Atlantic Canada Peatlands and Wetlands Symposium

Acadian Peninsula Convention Center

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Shippagan, New-Brunswick

Excursion

GUIDEBOOK

Institut de recherche sur les zones côtières inc.
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Booklet Design

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Organization of the symposium

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Peatlands and Soils
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Foreword

As a part of the "Atlantic Canada Peatlands and Wetlands Symposium'', this guidebook will provide you a set of information on the theme of sphagnum farming.

The "Atlantic Canada Peatland and Wetland Symposium" is for all people who is interested in wetlands, and it aims to:

- Provide an image of current wetland knowledge in Atlantic Canada.
- Create better synergy between government officials, researchers, industries and communities.
- Develop a list of topics that deserve further study.
- Create beneficial opportunities for various actors in the Atlantic provinces.

Contents

Sphagnum farming in Shippagan (NB)

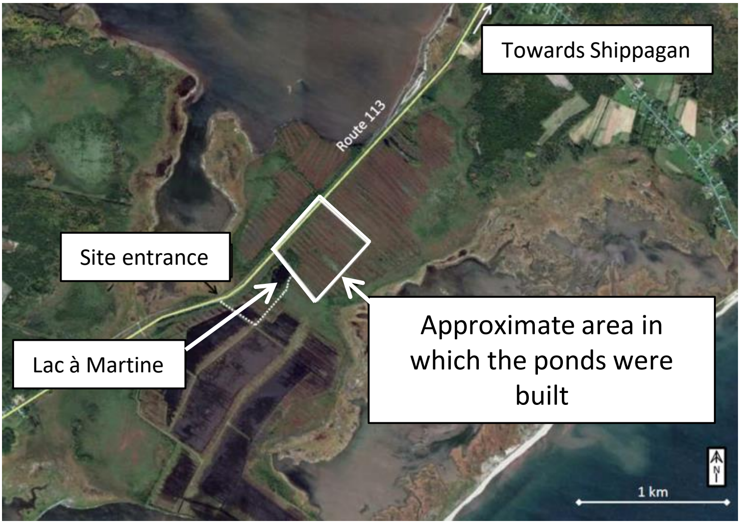
Sphagnum farming is the sustainable production of sphagnum moss. For a production on a renewable and cyclical basis, one or more species of sphagnum are sown in basins set up in peat bogs at the end of the peat exploitation. This cultivated sphagnum can have several uses: it can be used as plant material to restore exploited peatlands, or it can be used as an additive in growing substrates.

It is in this context that several experimental sites for sphagnum mosses have been developed in Shippagan (NB) since 2004, through peat bogs # 527 and # 530. These projects are the result of a partnership between the Peatland Ecology Research Group (PERG) from Université Laval, the Agroenvironment Research and Development Institute (IRDA) and the Coastal Zones Research Institute (CZRI).

The peat bog site # 530 differs from that of # 527 in the establishment of remotely managed pond irrigation system. In addition, specific sphagnum species were sown in plots in the basins.

Experimental site peatland #530

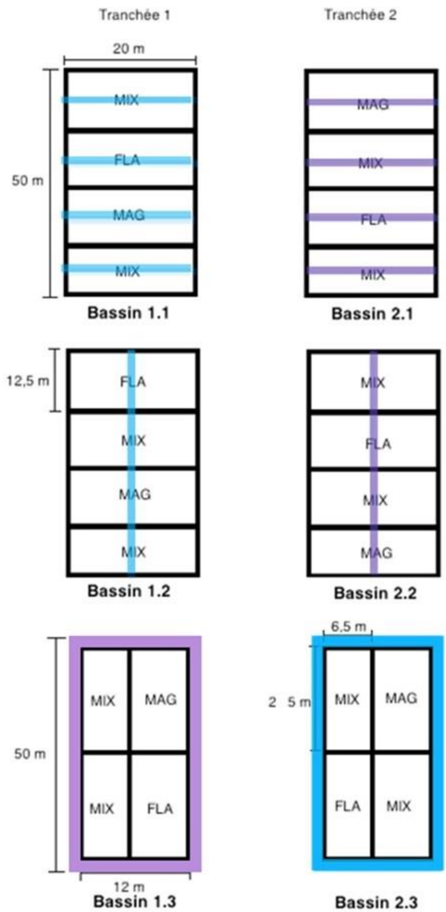
Today, most of the research is done on the bog site # 530.



