Summary and recommendations of the research carried out in the drained part of Kuresoo bog.

The drained part of the area under observation can hypothetically be divided into three, and the rest of the area into two zones or belts (Fig. 32). The first zone of the drained area is situated in the southern part, in the trenched bog pine forest spreading on the lower part of the slope and below it, where tree layer canopy closure and tree height are the biggest. After that comes the transitional zone, where tree height and canopy closure rapidly decline. The third zone, dominated by a sparse and low stand, captures roughly half of the drained area under observation.

In the first zone communities with relatively large shrub layer coverage (bog blueberry, Labrador tea) and with big red stem moss dominating in the moss layer are mainly spreading. The importance of sphagnum moss is relatively small, but in places patches of *S. angustifolium* and *S. magellanicum* can cover more than half of the area. The pre-drainage state of this area can be evaluated by comparing it to the paludifying pine forest right west of it. Pinetrees growing on the drained area are 16-18 m tall, compared to the maximum height of 8-9 m on the natural area west of it. Also the latter has lower canopy coverage and relatively many standing dead trees. The role of forest mosses is very low. *S. magellanicum* and *S. fuscum* form high, up to 50 cm turfs. In the shrub layer crowberry and cranberry dominate. The water level is on average more than two times higher (ca 25 cm below the ground) than in the drained bog pine forest. In the latter we were often not able to determine the water level at all – due to arid summer in 2006 the water level was deeper than 70 cm even in September.

On the presence of sphagnum mosses the moss layer can under favorable conditions start to expand fast. For that the water level needs to be raised close to the surface level. It is very probable that only closing the ditches and building dams will not be enough. There will be a need to remove the tree layer.

The effect of tree layer on the water level and moss layer is diverse. Much of the soil water is transpired into air through the roots-trunk-leafage of the system. This lowers the water level of the bog. On the other side only a part of the precipitation reaches the ground, a big part of it is sucked in by the canopy and transpires. Low water level and relatively small humidness inhibit the spreading of sphagnum mosses.

Removal of tree layer decreases transpiration and with the concurrent damming of the ditches the water level should rise. Shrub layer species fond of shady habitats (bog blueberry, blueberry) and also forest mossses (e.g. the dominating big red stem moss) will fall back. Their place in the shrub layer should be taken by heather, in the moss layer by *S. magellanicum* – a species with a wide ecological scope but weak competitive capabilities. In the southernmost and lowest part of this zone the rise of water level should bring more reed, but also widen the coverage of *S. angustifolium*.

<u>In the second zone</u> communities no 7 and 8 dominate. Tree level coverage declines fast when moving north. Here it is already possible to see the pre-drainage orientation to ridge-pool complexes. Moss layer is dominated by either *S. angustifolium* or *S. fuscum*, but due to rather deep water level (43 cm on average) the moss layer coverage is low and only in places exceeds 60 %. Because of that the shrub layer coverage is high (35-45%). To restore the paludifying processes in the zone it is necessary to raise the water level to the the level of the ridge pools and to make the tree layer more sparse. It is advisable to remove all trees taller than 3 metres. Before drainage the area was probably covered with a sparse tree layer with the average height of 3 m (canopy coverage 0,2), high turfs (average relative height 40 cm) and was the bog covered with shrubs and sparse trees. The plant cover analysis conducted right west of the drained area showed the sphagnum moss coverage of ca 80%, dominant species were *S. angustifolium* and *S. magellanicum*. Water level was nearly twice as high as that of the drained area – 24 and 43 cm accordingly.

Raising the water level to the level of the ridge pools enhances the growth and expansion of sphagnum mosses on the turfs. At the same time the coverage of the dominant sphagnum mosses (especially *S. angustifolium*) should be decreasing and the spreading of turf species increasing (*S. fuscum* and *S. rubellum*). Reinhabiting of the ridge pools probably happens more slowly. Only in places where already now one can see beak sedge growing can its coverage increase. Restoration of sphagnum moss layer can also be a longer process. But with higher water content of the ground *S. magellanicum* can start spreading into ridge pools.

