LITHUANIAN FUND FOR NATURE

The International Workshop

BEST EXPERIENCES IN CONSERVATION AND RESTORATION OF HABITATS IN RAISED BOGS AND MIRES.

KNOWLEDGE TRANSFER TO AUKŠTUMALA RAISED BOG

ABSTRACTS

The Workshop is financed by the EU LIFE+ programme in frame of the project "Restoration of Aukstumala Raised Bog in Nemunas Delta Regional Park (AUKŠTUMALA LIFE12NAT/LT/000965)."
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Vilnius, 2014
The International Workshop

*Best experiences in conservation and restoration of habitats in raised bogs and mires. Knowledge transfer to Aukštumala Raised Bog*

Abstracts

11–13 June, 2014, Šilutė, Lithuania

**Editor** Jūratė SENDŽIKAITĖ

The International Workshop organized by
Lithuanian Fund for Nature

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WELCOME MESSAGE

KNOWLEDGE FOR BRINGING LIFE BACK TO AUKSTUMALA RAISED BOG

In the end of 19th century German botanist C.A. WEBER did a detailed research on the vegetation and the development of the Aukštumala raised bog and published the first scientific monograph in the world about raised bogs (WEBER, 1902: Über die Vegetation und Entstehung des Hochmoors von Augstumal im Memeldelta mit vergleichenden Ausblicken auf andere Hochmoore der Erde). Due to this monograph and its translation into English (COUWENBERG & JOOSTEN, 2002) Aukštumala raised bog became a locus classicus of peatland science and one of the most known wetlands, especially among those who are interested in peatlands. Even today this monograph retains its importance for understanding the main trends in peatland ecology of the 21st century.

However popular monograph did not protect the bog against negative impact of human activity. More than one hundred years on-going peat extraction did change the life of the bog. 2/3 of the former bog was drained for mechanized peat-cutting. In 1995 Lithuanian society made efforts to establish a telmological reserve in the unexploited western part of the bog to protect and restore remaining values of the bog. This is possible since Lithuanian scientists researched the bog and identified its values and estimated anthropogenic disturbances, which interfere natural development of the bog.

International Workshop on “Best Experiences in Conservation and Restoration of Habitats in Raised Bogs and Mires: Knowledge Transfer to Aukštumala Raised Bog” was organised as part of on-going LIFE+ project Restoration of Aukstumala Raised Bog in Nemunas Delta Regional Park (LIFEAUKSTUMALA LIFE12NAT/LT/000965. More than 50 participants from Baltic Sea region came to the seminar; lecturers from Lithuania, Latvia, Estonia, Finland, Denmark, Germany, Poland, Russia, and Belorussia did 20 presentations on best bog restoration experience, which will be applied in Aukstumala raised bog for establishment of necessary conditions to restore and maintain favourable status of the bog.

Organisers of the seminar expect that during seminar established group of experts and Lithuanian specialists will effectively continue the thread of international Aukstumala researches and save the history of researches of this unique wetland and successive evolution for future generations.

Dr. Romas Pakalnis
On behalf of the Workshop Organizing Committee
LIFE+ PROJECT “RESTORATION OF AUKSTUMALA RAISED BOG IN NEMUNAS DELTA REGIONAL PARK (LIFEAUKSTUMALA LIFE12NAT/LT/000965)”

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A project on reducing impact of drainage system in the Aukstumala Telmological Reserve was a necessity, which was identified by Lithuanian scientists many years ago. Researches on radial pine growth (PAKALNIS et al., 2008) clearly showed that peat-mining fields, which border the Reserve extract huge amounts of water, therefore degradation of the bog appears within entire border zone. Network of draining ditches, which concentrate in the eastern and northern parts, also in other parts of the Reserve, removes vast amounts of water from the bog. Even very old ditches, established in the end of 19th century still are functioning and do further harm the bog.

In 2006 the isolation layer of polyethylene membrane was placed in the eastern part of the Reserve, 4 composite dams and amount of smaller peat and plank dams were installed in ditches. However this was not enough to stop negative impact, as it was clear that much more dams are needed to keep water in the bog.

Therefore in 2012 Lithuanian Fund for Nature prepared LIFE+ project „Restoration of Aukstumala Raised Bog in Nemunas Delta Regional Park (LIFEAUKSTUMALA LIFE12NAT/LT/000965)“, which aims at restoration of natural hydrological regime in the Telmological Reserve; establishment of favourable conditions for conservation of active raised bogs (7110*), which predominate in the Reserve; establishment of preconditions for conversion from degraded raised bogs (7120) into active bogs; support good status of natural dystrophic lakes (3160), which amounts to 382 water bodies.

The main task is to install number of dams to block water outflow in at least 70 km of draining ditches and 10 km of main ditches. This action will raise water level within entire
Reserve, thus improving status of habitats, enforcing *Sphagnum* growth, and stopping degradation of the bog. Instalment of different types of dams: plastic, peat, composite dams are foreseen in the application. Precise number of dams and type will be defined in the technical simplified construction project of restoration of natural hydrological regime in Aukštumala Telmological Reserve.

Removal of invading bushes and trees from overgrown bog areas within 100 ha area will complement damming action. Part of felled trees and bushes will be put into ditches to foster overgrowth. All conservation actions will be defined by the Reserve management plan.

International group of experts will be established for exchange of information and advices for the project area, but also for other raised bogs in Lithuanian and Baltic region. Set of education activities will be performed within the project: reconstruction of education path, training of local nature guides, and exhibition about the bog in Nemunas Delta Regional Park visitors’ centre. Study tours to other countries will be performed to gather experience. Workshops will be organised in Lithuania, where experts from other countries will be invited to share best experiences. The first Workshop will be held in 2014.

Famous monograph of C.A.Weber (*Über die Vegetation und Enstehung des Hochmoors von Augstumal im Memeldelta mit vergleichenden Ausblicken auf andere Hochmoore der Erde*) will be translated into Lithuanian. So far, only English translation of this valuable book was made, however this book must be introduced to Lithuanian society to acknowledge more than hundred years long history of wetland research.

The project will be implemented in the period of 2013–2017 in cooperation with project partners: Administration of Nemunas Delta Regional Park, Amphi Consult (Denmark) and Silute Forestry Enterprise.

The total budget of the project is 733 077 EUR, 75% of which is co-financed by EU LIFE+.
Peatlands in Lithuania cover about 646,000 ha; however, only 178,000 ha could be considered as undisturbed. In the Nemunas delta region (Western Lithuania), large-scale land reclamation works were implemented already in the 19th century. Therefore, natural fens are almost absent in this area and most of large raised bogs such as Aukštumala are strongly affected by drainage. Currently, about 2/3 of Aukštumala raised bog have been turned into the peat mining fields and the rest part has been declared as the Thelmological Reserve (1,017 ha). Although the status of the Reserve prevents the western part of Aukštumala raised bog from further peat mining, it does not protect this area from negative influence of draining. Aukštumala is the first raised bog in the world described in the monograph (Weber, 1902).