The main current research activities and responsibilities of each actor are as follows:

- PERG : Monitoring of growth of sphagnum biomass, hydrological analysis of groundwater in basins, measurements of gas exchange between the bog and the atmosphere and the design of the experimental protocol.
- IRDA : Opening and closing of the site, designing and maintaining the irrigation system, monitoring and meteorological analysis, as well as determining the water requirements of sphagnum in the light of weather forecasts.
- CZRI : Monitoring and general maintenance of the site, development of the mechanization of the sphagnum harvest, monitoring of water levels in the basins and finally the study of the potentialities of the cultivated sphagnum.

Experimental site peatland #530



Niveaux d'eaux visés

- 20 cm

- 10 cm

Espèces végétales

MAG = *Sphagnum magellanicum*
FLA = *Sphagnum flavicomans*
MIX = *Mélange de S. rubellum et S. fuscum*

Experimental site peatland #530

The irrigation system installed on the site allows each basin to be supplied with water from the Lac à Martine to the respective canals. The sphagnum is thus fed with water by capillarity. In total, three irrigation systems are evaluated: two basins with lateral underground drains (basins 1.1 and 2.1), two basins with a central underground drain (basins 1.2 and 2.2), and two basins with open peripheral channels (basins 1.3 and 2.3).

At the same time, the level of the water table in each basin is monitored at the beginning of every week. This makes it possible, by means of the irrigation system, to maintain the water level of the constant water table at the predetermined depth for each basin. Thus, all the conditions are put in place to prevent the sphagnum from suffering from possible water stress.

Experimental site peatland #530

4 species have been selected for production in these basins:

Sphagnum magellanicum

Sphagnum flavicomans

Sphagnum rubellum

Sphagnum fuscum

They develop by block in the basins. These blocks are randomly distributed for each pool. The blocks called MIX constitute a mixture of two species, *S. rubellum* (about 80%) and *S. fuscum* (about 20%). Biomass monitoring is carried out annually to determine plant cover density and sphagnum biomass.

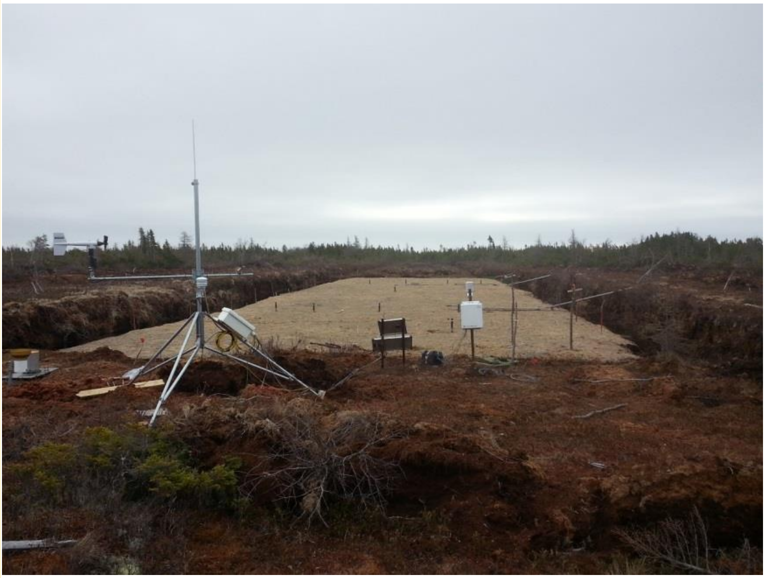
These species naturally exist in the Acadian Peninsula and have physiognomic differences that are sought to be characterized and compared.

