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DEVELOPMENT OF RADIAL GROWTH IN MINERAL SOIL STANDS BORDERING DRAINED PEATLANDS

PUIDEN SÄDEKASVUN KEHITYS OJITUSALUEESEEN RAJOITTUVISSA KANGASMAAMETSIKÖISSÄ

INTRODUCTION

According to the official statistics, a total of almost five million hectares of peatland and paludified mineral soil sites have so far been drained for forest production in Finland. The forest improvement programme calls for a 50 % increase in the total drained area during the coming ten-year period. This has been calculated as representing an annual growth increment of about ten million cubic meters by the turn of the century (Ervasti et al. 1970).

During the last decade, however, some doubts have been expressed about whether forest drainage does in fact increase overall wood production. The most serious charge has been that the growth increase obtained on the drained peatlands is cancelled out by the fact that the mineral soil sites surrounding the drained peatlands become too dry, with the result that their stand production capacity decreases. Discussion on this question has come to an impasse owing to the lack of concrete facts since the effect of peatland drainage on the growth of surrounding mineral soil stands has never been studied in Finland.

A number of research reports dealing with the effect of peatland drainage on the water conditions and stand growth of the surrounding mineral soil sites have been published during the 1970's in the Soviet Union. These studies were instigated by the alarming reports, published by Бойко and Смоляк (1971), about how drainage in the forested areas of White Russia had lowered the water table in mineral soil sites, even as far away as seven kilometers from the main ditch, and decreased growth in spruce stands by 20 % and slightly less than 10 % in pine stands. Peatland drainage and its effect on the water conditions of mineral soil sites has since been studied rather thoroughly in different parts of the Soviet Union (Сабо 1974, Вомперский et al. 1975, Михович 1975, Зернов

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et al. 1977, Михович et al. 1977). The subsequent effect of forest drainage on the surrounding mineral soil sites appears to depend on the macroclimate, the topography and permeability of the soil surface, ditch depth and the original water conditions of the site in question.

The type of forest drainage (ditch depth 80—100 cm) normally carried out in the humid parts of the Soviet Union (Baltic States, North Russia, Soviet Karelia), does not decrease the production capacity of stands growing on mineral soil sites, and on fresh sites the production capacity often increases slightly. In areas characterised by dry summers (e.g. White Russia, Ukraine), drainage has been found to result in growth losses if:

— the soil consists of highly permeable sand,
— the ditches in the area are so deep that the water table falls by more than one meter (mainly as a result of basic drainage for agricultural purposes),
— the site has originally been damp (not wet) and the tree roots are confined to the surface layer or the soil.

In such cases, the volume growth of mineral soil stands has sharply decreased immediately after drainage and then gradually started to recover as the drainage age increases; many researchers consider this is due to the fact that the tree roots are subsequently able to grow down into the deeper layers of the soil. In forest drainage carried out according to the norms used in the Soviet Union, the reduction in the level of the ground water table on mineral soil sites in the most critical areas, i.e. on the sandy soils of White Russia and the Ukraine, has remained rather small, neither has it been possible to show that the growth of mineral soil stands has been significantly reduced.

The authors of this manuscript were not familiar with the earlier mentioned soviet studies when this study was being planned in autumn 1972, and hence the effect of peatland drainage on the conditions prevailing in the surrounding mineral soil sites was regarded as not having been studied before. Since it was not possible to study the effect of drainage on the water conditions of the mineral soil sites, it was decided to restrict the scope of this study to the analysis of the growth reaction of trees on the mineral soil sites around the edges of the drainage area.

The study has been carried out by analysing the radial growth of the standing trees on the mineral soil surrounding peatlands which had been drained 30—40 years earlier. Radial growth both before and after drainage was analysed and then compared with the results of earlier growth series for mineral soil stands.

The study forms part of a research project, led by Professor L. Heikurainen, into the side-effects of forest drainage. The field work has been financed by a grant from the National Research Council for Agriculture and Forestry of the Finnish Academy of Science and Letters.