Five habitats of EU importance and 210 plant species were inventoried in the Reserve’s territory in 2012. It was ascertained that 40% (237 ha) of the Reserve’s habitats are significantly modified or degraded and not meet the requirements for the habitats of European importance. These belt-shaped habitats (40–500 meter wide) with dominating woody vegetation occur on margins of the Reserve, where anthropogenic activities (drainage network, peat mining, ect.) were most intensive.

The largest area of the Reserve is occupied by the habitats of Active raised bogs (7110*) – 47% (605 ha), which are mostly found in the central and western part of the Reserve. This habitat type is represented by the communities of the Ass. Sphagnetum magellanici and characterized by treeless plant communities with well-expressed Sphagnum moss and herb coverage. The ground water in active raised bogs is constantly high and rarely decreases less than 30 cm below the peat surface.

Degraded raised bogs (7120) are mostly found in the edges of the Reserve, places, which are adjacent to peat mining fields and territories, which were drained by the ditches. Due to low ground water level (>50 cm below the surface of the peat) and accelerated mineralization, trees and shrubs are abundant in this zone, whereas the moss layer is sparse. Pinus sylvestris, Ledum palustre and Vaccinium vitis-idaea are the main vegetation components here, leading to
identification of this vegetation type closest to Ass. *Ledo-Sphagnetum magellanici*. Degraded raised bogs occupy 12% (161 ha) of the Reserve’s territory.

*Bog woodlands* (91D0*) cover less than 1% of the Reserve’s territory. These woodlands penetrate to the active raised bog habitats, where the layer of peat is thinner and more mineralized.

Aukštumala raised bog is famous for the abundance of *Natural dystrophic lakes* (3160). Although there are 380 lakes counted of various size (the biggest 0.20 ha) and ecological conditions, they overall cover only 1% of the Reserve’s territory. Dystrophic lakes are mostly found in the surroundings of *Active raised bogs* and *Bog woodlands* in the eastern and western part of the Aukštumala. Some small fragments (<0.1 ha) of *Depressions on peat substrates of the Rhynchosporion* (7150) were identified in the areas affected by the fire of 2011.

Five redlisted plant species were recorded in the Reserve’s territory: *Erica tetralix*, *Trychophorum cespitosum*, *Carex magellanica*, *Nymphae alba* and *Sphagnum imbricatum*. Aukštumala is the only raised bog in Lithuania, where *Erica tetralix* and *S. imbricatum* can be found.

Research results will be used to develop the Nature Management Plan of Aukštumala Telmological Reserve. It will include measures aimed to reduce the impact of anthropogenic activities to raised bog ecosystem (to restore a hydrological regime, to increase the area of active raised bog at the expense of degraded bogs, to cut trees and shrubs in flooded areas, etc.).

**PREVIOUS EFFORTS ON REDUCTION OF PEAT MINING IMPACT IN AUKŠTUMALA RAISED BOG**

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The raised bog of Aukštumala is one of the first commercial mining peat lands in Lithuania since the end of the 19th century. Aukštumala is a *locus classicus* of peat land science because it
is the first raised bog in the world described in the monograph (Weber, 1902). This monograph demonstrates an understanding that peat mining will provoke negative impact on the natural peculiarities of raised bog.

At first, peat mining was carried out manually in almost undrained Aukštumala peat bog. The greatest changes took place in 1968, when protective embankments, water pumping stations, roads, canals and ditches were built, large area (2/3 of total bog) was drained for mechanized peat-mining.

After restoration of the Lithuanian independence, Aukštumala Telmological Reserve was established on the unexploited western part of the bog (1 017 ha). Nowadays, the contact zone of the Reserve and peat-mining fields is about 6 km, therefore, more than 30–60 ha occur in the zone of draining influence. Peat mining in the eastern part of Aukštumala raised bog provokes draining of the survived part of the bog and causes negative changes in vegetation cover. The first technical and technological solutions for insulation of the Reserve from draining activity was proposed and realized in 2006. Experimental water table maintenance system with a polythene membrane (1 km long) is efficient for the protection of normal water table and insulation of the edges of protected raised bog from negative impact of mining fields.

In previous time, we also tried to use different technological decisions for re-wetting of the raised bog: creation of the water table maintenance system using the peat material excavated from the lower layers, but the effect in this case wasn’t satisfactory. In necessity to re-wet the raised bog with old draining system we also try to use different means for blocking of small ditches by dams, which are formed from peat manually or by using technical means. Quite good effect was achieved by dams, which were established by using the pressed birch plates (plywood). Previously successfully employed measures can be used in the realization of LIFE+ project.

PROJECT "DEMONSTRATIVE RESTORATION OF THE TYRULIAI BOG AS A PART OF THE INITIATIVE OF RE-WETTING OF LITHUANIAN PEATLANDS" (LIFE12 NAT/LT/001186; TYRULIAI-LIFE)

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Tyruliai bog is one of the biggest wetlands in Lithuania with the total surface area covering 4,700 ha, located in Šiauliai region. The territory is seriously damaged, during soviet times was used for intensive peat extraction, and 40% of the total amount of the peat is excavated. Nearly 75% of the area is managed by the State Forest Enterprises, the remaining is owned by private owners. 200 ha of the area are still used for peat excavation. Mainly due to the activity of beavers, some parts of the area at the moment show signs of renaturalization. But the area still remains affected significantly because of long-lasting drainage and overgrowing with woody vegetation (mainly Betula sp.) and dense reed stands. Thus, the open sites and fragmented, slowly recovering habitats of fens, minerotrophic mires and raised bogs are facing further decline.

Tyruliai bog in 1992 was designated as a State Nature Zoological-Botanical Reserve. In 2004, Tyruliai bog was designated as an SPA for the protection of breeding populations of Bittern (Botaurus stellaris) and Spotted Crake (Porzana porzana). The third trigger bird species of the Tyruliai SPA is migratory Common Crane (Grus grus), which use open wet areas of the site for staging in autumn. The main project objective is to ensure favourable conservation status of the priority bird species, which will be achieved through: 1) improvement of the habitat condition and increasing their capacity; 2) restoration of the hydrological regime in dry peat areas; 3) supporting of the natural succession of the sedge-grass communities; 4) reduction of the bird disturbance; 5) maintaining of the fire prevention scheme and 6) raising of public awareness in restoration of destroyed peat bog.

