire has formed by ground paludification already during transgression and regression phases of the Ancylus Lake. Raised bog peat started to accumulate there during the Atlantic Time but the largest part of mire at that time was an ancient lagoon, because during the Littorina Sea transgression, seawater entered the low area between Ventspils and Sarnate through the area of the Venta River mouth. As a result, large and shallow lagoon formed. Pollen composition from sediment sequences deposited at that time reflects largest distribution of the broad-leaved trees (pollen zones *Ulmus-Tilia-Alnus*, *Corylus-Ulmus*-Poaceae) in the area.

Transgression and regression of the Littorina Sea has significantly influenced the

mire development. Sediment sequences indicate the changes from lake to mire and back as in Sarnate several sections from the central and southern part of area, where two transgression waters of Litorina Sea were observed (KALNINA & PAKALNE 2003). During Littorina Sea regression phase the lagoon was cut off from the sea through the process of long-shore drift, the salinity of the water decreased progressively, the water level fell and the lagoon rapidly was divided into separate lakes. The gyttja layer formed in these shallow lakes. This produced pollen spectra with significant proportions of *Quercus* and *Alnus* pollen, and *Carpinus* (KALNINA 1998).

Sarnate Mire is a paleobotanically interesting place with a macrofossil record of *Trapa natans* in the gyttja under the fen peat. During the Atlantic Time *Trapa natans* grew in the lake and was used for food by Neolithic people. At this time it was situated on a narrow strip of land between three lakes, which at present are almost entirely terrestrialised.

The shallow lagoon lakes during the Subboreal Time were separated by low, paludified flat lands. Since the second part of the lakes have gradually terrestrialised and filled-in with fen peat and latter also raised bog vegetation. Raised bog vegetation occurs at that time in the northern part of mire.

The Subboreal was characterized by a warm, dry climate, and during this period the Sarnate lagoon lake became terrestrialised and fen vegetation developed. In the pollen diagram we may trace a significant increase in herb pollen, as well as the *Picea* maximum, indicating the Subboreal Time.

During the Subatlantic period, as the climate became cool and wet, the raised bog vegetation developed and *Sphagnum* peat formed in almost entire area of Sarnate Mire.

Pollen diagram from Sarnate Mire reflects vegetation development since the Boreal Time when pine forests were distributed in the area before the climatic maximum. The data obtained and compared with that from earlier studies allow us to find out that raised bog vegetation earlier developed in the northern part of the Sarnate Mire than in the largest par of area, which was occupied by lagoon during Littorina sea transgression phase. Fluctuating pollen curves indicate the impact on the vegetation by the Neolith man.

Nowadays, the largest part of the ancient lagoon area is replaced by raised bog although fen vegetation in Sarnate Mire although occurs as well, mainly in the area of the earlier lakes.

Raised bog vegetation dominated in Sarnate Mire and has typical hummock–hollow complex with *Sphagnum magellanicum*, *S. rubellum*, *S. fuscum* in the bryophyte layer. Hummocks are the driest place in the mire expanse and include *Calluna vulgaris*, *Oxycoccus palustris*, *Andromeda polifolia* and *Drosera rotundifolia*, *Empetrum nigrum*.

In the hollows *Rhynchospora alba* dominates and bryophytes, like *Sphagnum cuspidatum* and *S. tenellum* are common while *Scheuchzeria palustris*, *Rhynchospora alba* and *Drosera anglica* are typical vascular plants in these microhabitats. *Cladina stygia*, *C. nitis*, *C. portentosa* appear on higher hummocks. *Calluna vulgaris*, *Eriophorum vaginatum*, *Andromeda polifolia*, *Rubus chamaemorus* are common species in the mire. In lawns occasionally *Trichophorum cespitosum* occurs. *Pinus sylvestris* is scarce in the mire expanse.

Raised bog communities, like Sphagnetum magellanici, Empetro nigri–Sphagnetum fusci, Rhynchosporetum albae are common in Sarnate Mire.

The central part of Sarnate Mire is in a natural status, but the margins in some parts are influenced by drainage and due to the changes in hydrology soil erosion takes place. In areas with the influence from the artificial drainage the dense cover of *Calluna vulgaris* and the decrease of *Sphagnum* carpet are observed. Bryophyte species, like *Pohlia sphagnicola*, *Calypogeia sphagnicola*, *Kurzia pauciflora*, *Mylia anomala* become rare or disappear near the ditches. It results in the change and even degradation of the species composition of raised bog communities. Invasion of birch and pine takes place.

Fig. 13: Klani Lake.

Klani Mire Nature Reserve

Klani Mire Nature Reserve is situated in the Coastal Lowland geobotanical district. Klani Mire Nature Reserve with the total area of 1.615 ha is located in about about 9-12 km south from the coast of the Baltic Sea.

Klani Mires Nature Reserve includes two raised bogs (Klani Mire covers 442 ha, Punu Mire 325 ha), forests, meadows, rich and poor fens and Klani Lake (67 ha). Klani Lake (Fig. 13) is one of the few ancient lagoon lakes of the Littorina Sea in Latvia and is characterised by high species and habitat diversity.

According palynological analysis Klani Mire started to develop as a result of the terrestrialization of Klani Lake about 6000 years ago after the regression of the Littorina Sea. Klani Mire has originated from the coastal lagoon lake and therefore transgression and regression of Littorina Sea has significantly influenced mire development there.