<u>In the third zone</u> a clear-cut positioning of the ridge-pool system that once covered the area can be seen. Probably the maintainers did not have time or did not even plan to peel the ground. Though the ridge-pool structure has not vanished, the lowered water level has caused lower coverage of sphagnum moss layer and the pools are usually without moss cover, but in places white beak sedge and *Sphagnum tenellum* grow. Sphagnum moss patches (*S. fuscum, S.magellanicum, S.rubellum*) formed on the ridges create favorable conditions for the rapid restoration of moss layer when the water level rises. The coverage of lichen is low and is not a hindrance to the rapid spreading of the sphagnum moss patches. The now sparse coverage of the shrub layer (heather or crowberry) should

not increase. More probably rise in water level should mean the decline of crowberry, which in turn enhances the restoration of sphagnum moss layer on turfs and ridges.

The bog right west of the drained area is also dominated by community 13 (*Calluna vulgaris – Sphagnum fuscum*). But here community no 14 is missing (*Empetrum nigrum – Cladina*). In the sphagnum moss layer of the pools (coverage 80%) *S. cuspidatum* dominates. The pools of the drained area on the other hand are dominated by *Rhynchospora alba – S. tenellum* community, where sphagnum mosses cover only 30% of pool surface and water level is two times deeper than on the adjacent area – 25 and 16 cm accordingly. Because the tree layer is sparse in this zone of the drained area (canopy coverage only 0,1), it is necessary to raise the water level to the surface level of the ridge pools to restore the moss layer. Probably the coverage of *S. tenellum* will increase in the pools that it already inhabits. Coverage of *S. cuspidatum* in the pools will recover in 4-5 years after the rise in water level. Now this species is missing from the drained ridge pools and its spreading from the neighbouring undrained area is a time-consuming process.

Our results showed that 55-57% of the area is covered with declivities 0,0-0,2 ‰ pixel to 1 m, 18-24% is covered with declivities 0,3-0,4 ‰ pixel to 1 m. Overall declivity from north to south is 3 m, from NW to SE 4 m. Thus, after damming the water should start to flow from NW to SE diagonally over the drained area, and also along the ditches from N-NE to S-SW. The exact effect of damming depends on the difference of water levels. As we saw in 2006 in Latvia, the difference between the water levels of the dams must not exceed 20 cm. Otherwise damming will not be effective and in greater part of the area between the dams the water level remains too low for the recovery of sphagnum mosses, i.e. the influence of draining remains intact. Water level in the trenches should be raised to the level that would enable the water to flow on the drained part of the bog. This way we ensure slow flow of water from NW to SE over the drained area.

Under the slope of the bog the peat layer rests on layer of fine sand with fast filtration capability. Thus, water can infiltrate through the peat layer into the sand and after damming the rise in water level can in the southern part of the area, at least at first, remain quite modest. It is possible that it can be alliviated by removal of the tree layer, which reduces evapotranspiration through leafage. But at the same time the roots form an excellent network of narrow canals that allows the water to flow fast through the peat layer. Because of that damming can start affecting the water level of the southern part of the bog, under the slope on the verge of the bog only in many years time, when the peat layer network of canals has disappeared. But when sphagnum moss coverage is after the removal of tree layer still capable, despite continued deep water level, spreading, then the water level should also start rising . After the removal of tree layer new seeds can cause the spread of Downy birch (*Betula pubescens*). They must be uprooted after every two-three years. In the north ditches affect 250-350 meter wide area outside of the drainage system. In the SW and west drainage affects only 50-100 meter area outside the boundaries. Though the effect of drainage to the NW is according to hydrological studies 100 meters weak influence can be detected by observing plant communities to reach up to almost 200 meters from the trench. Thus after damming the ditches the direction of flow and average depth of water level should also change on the so called natural area to the west.