The main expected results are related to increasing of the breeding population of Bittern (at least 20 pairs), Spotted Crake (up to 30 males) as well as staging Common Cranes (exceeding 1,000 birds). These results are connected with the implementation of the following activities: 1) more than 500 ha of dry peat areas will be re-wetted; 2) improved quality of at least 200 ha of former open sedge-grass areas and more than 100 ha dense reed stands overgrowing wet peatland areas; 3) increased capacity of more than 200 ha dense reed stands in ponds through removing of read by „belt“ method; 4) raising of public awareness (web-site www.tyruliai-life.lt, printed materials, visitor infrastructure etc.); 5) implementation of fire-prevention measures through improvement of the local roads (and re-wetting); 6) setting bounds for public traffic. The project is implemented by LOD, along with the partner UAB “Didysis tyrulis”. Duration of the project is 4 years (31-Jul-2013 to 31-Aug-2017).
RESTORING HYDROLOGY AND VEGETATION CHANGES
IN AMALVAS WETLAND COMPLEX

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Amalvas mire is a part of Žuvintas Biosphere Reserve, which is situated in the southern part of the Middle Lithuanian Lowlands. Žuvintas mire complex is the biggest in the country and together with the neighbouring Amalvas mire covers more than 10 000 ha. A total of 16 habitat types of Community EU importance are present in the site. Habitat type 7120 Degraded raised bog still capable to regenerate constitutes 1158 ha of Amalvas mire is the biggest degraded bog area in the country.

Amalvas mire (3 414 ha) is formed of raised bog (47%), transitional mire (9%) and fen (44%). More than 60% of the area of Amalvas mire (2 160 ha) was drained in 1970–1980. Winter polder (638 ha) was established in the northern part of the mire (former fen and transitional mire). Groundwater level in the polder was reduced by more than 2 m, what in turn affected significantly the ground water level in the remnant of the mire despite of instalment of protective dike. The southern part (~1 500 ha of former active raised bog, bog woodland and swamp woods) was intersected with drainage channels and transformed into grasslands or left for forest development (approximately one third of the area). The drainage channel was also dug along the western edge of Amalvas wetland and further increased water runoff from the undrained remnant of the mire.

Negative alterations of hydrology in Amalvas wetland caused degradation of active raised bog and part of bog woodlands (~1 600 ha). However, approximately 1 200 ha area of the degraded raised bog habitat was still capable to regenerate. Tree cover in the mires expanded at the expense of open places required by species such as Black grouse, Golden plover, Curlew, Wood Sandpiper. Fires, sometimes very severe, appeared periodically in the degraded bog area and caused additional damage to the bog.

According to the Amalvas Wetland Nature Management Plan in 2009–2011, the Nature Heritage Fund (lead partner), Marijampolė Municipality Administration, Marijampolė Forest Enterprise and Žuvintas Biosphere Reserve Directorate implemented ‘WETLIFE’ project (LIFE07 NAT/LT/530) set out to achieve a favourable conservation status for the bog and swamp wood habitats of Amalvas and Žuvintas wetlands through hydrological restoration and the
introduction of management practices to achieve the necessary balance between the needs of farmers and the requirements for wetland conservation.

Actions mirrored those of a number of previously successful wetland restoration projects in other Member States and were targeted at improving the general hydrological conditions of the project area.

The effect of draining of Amalvas mire, which was caused by Amalvas polder (638 ha), was reduced by reconstructing the Amalvas winter polder into summer polder, i.e. allowing natural water levels during autumn, winter and early spring; improving more than 2 km of the most crucial sections of protective dike; blocking the section of the drainage ditch closest to Amalvas bog; installing technical measures to ensure the maintenance of ground water level in peaty soils, 30–60 cm from the surface during the farming season.

The above-mentioned actions resulted in reduced seepage from Amalvas mire to Amalvas bog that should positively affect ~100 ha of degraded Amalvas raised bog. Furthermore, new water management regime in the Amalvas polder should significantly reduce peat mineralization processes along with emissions of greenhouse gasses and washing out of nitrates, peat particles. This should positively affect ecological status of Lake Amalvas.

Draining effect on the southern part of Amalvas bog was reduced by cutting trees and restoring water level to natural (0.0–0.3 m from the surface) in approximately 210 ha of the formerly drained area.

The action resulted in raising water in the drainage ditches close to the surface. Short monitoring data revealed that ground water level in the very southern part (south from the road crossing the bog, where blocking of the ditches was completed in 2010) vary in the range from 0 to 30 cm from the surface except at the very edge of the restored area, where ground water level increased by ~60 cm, but remains 50–60 cm from the surface. Surprisingly, vegetation changes were also registered as in the central part, there was a 30% increase in cover of Sphagnum species. Similar increase was also registered in the degraded bog neighbouring the restored area, clearly indicating broader impact.

Draining effect on the south-eastern part of Amalvas mire was reduced by reconstructing the protective dike and restoring water level in approximately 50 ha of formerly drained mire. The action improved hydrological conditions in the eastern part of Amalvas wetland, i.e. approx. 100 ha of Bog woodland and approx. 90 ha of Fennoscandian deciduous swamp woods. Additionally, approx. 50 ha of former mire area were restored and should develop into transitional mire or fen.
RAISED BOG RESTORATION EXPERIENCE IN LATVIA

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Importance of raised bog conservation is determined by the fact that half of mires, covering 4.9% of Latvia’s total area, are influenced by human activities such as drainage and peat extraction. At the same time, especially protected areas include vegetation of high conservation value such as intact raised bogs with labyrinths of bog-pools, old growth forests and lakes where restoration management is not needed.

The aim of the study was to follow the vegetation and site hydrology change after rising of water level in raised bogs, and evaluate management effectiveness.

In 2003–2013, the studies on raised bogs were carried out on seven especially protected areas of the Western and Eastern Latvia: Cena Mire, Stikli Mires, Klani Mire, Melnais Lake Mire, Aklais Mire, Rozu Mire and Aizkraukle Mire and forests, which include investigations on vegetation and site hydrology. In 2003, the first studies were carried out in Cena Mire, where a total of 114 relevès were made to characterize vegetation and 130 permanent plots were established next to hydrological monitoring areas. Similarly, habitat and hydrological studies were carried out at the other sites such as Melnais Lake Mire.

In 2006, raised bog habitat restoration was carried out in Cena Mire Nature Reserve. One year after increasing of groundwater level, the first changes in the mire vegetation were observed, which became more obvious in the next years. The cover of Eriophorum vaginatum increased gradually, the die back of Calluna vulgaris was observed as well as ditches were colonized by Sphagnum cuspidatum. At another site – Vasenieki Mire – Utricularia minor and Warnstorffia exannulata appeared in ditches.

Similarly, the changes in vegetation were observed also in Melnais Lake Mire, where in winter 2012 the raised bog restoration by building of dams on the drainage ditches was carried out within the EC LIFE+ Project „Restoration of Raised Bog Habitats in the Especially Protected Nature Areas of Latvia“. Six months after the building of dams, the cover of Eriophorum vaginatum, Rhynchospora alba, Sphagnum angustifolium, S. cuspidatum and S. rubellum slightly increased. Development of Sphagnum mats was observed in ditches, thus diminishing water outflow from the raised bog. The greatest impact of increased water level in the raised bog was
observed in 20 m zone along ditches, where most significant vegetation changes occurred. However, changes were observed up to 40 m distance from the ditch. Overall, in the moderately-influenced areas of the raised bog, the vegetation recovered more successfully compared to strongly-influenced raised bog areas.