Sediment layers at the lake bottom are represented by sand gyttja that has started to accumulate at the climatic optimum during the Atlantic Time. This is approved by pollen data indicating high values of *Alnus*, *Corylus*, and broad-leaved trees (*Ulmus*, *Tilia*, *and Quercus*). Towards the top of the peat layer, gyttja becomes rich in organic matter and contains a large number of the aquatic plant and un-differentiated herb pollen (Fig. 14). Presence of *Trapa natans* pollen at the late course of the climatic maximum is similar as in the Sarnate and indicates favorable growth conditions for *Trapa natans*, which was widely distributed in the lakes during end of the Atlantic Time.

During the Subboreal, under conditions of warm and dry climate the terrestrialisation of Klani Lake took place. Shallowest places of the lake have filled- in with *Carex* peat during that time. Pollen of aquatic plants as well as of broad-leaved trees decreased, but *Picea* was widely distributed in the forests. Ericales, mainly *Calluna vulgaris* increased as well as was *Juniperus* was present in the surrounding of the site. Sharp decrease in *Picea* and Ericales and increase in *Pinus* and *Betula* indicate the change of the climate and hydrological conditions towards the upper part of the section.

Presence of cultivated plant pollen (*Hordeum*, *Triticum*, *Cannabis* type) indicate human activities in the surrounding areas of the Klani Lake already since climatic optimum, when there were favourable conditions for growing of broad-leaved trees.

At present, development of mire vegetation can be still observed near Klani Lake where reed swamp and tall-sedge vegetation (Phragmitetum communis); fen vegetation (Caricetum rostratae, Caricetum lasiocarpae) is present. Fen vegetation leads into raised bog communities, like Sphagnetum magellanici, Eriophoro-Trichophoretum cespitosi, Empetro nigri-Sphagnetum fusci, Rhynchosporetum albae.

On sandy shores of Klani Lake plant communities with *Rhynchospora fusca* and *Eleocharis multicaulis* as well as *Lobelia dortmanna* are characteristic.

Klani Lake is the only locality of *Eleocharis multicaulis* in Latvia and one of the four of *Rhynchospora fusca*. *Eleocharis multicaulis* may formsalso mono-dominant growths near Klani Lake. Also *Myrica gale*, *Lythrum salicaria* and *Carex lasiocarpa* occur on lake shore.

The raised bog vegetation is characterized by bog pools and hollows. On raised-

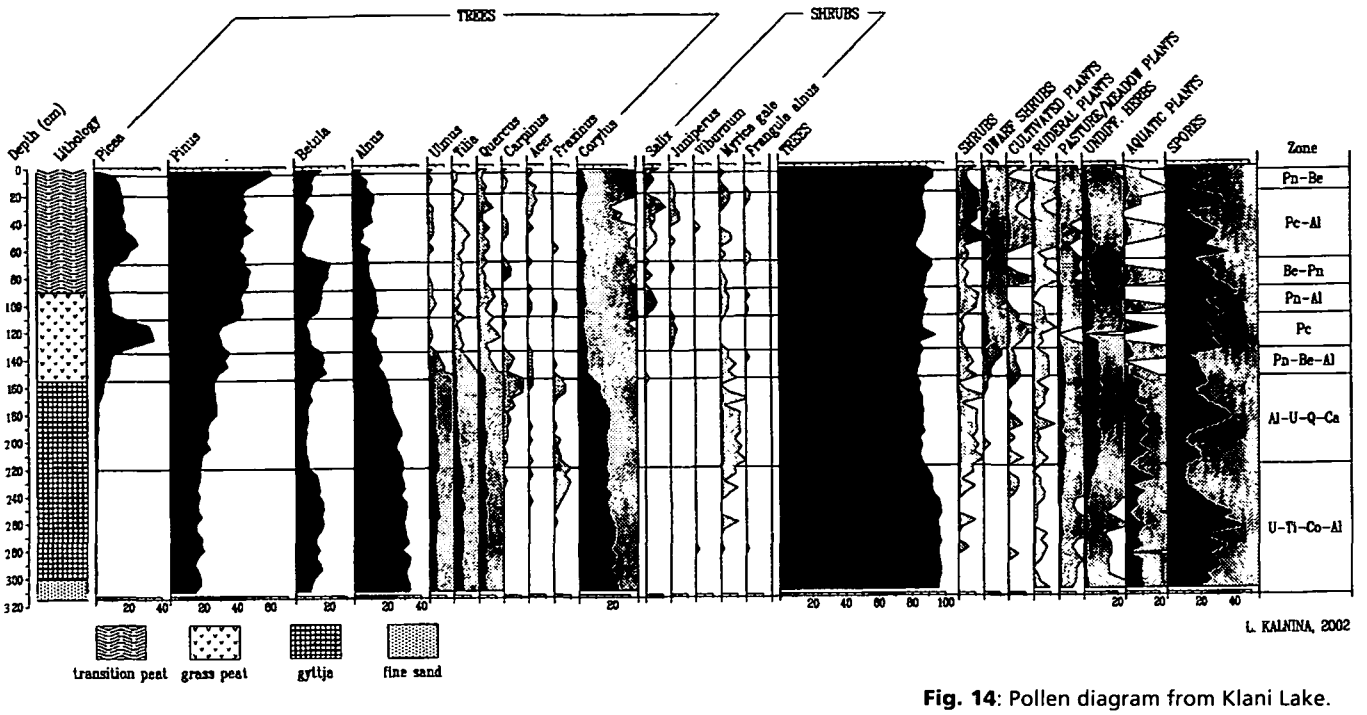


Fig. 14: Pollen diagram from Klani Lake.

bog hummocks *Calluna vulgaris*, *Ledum palustre*, *Rubus chamaemorus*, *Eriophorum vaginatum*, *Empetrum nigrum*, *Oxycoccus palustris* and *Drosera rotundifolia* occur in herb layer. *Sphagnum magellanicum*, *S. rubellum* and *S. fuscum* are the most common bryophytes; the other species on hummocks include *Dicranum affine*, *Pleurozium schreberii*, *Mylia anomala*, *Calypogeia sphagnicola*, *Kurzia pauciflora* and *Pohlia sphagnicola*. In hollows *Rhynchopora alba*, *Andromeda polifolia*, *Oxycoccus palustris* and *Drosera anglica* appear, while in the bryophyte layer *Sphagnum cuspidatum*, *S. flexuosum* and *Cladopodiella fluitans* are common.

