Active raised bogs* (7110) – Estonia

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Conservation status	EU28: Endangered (EUNIS D1.1[1]) EE: U2 (+)
Protection status	HD: Annex I (priority habitat)
Area (2007-12)	EU: 10,200 km^2 EE: 1,580 km^2
MS with genuine improvement	EE (sub-reporting level), DK, BE (CON)
Other MS	AT, BE (ATL), CZ, DE, DK, ES, FI, FR, HU, IE, IT, LT, LV, NL, PL, PT, RO, SE, SI, SK, UK

Summary: Active raised bogs are a highly endangered habitat in the EU, with an estimated 90% of the original habitat lost, and the current area in unfavourable condition due to drainage, peat extraction, and afforestation. Estonia, reported an unfavourable-inadequate conservation status for the habitat in both the 2001-06 and 2007-12 periods, but a sub-reporting level improvement in the last period. This improvement resulted from strategic planning and government target setting, protection in Natura 2000 areas, and restoration projects both inside and outside conservation areas. Estonia carried out a comprehensive national inventory of mires, which was used to define the list of disturbed sites where peat extraction and drainage may still be permitted. Since 2012, the national nature conservation plan and the mire action plan set targets for peat bog restoration. Most of the active raised bog habitat is on state land, and the responsible government agency has undertaken an increasing number of large scale restoration projects. ERDF funding was used for 1,916 ha of habitat between 2007-13, and Cohesion funding has restored 369 ha since 2014, with restoration of another 4,990 ha ongoing. Ditch blocking and dam construction methods have been substantially improved from early projects, and hydrological planning and monitoring has enabled sustainable water table restoration. Exchanges of experience with other Baltic countries and NGO and scientific community leadership were also key supporting factors.

Background

Status and EU occurrence

The habitat is found in every biogeographic region except the Steppic and the Black Sea. The range is favourable in the Boreal and Macaronesian biogeographic regions, but unfavourable-inadequate in all the other regions, primarily because of the influence of climate change (Annex 1). Historic habitat losses have been enormous; it is estimated that 90% of the habitat was lost in the last 150 years (Janssen et al, 2016).

The Boreal biogeographic region has the largest range and the largest remaining habitat area (9,670 km^2). Finland has the largest area of Boreal habitat (4,000 km^2), Latvia has 2,662 km^2, Sweden has 1,250 km^2 in the Boreal part. Estonia reported 1,580 km^2 of the habitat in the Boreal biogeographic region, which is 16% of the boreal total area. Lithuania has 178 km^2 of habitat in the Boreal region (ETC-BD, 2018). The conservation status of active raised bogs in the Boreal biogeographic region in 2007-12 was assessed as unfavourable-bad with a declining trend. The change from the unfavourable-inadequate assessment in the previous period is not real as it is primarily because of changed assessment methods.

In Estonia, the conservation status of the habitat was reported as unfavourable-inadequate in both the 2001-06 and 2007-12 periods (ETC-BD, 2018). Range, area and future prospects were assessed as favourable, whilst the structure and functions were unfavourable-inadequate. In the recent period the trend was reported as

[1]European Red List assessed EUNIS habitat D1.1 but note that habitat 7110 also overlaps with EUNIS G5.6, C1.4

improving, but this change is considered to be due to more accurate data being available. However, as part of the European Commission Drivers of Success study, Estonia reported a sub-reporting level improvement in the habitat's structure and functions.