The habitat monitoring results prove that changes in vegetation occur already in the next vegetation period, which testifies about the positive effect of the increased groundwater level.

VEGETATION RECOVERY ON ABANDONED PEAT FIELDS IN ESTONIA

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Recovery of abandoned peat-fields by Sphagnum as keystone genus on bogs is a long-lasting process. We tested the North-American technology for Estonian conditions at two experimental sites. In 2006, diasporas with Sphagnum were disseminated on bare peat, covered with straw or hay mulch and water level risen up. Establishment and development of plant cover was monitored. The results indicated that the species composition of established plant cover is sensitive even to small differences in hydrological conditions and may vary importantly. In the presentation we’ll discuss about some results concerned spatial and temporal changes in the plant cover species composition on two abandoned peat-fields actively revegetated.

ON THE RECENT DEVELOPMENTS IN THE RESTORATION OF EXTRACTED MILLED PEATLANDS IN ESTONIA

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In Estonia, peatlands of various status cover approximately 22% of the territory and, therefore, we also do have long history of peat extraction. Evaluated exploitable peat resources (775 milj. t) allow continuing at current level (0.8–1.2 milj. t yr⁻¹) for several hundred years. Until 1950s peat was mostly extracted manually from bog margins without drainage – the effect on the environment was small and these areas re-vegetated spontaneously. The situation changed drastically from the mid 1950s, when milling method was introduced, requiring large areas with deep drainage and removing bog vegetation prior mining.

Abandoned extracted peatlands in Estonia are left during or shortly after the end of the Soviet period. They do have negative influence on the environment and, therefore, according to the legislation, all mined areas should be restored after the end of mining, but so far only few attempts to restore the extracted peatlands have been done.

According to the recent revision (Estonian Geological Survey, 2005–2008), there are 98 abandoned extracted milled peatlands in Estonia with total area >9 400 ha. This revision estimates the area and the status of the extracted peatlands, gives the overview of their vegetation, and, based on the residual peat layer, gives the recommendations for further peat extraction or restoration. Currently, there are 18 000–19 000 ha of peatlands with ongoing peat production. Due to the depletion of resources, most of these will be closed in coming decades and the area of extracted peatlands will increase considerably.

Recently, the restoration has been carried out in Viru and Hara extracted milled peatlands in Lahemaa National Park. Unfortunately, in Hara, the work was done only to increase the water level, whereas in Viru bog, in some areas plant fragments from donor site were spread also. However, the results were not so good, partly because the work was done by the hired company, without knowledge and supervision of peatland expert.

In the beginning of May 2012, we restored 0.3 ha of milled extracted peatland in Tässi, using the variations of „The Moss Layer Transfer Method“. In the end of the second vegetation period, the total plant coverage reached 60–70%, and most of it from Sphagnum mosses – with the highest coverage of *Sphagnum fuscum*, *S. magellanicum* and *S. rubellum*. We also studied the effect of water table depth, peeling of surficial peat layer and spreading density of plant fragments on the re-vegetation. In our presentation, we will focus on these results. The restoration of >2 000 ha is starting now with the help of EU support (10.9 milj Euros in 2014–2020) to reduce the mineralization of residual peat and to create near-natural self-regulating ecosystems. The priority is given to extracted peatlands located on or bordering with protected areas and where extraction of residual peat layer is not reasonable. The preliminary criteria for
the selection of sites, recommendations for the restoration and methods for monitoring have been worked out.

BOG RESTORATION EFFORTS IN ESTONIA

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Targeted bog restoration activities were virtually unknown in Estonia ten years ago. Only some small research-oriented field experiments were conducted in Viru bog (N-Estonia) by Ecological Institute of Tallinn University. Experimental setup was mostly based on Swedish experience as some of the researchers had personal contacts and/or even worked some time in Sweden. Self-restoration that has occurred at some former peat extraction sites, was also investigated by botanists from both Tartu and Tallinn Universities.

First large-scale bog restoration effort was led by Estonian Fund for Nature in 2007 with partners from the Latvian Fund for Nature and Tallinn University. The target site (around 60 ha) is located in Soomaa National Park, the most known wetland complex in Estonia, and was damaged by drainage systems. Extensive field surveys were followed by detailed restoration plan and technical project in 2009. However, the organizational changes in Estonian nature protection agencies and lack of funding prevented dam construction and tree cutting until 2011. The money for restoration came from European Development Fund via project „Conservation of biodiversity of nature“, managed by State Forest Management Centre (RMK). Additional four sites were restored within that project, former extraction fields in Hara, Viru, Rannu bogs and drained bog border in Toodiksaaare. General workflow required by RMK and local municipalities has been so far the following: restoration plan by experts, technical project in co-operation between RMK, engineers and experts, building permit by local municipality and actual work in the field by hired sub-contractor.

State-wide inventory of potential restoration sites was again initiated by the Estonian Fund for Nature, who mapped potential damaged sites at Estonian Ramsar sites in 2011–2012. The project was funded by Coca-Cola Foundation and restoration plans were created for 10 sites
with the highest recovery potential. Significant amount of European funding is already acquired for mire restoration for the next six years and major project preparation is currently underway.

Due to drainage, the total surface of Estonian mires has decreased nearly 2.8 times as compared to the data from 1950s. Therefore, the Estonian mires have become sources of carbon instead of sink. We estimate that carbon accumulation in undisturbed mires (app. 250 000 ha) is from 46 000 to 58 000 t C y\(^{-1}\) (169 000 to 213 000 t CO\(_2\) y\(^{-1}\)), which does not compensate emissions from peat mining and other drained peatland areas. In Estonia, there are 19 574 ha active and 9 371 ha abandoned peat mining areas – the global warming potential of these areas is 126 738 and 64 761 t CO\(_2\) eq y\(^{-1}\), a total of 191.499 t CO\(_2\) eq y\(^{-1}\).

**PEATLAND RESTORATION IN FINLAND**

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The diversity of mires in Finland is the largest in the world compared to any other similar sized area because of the cold and moist climate. There was large scale ditching of mires for forestry purposes in the last decades of the 20\(^{th}\) century. This had an immense degrading impact on the natural values of mires.

There is over 20 year of experience of mire restoration in Finland. More than 20 000 hectares of different types of mires have been restored from the beginning of 1990’s. The work has been funded by several EU LIFE+ projects and the Finnish government.