Stikli Mires Nature Reserve

Stikli Mires Nature Reserve is the largest raised bog complex in the West Latvia geobotanic District. It includes five raised bogs. The largest raised bog is Stikli Dispurvs Mire with the total area of area of 724 ha. The others include – Vasenieku Mire (497 ha), Vanagu Mire (354 ha) and Zvagulu Mire (244 ha), Pumpuru Mire (283 ha). The raised bog vegetation has the hummock-hollow complex and the bog pool labyrinth. The bogs are mostly open with sparse pine belts on the bog 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. In bog hollows communities with Rhynchosporetum albae and Caricetum limosae occur. Transitional 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. The rare bryophytes *Bryum cyclophyllum* and *Sphagnum lindbergii* grow on this raised bog.

Drainage ditches in Vasenieku Mire still damage the mire hydrological regime. This has resulted in the degradation of the raised bog habitats on mire margins. In Vasenieku Mire the drainage ditches are even up to 2 m deep.

Raised bogs, forests and grasslands in the Slikli Mires Nature Reserve are important habitats for 24 protected bird species of Latvia – *Aquila pomarina*, *Crex crex*, *Cygnus cygnus*, *Ciconia ciconia C. nigra*, *Aquila pomarina*, *Grus grus*, *Pluvialis apricaria*, *Tringa glareola*, *Columba oenas*, *Circaetus gallicus*, *Numenius arquata*, *Circus pygarcus*, *Glaucidium passerinum*, *Pandion haliaetus*, *Aegolius funereus*, *Tringa glareola*, *Columba oenas*, *Glaucidium passerinum*, *Caprimulgus europaeus*, *Picoides tridactylus*, *Dryocopus martius*, *Picus canus* and *Lanius excubitor*. Stikli Mires Na-

Fig. 15: Satellite image from Engure Lake Ramsar site.

ture Reserve is considered as an important resting and overnight site for the migrating *Anser fabalis* /*A. albifrons* and *Grus grus* species.

Ramsar sites in Latvia

Currently there are 6 Ramsar sites in Latvia – Kanieris Lake, Engure Lake, Teici and Pelecare Bogs, Northern Bogs, Lubana Wetland Complex and Pape Wetland Complex.

Kanieris Lake

Kanieris Lake lies on the southwestern coast of the Gulf of Riga, in the Coastal Lowland. It is the largest lake in the Kemeri National Park, comprising 1.130 ha (OPERMANIS 1998). According to the geomorphologic features Kanieris Lake belongs to a coastal lagoon lake type. The lakebed is almost entirely covered by stoneworts *Chara* spp. During growing season, rich emergent vegetation (*Phragmites*, *Typha*) covers about 40% of the lake, which is surrounded by sedge meadows, fens, and both wet and dry coniferous forest.

Sulphur springs, rich fens and swamps occur near the lake. In the northern part of the lake very dense *Phragmites australis* stands occur, but in the western and southern parts they are separated by water. The eastern part is mainly open water.

In Kanieris Lake filling-in of *Cladium mariscus* vegetation forming large stands (Cladietum marisci). Rich fen vegetation Schoenetum ferruginei and Caricetum lasiocarpae occurs there as well. The rich fen vegetation includes *Schoenus ferrugineus*, *Primula farinosa*, *Pinguicula vulgaris*, *Epipactis palustris*, *Carex panicea*, *C. hostiana*, *C. buxbaumii*, *Scorpidium*, *scorpioides*, *Fissidens adianthoides*, *Campylium stellatum*, *Calliergoinella cuspidata* and *Drepanocladus revolvens*.

Kanieris Lake is recognised as one of the most important coastal wetlands in Latvia and has been identified as an internationally significant nature conservation area by HELCOM, the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF) and BirdLife International. The territory supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plants including *Allium schoenoprasum*, *A. ursinum*, *Carex buxbaumii*, *C. scandinavica*, *Ceratophyllum submersum*, *Cladium mariscus*, *Dactylorhiza incarnata*, *Dentaria bulbifera*, *Lemna gibba*, *Liparis loeselii*, *Najas marina* and *Schoenus ferrugineus*, *Ophrys insectifera*, *Liparis loeselii*, *Potentilla anglica*, *Carex reichenbachii*, *Dactylorhiza incarnata*, *Epipactis palustris* and *Schoenus ferrugineus*.

The site regularly supports substantial numbers of moulting and breeding waterfowl. These include nesting *Podiceps cristatus*, *P. grisegena*, *Botaurus stellaris*, *Ixobrychus minutus*, *Ciconia nigra*, *Cygnus olor*, *Anser anser*, *Anas crecca*, *A. platyrhynchos*, *A. strepera*, *A. querquedula*, *A. clypeata*, *Aythya ferina*, *A. fuligula* and *Circus aeruginosus*, the globally threatened *Haliaeetus albicilla and Crex crex*, *Grus grus*, *Porzana porzana*, *P. par-*

va, Fulica atra, Philomachus pugnax, Larus ridibundus, Sterna hirundo, Bubo bubo and *Ficedula parva*.