Ecological requirements

Active raised bogs are acid bogs, poor in mineral nutrients, sustained mainly by rainwater, with a water level generally higher than the surrounding water table. The perennial vegetation is dominated by colourful Sphagna hummocks which drive the growth of the bog by forming peat (Erico-Sphagnetalia magellanici, Scheuchzerietalia palustris p., Utricularietalia intermedio-minoris p., Caricetalia fuscae p.) (European Commission, 2013). The vegetation is ombrotrophic, i.e. the peat layer is already so thick that the plant roots do not reach the groundwater and so receive all nutrients only from precipitation (Paal & Leibak, 2011). The term "active" means that the habitat still supports a significant area of vegetation that is normally peat forming, but the habitat classification includes bogs where active peat formation is temporarily at a standstill, such as after a fire or during a natural climatic cycle e.g., a period of drought (European Commission, 2013). In contrast, areas of habitat where the vegetation composition change, due to peat extraction or drainage, has stopped active peat formation are classified as degraded raised bogs still capable of natural regeneration (habitat 7120). Raised bogs covered in coniferous or broad-leaved forest are classified as bog woodland (habitat 91D0), but if the trees have developed as a result of human activities (i.e. planting) , the bog woodland is not a priority habitat and the trees may be removed in order to restore favourable conservation status of the former bog. However, in order to support the conservation of active raised bog in Natura 2000 sites, it may be necessary to include marginal areas of lower quality habitat as a result of damage or degradation which abut active raised bogs, and the habitat in Estonia is considered to include areas with old partly blocked ditches (Paal, 2007).

According to Paal & Leibak (2011), the reported raised bog area of 1,580 km^2 in Estonia is too high as it includes around 200 km^2 which should be classified as bog woodland (habitat 91D0) (due to succession). Estonia reported 440 km^2 of bog woodland (habitat 91D0) and 265 km^2 of degraded raised bogs (habitat 7120) for the 2007-12 period (ETC/BD 2014). The small area reported as degraded is explained by the fact that damaged and drained bogs become rapidly covered in trees and are either reported as bog woodland or not assigned to an Annex I habitat at all (Paal & Leibak, 2011).

The active raised bog[2] habitat in Estonia includes heath moor bogs in depressions between sand dunes in the northwestern coastal area and western islands, which have thin peat deposits less than 40 cm underlain by pure sandy subsoils; open plateau bogs in western Estonia; and convex bogs with ridges, hummocks, and pools in eastern Estonia (Ilomets, 2015). Characteristic defining plant species are *Sphagnum balticum, Sphagnum cuspidatum, Sphagnum rubellum, Sphagnum tenellum, Trichosporum caespitosum* (typical of the western bogs) and *Sphagnum fuscum* and *Chamaedaphne calyculata* (typical of the eastern bogs).

Species listed in the Habitats Directive typical of the habitat in Estonia include: Yellow-spotted Whiteface dragonfly (*Leucorrhinia pectoralis*), White-faced Dragonfly (*Leucorrhinia albifrons*) and Moor Frog (*Rana arvalis*).

Typical bird species listed in the Birds Directive Annex I include Western Capercaillie (*Tetrao urogallus*), Western Marsh-harrier (*Circus aeruginosus*) and Eurasian Curlew (*Numenius arquata*).

The largest raised bog sites in Estonia (with over 20km^2 of protected habitat) are Soomaa, Puhatu, Alam-Pedja, Muraka, Nätsi-Võlla, Lavassaare, Suursoo-Leidissoo, Kõrvemaa, Kõnnumaa, Marimetsa-Õmma, Lihula, Endla, Agusala, Luitemaa, Mahtra, Sirtsi, Põhja-Kõrvemaa, and Lahemaa. The deepest is Vällamäe mire (with 17m peat depth) in the Haanja Natura 2000 site.

Pressures and threats

In its Article 17 report for 2007-12 Estonia indicated that the pressures on habitat 7110 (based on expert judgement and other data) as: mechanical removal of peat (high importance) and unspecified forestry activities (other than afforestation and replanting, clearance, exploitation and grazing) (medium importance)[3].

[2]Looduslikus seisundis rabad

[3] Estonia's Article 17 report http://cdr.eionet.europa.eu/Converters/run_conversion?file=/ee/eu/art17/envuc0mhq/EE_habitats_reports-13917-125328.xml&conv=350&source=remote#7110BOR

A recent review estimates that 30,000 ha of mires in Estonia have been destroyed by peat extraction, and another 30,000 ha affected indirectly by drainage caused by peat extraction (though it should be noted this includes other mire habitats as well as raised bogs) (Ilomets, 2015). A review published in 2011 estimated a doubling of the previous estimate of about 9,400 ha of abandoned extracted peatlands in 2008 (Ramst and Orru 2009 cited in Paal & Leibak, 2011). Most extracted peatlands, located largely on public land, were abandoned without restoration during or shortly after the end of the Soviet period at the beginning of the 1990s. Since the 1990s, peat extraction has mainly been destined to the export of high quality horticultural *Sphagnum* peat to western European countries (Paal & Leibak, 2011).

