Loss of Peat on Drained Peatlands in Estonia

JAAK PIKK
Agricultural University of Estonia, Forest Research Institute
5 Kreutzwaldi St., 51014 Tartu, Estonia
e-mail: jpikk@ph.eau.ee
HEINO SEEMEN
Agricultural University of Estonia, Faculty of Forestry
5 Kreutzwaldi St., 51014 Tartu, Estonia

Pikk J., Seemen H. 2000. Loss of Peat on Drained Peatlands in Estonia. *Baltic Forestry*, 1: 25–29.

Hitherto 27 % of forest land is drained in Estonia. The analysis of forest inventory data in 25 years interval and the investigations of the areas drained more than 40 years ago enabled us to get new information on the transformation of forest site types and peat thickness of peatlands. On drained peatlands the area of alder fen, transitional bog and alder-birch fen has considerably decreased, simultaneously transformed swamps and *Filipendula* site type areas have increased. Drained alder fens and alder-birch fens with thin peat have transformed into *Filipendula* site type or other more fertile site types. On drained alder and birch fens with thin peat on the clay subsoil the loss of the peat layer is about 0.8 cm per year and on transitional bog 0.6 cm per year, respectively. The loss of peat on loamy basis exceeds up to 1.3 cm per year.

Key words: drainage; peatland forest; decomposition; peat loss; site type.

Introduction

Estonia (57°30'-59°49'N; 21°46'-28°13'E) is situated in the climate and hydrological conditions favouring the genesis and development of swamps. Annual precipitation on average are 550 - 650 mm and the sum of active temperatures (≥+10°C) 1750°C. The raised bog transgression value to mineral soil varies from 4 to 53 cm year^{-1} (Kuzmin, Petrovsky,1988) and depositions of the peat layer depending on peatland types 0,5...1,5 mm year^{-1} are determined (Ilomets, 1994; Veber, 1966). As it is generally known the natural paludification is proceeded by bogged area, i. e. a decrease in plant community species is followed by a decrease in the biodiversity. To reduce the distribution of peatlands towards forest lands the digging boundary ditches and ditching paludified areas has been used for about 165 years. In Estonia there are forest lands 2.02 × 10^6 ha, 27% is drained. Drainage has been used for improving not only forest growth, but also forest management, forest guard, forest protection and service condition as well. For example, without preliminary drainage it is impossible to build roads on lowlands with loamy or clay subsoil.

The basic material of Estonian soils is variable. It is the reason for mosaic locating of forest site types. Moraines are the most important parent materials for the soils. In Northern Estonia whitish grey carbonate, often gravely moraine is the most widespread type; in Central Estonia yellowish grey or greyish-brown carbonate loamy moraine and in Southern Estonia reddish brown sandy clay or loamy moraine poor in carbonate prevails. In addition to moraines we can often find sediments with different structural composition which come from the Late and Post Glacial reservoirs, and also the sands of fluvio-glacial, eolian and other origin (Lõhmus, 1995). If to add response of regulated water regime (drainage or repaludification), the development presumptions for evolution of various kinds of new plant community are unbounded. At present situation digging of new ditches is unreasonable, excluding some cases. Currently, we do not have enough adequate information about forest peatland site types evolution and intensity of this process, nor the data on what kind of changes occur in the peat layer. Therefore, it is purposeful to investigate changes occurring in peatland forests with thin peat layer in long-term drainage conditions.

Material and methods

The forest site type may be defined as a set of woodlands with similar silvicultural effect (i.e. a complex of similar natural factors influencing the vegetation). In order to obtain the data on the changes in site type areas of wet and potentially wet state forests in a period of draining over 25-years were determined. It was possible to use the results obtained by P. Kollist (1972, 1973) and compare those with the data collected and analysed later. Depending on forest inventory time P.Kollist's material was gathered from 1958 till 1967. Therefore, the data characterize the average situation of the state forests in 1962-1963. The collecting of the material, dividing it into groups and analysing were carried out on the basis of forest typology compiled by A. Karu and L. Muiste (1958) used in forest inventory at that time.