Engure Lake

Engure Lake covering 3.500 ha (OPERMANIS 1998) is located in the western part of Latvia, in the Coastal Lowland geobotanic district. Engure Lake is situated at the western coast of the Gulf of Riga, from which it is separated by 1.5 to 2 km wide dune area. Protected nature area was established there in 1957 but the status of the Ramsar site Engure Lake obtained in 1995. The lake is included in the List of Important Bird Areas with the total area of 11.433 ha.

It is the largest relict lake in the coastal area and has remained there since the Littorina Sea time (Fig. 15). During the first and the second regressions, a 20 km long sandy buried split with dunes separated a wide inlet from the open sea (EBERHARDS & SALTUPE 2000).

Engure Lake is connected to the Gulf of Riga through the canal that was built in 1842. Construction of this canal lowered the water level for 1.5 m and the area and depth of Engure Lake abruptly decreased, causing the terrestrialisation of the free from water areas. The area of Engure Lake was reduced from around 90 km? to 45-52 km?.

Reedbeds formed by *Phragmites australis, Typha angustifolia, Scirpus lacustris* and rich submerged vegetation dominate in the lake. Also *Cladium mariscus* and *Myrica gale* occurs on lake shores.

The silty lake-bottom is covered with algae (stonewort *Chara*). Engure Lake is shallow, filled with organic deposits, with the depth which during the growing season does not exceed 2.5 m. To the west of the lake, there is a 1-3 km wide zone of wet, mixed forest. To the east, there are *Pinus* forests between the lake and the sea. In the lower depressions rich fen vegetation with *Schoenus ferrugineus* has been developing since 1842 when the water level in Engure was lowered.

The rich fen vegetation surrounding Engure Lake is characterized by high species diversity and includes tall-sedge vegetation as well as rich fens.

Fig. 16: Rich fens near Engure Lake.

After the lowering of the water level in 1842 on higher ridges of the exposed area *Pinus sylvestris* forest started to develop while in lower areas extremely rich fen vegetation with *Schoenus ferrugineus* originated between the former coastal formations of the Litorina Sea.

In the western part of the in the terrestrialised area of Engure Lake rich fens with have developed on more thick peat layer than in the eastern part where they are located in the depressions of the ancient formations of the Littorina Sea on the on lake sediments.

Schoenus ferrugineus tussocks is a common feature in this rich fen vegetation which in places have united forming larger hummocks where bryophytes such as *Campylium stellatum, Calliergonella cuspidata* and *Scorpidium scorpioides* are common (Fig. 16).

Rich fen community Schoenetum ferruginei is most typical in the area surrounding Engure Lake (PAKALNE 1994). *Schoenus ferrugineus* often is together with *Phragmites australis* and other species, like *Primula farinosa, Epipactis palustris, Carex panicea, C. flacca, Dactylorhiza incarnata, D. cruenta, Liparis loeselii, Parnassia palustris, Pinguicula vulgaris, Ophrys insectifera* and *Equisetum variegatum*. In the bryophyte layer *Scorpidium scorpioides, Campylium stellatum, Calliergonella cuspidata, Fissidens adianthoides, Bryum pseudotriquetrum, Preissia quadrata, Riccardia multifida* and *Aneura pinguis* appear. Bryophyte species, such as *Moerckia hibernica* firstly was found in Latvia near Engure Lake in the rich fen. It is still one of the few known habitats of this species in Latvia.