A large area of raised bog has also been affected by drainage for afforestation purposes over the last century. Although drainage of the core area of raised bogs was recognised as uneconomical in the 1960s and no longer publicly funded, drainage for forestry purposes has continued to affect the bogs indirectly through drainage of bog margins (laggs) and/or the digging of border ditches (Paal & Leibak, 2011). Environmental Impact Assessments are mandatory for new amelioration schemes but usually not done for drainage projects carried out under an existing amelioration scheme (Paal & Leibak, 2011).

In north-eastern Estonia, some 500 ha of mires have been destroyed directly and another 1,500 ha indirectly by excavation of oil shale in open-cast mines (Ilomets, 2015).

Alkaline dust from power plants burning oil shale has affected the plant cover of bogs in north-eastern Estonia (mainly Puhatu and Agusalu Natura 2000 areas) causing significant habitat loss (Vellak et al, 2014). However, the pollution level has recently decreased substantially, removing the pressure, and there are signs that *Sphagnum* carpets are re-establishing in the remaining areas (Ilomets, 2015).

Estonia reported that coming threats are the same as the reported pressures. But the demand for horticultural *Sphagnum* peat from western Europe is growing, notably from the Dutch flower industry.

Proposed mining of the oil shale resources under Estonian raised bogs poses a risk of drastically altering the hydrology of the sites by lowering the groundwater levels below mining depth (Marandi, Veinla and Karro, 2014).

Drivers of improvements: actors, actions and their implementation approaches

Organisers, partners, supporters and other stakeholders

Organisers:

- Estonian Ministry of the Environment is responsible for Natura 2000 legislation and governance.
- Estonian Environmental Board (under Estonian Ministry of the Environment) is responsible for implementing the state's policies on the use of the environment and nature conservation, providing guidance on the use of the environment, and issuing permits and licenses.
- State Forest Management Centre (RMK) is responsible for Natura 2000 site restoration and management on state owned land (NB most of the active raised bog area is on state owned land).

Partners:

- Estonian Fund for Nature (Eestimaa Looduse Fond ELF) – environmental NGO.
- Estonian Wetland Society – environmental NGO.

Supporters:

- Tooma mire station has carried out meteorological, hydrological, peat hydro-physical and hydrochemical monitoring on Männikjärve raba (Endla mire system) since 1951.
- Institute of Ecology of Tallinn University develops restoration techniques for re-vegetation of abandoned peat fields.
- Institute of Ecology and Earth Sciences of Tartu University.
- Institute of Agricultural and Environmental Sciences of Estonian University of Life Sciences.
- Institute of Geology of Tallinn University of Technology.

Other stakeholders:

- Estonian Peat Association representing 32 peat extraction, processing and consulting companies.

Funding for raised bogs was administered through the Environmental Board, Environmental Agency, Land Board, State Forest Management Centre, the national environmental programme of the Environmental Investment Centre, and NGOs and universities.

The Estonian Fund for Nature and Estonian Wetland Association were the first to develop detailed plans for restoration activities in a number of pilot areas since 2007.

Contributions / relevance of strategic plans

In the course of the project 'Estonian Wetlands Conservation and Management Strategy', carried out in 1997, 1,376 wetlands were inventoried using unified criteria and a GIS database, recommendations made for their conservation and drainage restoration (Paal & Leibak 2011). The Estonian Fund for Nature and the Environmental Board continued this work in the 'Estonian Mires: Inventory of Habitats' project in 2009-2010, mapping 13,901 sites (Paal & Leibak 2011); a revised version, which corrected some previous errors, includes 14,797 sites (Paal & Leibak 2013). The resulting database gives a complete overview of all areas covered by mire vegetation in Estonia.

The Estonia Environmental Action Plan for 2007-13 set the indicator for the favourable conservation status of mires as maintaining 22% of the total land area as peatland. However, the indicator is problematic as the actual coverage of peat soils is unknown but significantly lower than the estimated coverage of 22% in 1990s, due to degradation (ELF pers comm, 2018).