After 25 years the forest inventory data from 1982-1992 represent conventionally the situation in 1986-1987 and the typology by E. Lõhmus (1984) was used for inventory. During the last decades in the forest inventory the typology of site types was based mainly on earlier typology which has developed. It enabled us to compare the forest inventory data collected earlier with these collected later.

More exact data were gleaned on fieldwork at forest districts of Orajõe (NW-Estonia), Maidla and Paasvere (NO-Estonia) from the oldest drained forest parts. The data on drainage projects before the drainage work were compared with the data collected decades later on the same areas. In each stand the changes which had taken place were separately recorded (about 2250 ha). The thickness of peat deposit marked on longitudinal profile of ditches (21 km) was compared with the thickness near ditches at present. The relations between the site types, thickness of peat and ground materials were investigated. The loss of peat deposit thickness per year was determined.

Results and discussion

The area of state forest land has essentially enlarged: in 1962 860,000 hectares and in 1988 - 1,151 800 hectares. The increment is mainly based on former agricultural lands and forest lands of collective farms situated mainly on relatively dry areas. Thus, we may presume its little influence on the areas of wet site types.

Over the last decades some re-estimations for suitable forest areas occurred in forestry in Estonia. Taking into account the above-mentioned it was planned to afforest all treeless peatlands, including raised bogs. Later, the majority of oligotrophic bogs were excluded from forest lands, as seen in Table 1. Every site type is presented as a total of drained and natural site type areas.

In today's typology classification the meso-oligotrophic peat-bog is not in use, therefore, it has been allowed to consider the half of the area as the raised bog area and the other half as the transitional bog area. In this case according to P. Kollist's (1972) data in state forests the area of transitional bog will be 112,550 hectares and we can compare it with the area of transitional bogs - 79,800 hectares 25 years later, which comprises only 71 % of the original. In Table 1 we can see a decrease in fertile natural wet site type area. The area of alder-birch fens remains at 89 % and alder fens at 48 %. On the other hand, the areas of transformed swamps have been doubled. We may notice the same about *Filipendula* site type. Such changes on large areas let us conclude that the influence of drainage for improving moisture conditions, soil fertility, vegetation

Table 1. Area of wet site types in state forest lands

Site type	Forest inventory 1958 – 1967 (ha)		Forest inventory 1982 – 1992 (ha)	
	Area (ha)	State forest land (%)	Area (ha)	State forest land (%)
Raised bog	170 000	19.8	27 900	2.4
Meso-oligotrophic peat-bog	49 100	5.7		
Transitional bog	88 000	10.2	79 800	6.9
Alder-birch swamp	66 000	7.7	59 000	5.1
Alder fen	24 000	2.8	11 500	1.0
Drained swamp	48 900	5.7	95 600	8.3
Filipendula	80 000	9.3	142 600	12.4
Carex-Filipendula			21 500	1.9
Carex			65 600	5.7
Paludifyed dune	23 000	2.7		
Equisetum-Carex	20 000	2.3		
Equisetum			27 300	2.4
Vaccinium uliginosum	28 000	3.3	34 900	3.0
Polytrichum	53 000	6.1	17 400	1.5
Polytrichum-Myrtillum			39 700	3.4
Dryopteris	9500	1.1	14 500	1.3
Other site types	200 500	23,3	514 500	44,7
Total	860 000	100	1151 800	100

and stand productivity over the last decades was by far stronger than the previous investigations by P. Kollist (1972) had shown.

The area of *Polytrichum* site type has decreased by two third but as in the new typology there are separately *Polytrichium* and *Polytrichum-Myrtillum* site types represented, its total area forms more or less the same of earlier *Polytrichum* site type. In the typology by E. Lõhmus (1984) the *Carex-Filipendula* site type is separated from the former *Filipendula* site type, where the area may be divided approximately between *Filipendula* and *Carex* site types. In this case the area of *Filipendula* site type is 1.9 time larger than 25 years earlier. The relatively large area of *Carex* site type together with the half of *Carex-Filipendula* site type area form 76,350 ha. It may partly be caused by adding the former collective farm meadows, but the influence of drainage on the development of other site types to *Carex* site type cannot be eliminated.