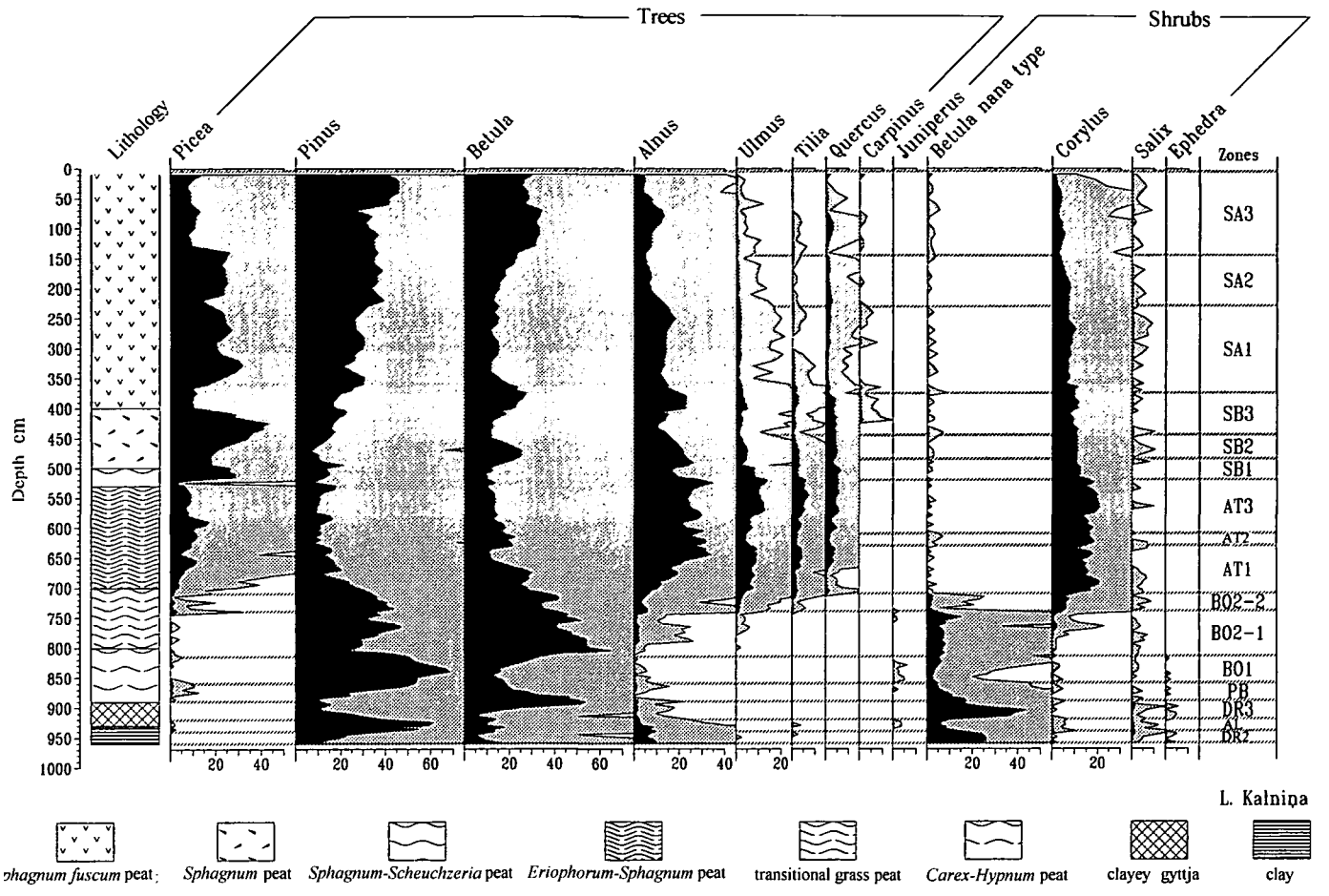


Fig. 17: Pollen diagram from Teici Mire.

The lake itself and the surrounding buffer zone meets all the requirements of the Ramsar convention: holds high biodiversity (more than 800 vascular plant species, 170 nesting bird species), high number of threatened species (40 threatened vascular plant species, 2 bird species globally threatened, 38 bird species threatened in Europe), holds simultaneously much more than the necessary 20.000 specimens of waterfowl, represents a specific group of water bodies, i.e. remnants of Littorina Sea being at the same time unique as the only of them still relatively unpolluted.

Teici and Pelecare Mires

Teici and Pelecare Mires are located in the East Latvia geobotanic district. The total area of the Ramsar site reaches 24.000 ha. The mires are a part of the Teici Nature Reserve with the total area of 19.047 ha. The area is recognized as an IUCN Management Category I: a protected area managed mainly for science or wilderness protection (BERGMANIS 1996).

Teici Mire is a typical raised bog of eastern type. Raised bog vegetation is most common, fens occur fragmentary, mainly near lakes and on mire margins. Its origin has begun already in the Preboreal and had passed the minerotrophic phase of mire development to reach the ombrotrophic phase of a raised bog (LACIS & KALNINA 1998). During the Atlantic period, raised bogs had already developed in the large mire complexes, but during the Subatlantic they also developed in the smaller ones. Teici Mire has developed both as a result of lake terrestrialization and ground paludification.

The base of the raised bogs formed about 10.000 years ago during the de-glaciation phase of the latest ice age. Peat formation started some 8000 years ago. Sand and gravel and lacustrine clay underlie the peat layer, which has a mean depth of 3.5 m (with a maximum peat layer of 9 m). Today all 19 larger bog lakes cover more than 400 hectares. The bog is situated in an elevated position between the Rivers Daugava and Aiviekste and therefore the direction of all

water flow is out of the bog. The site fulfils an important role in groundwater filtration, and in providing local hydrological stability. The climate is continental when compared to other parts of Latvia.

Teici Mire is a typical raised bog of eastern type. Its origin has begun already in the Preboreal and had passed the minerotrophic phase of mire development to reach the ombrotrophic phase of a raised bog (LACIS & KALNINA 1998). During the Atlantic period, raised bogs had already developed in the large mire complexes, but during the Subatlantic they also developed in the smaller ones.

During the final stage of Late Glacial, dead ice blocks covered the area of Teici Mire (ZELCS et al. 2003). After complete melting, about 12.000 years ago, the glacier and its melting waters had left an undulating relief in the area with well distinguished hollows and ridges. The position of different events is regarded as rough estimations using pollen data. The diagram obtained from spore-pollen data (LACIS & KALNINA 1997, 1998) reveals that sand and clay in the mire bottom have accumulated during the older Dryas (DR2) period under arid and cold subarctic climatic conditions (Fig. 17). Dominance of *Betula nana* and *Artemisia* pollen, *Bryales* spores as well as presence of *Ephedra* and *Selaginella* are noticed.

About 10.300 years ago at the beginning of the Preboreal, climate became milder and in the bottomland sites around lakes and in other depressions fen peat and gyttja started to accumulate in narrow zones. It is formed by plant remnants that have been growing under excess humidity. *Hypnum*, *Carex*- Poaceae, *Carex*- Poaceae-*Hypnum*, more seldom wood- *Carex*- Poaceae and wood peat cover the mineral bottom of the depressions, the absolute elevation of which ranges within 95-103 m a.s.l. In the surrounding area very scanty woodland dominated.