Commercial peat companies are legally obliged to restore peatland after extraction. The Earth's Crust Act revised in 2016[4] specifies that peat extraction permits can only be granted in areas which are on the list of peat areas disturbed by extraction and abandoned or listed as suitable for extraction by government regulation, and that the holder of an extraction permit is required to restore land disturbed by the extraction of mineral reserves to a wooded area, body of water, other land having value in use or a landscape of a recognised value, on the basis of a restoration project agreed by the Environment Board. The Ministry of Environment compiled a corresponding list of sites with all stakeholders (including nature conservationists and peat miners), adopted January 2017[5].

The Ministry of the Environment launched a consensual process together with the peatland interest groups (users of mineral resources, foresters, environmental groups) to define an economically reasoned annual limit to peat extraction, agreed purposes and technologies/methods for peat extraction that ensure a sustainable use, and restoration plans for residual mires, in order to guarantee the protection and sustainable use of Estonian peatlands to 2020 (Paal & Leibak 2011). The policy was never finished and therefore not published, but the results were used in updating relevant legislation and strategical documents, in particular the Action plan for Protected Mires and the above mentioned list of peat areas suitable for extraction (MoE, pers comm, 2018).

In the period since 2012, two new strategic plans have set objectives and targets for active raised bogs: the Estonian Nature Conservation Development Plan; and the Action Plan for Protected Mires.

The Estonian Nature Conservation Development Plan (2012-20) establishes the following objectives for mires (fen, transitional fen, bogs and bog margins) to 2020 (Estonian Environment Agency, 2017):

- avoiding additional drainage of natural peat bogs, preferring to continue peat extraction in territories already drained and damaged;
- regenerating 1,000 ha of cutover peatlands by 2020; and
- restoring the natural hydrological regime in 10,000 ha of mires by 2020.

The Action Plan for Protected Mires 2016-2023, adopted by the Ministry of Environment in 2015, sets a target to restore the natural water regime of at least 10,000 ha of mires and also to restore 2,000 ha of extracted

[4] Earth's Crust Act (213 SE) passed 27.10.2016 § 45 Extraction of peat and § 80 Obligation to reclaim explored land and land disturbed by extraction. Available at: https://www.riigiteataja.ee/en/eli/513022017001/consolide

[5] Ministry of Environment Regulation 1.1.2017 based on decision 27.12.2016. Available at: https://www.riigiteataja.ee/akt/129122016064

peatlands abandoned during Soviet times by 2020 (Ministry of the Environment, 2015). As these are mainly on state land the targets are realistic[6].

Measures taken and their effectiveness

The conservation measures taken by Estonia for the conservation of active raised bogs are listed below.

Application of conservation measures for active raised bogs for 2007-12

Measure	Type	Ranking	Inside or outside N2k	Broad Evaluation
6.1 Establish protected areas/sites	Legal	High	Inside	maintain
4.2 Restoring/improving the hydrological regime	Administrative	High	Inside	maintain enhance long-term

Source: Estonia's Article 17 report available at https://bd.eionet.europa.eu/activities/Reporting/Article_17/Reports_2013

Estonia had designated 98 Sites of Conservation Interest for active raised bog habitat by the end of 2012. The mire inventory 2010 classified the conservation value of all ombrotrophic raised bogs in Natura 2000 sites as indicated in the table below, taken from Paal & Leibak (2011).

Conservation value of habitat	Number of protected ombrotrophic raised bogs	Habitat area (ha)
excellent protection value	85	42,768
good protection value	461	71,190
significant protection value	456	19,599
low or lacking protection value	62	1,475
unknown value	6	3,699
TOTAL	**1,070**	**138,731**

Therefore, around 90% of the raised bog surface area within Natura 2000 sites has high conservation value, and the Natura 2000 network now contains 80% of the total raised bog surface area and around 120,000 ha of active raised bogs in good condition. However, in 2011 there were also 116 active raised bogs of excellent or good condition outside Natura 2000 sites (Paal & Leibak 2011).