More significant changes are related with *Filipendula* site type. *Filipendula* site type represents mixed stands with dominating spruce, aspen, birch or alder, mainly with II...III quality class (stand height degree in defined age), where lime and ash may occur. The relief is even or with slight inclination, in some places is bumpy. The site type includes mainly moisture to wet gley-podzol sand soil in relatively lower areas. The surface horizon of the soil often forms from the raw humus layer (10...25 cm). The ground water level is near the surface and has relatively good mobility. With such description it is possible to place *Filipendula* site type easily among swampy type, in case the conventional border of the Estonian peatland site types is ignored, i. e. the thickness of the peat layer has to be more than 30 cm (more than 25 cm on drained lands). Large swamp areas with thin peat layer may become paludified site types after thinning and partial decomposition of the peat layer.

Drainage has direct influence on peat layer sinking, thickening, decomposition, the water content, the amount of nutrient per bulk density unit, etc. The decomposing of peat is influenced by the groundwater level. The influence of groundwater lowering is greater to the peat deposits placed above the groundwater level. After drainage peat mineralization intensity largely depends on climate conditions and increases from north to south where the intensity, for example in Byelorussia, is essentially greater than that in Finland. In the research stations of Novgorod and Minsk the loss of 1.5 - 2.0 m-thick-peat-layer was observed over 70 years (Efimov, Lunina, 1988). The duration of peat mineralization depends on botanical composition, decomposing stage, acidity, drainage unit and on agricultural lands also the duration of cultivation, the type of crop rotation, etc. By using nitrogen fertilizers it is possible to accelerate the mineralization process. In Germany the loss of oligotrophic peat on grasslands after drainage is 0.5 cm year^{-1}, but together with grassland fertilization it has extended to 1.1 cm year^{-1}. In case soil acidity is high the loss of peat is smaller (Kunze, 1992).

We may presume that less decomposed peat layer sinks after drainage faster than peat with good decomposition, because the density is smaller. We can study the decrease in peat thickness after the removal of excessive water and also the decomposing and humification of peat. Sphagnum peat contains more water than peat of fens, but the sphagnum peat decomposes more slowly, because the pH level is lower (Veber, 1966). The sphagnum peat has an essentially less amount of minerals, as compared to the peat of fens and, therefore, the ash content is lower. It is clear that there are many factors connected with peat layer loss and it has become more difficult to find regularities.

In case of complete disappearance of the organic horizon the underlying mineral horizon appears on the surface. The character of underlying rock is of great importance in soil development. Gley soils characterized by poor water-physical properties and low contents of nutrients are formed on underlying loam (Efimov, Lunina, 1988).

On the areas with deep peat layer the roots of trees are near the surface and trees sink together with the peat layer and root collar does not rise up. The removal of excessive water causes peat thickening with downfalls and the drop of surface on a large area. The overall drop of surface on the area with thick peat layer during decades may reach the stage where the drainage ditches do not lead water to the needed direction. The water flow often does not coincide with old ditches and we must establish new collecting ditches.

More often on drained peatlands the downfall of peat is visible from the rise of root collars. It is conspicuous in the stands on relatively thinner peat deposit only, where the roots of trees are supported by mineral ground and the trees do not sink simultaneously with the peat.