MATERIAL

The study was concentrated on two areas of Finland which differ from each other both climatically and topographically. The first area included the south-western part of northern Tavastia and Central Finland, and the second the northern Ostrobothnian coastal plain stretching from Siikajoki to Iijoki. The sample plots in the former area were measured during the summers of 1973 and 1974, and in the latter area during the summers of 1975 and 1976. The sample plots measured during 1973—75 were selected from the edges of peatlands which had been drained at least 30 years earlier. The measurements made in summer 1976 were carried out at sites where drainage had been performed either 20 or 40 years before the measurement date. The drainage age of the sample plots was changed so as to make it possible to eliminate the errors resulting from periodic growth variations caused by climatic factors.

The sample plots were chosen in two stages. Suitable sites which fulfilled the following requirements were first selected from maps of drainage undertakings belonging to the Central Forest Board Tapio and to the State Board of Forestry. The prerequisites were as follows:

— the peatland adjacent to the sample plot had been drained using regularly spaced contour ditches
— a trap ditch passed at right angles to the main gradient between the sample plot and the peatland area

— the height of the sample plot above the trap ditch gradually increased for a distance of 100 meters when travelling from the trap ditch towards the mineral soil site.

The possible sites marked on the map were then inspected. If the tree stand was fully mature, consisted primarily of coniferous species, unthinned or only slightly thinned, free from fungal, insect or other damage and if the trap ditch around the edges of the mineral soil site was in satisfactorily working order, then a sample plot was marked out.

Each sample plot consisted of a line stretching for 100 meters from the side of the ditch against the main gradient. (Fig. 1). Measuring points were marked off every five meters along the line. The height of the measuring points above the edge of the ditch was measured using a levelling device. The nearest dominant or sub-dominant tree to each measuring point was taken as the sample tree, giving a total of 21 sample trees for each sample plot. If the sampling line bisected an open space, no sample tree was taken for that point.

The following sample tree data was recorded: tree species, distance from the trap ditch, height of the tree base above the edge of the ditch, diameter at breast height (cm), double bark thickness (mm), tree height (m), height growth during the previous five year period (dm) and the distance between the sample tree and the two nearest trees. In addition, the site type and the thickness of the humus layer around each sample tree were estimated.

Increment cores passing right to the center of the trunk were taken from each sample tree. The cores were taken from the side of the tree which faced the field worker when he walked in a random manner along the sampling line. The incre-