Raised bog restoration requires the restoration of the habitat's ability to retain a sufficient supply of rain of appropriate quality, with the presence of a suitable range of species that can recolonise the peat. Several LIFE projects pioneered hydrological restoration methods on degraded bogs on a small scale in the period before 2006 (Annex 2). Since 2011 many large scale restoration projects have been carried out.

- The LIFE+ project 'Restoration and management of the Häädemeeste wetland complex' (2001-2005) reduced drainage effects on Tolkuse bog in the Luitemaa Natura 2000 site and restored around 1,500 ha of raised bog habitat. The dam building (consisting of one row of pine log wall sealed watertight with geotextile) did not achieve the results envisaged, although small test dams functioned as expected (Eglīte, 2005). The project successfully established 3 ha of cranberries and small test plots of *Sphagnum magellanicum* in the former peat extraction site after raising the water level.
- The LIFE project 'EE Priority Forests - Protection of priority forest habitat types in Estonia' (2001-2005) pioneered the construction of light weight dams of local materials (wood and soil) to block ditches draining small raised bog areas within forests. This was cheap and the dams were easy to remove in response to changed conditions or management needs (Eglīte, 2005). Monitoring has shown that these dams also failed to function and were eroded by water and ice during the first five years.

[6] However, at the same time an abandoned peat field of around 3,000 ha in Pärnu county will probably be afforested with the remaining drainage system left intact, and therefore the remaining peat in this area will probably be lost (ELF pers comm, 2018).

The following restoration projects were carried out on a total of 1,916 ha using ERDF funding in 2007 to 2013:

- Soomaa National Park – 80 ha of southeastern part of Kuresoo bog
- Lahemaa National Park – 37 ha of Viru bog (abandoned peat field restoration)
- Lahemaa National Park – 103 ha of Hara bog (abandoned peat field restoration)
- Aseri Landscape Protection Area – 42 ha of Rannu (Kestla) bog (abandoned peat field restoration)
- Endla Nature Conservation Area – 184 ha of Endla bog (forestry drainage system)
- Muraka Natura 2000 site – 1,476 ha of Muraka bog (228 ha), Ratva bog (202 ha) and Matkasoo bog (1,056 ha)

The Cohesion fund 2014-2020 has been used to fund the restoration of 369 ha to date in the following:

- Soomaa National Park – 30 ha of northeastern part of Kuresoo bog
- Soomaa National Park – 64 ha of northern part of Kuresoo bog, object named as Liinoja
- Soomaa National Park – 21 ha of southern part of Riisa bog
- Soomaa National Park – 31 ha of northern part of Riisa bog
- Soomaa National Park – 5 ha of north-eastern part of Riisa bog
- Soomaa National Park and Kikepera Nature Conservation Area – 218 ha of degraded bog and transitional mire habitats used as habitat by Western Capercaillie

In addition to these finished projects, active restoration works funded by the Cohesion Fund are being carried out on 4,990 ha all over Estonia during 2018 and 2019.

The State Forest Management Centre undertook the first larger-scale (c. 40 ha) restoration work of an abandoned peat field in 2012 on the Viru bog in the Lahemaa Natura 2000 site, including ditch blocking and diaspore transfer on some 4 ha (Ilomets, 2015). Because of planning mistakes the dams failed to block enough water to keep the water table high, but additional corrective actions have improved the situation (ELF pers comm, 2018). A much larger restoration project of Kuresoo bog in Soomaa National Park restored around 80 ha of drained degraded transitional mire, raised bog and bog woodland between 2010 and 2013 (Kohv, 2014). Restoration actions included: clearance of all trees from 14.3 ha, cutting of taller trees from another 12.7 ha, construction of 29 dams from logs, peat and geofabric with different constructions, levelling of peat mounds along ditch banks. Similary to Viru bog the initial project design were poor and major corrective actions had to be carried out some years after finishing initial works.

Improved methods were first used for the restoration of 218 ha in Western Capercaillie habitats in Soomaa NP. Ditches were filled back totally and all the dams were made from peat or other local soil material. The length of dam wings were increased significantly to direct water out of the ditch depressions. Monitoring has shown that this methodology works well and is sustainable in the long-term. Additional improvements can still be made to make infilled ditch lines look more diverse and natural by leaving some trees growing or felling trees as if they had been wind thrown.