About 9000 years ago when the Boreal climate became warmer and less humid, the ground-water level lowered (LACIS & KALNINA 1998). The mire vegetation was fed more by precipitation. The eutrophic plant species were gradually replaced by mesotrophic ones. *Hypnum* moss was replaced by *Sphagnum* species, *Eriophorum vaginatum* appeared. In the woody stands *Pinus* became important, then alder and some broad-leaved trees appeared on the mire margins. The mire rose vertically and water streamed away to its edges promoting a horizontal widening of the bog and paludified the lowest sites (100-104 m a.s.l.). Lake terrestrialisation started on silty gyttja. Transitional peat is formed by well-decomposed (36%) grass-*Sphagnum* peat, where *Sphagnum angustifolium*, *S. fuscum* and *S. subsecundum* comprise 35-80 %. According to the pollen data, the upper limit of Boreal is marked in pollen diagram by a sharp raise of *Alnus* and *Ulmus* pollen curves that demonstrates significant changes in regional vegetation.

About 7400 years ago the climate changed and warm and humid Atlantic climatic conditions commenced. In the central areas of the mire where 2-3 m thick layer of peat had accumulated ombrotrophic vegetation developed.

During the Atlantic Time a 1-2 m thick layer of *Eriophorum-Sphagnum* peat accumulated, where *Sphagnum* residues comprised 55-70 % in the peat. Pollen data indicates more favourable climatic conditions for upsurge of broad-leaved trees in the region. Although, during the Atlantic Time, particularly during its second part, the raised bog conditions and microclimate in the mire had already formed and regional climate and vegetation changes did not effect the mire vegetation. Such feature allows explaining also the maintenance of *Betula nana* through the Atlantic climatic optimum until the present time.

The Subboreal set in before 4800 years ago, when climate became slightly cooler and in the surroundings of the mire spruce forests became dominant. During this period *Sphagnum* and *Eriophorum* basically formed bog vegetation that produced *Sphagnum magellanicum* peat. In this period an intensive accumulation of peat occurred all over the mire.

About 3000 years ago the climate became cooler and more humid. During the Subatlantic Time *Sphagnum fuscum* peat developed, occupying the upper part of peat.

Sphagnum fuscum constitutes 45-90 % the residue of peat. The other part of peat consists of *Sphagnum angustifolium* and *S. magellanicum* remnants and *Eriophorum*. *Sphagnum fuscum* peat occupies a layer of 3-6 m. During the Subatlantic Time raised bogs became dynamic systems, growing rapidly in both vertical and horizontal directions, exerting considerable effect on dynamics of the landscapes with 3-6 m high domes in central part of some mire.

During the Subatlantic period smaller mires joined together and some lakes became terrestrialised. Filling-in of the lakes was facilitated by their disposition close to the bog's edge, and they received waters rich in mineral substances. In those areas transitional *Sphagnum angustifolium* peat covers the gyttja.

The most typical mire communities are representative of the *Oxycocco-Sphagnetea* and *Scheuchzerio-Caricetea fuscae*. The raised bog vegetation dominated, fens occur mainly near lakes where terrestrialisation processes take place.

Teici Mire supports an appreciable assemblage more than 20 rare or threatened plant species of Latvia. *Betula nana* grows near the bog lakes and near bog pools. *Salix myrtilloides* occurs in transitional mires. *Nymphaea alba* and *N. candida* are associated with lakes. *Utricularia ochroleuca*, *Carex heleonastes*, *Liparis loeselii*, *Hammarbya paludosa*, *Carex aquatilis*, *Dactylorhiza incarnata*, *D. maculata*, *Sphagnum subnitens*, *Helodium blandowii*, *Cynclidium stygium* and *Scapania irrigua* grow in fens and transition mires. *Corallorhiza trifida*, *Eriophorum gracile*, *Drepanocladus vernicosus* and *Preissia quadrata* occur in fens. *Sphagnum molle*, *Calypogeia sphagnicola* and *Sphagnum papillosum* grow in raised bog vegetation (BAMBE 1993).

The Mire is particularly good representative example of a near-natural bog. The site plays a substantial hydrological biological and ecological role in the natural functioning of its locale. Teici Mire is the largest intact raised bog in the Baltic region.

Teici Mire is especially rich in wetland bird species: both quantitatively and qualitatively. It is a highly significant area for birds, not only in Latvia but also in Europe. Great numbers of bird species breed there. For some bird species Teici Mire is one of the most important nesting sites in Latvia. The area also supports an important assemblage of nesting birds, including a number of species of European conservation concern (e.g. *Gavia arctica*, *Ciconia nigra*, *Circaetus gallicus*, *Aquila pomarina*, *Grus grus*, *Tetrao tetrix* and *Limosa limosa*. The territory regularly supports substantial numbers of individuals of waterfowl. More than 8.000 geese and 1,200 cranes use the site during their migration. Most of the rare and important bird species breed at the bog pools. Dominant species there are *Anthus pratensis*, *Alauda arvensis*, *Anthus trivialis*, *Saxicola rubetra* and *Fringilla coelebs*.

Northern Bogs

Northern Bogs (Kodu Mire and Saklaura Mire) are located in the North Vidzeme Biosphere Reserve. They include two raised bogs with the total area of 5.318 ha. Kodu Mire is the largest mire in the North Vidzeme Biosphere Reserve. The northernmost part of the mire is about 1 km from the Estonian mire reserve Nigula. It is an open raised bog, with a large bog lake in the middle of the mire, surrounded by a bog pool labyrinth and hummock-hollow complex. Small mineral islands within the bog are covered with pine forest. Transitional mire vegetation is characterised by Caricetum lasiocarpae and Caricetum rostratae occurring on the mire margin.