After the restoration, the mire must become more permanently waterlogged again. Rising of water levels is best achieved by completely filling in ditches by excavator. In the early years of peatland restoration, the ditches were filled in evenly. Later, it was observed that water still flows along the ditchlines. The ditchlines remain at lower level than the peatland between ditches. This is because the drainage and decaying of peat has been more effective near the ditches. This results to “striped ecosystem”; i.e. ditchlines differ from vegetation compared to peatland between ditchlines.
Therefore, it is urgent to make dams on the filled in ditches, which stop the water flow along ditchlines and spread the water over a larger area. Dams are made of peat approximately 40 meters from each other. They are normally about eight meters wide and one meter high. The best place to make a dam is on a ridge, or higher place on the peatland surface. Pristine bogs have pools and ridges, and after restoration these dams will be a part of those natural microformations.

It is also often necessary to remove trees, since trees lose a lot of moisture through transpiration. The trees felled are those growing on drained mires that would naturally be open. The work is done at wintertime, when the mire is frozen and it will carry heavy machines. Only pines are removed. The birches will prune, if they are cut. There are normally quite a few birches in ombrotrophic bogs after drainage.

The results of restoration are evaluated by different monitoring methods. The latest results show that the water level fluctuation after restoration seems to be similar to pristine mires.

CONSERVATION OF RAISED BOGS IN NORTHERN POLAND, 2003–2014

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Baltic raised bogs (= "true raised bogs" according to ELLENBERG, 1988) are special kind of raised bogs, with limited distribution – around the Baltic See. Ca 80 Baltic raised bogs were recorded in northern Poland, but no more than 30 are preserved till now. Formal protection and passive management, applicated as a rule to raised bogs in Poland till now, seem to be not appropriate to successful conservation of the Baltic bogs.

Even on the best preserved bogs, active management, with blocking old anthropogenic drainings, sometimes also with taking other conservation measures, seems to be necessary. Probably it was "the last minute" to stop degradation processes. In 2003–2007, LIFE project LIFE04NAT/PL/000208 PLBALTBOGS was implemented in northern Poland, covering 23 bogs. In 2007–2011 it was continued as a project financed from the European Regional Development Fund. Some parallel projects were started.
Basic restoration measure was blocking of draining ditches using various technical solutions. Multiple blocking is generally necessary. The outflow was blocked in ca 800 points. Practical experience with finding the appropriate locations (incl. remote sensing methods, as LIDAR scanning) and ditches blocking will be presented. Removing of trees from bogs was applied together with improving water conditions. Practical problems and solutions will be presented.

On some bogs (degraded by former peat extraction), experiments with the *Spahagnum* reintroduction, with the objective to restore peat forming process, was implemented, started as a part of LIFE project and then continued as a separate project managed by Gdansk University Foundation, with promising results, but full effects not achieved yet.

The Baltic bog experience was supplemented by the experience in conservation of other types of raised bogs, dispersed in the landscape of northern Poland, also small raised bogs in the forest landscapes. Some specific problems are related to small raised bogs, degrading even without human induced drainage, and to bogs threatened by invasive alien species – *Spiraea tomentosa* expansion.

**HYDROLOGICAL CHALLENGES IN RESTORATION OF HOLMEGAARD MOSE**

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LIFE08 NAT/DK/000466, “Restoration of raised bog Holmegaard Mose”, was carried out in 2010–2013. Holmegaard Mose in South-Zealand has a size of approx. 450 ha, of which around 50% was covered by the LIFE project. During the project, 100 ha of secondary birch wood were removed, and a total of 150 ha are now cleared. The bog was made wetter by several means, but primarily by elevating the runoff threshold of minerogenic water, which runs through and around the bog. Monitoring of the coverage of peat moss during the project indicates that the bog is getting wetter also where this was not predicted due to elevation of the minerogenic runoff threshold. This must be explained by reduced evaporation. However, signs are recorded of spreading of alkaline and nutrient demanding plants along the crossing stream. Moreover, a permanent crossing stream will not fulfil the demands of the overall Natura 2000 plane, i.e. hydraulic connection of the existing fragments of the original raised bog. Therefore, attempts
are made to succeed the LIFE project by a phase II, which should comprise the whole bog and modify the described hydraulic effort in the sense that the crossing minerogenic water will be redirected around the bog during the winter season, where there is a surplus in the internal water balance of the bog.

RESTORATION OF RAISED BOG BY MEANS OF LARGE DAMS ALONG THE MARGINS

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LIFE10 NAT/DK/000102 – “Restoration of active raised bog – Lille Vildmose” 2011–2016. Lille Vildmose is a complex of originally about 6 000 ha of raised bog. Today approx. 2 100 ha of undisturbed raised bog remain. The largest part of this consists of the Tofte Mose area of about 2 000 ha, which is the largest intact area of raised bog in the lowland of Western Europe. Unfortunately, the area still suffers from drainage along its margins, where peat excavation has continued up until recently.

In this LIFE+ project, the problem with continued drainage along the bog margin will be solved by creating almost 3 km of dams along the margins of the bog. The dams will be constructed with a mull-clay mineral soil with an embedded bentonite (clay) membrane impermeable to water. The dam will be partly built on peat on the bog margin and the problem with subsidence/compression of the peat will be solved by constructing the dam with surplus height. In addition, the crown of the dam will be constructed in a way so that additional mineral soil can be added easily in the future if necessary.

REMOTE SENSING DATA AS A TOOL TO ASSESS NEED AND EFFECTIVENESS OF PEATLAND RESTORATION IN RUSSIA

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Hundreds of thousand hectares of drained peatlands were left abandoned in Russia and other CIS countries during 1990s. Those having no perspectives for economic use require rewetting and restoration measures for fire prevention, mitigation of carbon loss and GHG emissions as well as biodiversity support. Vast highly impassable areas vulnerable to climate change and human impacts require economically reasonable methods to assess and monitor their conditions and fire hazard status, prioritization for restoration and to test the effectiveness of restoration measures applied, to evaluate areas used to bind EFs and carbon data. Such methods based on EO data were improved, developed and verified within the project “Restoring Peatlands in Russia – for fire prevention and climate change mitigation” financed under the International Climate Initiative (ICI) by the German Federal Ministry for the Environment, Nature Conservation, Construction and Nuclear Safety (BMUB) and jointly conducted by the Ministry of Nature Resources and Environment of the Russian Federation, Moscow Province Government, Wetlands International, the Michael Succow Foundation, Greifswald University and the Institute of Forest Science, Russian Academy of Sciences.

Methodology based on high resolution (Spot 5) space imagery was introduced and approved for mapping of over 250,000 ha of peatlands of different type and conditions belonging to different land categories on the example of the Moscow region, and it can be used for various scientific and practical tasks, which need development of regional peatland’s GIS.