Funding sources (current and long-term) and costs (one-off and ongoing)

Raised bog restoration and investments in the infrastructure for the management have been financed by the EU Regional Development Fund (ERDF) and Cohesion Fund 2007-13 and 2014-20, and national funds in the environmental programme.

ERDF & Cohesion funding: The Estonian ERDF operational programme 2007-14 (Keskkonnaministeerium, 2014) included an investment programme (budget €12.1 million) to the Estonian Environment Board and the State Forest Management Centre (RMK) to restore threatened habitats, including the restoration of the water regime of mires. RMK received support for restoration of abandoned peatlands, general nature conservation activities, visitor infrastructure, and ex situ conservation actions (RMK 2014a,b). During 2007-13 a total of €958,063 from the ERDF[7] was spent restoring bog habitats (MoE pers comm 2018).

[7] No Estonian co-funding was required during this period

National funds[8]: National public finances of €47 million were used between 2007-12 for the improvement and implementation of the Natura 2000 network (including inventories, monitoring, protection and management planning, data management, restoration and ongoing management, land purchase, environmental education and awareness raising, restoration of infrastructure, including infrastructure for public access) (Keskkonnaministeerium, 2013).

Actions since 2012 and future actions

The Estonian 2014-2020 Prioritized Action Framework (PAF) for Natura 2000 (Keskkonnaministeerium, 2014) identifies the objective for habitat 7110 as being to increase the area of restored habitats from 100 ha up to 8,000 ha and identifies ERDF/Cohesion Fund and the LIFE programme as funding sources. The State Forest Management Centre has the target of restoring 10,000 ha of fens and bogs by 2022 (Kohv, 2014).

Funding from 2012 onwards.

The Estonian Operational Programme for Cohesion Policy Funds 2014-20 (combined ERDF, Cohesion and Social Fund) (Rahandusministeerium, 2018) has budgeted €54 million for preservation and restoration of protected species and habitats, from which €24.7 million is foreseen for the restoration of protected habitats. It includes a support programme for the State Forest Management Centre and Environmental Board, and an open call fund for NGOs and local municipalities. As of today, €4,295,773 has already been allocated for active bog restoration (MoE pers comm, 2018).

Two current LIFE projects (Annex 2) have targets for restoration of active raised bogs:

- The LIFE Mires Estonia - Conservation and Restoration of Mire Habitats (2015-2020) objective is to secure the most favourable conservation status for wetlands, especially mires and the priority habitats active raised bogs (7110*), bog woodland (91D0*), and Fennoscandian deciduous swamp woods (9080*). It aims to restore 2,447 ha of active raised bog. It will regenerate favourable conditions for the development of natural hydrology in Alam-Pedja (Soosaare mire), Agusalu (Feodorisoo mire), Ohepalu, Tudusoo and Sirtsi Nature Conservation Areas, and Lahemaa National Park (Laukasoo mire). The project had started some tree cutting and manual restoration of mires as of end 2017, and put substantial efforts into awareness raising and building of acceptance among various stakeholders (ELF 2017). LIFE Mires Estonia has a total budget of €2,815,576 for five years, with the national co-financing provided by the Estonian Environmental Investment Centre.
- The LIFE project Peat Restore (2016-2021) has the target of restoring 3,343 ha of mire complex (mostly fen, but also bog habitats) by 2021. The project is spending €347,589 EU funds and €200,743 Estonian co-funding.

Achievements

Impacts on the target habitat

The Estonian government has set in place a legislative and administrative framework to support the conservation of active raised bogs. This has resulted in 120,000 ha of active raised bogs being in good conservation status (80% of the total reported habitat) with legal protection from further interference in their hydrological regime through drainage and from exploitation. However, underground oil-shale mining proposals in and around Natura 2000 sites still pose a high threat of negative impacts.