Raised bog species include *Calluna vulgaris*, *Rubus chamaemorus*, *Eriophorum vaginatum*, *Drosera rotundifolia*, *Oxycoccus palustris* and *Andromeda polifolia* accommpanied by typical bryophytes, such as *Sphagnum magellanicum*, *S. rubellum*, *S. fuscum*, *S. angustifolium*, *Mylia anomala*, *Kurzia pauciflora*, *Polytrichum juniperinum*, *Aulacomnium palustre* and *Pleurozium schreberi*. The most common mire communities are Sphagnetum magellanici on hummocks and lawns and Empetro nigri–Sphagnetum fusci on hummocks. Rhynchosporion communities (Rhynchosporetum albae, Sphagnetum cuspidati) occur in bog hollows. Kodu Mire supports the rare plant species *Trichophorum cespitosum*, forming a good example of Eriophoro vaginati–Trichophoretum cespitosi

community characteristic for this western raised bog type.

Saklaura Mire is a typical raised bog, comprising two bog lakes – Lielezers Lake (170 ha) and Mazezers Lake (25 ha) and a labyrinth of bog pools. Raised bog vegetation includes mainly Sphagnetum magellanici, Empetro nigri– Sphagnetum fusci and Rhynchosporetum albae. Species diversity is supported by a number of lichen species, for example, *Cladina rangiferina*, *Cladonia sylvestris* and *Cladonia stellaris*, sometimes occurring in great abundance. It differs from the other mires of the North Vidzeme Biosphere Reserve owing to the presence of species both of northern and north-eastern distribution, *Betula nana*, and species of western distribution in Latvia, *Trichophorum cespitosum*.

Northern Bogs are one of the most valuable mires in Latvia, both from the point of view of mire vegetation and bird species. The raised bogs are characterised by large bog pools. Protected plant species, like *Trichophorum cespitosum* and *Dactylorhiza incarnata*, as well as *Betula nana* are known there, as well as protected bryophytes, such as *Calypogeia sphagnicola*. Northern Bogs is an Internationally Important Bird area (RACINSKIS & STIPNIECE 2000).

Northern Mires are a part of a UNESCO Biosphere Reserve. They support an appreciable assemblage of rare, vulnerable and endangered species of birds and plants, some of them occurring in great numbers or densities especially during migration. In autumn, at least 10.000 *Anser fabalis* and *A. albifrons* are roosting. Breeding species include *Circus pygargus*, *Falco columbianus*, *Grus grus* and *Philomachus pugnax*.

Pape Wetland Complex

The total area of Pape Lake and Nida Mire reaches 6.800 ha (OPERMANIS 1998) but that of Pape Lake comprises 1.200 ha. Pape Lake and Nida Mire are included in the Internationally Important Bird areas (RACINSKIS & STIPNIECE 2000).

The Pape Wetland is unique in the diversity of ecosystems concentrated in relatively small territory, including coastal lagoon, oligo-mesotrophic waters, natural eutrophic lakes, coastal dunes and raised bogs. The area is an internationally significant breeding, migrating and wintering site for birds.

Pape Lake and Nida Mire Complex is situated in the very south-western part of Latvia. The area has a high natural history value, representing the Baltic Sea development history records in detail from the very beginning of the Littorina transgression up to the present day. A series of more ancient Baltic Ice Lake coastal terraces and accumulative landforms are located in the neighbourhood of the mire and the lake, subdivided by ancient mires, which are partly buried by the Litorina Sea and present dunes.

Pape Lake and Nida Mire represent the southern part of a large terrestrialised Littorina coastal lagoon chain that extends along the entire Latvian coast of the Baltic Sea.

The area comprises raised bog, transitional mire and fen vegetation. Part of Nida Mire includes a considerable area of rich fen vegetation dominated by Caricetum lasiocarpae, C. diandrae and includes a large population of *Dactylorhiza ochroleuca*. Amongst the bryophytes Scorpidium *scorpioides*, *Drepanocladus revolvens* and *Campylium stellatum* are in great abundance.

Raised bog vegetation of Nida Mire is represented mainly by Sphagnetum magellanici on hummocks and Rhynchosporetum albae in hollows. The species diversity is supported by diverse lichen species. A lawn community with *Trichophorum cespitosum* occurs there. Transitional mire communities are characterised by the dominance of *Carex rostrata* and *Sphagnum flexuosum*.

Fens near Pape Lake contain Caricetum elatae, Caricetum distichae, Caricetum rostratae and Caricetum lasiocarpae. Other communities with *Cladium mariscus* and *Myrica gale* cover large areas around the margins of Pape Lake.

The narrow strip of land between Lake Pape and the sea is important for migratory birds such as the goose *Anser fabalis* and supports thousands of bats, notably the *Myotis dasycneme*. The site is an important place for other species considered as vulnerable or en-

dangered within international frameworks like *Lynx lynx*, *Castor fiber*, *Lutra lutra* and *Lampetra fluviatilis* .

Lubana Wetland Complex

The Lubana Wetland Complex (48.020 ha) is located in the Eastern Latvia and the largest wetland in Latvia, with a shallow freshwater lake – Lubana Lake, seven raised bogs, transition mires and fens, inundated grasslands, fishponds and wet forests. Lubana Lake, the largest lake in Latvia (80.7 km^2) is a part of this complex. Lubana Wetland Complex and includes good examples of almost all types of wetlands found in Latvia – raised bogs, transition mires, fens, wet forests, river floodplain meadows and lakes, where a wide range of plant communities occurs.