Experimental site peatland #530

Currently, the overall results[1] that have been observed are:

- That after 3 growing seasons in an automated irrigation system, the accumulation of sphagnum biomass is higher than in the natural irrigation ponds of bog # 527, regardless of vegetation treatment, water level or type of drainage.

- That basins with a “-10 cm” water level target have the best results of sphagnum biomass accumulation. Moreover, at -10 cm, the accumulation of biomass remains similar whatever the types of drainage.



[1] Forest, F.J., S. Hugron, M.T. Simon, B. St-Hilaire et L. Rochefort (2017). *Sphagnum* Farming: Update of the results for New Brunswick (#530). 23rd PERG Symposium, February 21st 2017, Québec.

Harvest techniques for sphagnum moss

Another aspect that must be taken into account for the cultivation of sphagnum is the harvesting method. The challenge of harvesting sphagnum moss is to preserve the plant to allow its natural regeneration.

Preliminary research has led to existing machines that can adapt to the sphagnum harvest.

Pictures 1 and 2 show an existing machine in Germany that clearly shears the plant.

Pictures 3 and 4 show an existing machine in New Brunswick that carries out block cuts of peat. The tests have shown that it can also harvest the sphagnum.

CHARACTERISTICS OF EASTERN CANADIAN CULTIVATED SPHAGNUM AND POTENTIAL USE AS A SUBSTITUTE FOR PERLITE AND VERMICULITE IN PEAT-BASED HORTICULTURAL SUBSTRATES

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Sphagnum cultivation on harvested peatlands to meet wetland restoration objectives could be an economically feasible activity since cultivated Sphagnum has potential horticultural applications. We compared the characteristics of cultivated Sphagnum from Shippagan (Canada) with those of non-cultivated Sphagnum products from Chile, New Zealand and Canada, and assessed its potential as a perlite and vermiculite substitute in horticultural peat-based substrates. Shippagan cultivated Sphagnum was shorter than the Chilean and New Zealand products with which it was compared, yet more similar to them than to the Canadian product currently on the market. Laboratory tests on physical properties and greenhouse growth trials indicated that 50–100 % of the perlite or vermiculite of a peat-based substrate can be successfully replaced with cultivated Sphagnum. Non-sieved coarsely shredded Sphagnum or the large (> 6.3 mm) fragments of sieved coarsely shredded Sphagnum best replicated the aeration provided by perlite and vermiculite in the substrates that were tested. Decomposition tests and comparisons of changes in physical properties of substrates containing Sphagnum after six weeks of growth trials indicated that Sphagnum degradation leading to reduced substrate performance is not likely to be an issue. Therefore, cultivated Sphagnum has great potential as a substitute for perlite and vermiculite.