The horizon of well-decomposed peat is formed under forest litter on drained peat soils as a result of soil development process. For example, in Sweden the thickness of this layer may extend even one metre, but the formation of this is greatly modified. On the bog in Järvselja (Estonia), drained in 1892, the thickness of well-decomposed layer is only 5 cm at 10 m distance from the ditch a hundred years later (Pikk,1997[1]). Although according to the vegetation *Myrtillus* swamp occurs there on a large area, the well-formed decomposed peat layer further from the ditch has not properly been formed. The organic matter of peat in fertile swamps mineralizes rapidly. It is more visible on the areas with thin peat layer. For example, in forest district Orate on former peatlands the thickness of peat was up to 60 cm. The peat layer was decomposed to such a degree that 42 years after drainage the traditional peat layer was missing on large areas, very little decomposed peat remained. More particular is the soil profile in forest district Paasvere, where in the fifties before drainage the peat layer was 40...50 cm thick, but now nothing has remained and above gleyey sandy clay only a thin forest litter forms. Today such areas are named as *Aegopodium* site type. In some parts of stands placed far from a drainage ditch a thin decomposed peat layer is still preserved. It belongs to a drained *Filipendula* site type. On drained areas there occur even more other variations of site types and stand quality classes (Table 2). In such a way during decades on former relatively similar peatlands very mosaic forest ecosystem was established and the biodiversity of vegetation grew. The data from forest drainage projects on longitudinal profile diagram of ditches and soil research with present data allowed to determine the rate of peat loss in different peatlands. Figure 1 reveals peat loss of peatland types lying on diferent subsoil. The loss of peat on loam or clay has been more significant in alder fens and alder-birch fens (0.8 - 1.3 cm year^{-1}) and smaller in transitional bogs (0.6 - 1.1 cm year^{-1}). The peat consisting of vegetation growing on fertile soil decomposes relatively rapidly. On subsoil with better filtration the loss of peat in transitional bog may be more intensive than on clay.

Relatively intensive was the loss of peat in swamps at Paasvere and Maidla lying on loamy bases, where the ground material was carbonic (limy) and abundance of species of vegetation was greater. Thus, we must place emphasis on the fact that the obtained results characterize the situation after drainage on peatlands with thin peat layer where the bottom of ditches is situated in mineral subsoil. In the peatland classification in Estonia there are few site types and for that reason the variation in the conditions within site type is significant. Therefore, great differences of peat decomposition intensity occur in the same site type. It is notable that today we have no facts about deterioration forest productivity caused by decreasing of peat thickness on peatlands.

The transformation of thin peat of alder and alder-birch fens into gley soil, the work conditions for timber harvesting and logging machines have essentially changed. The use of machine power, traffic velocity and, in total, labour productivity (Pikk, 1997[2]) have increased.

Table 2. The site types and stand quality classes before and after drainage (drainage age 42...45 years)

Forest district	Site type		Quality class		Ground material
	Before drainage	In 1995	Before drainage	In 1995	
Orajõe	Alder fen	Transformed swamp	4	3	clay
	Alder-birch fen	Transformed swamp	5	3	clay
	Transitional bog	Transformed swamp	5	3	clay
	Alder-birch fen	Transformed swamp	4	1	sandy loam
	Alder fen	Drained *Filipendula*	4	1	sandy loam
	Alder-birch fen	Drained *Filipendula*	4	2	sandy loam
	Alder fen	*Filipendula*	3	2	sand
Maidla	Alder-birch fen	*Filipendula*	4	2	sandy loam
	Transitional bog	Drained Transit. bog	5	4	loam
Paasvere	Alder fen	*Filipendula*	4	2	loam
	Alder fen	Drained Filipendula	4	2	loam

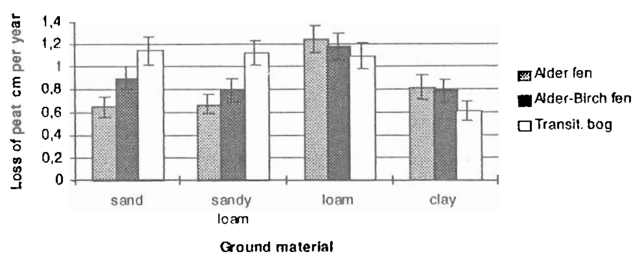

Figure 1. Peat layer loss (mean and standard error) per year in site types at drainage age of 42...45 years

Conclusion

After forest drainage on former relatively similar peatlands during decades very mosaic forest ecosystem was established and the biodiversity of vegetation grew. If we presume such evolution of peatland on millions of drained hectares around the Baltic Sea the influence on the environment is predicted.