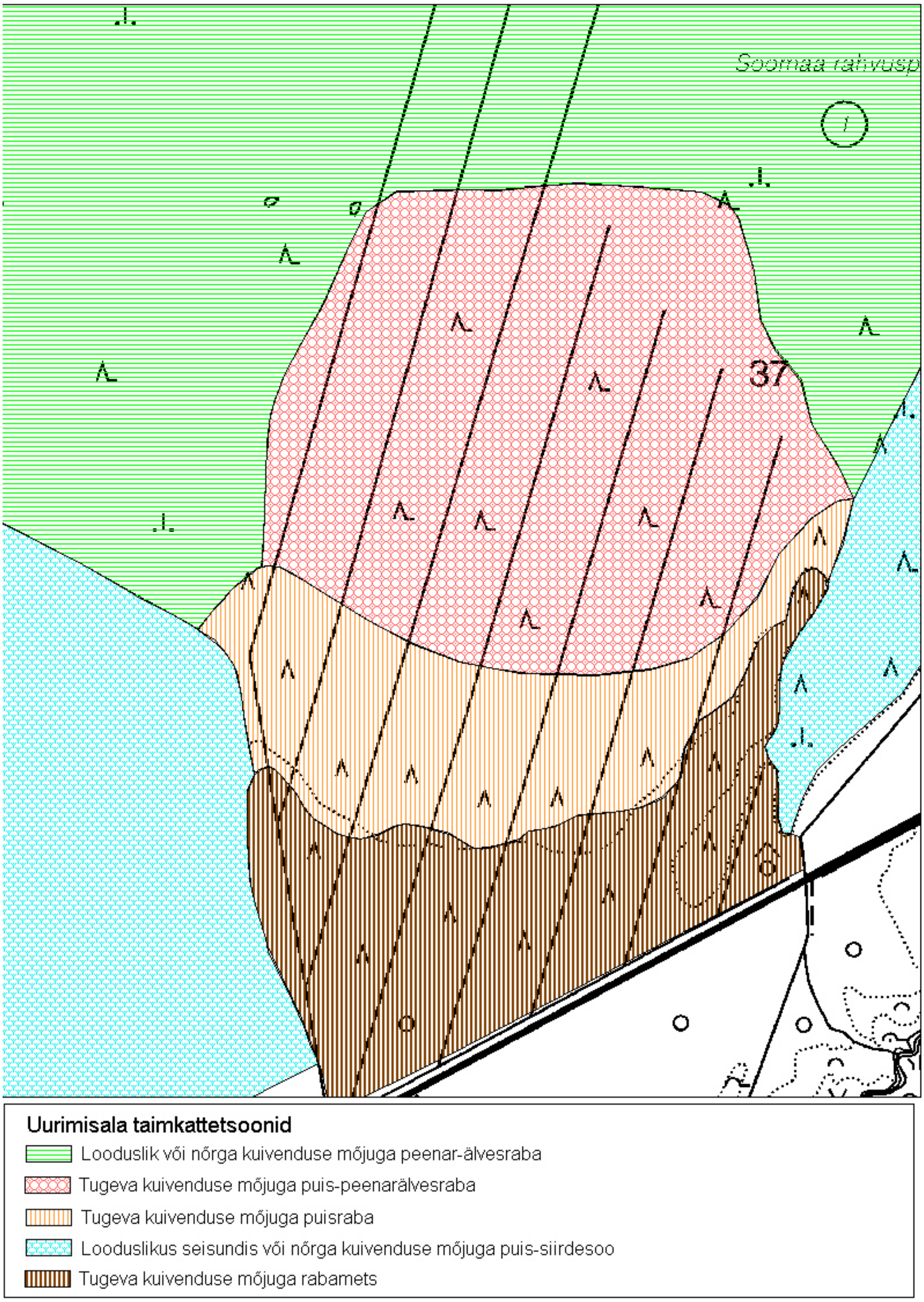

Figure 32. Plant coverage zones describing bog type and the effect of drainage differentiated on the basis of plant coverage clusters.

5. Recommendations

5.1. Raising of the water level

Even though natural bog water levels depend largely on precipitation, they are still to some extent seasonal. Water level data analysis monitored in Männikjärve bog from 1998-2005 exhibited that in arid summers water levels in the ridge-turf area of the bog descend 60-70 cm below the bog surface and in the ridge-hag area of the bog up to 20-30 cm below the surface. The winter-spring time water level is 10-30 cm below bog surface on average.