THE CO2 DYNAMICS AND HYDROLOGY OF AN EXPERIMENTAL *SPHAGNUM* FARMING SITE

C. Brown
Thesis presented to the University of Waterloo, Ontario, Canada

Sphagnum farming (or cultivation) is a recent land management strategy in reclaimed peatlands. The goal of *Sphagnum* farming is to cultivate *Sphagnum* fibers on a cyclic basis. *Sphagnum* moss is non vascular and requires high and stable moisture availability at the growing surface to reduce capillary stresses. However, specific hydrological requirements to maximize *Sphagnum* biomass accumulation (CO2 uptake) are uncertain, and there is interest in evaluating the water management design (i.e. irrigation) that is best suited for effective water distribution in *Sphagnum* farming operations. The purpose of this thesis was to evaluate the hydrological thresholds to increase *Sphagnum* CO2 uptake in an experimental *Sphagnum* farming site, and to provide recommendations on how irrigation can be used to increase productivity and upscale the size of operations. The experimental site is in a blockcut peatland south of Shippagan, New Brunswick. From May to July 2014, six 20 x 50 m *Sphagnum* cultivation basins were established within the lowered trenches of the blockcut peatland, each with a different type of active water management design. The CO2 fluxes were monitored with the closed chamber method, along with hydrological data collected from July 10 to August 14 in 2014, and May 11 to August 22 in 2015. A CO2 and water balance were calculated for each basin for the 2015 study period. Research has demonstrated that CO2 uptake by *Sphagnum* moss in postextraction peatlands is affected by the position of the water table (WT). At this experimental site, CO2 uptake by the moss was not limited by dry (WT 15 to 25 cm) or wet (WT < 15 cm) treatments. When the mean WT was shallow (< 25 cm), the fluctuations in WT were found to be more important in limiting/increasing CO2 uptake. Carbon dioxide uptake was highest where the range in seasonal WT position was < 15 cm. A WT position of 10 to 15 cm is recommended to reduce WT fluctuations and limit excess moisture at the surface. Productivity has the potential to be further improved by maintaining the daily WT fluctuations < ± 7.5 cm from the seasonal WT mean. When these conditions were met, moss grew by a mean of 1.8 mm/month. To maintain hydrological conditions necessary for maximum biomass accumulation, topographical features of the reclaimed peatland, such as baulks, drainage canals and adjacent trenches, are important considerations for site scale water flow. Water regulation canals are important hydrological features because they have stabilizing effects on WT levels when they are water input sources, and behave as water sinks when water tables are high in the peat basins. The majority of the water flow occurred towards the deep primary drainage canals. The baulks not adjacent to drainage canals formed water mounds, limiting water flow between the basins. An unmanaged trench that is a relic of the blockcut extraction outside but adjacent to the experimental area, was a large source of ground water input to the site. Leveling the site to a common datum and establishing buffer zones adjacent to drainage canals and adjacent unrestored trenches could reduce water transfer within the sites. Pumping water into the canals was necessary to reduce the water deficit from high ET and low P during a dry study period. The variability in WT position increased with distance from the water input feature (canals or subsurface pipes). Increasing the irrigation density (ratio of pipe/canal length to basin area) of the water management design will assist in maintaining stable WT positions. To upscale production sites, irrigation features (canals and pipes) should be installed in ways that complement the topography of the site. Installing these features upslope, and increasing their density (maximum spacing of 12 m) will reduce pumping demands and maintain a stable WT. Postextraction vacuum harvested sites may be better suited for *Sphagnum* farming than blockcut sites, as they are more accessible to machinery and less landscape manipulation is required. Future studies should evaluate the feasibility of establishing *Sphagnum* farming sites on postextraction vacuum harvested peatlands.

SPHAGNUM FARMING ON CUT-OVER BOG IN NW GERMANY: LONG-TERM STUDIES ON *SPHAGNUM* GROWTH

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Mires and Peat, Volume 20 (2017/18), Article 04, 1–19, ISSN 1819-754X
 DOI: 10.19189/MaP.2016.OMB.238

Sphagnum farming allows sustainable and climate-friendly land use on bogs while producing a renewable substitute for peat in horticultural growing media. We studied *Sphagnum* productivity on an experimental *Sphagnum* culture established on a cut-over bog in Germany with strongly humified peat at the surface. Preparation of the site included levelling of the peat surface, construction of an irrigation system, spreading of *Sphagnum papillosum* fragments, covering them with straw, and finally rewetting. Provided there was an adequate (95 %) initial cover of *Sphagnum* fragments, the most relevant variables for *Sphagnum* productivity were found to be water supply and regular mowing of vascular plants. As long as sufficient water was supplied, the dry biomass accumulation of the established *Sphagnum* lawn remained high, reaching 3.7 t ha-1 yr-1 between 2007 and 2011. Annual dry *Sphagnum* biomass productivity over the period 2010–2011 was up to 6.9 t ha-1. During periods when high water table could not be maintained, substantial decomposition of the previously accumulated biomass occurred. After nine years the net accumulated dry mass *per* hectare was on average 19.5 t of pure *Sphagnum* and 0.7 t of subsurface vascular-plant biomass. Nitrogen deposition in the study region is apparently sufficient to support fast *Sphagnum* growth, whereas phosphorus and potassium may be limiting.