The results of mapping were used to separate out peatland fires from archive data for forest-peat ones fixed in 2010. On the example of Meshera National Park (Vladimir region) and using Landsat-TM and ETM+ satellite images for the period of 1992–2007, the possibility to monitor vegetative cover of the abandoned peat extraction lands and humidity of bare peat surfaces is shown. The developed methodology was tested using modern EO data using Spot-5 HRG, Spot-6 HRG, UK-DMC2 MSI and Landsat-7 ETM+ (Landsat-8) satellite images. Verified approach was used later to monitor and condition analysis of over 50,000 ha of re-wetted peatlands in Moscow oblast. Developed methods based on remote sensing data will be applied for mapping and assessing peatlands in other regions of Russia not only in the boreal, but also to the north in tundra and to the south in forest-steppe zone.
COMPARISON OF THREE DIFFERENT METHODS FOR THE DETERMINATION OF CLIMATE RELEVANT GAS EXCHANGE IN MIRES

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The study compares different methods for determining greenhouse gas emissions of raised bogs in Lower Saxony, Germany. Background of this publication is the joint venture project between Volkswagen Leasing GmbH and NABU (German Society Nature Conservation) in the area of mire protection. As a result of rewetting of depleted peat fields and agricultural used areas goals as mire protection and the avoidance of CO₂ emissions for the climate protection at the same time shall be achieved. Even if it is a matter of voluntary measures, the engineering company for ecology, environmental protection and landscape management, Hofer & Pautz, BGB, was ordered to analyse the potential savings of climate relevant gases.

Different methods were adopted for the investigation:
1) on the one hand, the annual emission of CO₂ was determined by means of comparison by loss of thickness of the peat layer on the basis of new and ancient stratigraphical drilling profiles (HOFER & WITTE, 2010);
2) on the other hand, the emission of CO₂ was calculated by emission factors, which were differentiated by type of mire and its way of land-use (HÖPER, 2007) or by classification of emission factors for different of stages of humidity (COUWENBERG et al., 2008).

For furnishing an expertise to quantify the emissions the following items of climate relevant questions must be considered and cleared:
- what is the total volume of the peat layer?
- which climate relevant gas exchange happens actually?
- which emissions of carbon dioxide equivalent in this area can be avoided by future rewetting measures?

The following investigations were carried out:
- stratigraphical drilling of the peat layer;
- mapping of land use and types of biotopes with classification of humidity grades;
- monitoring of groundwater regime and depth of aeration;
- digital surface model.
After calculation of the total amount of the peat body under consideration of the hydrological conditions, the part of the peat body which is affected by oxidation was designated. On the base of this volume it is possible to determine the emission factors, area and time, the expected behaviour of emission in the respective mire area.

The following table shows the average actual emissions of three project areas.

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<tr>
<td>2009</td>
<td>Theikenmeer</td>
<td>3.619 kg C/ha/a</td>
<td>–</td>
<td>4.852 kg C/ha/a</td>
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<tr>
<td>2010</td>
<td>Sauerbach</td>
<td>4.430 kg C/ha/a</td>
<td>5.060 kg C/ha/a + 4%</td>
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<tr>
<td></td>
<td>Difference</td>
<td>–</td>
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<td>2011</td>
<td>Lichtenmoor</td>
<td>3.782 kg C/ha/a</td>
<td>3.625 kg C/ha/a + 4%</td>
<td>3.500 kg C/ha/a</td>
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<tr>
<td></td>
<td>Difference</td>
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The discrepancy of the absolute altitude between each territory reflects the different degree of humidity. The differences between the emission factors, which were determined by the loss of thickness of the peat layer that proceeded during the last years and by the attribution of the actual vegetation/land-use are low and lie between +/- (8%). They are less estimated than the expected inaccuracy of the relatively roughly effected classification into land-use and degrees of humidity. The occurred emission of the past years can be quantitatively well determined by means of the height loss, depending on the quality of drill data.

Owing to the difficult classification of vegetation stages (degrees of purple moor-grass stages) and the pedological classification (transitional peat bogs, which are characterized by transition from bog to fen due to peat oxidation) the method for the deduction from the comparison of thickness of the peat body by time staggered stratigraphical recordings – insofar as appropriate drill data are available – is given the priority.

**SPHAGNUM FARMING – EXPERIENCES FROM GERMANY**

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To cover the growing demands from world-wide urbanisation, the cultivation of vegetables, fruits and flowers takes place in pre-prepared growing media, consisting mainly of slightly humified peat (white peat) which is built up in natural bogs by Sphagnum species. Extracting this fossil resource destroys raised bogs and their associated ecosystem functions, including carbon storage and water regulation. As a result, the stocks of white peat in most countries of Western and Central Europe are largely depleted, and living bogs have become so rare that the few remaining examples are strictly protected. There is thus an urgent need for the growing media industry to find sustainable alternatives for peat. The most promising alternative for white peat is Sphagnum biomass. Its use as a raw material for growing media in modern professional horticulture has been successfully tested and in some cases demonstrates even better results than the peat-based substrates developed over many years.

The cultivation and harvest of Sphagnum biomass (Sphagnum farming) aims to replace fossil peat in horticultural growing media with a renewable raw material. In contrast to conventional drainage based agricultural use or peat extraction, wet cultivation, known as paludiculture, maintains the peat body as a carbon store. In cooperation with various research and industrial partners, the University of Greifswald has spent the last decade studying Sphagnum farming, including diaspore recruitment, plant establishment, optimisation of site conditions, productivity, and regeneration after harvest (see www.sphagnumfarming.com).

In successful field experiments Sphagnum cultures were established on bog soils (i.e. on bogs formerly used as pasture, meadow or arable field and on bogs after peat extraction), but also on artificial floating mats on water bodies resulting from peat, sand and lignite extraction.

In spring 2011, the research team, set up by the university and peat industry, established an almost 5 ha large industry scale pilot site on agricultural bog grassland near Rastede (Lower Saxony, Northwest Germany). To do this, the team removed the upper topsoil, which was strongly degraded, and installed a water management system for irrigation and drainage. They then introduced Sphagnum diaspores with a manure spreader mounted on a former snow groomer. 1.5 years after initial establishment Sphagnum palustre, S. papillosum and S. fallax already covered 95% of the area with an average lawn height of 8.3 cm (maximum 22.4 cm). This field site has convincingly proven the feasibility of large scale Sphagnum farming already during the establishment phase.

The research results for Sphagnum farming can also be utilized for restoration purposes for the establishment of Sphagnum vegetation at abandoned bog areas as well as the Sphagnum cultures can work as donor sites for ‘seeding material’ for restoring bog vegetation.
EXPERIENCES IN REWETTING RAISED BOGS IN SCHLESWIG-HOLSTEIN, GERMANY

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In 2011, the Foundation for Nature Protection (FNP) in Schleswig-Holstein (Stiftung Naturschutz Schleswig-Holstein) has engaged in rewetting of raised bogs in Schleswig-Holstein. Since then the foundation has restored approximately 600 ha of raised bog in Hartshoper Moor, Dellstedter Moor and Königsmoor, about 20 km to the west of Rendsburg. They are situated in the so called “Eider-Treene-Sorge-Niederung”, a lowland in the middle of the northern province. This was possible through a financial program which was created by the regional government supported by the European Union to protect and restore bogs. In the “Eider-Treene-Sorge-Niederung” the average precipitation is 850 mm/year. During the last centuries most of the implementation areas were mainly used as meadows. Therefore down to approximately 20 cm deep the soil was highly mineralized. Beneath, a layer of approximately one to two meters barely decomposed white peat can be found. The quality of the white peat varies depending on the period and intensity of the agricultural use of the land. Finally, highly decomposed black peat can be found, likewise approximately one to two meters thick. All areas included in the project were drained by ditches and drainage systems. Because the bogs are furrowed by paths the largest connected area covers 140 ha.