Restoration actions have been, or are being, carried out on over 2,000 ha of bog habitat, and according to the Ministry, the trend of the conservation status of the habitat has turned and is now improving (as reported under Article 17 for the period 2007-12) (MoE, pers comm, 2018). The reported improvement in structure and functions refers to the fact that the drainage ditches on most bogs are no longer cleared and are infilling (Illomets, M, pers comm, 2018). However, some experts consider that it is premature to conclude that the habitat has improved (ELF pers comm, 2018). Many of the protected bogs are still surrounded by drainage ditches on their edges that negatively affect their hydrology and encourage tree growth, and several drainage networks within bogs (supported by legislation and public funding) are still actively draining bogs and causing peat loss (ELF pers comm, 2018).

[8] Land protected as strict nature reserve or conservation zone is exempt from land tax according to the Land Tax Act 1993. However, as almost all raised bog areas are on state owned land this is not a significant financial factor.

Other impacts (e.g. other habitats and species, ecosystem services, economic and social)

The restoration of peat extraction sites and restoration of the water regime of bog areas with damaged hydrology will significantly reduce Estonia's greenhouse gas emissions. Research in Estonia has shown that emissions of carbon dioxide and nitrous oxide are higher from peat mining sites compared with those of natural peatlands, and abandoned sites continue to be net emitters of carbon dioxide and nitrous oxide (Salm et al, 2011). Although methane emissions are lower from drained peat, it is emitted from drainage ditches and stockpiles.

Estonian bogs have a high recreational significance and many local people visit the larger sites during their summer holidays, with wild berry picking a widespread recreational activity (Paal & Leibak, 2011). Wooden walkways and observation towers have been constructed across numerous bog sites, and some Estonian tourist companies offer bog visits. Mire tourism is still growing; however, as the presence of wooden paths has been shown to depress the breeding success of waders, they are no longer being constructed on the larger Natura 2000 sites (Leivits, 2009, cited in Paal & Leibak, 2011).

Conclusions and lessons learnt

The key targeted conservation measures that led to the improvements

- Protection of the intact habitat areas within Natura 2000 sites, preventing any further drainage.
- The use of watershed level hydrological modelling as a key process in restoration planning.
- The use of peat dams with longer wings and total back filling of ditches with local soil creates sustainable result.

Conservation measures that have not been sufficiently effective

- Some dam constructions, based on a combination of wood and peat have not been sustainable and failed during their first 5 years. Building only dams without levelling the peat mound and filling back the ditches creates unstable results and the effect of works can remain limited depending on specific local conditions.

Factors that supported the conservation measures

- Formalised cooperation protocols with institutions responsible for maintaining drainage systems has made the planning process much smoother.
- Political support and strategic planning documents with clear goals for mire restoration.
- Experience exchange between Nordic and Baltic countries has been useful for developing effective restoration approaches.
- NGO and scientific community leadership in initial communications about the importance of mire restoration.

Factors that constrained conservation measures

- Many of the protected bogs are still surrounded by drainage ditches on their edges that negatively affect their hydrology and encourage tree growth.
- Local officials have sometimes been against the planned measures because it eliminates walking routes along the ditches and people are afraid of massive forest dieback.
- Some private landowners oppose the planned actions and this hinders a holistic restoration approach.

Quick wins that could be applied elsewhere for the habitat

- Total back filling of ditches and peat dams on various sites (e.g. Ördi in Soomaa NP) has raised water tables sustainably and initiated *Sphagnum* recolonization.
- Cuttings have been an effective tool for accelerating the process of recolonization in open mire habitat (e.g. Kurasoo in Soomaa NP).

Examples of good practice, which could be applied to other habitats

- The use of watershed level hydrological modelling in developing restoration plans and subsequent automatic water level monitoring has provided objective information about the effectiveness of restoration actions on each bog's hydrology.
- The restoration projects have been thoroughly monitored and documented, and lessons learned have increased the effectiveness of subsequent restorations.