DEVELOPING NEW POTTING MIXES WITH SPHAGNUM FIBERS

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Can. J. Soil Sci. (2014) 94: 585593 doi:10.4141/CJSS2013-103

Researchers are developing techniques to mass produce Sphagnum fibers (SF) on a sustainable basis since this material has properties that could benefit the growing-media industry. The objective of this study was to incorporate SF into peat-based substrates to enhance the value of brown Sphagnum peat and/or replace perlite in blond peat mixes. Nine substrates were prepared by mixing brown Sphagnum peat (BrSP) or sieved brown Sphagnum peat (sBrSP) with 0, 15 and 30% of SF and substituting 0, 50 and 100% of the perlite in a 70% blond Sphagnum peat (BSP) and 30% perlite mix with SF. The growth of Pelargonium was unaffected by the addition of SF, with the exception of above-ground biomass which was 15% lower in the BrSP substrate containing 15% SF. In the case of Petunia, above-ground biomass increased with a 30% SF addition to sBrSP, and below-ground biomass increased with a 30% SF addition to BrSP and sBrSP. Adding SF to peat increased water retention and hydraulic conductivity, but either reduced or had no impact on air - filled porosity. Removing fine particles from BrSP and adding 30% SF provided promising results, although the effect varied with plant species. Moreover, it is clear that SF can be used as a substitute for perlite in BSP mixes.

SPHAGNUM FARMING: A LONG-TERM STUDY ON PRODUCING PEAT MOSS BIOMASS SUSTAINABLY

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Ecological Engineering 74 (2015) 135–147

Researchers are developing techniques to mass produce Sphagnum fibers (SF) on a sustainable basis since this material has properties that could benefit the growing-media industry. The objective of this study was to incorporate SF into peat-based substrates to enhance the value of brown Sphagnum peat and/or replace perlite in blond peat mixes. Nine substrates were prepared by mixing brown Sphagnum peat (BrSP) or sieved brown Sphagnum peat (sBrSP) with 0, 15 and 30% of SF and substituting 0, 50 and 100% of the perlite in a 70% blond Sphagnum peat (BSP) and 30% perlite mix with SF. The growth of Pelargonium was unaffected by the addition of SF, with the exception of above-ground biomass which was 15% lower in the BrSP substrate containing 15% SF. In the case of Petunia, above-ground biomass increased with a 30% SF addition to sBrSP, and below-ground biomass increased with a 30% SF addition to BrSP and sBrSP. Adding SF to peat increased water retention and hydraulic conductivity, but either reduced or had no impact on air - filled porosity. Removing fine particles from BrSP and adding 30% SF provided promising results, although the effect varied with plant species. Moreover, it is clear that SF can be used as a substitute for perlite in BSP mixes.

SWIFT RECOVERY OF *SPHAGNUM* CARPET AND CARBON SEQUESTRATION AFTER SHALLOW *SPHAGNUM* BIOMASS HARVESTING

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Mires and Peat, Volume 20 (2017/18), Article 01, 1–11, ISSN 1819-754X
 DOI: 10.19189/MaP.2015.OMB.198

White horticultural peat is a microbiologically active growing medium which binds significant quantities of nutrients and water due to its favourable cation exchange capacity and porosity. Unfortunately, horticultural peat is only very slowly renewable, and good quality horticultural peat is not common even in peatland-rich countries. Therefore, good-quality and simultaneously renewable alternative growing media are needed. A new growing medium based on *Sphagnum* moss biomass is introduced in this study. According to our results, harvesting of *Sphagnum* biomass to a depth of no more than 30 cm will have a relatively short-term effect on *Sphagnum* carpet coverage and carbon sequestration, allowing a harvesting cycle of ~30 years to be achieved. Therefore, the average harvesting depth will be 30 cm. Only half of the mire surface on each harvesting area will be utilised, the other half being kept intact for transportation routes. This will also secure a reserve of *Sphagnum* mosses for reseeding and recovery. The end product - *Sphagnum* biomass based growing medium - will be truly renewable, and environmental effects will be negligible compared with conventional extraction of white horticultural peat. Therefore, *Sphagnum* biomass harvesting is more comparable with sustainable forestry management than with the production of white peat, which causes drastic and long-term alterations of the mire ecosystem.