The FNP in Schleswig-Holstein has put certain measures into action to restore these bogs. For instance, some areas were enclosed by peat dams or banks which were 1.1 m high at maximum. At their feet the dams width measures 8 m. Before raising the dam a consistent investigative trench with a depth of 1.5 to 2 m was excavated to destroy hidden drain pipes. The excavation is filled with peat and then compressed with the digger. With this measure the structure of the soil gets damaged. The soil pores are blocked and the lateral drain of water in the upper layers of the peat body is significantly minimized. Where there are differences in heights of 40 cm or more inside the area, another peat dam was built along the contour line. The dams were equipped with adjustable overflow pipes, made out of PVC. Ditches inside the plots were usually completely filled or separated by banks.
The decision regarding the material used for banks and fillings depended on the local conditions; either surface soil or a mixture of white and black peat was used. The latter characteristically subsides more than the former, approximately one-third of the whole dam. Through this method we succeeded to hold back the rain water in the bog areas. The water level fluctuation p.a. in the rewetted areas is now less than 20 cm. The monitoring shows that the soil swells up to 50 cm during the first month after the construction of the dams has been completed. The aim, raising the water level at surface level in the annual average, is reached. The chances of successful development largely depend on the duration and the intensity of the former agricultural use. Some plots were fallow fields over a period of time. On these, as well as on plots that were less manured, *Sphagnum* moss and bog cotton are growing even in the first years after the renaturalization measures have been implemented.

**PRELIMINARY HYDROTECHNICAL SOLUTIONS TO NEGATIVE CHANGES IN AUKŠTUMALA RAISED BOG**

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As part of the LIFE+ project “Restoration of the raised bog of Aukštumala in Nemunas Delta Regional Park”, *Nature Heritage Fund* (Lithuania) was subcontracted for preparation of the blueprint for restoration of hydrology in the main part of Aukštumala raised bog, surrounded by the road to the south, west and north and mined peatland – to the east. The blueprint is meant to be ready by November 2014.

Site assessment was already carried out in the area. It included topographic survey and assessment of drainage ditches and their parameters. Luckily, high resolution topographic data (cell 1×1 m), produced using remote sensing technology (LIDAR), were available for the area. Additional topographic survey included crosschecking of LIDAR data by manual levelling. Temporary benchmarks (30 units) were established in the area to be used during hydrology restoration works.

Aukštumala belongs to the type of raised bogs with strongly expressed cupola. Two main cupolas are clearly distinguishable, reaching more than 5 and 4 meters in the highest parts and peat thickness of almost 9 meters. Peripheral part of the raised bog is intersected by numerous
ditches with a total length of approximately 150 km. Out of these, approximately 130 km of ditches should be considered for blocking in order to improve hydrological state of the bog.

Ditches could be grouped into three main groups. First group – magistral ditches – 8–10 m wide and 2–2.5 m deep. These ditches collect water from collecting ditches and serve for discharging water from the bog towards the pumping stations. Such ditches get narrower and shallower upstream down to 5–6 m wide and 1.5 m deep. Second group – collecting ditches – 1.5 m wide and 1.5 m deep collect water from primary ditches. Ditches of such type go along the perimeter of the bog as well as intersect bog cupola every 500 meters. Peat subsidence and formation of valley is typical around these ditches. The third group – primary ditches – up to 1 m wide and 1 m deep, dug every 30, 40 or 60 meters. In the open raised bog they can be hardly distinguishable due to sedge cover, but in most cases well-functioning. In more degraded forested areas, big part of such ditches are dry most of the year.

Dams are preliminary proposed to be built at every 20 cm of the slope. Based on parameters of the ditches and quantity of water that discharges through them, four types of dams were proposed. These include: four ground dams with overflow pipes for blocking of magistral ditches at their discharge points; 33 peat dams with pipe blocks for blocking of primary ditches discharging through the pipes directly to deep peat-mining ditches; 104 peat dams for blocking accessible primary ditches with degraded moss cover and small water discharge; 1160 plastic pilling dams for blocking upstream magistral, collecting ditches with their valleys and difficult to access primary ditches with high water discharge. Further development of the blueprint will be based on the budget available for implementation, comments from the international expert group and authorities responsible for approval of the blueprint.
EFFECTS OF FIRE IN AUKŠTUMALA THELMOLOGICAL RESERVE

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At the beginning of June 2011, the north-eastern part of Aukštumala Thelmological Reserve was affected by fire, during which vegetative cover in the area of 265 ha was affected. The greatest damage was done to dry upper march edges along the peat mining fields, where habitats of degraded raised bog with abundantly growing Calluna vulgaris, tall Betula pubescens and B. pendula trees dominated. At the end of the summer, the place of fire was dominated by regenerating Caluna vulgaris shrubs and birch sprouts, Molinia caerulea was growing, plant species (Rumex acetosella, Cirsium arvense, Pilosella lactucella, etc.) not typical to upland marshes were found. Specialized species of vegetation have not yet established within a year, only a large spread of liverwort Marchantia polymorpha has been found.

Considering the importance of the entire bog complex and on purpose to preserve the only currently known place, where Sphagnum imbricatum is found, it is necessary to restore the greatest possible level of groundwater, to inhibit the penetration of woody plants to the marsh, to create favourable conditions in the place of the fire for regeneration of typical upland marsh habitats, and to restore peat formation process. Due to its importance to biodiversity, it is necessary to leave the stand lost in fire to self-decay (or at least the greater part of it), by using the part of it for the impoundment of barrel ditches.

In 2007, the first hydrological regime restoration works began in damaged areas of the Reserve. Water level in backbone ditches was increased, the outflow of water from barrel ditches in the preserve were restricted. However, the level of groundwater was not increased sufficiently. Sphagnum cover and other hygrophilic grass-scrub vegetation Rubus chamaemorus, Ledum palustre, Eriophorum vaginatum recover rather weakly, apart from the edges of barrel ditches, and several cavities.
ROZHDHESTVENSKY MOKH RAISED BOG: PAST AND FUTURE (LENINGRAD REGION, RUSSIA)

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Rozhdestvensky Mokh raised bog is situated about 70 km to the south from St. Petersburg city on the watershed of the Oredezh and Divenka Rivers. It has attracted our attention due to the novel by V. Nabokov “Speak, Memory” (1951), where the world-known writer described his childhood in Batovo, Vyra and Rozhdestveno – the countryside estates of his family. As a boy, V. Nabokov used to catch butterflies walking through the bog – “my moss paradise” as he called the “Rozhdestvensky Mokh”.