On drained alder and birch fens with thin peat on the clay subsoil the loss of peat layer is about 0.8 cm per year and on transitional bog 0.6 cm per year. The peat loss on basis with better filtration exceeds up to 1.3 cm per year.

The loss of peat on peatlands has an important practicable value. In our opinion too little attention has been paid to determination of the value of forest drainage at present, to logging conditions and to the respective research.

Acknowledgements

The authors gratefully acknowledge Professor Uno Valk for valuable comments on the text. This research was supported by the Estonian Science Foundation (grant 2685).

References

Efimov V. N. and Lunina N. F. 1988. Evolution of bog soils in the European part of the USSR due to their agricultural use. In: Proceedings VIII International Peat Congress Section III, Leningrad, 71-78

Ilomets M. 1994. On the growth of peat in Estonia. In: Eesti Geograafia Seltsi Aastaraamat, Tallinn, 26 13-18 (In Estonian with English summary)

Karu A. and Muiste L. 1958. Eesti metsakasvukohatüübid [Estonian forest site types]. Tallinn, 44 p. (In Estonian)

Kollist P. 1972. Lodumetsadest ja seniste kuivenduste mõjust nende tootlikkusele takseereralduste andmetel [About alder fens and influence of drainage on their productivity based on forest taxation data]. In: Metsanduslikud uurimused IX, Tallinn, 93-123 (In Estonian with German summary)

Kollist P. 1973. Metsakuivendusfond ja seniste kuivenduste tulemused massandmestiku analüüsi alusel [The forest drainage fund and results of drainage analysed by forest inventory data]. Metsamajandus II, Tallinn, 75-82 (In Estonian)

Kunze H. 1992. Peat losses by liming and fertilizing of peatland used as grassland. In: Proceedings of the 9th International Peat Congress. 22-26 June 1992 Uppsala, Sweden, 306-314

Kuzmin G. F. and Petrovsky E. E. 1988. Background of bog utilization system. In: Proceedings VIII International Peat Congress Section III, Leningrad, 3-9

Lõhmus E. 1984. Eesti metsakasvukohatüübid [Estonian forest site types]. Tallinn, 121 p. (In Estonian)

Lõhmus E. 1995. Conditions of Forest Growth. In: Estonian forests and forestry. Tallinn, Estonia, 6-20

Pikk J. 1997[1]. Metsakuivenduse mõju metsakasvukohatüüpide kujunemisele [Influence of forest drainage to forest site type evolution]. Eesti Mets, Tallinn, 3 14-15 (In Estonian.)

Pikk J. 1997[2]. Results of long-term drainage to fens with thin peat. In: Transactions of the Estonian Agricultural University, Tartu, 189 148-156 (In Estonian with English summary.)

Veber K. 1966. When Were the Bogs of Estonia Formed? Eesti Loodus, Tallinn, 5 286-198. (In Estonian with English summary).

Received 14 February 2000

РАЗЛОЖЕНИЕ ТОРФА НА ОСУШЕННЫХ БОЛОТАХ В ЭСТОНИИ

Я. Пикк, Х. Сээмен

Резюме

В Эстонии в настоящее время осушено 27% лесных земель. Анализ лесотаксационных данных в интервале 25 лет и исследования на осушенных объектах, заложенных 40 лет назад, дали возможность получить новую информацию о трансформации типов местопроизрастаний леса и о гумификации и минерализации органического вещества торфа. В осушенных лесах площадь топей, переходных и низинных болот уменьшилась и соответственно увеличилась площадь перегнойных болот и таволгового типа местопроизрастания. Низинные болота и болота топяного типа с неглубоким слоем торфа трансформировались, в основном, в таволговый тип местопроизрастания или в какой-либо другой плодородный тип.

Исчезновение неглубокого топяного и низинно-болотного торфа на подстилающей глине составляло в среднем 0,8 см в год, переходно-болотного торфа 0,6 см в год. Исчезновение торфа на суглинках достигало 1,3 см в год.

Ключевые слова: топяной торф, болотный торф, гумификация, минерализация