ANNUAL CARBON BALANCE OF A PEATLAND 10 YR FOLLOWING RESTORATION

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Biogeosciences, 10, 2885–2896, 2013 doi:10.5194/bg-10-2885-2013

Undisturbed peatlands represent long-term net sinks of carbon; however, peat extraction converts these systems into large and persistent sources of greenhouse gases. Although rewetting and restoration following peat extraction have taken place over the last several decades, very few studies have investigated the longer term impact of this restoration on peatland carbon balance. We determined the annual carbon balance of a former horticulturally-extracted peatland restored 10 yr prior to the study and compared these values to the carbon balance measured at neighboring unrestored and natural sites. Carbon dioxide (CO_2) and methane (CH_4) fluxes were measured using the chamber technique biweekly during the growing season from May to October 2010 and three times over the winter period. Dissolved organic carbon (DOC) export was measured from remnant ditches in the unrestored and restored sites. During the growing season the restored site had greater uptake of CO_2 than the natural site when photon flux density was greater than 1000 $\mu mol m^{-2} s^{-1}$, while the unrestored site remained a source of CO_2. Ecosystem respiration was similar between natural and restored sites, which were both significantly lower than the unrestored site. Methane flux remained low at the restored site except from open water pools, created as part of restoration, and remnant ditches. Export of DOC during the growing season was 5.0 and 28.8 $g m^{-2}$ from the restored and unrestored sites, respectively. Due to dry conditions during the study year all sites acted as net carbon sources with annual balance of the natural, restored and unrestored sites of 250.7, 148.0 and 546.6 $gC m^{-2}$, respectively. Although hydrological conditions and vegetation community at the restored site remained intermediate between natural and unrestored conditions, peatland restoration resulted in a large reduction in annual carbon loss from the system resulting in a carbon balance more similar to a natural peatland.

SPHAGNUM FARMING IN A EUTROPHIC WORLD: THE IMPORTANCE OF OPTIMAL NUTRIENT STOCHIOMETRY

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Ecological Engineering xxx (2016) xxx–xxx

Large areas of peatlands have worldwide been drained to facilitate agriculture, which has adverse effects on the environment and the global climate. Agriculture on rewetted peatlands (paludiculture) provides a sustainable alternative to drainage-based agriculture. One form of paludiculture is the cultivation of Sphagnum moss, which can be used as a raw material for horticultural growing media. Under natural conditions, most Sphagnum mosses eligible for paludiculture typically predominate only in nutrient-poor wetland habitats. It is unknown, however, how the prevailing high nutrient levels in rewetted agricultural peatlands interfere with optimal Sphagnum production. We therefore studied the effect of enriched nutrient conditions remaining even after top soil removal and further caused by external supply of nutrient-rich irrigation water and (generally) high inputs of atmospheric nitrogen (N) to habitat biogeochemistry, biomass production and nutrient stoichiometry of introduced *Sphagnum palustre* and *S. papillosum* in a rewetted peatland, which was formerly in intensive agricultural use. Airborne N was responsible for the major supply of N. Phosphorus (P) and potassium (K) were mainly supplied by irrigation water.