The most valuable mires of this complex are Lagazu-Snitku Mire, Berzpils Mire, Sala Mire and Lubana Mire. Large open raised bogs, bogs covered with pine and diverse minerotrophic mires support a high diversity of plant species, including rare ones. Hummock-hollow complex, bog pools and lakes occur in the raised bogs of the Lubana Mire Complex. Mire margins and mineral islands covered with forest are characteristic of some of the mires.

Mires in the around the Lubana Lake have originated due to the terrestrialisation of shallow water basins that remained from the ancient Lubana basin formed by glacier and its melting waters. Bottom of this ancient lake was very undulate and usually were covered by lake sediments – clay and gyttja. Filling-in of the basins took place in different times starting from the Boreal to the Atlantic Time. The favourable conditions for mire formation (relief, low permeable sediments and relicts of shallow glacier melting water basins in the depressions, as well as, warm and wet climate) in the surroundings of the Lubana areas resulted filling-in of shallow water basins and fen development in the Berzpils Mire (at the end of the Boreal) and in the Lielais Mire area (at the very beginning of the Atlantic Time). At the end of the Atlantic Time both the raised bogs occupied large area. The fen peat has been gradually replaced by raised bog peat (LOSANS 2004).

The eastern bog community Chamaedaphno–Sphagnetum magellanici occurs there, characterised by the presence of *Chamaedaphne calyculata*. Plant species with northern and north-eastern distribution, for example, *Salix myrtilloides* and *Nuphar pumila* also grow in these mires.

Lubana Wetland Complex supports a wide range of protected plant species of Latvia, like *Platanthera bifolia*, *Salix myrtilloides*, *Nuphar pumila*, *Hammarbya paludosa* and bryophytes including *Sphagnum lindbergii* (one of the few known species localities in Latvia).

The site is important for maintaining bog-specific and rare bird species and wetland characteristic plant species and communities. More than 26,000 waterfowl birds rest in the area during spring migrations. The site supports some particularly protected bird species like *Haliaeetus albicilla*, *Aquila clanga*, *Gallinago media*, *Crex crex* and protected mammals such as *Castor fiber*, *Lutra lutra*, *Canis lupus*, *Ursus arctos* and *Lynx lynx*.

Zusammenfassung

Moor-Ökosysteme in Lettland – In Lettland bedecken Moore 4.9 % der Landesfläche. Zu den Torflagern, das sind Torfvorkommen, die größer als 1 ha sind und eine Torftiefe von 30 cm überschreiten, gehören neben den Mooren mit mächtigen Torfschichten auch manche Waldtypen, entwässerte Moore und Torfstiche.

In Lettland gibt es sowohl minerotrophe Moore (Nieder- und Übergangsmoore) als auch ombrotrophe Moore (Hochmoore). Sie sind im gamzen Land verbreitet, allerdings ist ihre Größe in Abhängigkeit von der regionalen Verbreitung sehr verschieden. Die Moorverbreitung und die Diversität der Moorvegetation werden durch die geologischen Verhältnisse ebenso bestimmt wie von der Art der Moorbildung selbst und den Unterschieden zwischen dem ozeanischen Klima im küstennahen Bereich und dem kontinentalen Klima im Landesinneren.

Im Tiefland und in den kleinen Karstdepressionen des Hochlandes begannen sich die Niedermoore im frühen Holozän – dem Praeboreal etwa 10.000 Jahre vor heute – zu

entwickeln. Im Atlantikum wurden aus vielen Niedermooren dann Übergangs- bzw. Hochmoore. Etwa 35 % der Moore entstanden aus Verlandungen, viele aber auch aus Versumpfungsprozessen. Während des Boreals, als das Klima langsam wärmer wurde, stieg auch die Moorbildungsrate deutlich an und in den größten Mooren, wie z.B. im Kemeri-Moor oder im Teici-Moor, begann sich zu diesem Zeitpunkt die Hochmoorvegetation zu entwickeln, aber die Phase der stärksten Moorentwicklung in Lettland war das Atlantikum. Während dieser Zeit spielte das Littorina Stadium der Ostsee mit seinem 5-6 m höheren Wasserspiegel als heute eine bedeutende Rolle; große Küstengebiete lagen damals unter dem Meeresspiegel. Die Schwankungen und schließlich der Rückzug der Littorina See hinterließen Flachwasserlagunen, aus denen sich in der Folge Moore entwickelten (z.B. das Sarnate-Moor, die Bereiche um Kanieris, Engure und die Babite Seen).

Die lettischen sind Moore in unterschiedlichen Kategorien geschützt: Im Nördlichen Vidzeme Biosphärenreservat, in Nationalparks (Slitere, Kemeri und Gauja), in strengen Naturschutzgebieten (Teici, Krustkalni und Grini), Naturparks, Naturreservaten und Landschaftsschutzgebieten. Darüberhinaus gibt es in Lettland sechs Ramsar-Gebiete – der Kanieris See, der Engure See, Teici und Pelecare Hochmoor, die Nördlichen Moore sowie die beiden Feuchtgebietskomplexe Lubana und Pape. Immerhin gibt es in Lettland noch ursprüngliche, unberührte Moore und die meisten davon – etwa 12 % der lettischen Moore – stehen heute unter statlichem Naturschutz. Andererseits sind etwa die Hälfte aller Moore durch die verschiedensten menschlichen Einflüsse wie Torfstich, Entwässerung, Feuer und Eutrophierung geschädigt, und ihre Zerstörung durch Entwässerung geht immer noch weiter.

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