To raise the level of surface water in the drained border are of Kuresoo bog planning company ”*Maa ja Vesi”* has planned 29 dams on the existing trenches. On the horizontal profiles of the ditches compiled by the same company it is evident that the biggest declivities occur in the lower courses of the ditches ca 300-600 m towards mid course (table 13). Only on the basis of the declivities of the ground crossing with the trench bottom and the trench, the theoretical number of water dams was 5-9 dams to every critical ditsch length; see table 13 ”Distance from artificial recipient K-1, m”. Thus the number of dams in table 13 exceeds the number of dams planned so far, but considering the data presented by the **Institute of Ecology (ÖI)** about the enhanced infiltration capability of the mineral soils of the same area, the annual changes in water level should be closely monitored to create extra dams if necessary.

5.2. Removal of tree layer

Recovery of sphagnum moss layer is the prerequisite for restoration of sphagnum moss growth processes. In addition to regulating the surface water level the negative influence of tree layer must be dealt with. The canopy and leafage of trees stores a big part of precipitation water. The bigger the canopy coverage of the tree level is the less water reaches the ground. On the observed area the canopy coverage did not exceed the canopy coverage characteristic of wooded bog communities (usually 0,1-0,2).

That is why it is necessary to remove all trees above 3 m from the area. But as it is an experimental area we advise to remove the tree layer only on three different patches. The appropriate fields should be agreed in the process. It is vital to restore the tree layer on fields V and VI, where we created permanent transects for permanent monitoring. But on the fields where permanent transect II and III are situated all trees above 3 m height limit should be removed.
After every few years the birch sprouts arising here should be pulled out or cut down.

Table 13

Number of dams calculated on the basis of declivities of the ground adjacent to ditch bottoms and ditches in the border area of Kuresoo bog, where the number of dams is calculated after every 20 cm of the ground declivity

Indicator	Ditches surveyed by planning bureau ”Maa ja Vesi”				
	K-2	Kr-1	Kr-2	Kr-3	Kr-4
Distance from artificial recipient K-1, m (Picket no according to the distance)	782(Pk.13)	630(Pk.16+30)	473(Pk.24+73)	283(Pk.32+83) /579(Pk.32+83-Pk.32+27)	393(Pk.43+93)
General declivity of trench bottom, m	1,49	1,78	1,39	1,19/0,95	1,85
General declivity of the bog surface adjacent to the trench, m	1,93	1,19	1,37	0,91/0,54	1,60
$I_{trench,}$ cm/m	0,19	0,28	0,29	0,42/0,32	0,47
$I_{bog\ surface,}$ cm/m	0,25	0,19	0,29	0,16/0,09	0,41
Number of necessary dams	7-6	9-6	7	6-5/5-3	9-8

5.3. Organisation of the monitoring process

5.3.1. Hydrological monitoring

Piesometric levels

It is advisable to start already in spring 2007. Piesometric levels should be measured in six piesometric stations established by us at least once a month from April until the freezing of the ground.

Ground pH and electric conductivity

At least three times a year, advisably in April or May, July and October, pH and electric conductivity of pore water gathered from the piesometric tubes should be determined..
Samples should be taken from the upper and lower thirds of trenches K-2, Kr-2, Kr-4 and Kr-6.

Chemical components of soil and water

Once a year (July) water samples should be gathered from piesometric tubes and trenches for determining the levels of Ca, Mg, Fe, Na and K .

Monitoring the hydraulical conductivity of peat

With the rise in water level the hydraulic conductivity of peat changes, and thus also the speed of water movement (both horizontal and vertical) in the peat layer. Because of that once a year (e.g. in July) it is necessary to determine the hydraulic conductivity of peat in all piesometric stations.

5.3.2. Montioring of plant cover

Monitoring of plant cover on permanent transects

After damming the trenches and removing the tree layer plant cover monitoring should be started. Monitoring should be carried out at least on the **first, second, forth, sixth and tenth year** after the building of dams and removal of trees.

General monitoring of plant cover

On the second, forth, sixth and tenth year after building of dams and removal of tree layer general monitoring of plant cover should be carried out on 1x1m squares together with determining the depth of water level, pore water pH and electric conductivity measurements. It is also advisable to determine the amount of humidity and dry matter (0-5 and 5-10) in the surface level of the substrate.

5.3.3. Topographical surveying of the area

Due to rise of water level ground height ratios can change. Five years after building the dams and removal of tree layer the area should be topographicly surveyed again.