The prevailing high nutrient levels (P and K) are a result of nutrient-rich irrigation water from the surroundings. Peat porewater (10 cm below peatmoss surface) CO_2 concentrations were high, bicarbonate concentrations low, and the pH was around 4.2. Provided that moisture supply is sufficient and dominance of fast-growing, larger graminoids suppressed (in order to avoid outshading of Sphagnum mosses), strikingly very high biomass yields of 6.7 and 6.5 t DW $ha^{-1}yr^{-1}$(*S. palustre* and *S. papillosum* [including *S. fallax* biomass], respectively) were obtained despite high N supply and biomass N concentrations. Despite high P and K supply and uptake, N:P and N:K ratios in the Sphagnum capitula were still low. Sphagnum mosses achieved high nutrient sequestration rates of 34 kg N, 17 kg K and 4 kg P $ha^{-1}yr^{-1}$ from May 2013 to May 2014, which shows that the site acted as an active nutrient sink. Nutrient management still needs further improvement to reduce the competitive advantage of fast growing peatmoss species (cf. *S. fallax*) at the expense of slower growing but preferred peatmosses as horticultural substrate (*S. palustre* and *S. papillosum*) to optimize the quality of biomass yields. In conclusion, Sphagnum farming is well able to thrive under high N input provided that there is a simultaneous high input of P and K from irrigation water, which facilitates high production rates. Due to the lack of suitable, nutrient poor sites, it seems to be useful to remove the topsoil (mainly P removal) prior to start growing Sphagnum mosses. In addition, bicarbonate concentrations have to stay sufficiently low to ensure a low pH, CO_2 supply from the peat soil should be sufficiently high to prevent C limitation, and graminoids should be mown regularly.

MICROTOPOGRAPHY AND THE PROPERTIES OF RESIDUAL PEAT ARE CONVENIENT INDICATORS FOR RESTORATION PLANNING OF ABANDONED EXTRACTED PEATLANDS

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 doi: 10.1111/rec.12030

The natural recovery of vegetation on abandoned peat extraction areas lasts for decades and the result of restoration succession can be unpredictable. The aim of the study was to specify environmental factors that affect the formation of the pioneer stages of mire communities and, therefore, be helpful in the prediction of the resulting ecosystem properties. We used the national inventory data from 64 milled peatlands in Estonia, distributed over the region of 300×200 km. This is the first national-scale statistical evaluation of abandoned extracted peatlands. During surveys, vascular plants, bryophytes, and residual peat properties were recorded on three microtopographic forms: flats, ditch margins, and ditches. The microtopography was the main factor distinguishing the composition of plant communities on flats and ditches, while ditch margins resembled flats. The extracted indicator species suggested two successional pathways, toward fen or raised bog community. A single indicator trait—the depth of residual peat, which combines the information about peat properties (e.g. pH, ash content, and trophicity status), predicted the plant community succession in microtopographic habitats.

We suggest that peatland management plans about the costefficient restoration of abandoned peat mining areas should consider properties of residual peat layer as the baseline indicator: milled peatfields with thin (<2.3m) and well decomposed residual peat should be restored toward fen vegetation types, whereas sites with thick (>2.3m) and less decomposed residual peat layer should be restored toward transitional mires or raised bogs. Specific methodological suggestions are provided.

Thanks :

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Thanks to our sponsors !

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sur les zones côtières inc.
Coastal Zones
Research Institute Inc.

The Coastal Zones Research Institute Inc. (CZRI) is a private non-profit institution affiliated with the Université de Moncton, campus de Shippagan (New Brunswick), incorporated in December of 2002.

The CZRI was born of the merger of three research and development centres from New Brunswick's Acadian Peninsula: The Peat Research and Development Centre; the Marine Products Research and Development Centre, and the aquaculture research team of the New Brunswick Aquarium and Marine Centre.

The Institute encourages a multidisciplinary approach that focuses on three main areas of research: aquaculture, fishery and marine co-products, and peat and peatlands. A fourth research orientation relating to the sustainable development of coastal zones is currently taking shape. These dominant institutional research areas are supported by laboratory analysis and environmental services.

the Coastal Zones Research Institute is helping to make the Acadian Peninsula – and indeed all of New Brunswick – a hub for research, for scientific dissemination, and for technology and knowledge transfers to industry, professionals and the general public.