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Annex 1 Status of active raised bogs (7110) at Member State and biogeographic levels

Favourable	FV	Unknown	XX	Unfavourable - inadequate	U1	Unfavourable - bad	U2

Qualifier (+) improving (-) deteriorating (=) stable (x) unknown (n/a) not reported

	2001-06	2007-12				
	Overall	Range	Area	Structure	Future	Overall (with qualifier)
AT (ALP)	U2	U1	U2	U1	U1	U2 (=)
DE (ALP)	FV	FV	FV	FV	FV	FV
ES (ALP)	XX	U1	U1	U1	U1	U1 (-)
FR (ALP)	U2	FV	FV	U1	U1	U1 (=)
IT (ALP)	FV	U1	U1	U2	U2	U2 (-)
PL (ALP)	U1	FV	U1	U1	U1	U1 (=)
RO (ALP)	N/A	U1	U1	FV	U1	U1 (n/a)
SI (ALP)	U1	FV	FV	U1	FV	U1 (=)
SK (ALP)	U1	U1	U1	FV	U1	U1 (=)
EU (ALP) overall	U2	U1	U1	U1	U1	U1 (-)
BE (ATL)	U2	U2	U2	U2	U1	U2 (=)
DE (ATL)	U2	XX	U2	U2	U1	U2 (=)
DK (ATL)	U2	FV	U2	U2	U2	U2 (+)
ES (ATL)	XX	U1	U1	U1	U1	U1 (-)
FR (ATL)	U2	U1	U1	U2	U2	U2 (-)
IE (ATL)	U2	U2	U2	U2	U2	U2 (-)
NL (ATL)	U2	U2	U2	U2	U1	U2 (=)
UK (ATL)	U2 (+)	FV	U2	U2	U2	U2 (-)
EU (ATL) overall	U2	U1	U2	U2	U2	U2 (-)
EE (BOR)	U1 (-)	FV	FV	U1	FV	U1 (+)
FI (BOR)	U2	FV	U1	U2	U2	U2 (-)
LT (BOR)	U1	FV	U1	U1	U1	U1 (=)
LV (BOR)	U1	FV	U2	U1	U1	U2 (-)
SE (BOR)	U1	FV	U1	U1	U1	U1 (=)
EU (BOR) overall	U1	FV	U2	U2	U2	U2 (-)
AT (CON)	U2	U1	U2	U2	U2	U2 (=)
BE (CON)	U2	FV	U2	U2	U2	U2 (+)
CZ (CON)	U1	FV	FV	U1	U1	U1 (=)
DE (CON)	U1	U1	U1	U1	FV	U1 (=)
DK (CON)	U2	FV	U2	U2	U2	U2 (+)
FR (CON)	U2	U1	U1	U1	U1	U1 (-)
PL (CON)	U2	U1	U2	U1	U1	U2 (=)
SE (CON)	U2 (-)	FV	U2	U2	U2	U2 (-)
EU (CON) overall	U2	U1	U2-	U2	U2	U2 (-)
PT (MAC)	U2	FV	U2	U1	U1	U2 (=)
EU (MAC) overall	U2	FV	U2	U1	U1	U2 (=)
ES (MED)	XX	U1	U1	U1	U1	U1 (-)
FR (MED)	U2	FV	U2	U1	U2	U2 (-)
EU (MED) overall	U2	U1	U2-	U1	U2	U2 (-)
HU (PAN)	U1	U1	U2	U1	U1	U2 (=)
EU (PAN) overall	U1	U1	U2	U1	U1	U2 (=)

Source: Member State Article 17 reports for Active Raised Bogs as compiled by ETC-BD on EIONET https://bd.eionet.europa.eu/article17/reports2012/habitat/summary/?period=3&group=Bogs%2C+mires+%26+fens&subject=7110&region=

Annex 2. LIFE Nature Projects in Estonia that aimed to help conserve active raised bogs

Project Title	Project N°	MS	Time period	Type Of Beneficiary
LIFE Mires Estonia - Conservation and restoration of Mire Habitats	LIFE14 NAT/EE/000126	EE	2015-2020	NGO-Foundation
LIFE Peat Restore	LIFE15 CCM/DE/00138	EE	2016-2021	NGO-Foundation
EE Priority Forests - Protection of priority forest habitat types in Estonia	LIFE02 NAT/EE/008555	EE	2001-2005	NGO-Foundation
Häädemeeste - Restoration and management of the Häädemeeste wetland complex	LIFE00 NAT/EE/007082	EE	2001-2005	NGO-Foundation

Source: Life Programme database, projects with *active raised bogs* listed as a key word