This raised bog was chosen as an object of our studies. Surprisingly, the bog has not been investigated yet. A field work was done during the summer 2013, but we visited the bog in the late spring and autumn also. A purpose of our studies was to obtain the data on mire typology, vegetation structure, and floristic composition of bog plant communities. As a separate task we formulated to make a large-scale landscape map showing the dynamic processes of the bog. According to the peat survey data (1950), the average depth of peat deposits is 3.3 m, maximum – 6.6 m.

The satellite images available from Yandex source were used to observe a current status and spatial structure organization of bog sites. It is supposed to be a concentric raised bog with bog pools and hummock-hollow complexes on the slopes. We discovered a dense and regular net of drainage ditches and channels covering over 2/3 of the whole bog area. The drainage system crosses the bog margins, the hummock-hollow complexes and even pool bog sites close to the centre of the bog. We think that this was done in late 1970s – early 80s, when the bog was prepared for peat extraction.

At the same time, the several dacha cooperatives appeared along the eastern periphery of the bog. The total drainage caused serious changes in the floristic composition of bog communities, particularly in the marginal parts. Pine bog sites have changed into afforested peatland with predominance of green mosses in the moss layer instead of sphagnum species. The bog hollows become smaller and dryer and in some places they are hardly seen covering with cotton grass carpets. We experienced the difficulties to traverse the bog as ditches were
made every 100 m. In spite of dramatic man-made disturbances Rozhdestvensky Mokh raised bog preserves the typical floristic features of the southern boreal raised bogs situated close to the Atlantics. Calluna vulgaris occurs on bog hummocks formed by Sphagnum magellanicum. Rhynchospora alba and S. cuspidatum grow in bog hollows. S. rubellum can be found in the better preserved central parts of the bog.

To conclude, Rozhdestvensky Mokh raised bog still provides important ecosystem services such as regulation of hydrological regime of the area, berry resources, hosting the wildlife, etc. It is hardly reachable, so it can be considered as an important large buffer ecosystem protecting the local landscape from the forest fires.

CHANGES IN THE FLORA OF DECIDUOUS SWAMP WOODS AFTER RESTORATION OF NATURAL HYDROLOGICAL CONDITIONS IN KAMANOS BOG

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The aim of research: to find out changes in the flora of deciduous swamp woods after restoration of natural hydrological conditions.

Place of study: two sample plots of 10x10 m in different parts of Kamanos Nature Reserve. Swampy forests were under influence of drainage for 5–6 decades. The ditches were blocked in 2002 (1st sample plot) and in 2010 (2nd sample plot). Vegetation cover was assessed in 20 squares in size 1x1 m in each sample plot. The species composition of the ground vegetation and shrub layer was evaluated by assessing the cover (%).

Results: Elevation of groundwater table influenced changes in moss abundance and species distribution. Mean coverage of moss layer (except Sphagnum) enlarged by two times in both sample plots. Sphagnum are absent in the second place, while the cover of peatmoss increased by four times in the first sample plot. Growth of moss species number was observed in the second sample plot as well as the number of various Carex species in both places. Seasonal flooding is not favourable for undergrowth except Frangula alnus. The coverage of this species is growing in both research areas and the number of squares occupied by seedlings of F. alnus is increasing in the second sample plot.
Accumulation of phytomass and its structure is one of the main indicators showing success or failure of milled peat field revegetation. Two abandoned peat fields in Northern Estonia were restored using the North American technique (Rochefort et al. 2003) in 2006. Various factors, including microtopography (at Viru site) and different fertilizers (at Ohtu site) were used at these two sites. Phytomass (bryophyte, shrub, herb and tree biomass) and peat mineral content were measured from Viru and Ohtu sites. Bryophyte and peat samples were collected in November 2012 (Ohtu site) and in July 2013 (Viru site) and vascular plant samples in August 2013 (both sites).

At Ohtu site, the vegetation had more plants specific to mineral soils and at Viru site, the vegetation was similar to bog vegetation. Bryophyte and vascular plant (including shrub, tree and herb biomass) biomass and peat mineral content differed significantly between Ohtu and Viru sites. Vascular plant biomass and peat mineral content were higher at Ohtu site, but bryophyte biomass was significantly higher at Viru site. Fertilization had significant impact only on bryophyte biomass, it was the highest in case of ammonium nitrate fertilization and also high bryophyte biomass was measured on plots with urea fertilization, bryophyte biomass was the lowest in case of superphosphate fertilization. In case of microtopographic differences at Viru site, where ridges and depressions had height difference of 5 cm, only tree biomass differences were significant, their biomass being higher on ridges. In conclusion, further research is needed on the impact of fertilization on phytomass accumulation, also site-specific factors should be more emphasized in revegetation activities.

MIRES IN THE SOUTHERN PART OF NEMAN DELTA: IMPORTANCE, PRESENT-DAY STATUS AND CHALLENGES

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Lower Neman Plain (Neman Delta s.l.) – coastal lowlands in the north-west of Kaliningrad Region of Russia – is the most paludified part of the area, its mean mire percentage is up to 20%. All types of mires are found here. Huge plateau bogs is a specific feature of this district, although most part of area is covered with different type of alder swamps stretching by a broad stripe along Curonian Lagoon coast.

Present-day status of this area can be considered as semi-natural (or natural-anthropogenic) complex being sustainable only under condition of narrow and wise interaction between natural processes and human activity. At the same time an essential part of Neman Delta (on the southern side) due to remote localization, absence of settlements and hard access is very close to pristine nature and is maintained to great extent by natural processes, in first order, by water regime dynamics. These territories are of great value as reference ecosystems, habitat forming areas biodiversity conservation and migration sites. They have high priority for nature conservation activity either on regional and European and Russian Federation level. Almost all of them are different types of wetlands – raised bogs, alder swamps, reed fens and flooded meadows in the river flood-plains.

The present-day nature reserves in the southern part of Neman Delta could scarcely be recognized as areas of nature protection, because they exist only de jure, being de facto the special kind of game-preserves. Thus, there is no for the day real and efficient nature protection authority in the southern part of Neman Delta which can manage such activity as ecosystems and rare species protection, cultural landscape conservation, eco-tourism regulation, land use and nature use restrictions as well as involving local people into sustainable development process on that area. Existing status of today’s nature reserves doesn’t imply their further transformation into trans-boundary areas of nature protected and UNESCO Biosphere Reservations.

Nevertheless, much have been done during last 20 years to assess the relevance, priorities and requirements for nature conservation activity on higher level in the Russian part of Neman Delta. The further steps should focus onto work with legislation in order to integrate the best practice of existing conceptions and more active trans-boundary local cooperation in the Neman Delta area.