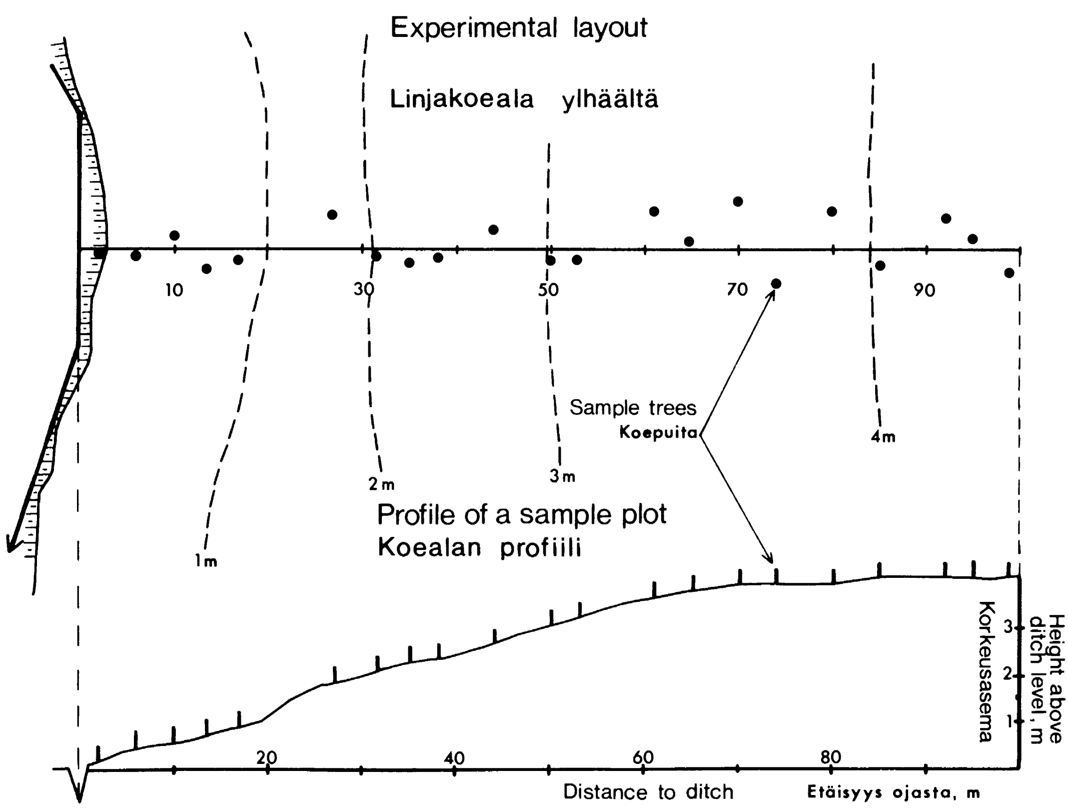

Fig. 1. Example of experimental lay-out showing type of sampling line used in the study and sample plot height profile.

Kuva 1. Esimerkki koejärjestelystä. Kuvassa on esitetty tutkimuksessa käytetyn linjakoealan rajoitusperiaate sekä profiilina että ylhäältä päin tarkasteltuna.

ment cores were stored for annual ring thickness determinations in the laboratory.

The sample plots and sample trees were divided up into data-groups as follows:

Data-group	Number of sample plots	Number of sample trees
Central Finland	17	350
Northern Ostrobothnia summer 1975 material	18	347
Northern Ostrobothnia (1976), drainage 20 years old	6	114
(1976), drainage 40 years old	8	132

A number of increment cores were damaged during transport and handling and could not be measured. Finally, only those sample trees which were more than fifteen years old at breast height when drainage was carried out were included in the final material. Thus the final number of sample trees for the Central Finland area was 237, for the first material collected from northern Ostrobothnia 265 and for the second material 111 (20 years) and 102 (40 years) sample trees respectively.

RESULTS

The main results of the calculations put in graphic form are presented in the following. The results calculated from a part of the material are described by Laine (1977) in more detail in his pro-gradu work.

The basic unit used in the calculations is a single sample tree. The material has been divided up for calculating purposes into classes based on tree species, height of tree above ditch, distance of tree from ditch and site quality. Oving to the relatively small number of sample trees, as few classes as possible were used. The classes were as follows:

- two tree species classes (pine, spruce)
- three classes on the basis of height of tree above ditch level (0—1.5 m, 1.6—3.0 m and ⩾ 3.1 m)
- three classes on the basis of distance of tree from ditch (0—35 m, 36—70 m and ⩾ 71 m)
- three site quality classes (peatlands, fresh and dry mineral soil sites).

The annual radial growth figures were determined to an accuracy of 0.01 mm. When the group averages were calculated, the annual ring corresponding to the year when drainage was carried out was given the value nought. Radial growth before and after drainage was subsequently numbered from this point. The summed radial growth for each five year period before drainage (three five-year periods) and after drainage (seven five-year periods) can be seen in Figures 2, 3 and 4. In this way the effect of annual and also periodic variations in growth caused by the climatic conditions can be reduced. An attempt has been made to reduce interpretation errors caused by variations in growth by means of control material collected in summer 1976 from the areas affected by drainage carried out 20 years ago. On the other hand, no attempt has been made to eliminate variations in growth by using a general growth index. Owing to the sampling method used, the sample trees along the edge of the ditch grow on a peatland site, those in the middle of the measuring line usually on a fresh mineral soil site and those at the end of the line on a dry mineral soil site. Since it is known (Seppälä 1969) that trees growing on peatlands and dry mineral soil sites, at least, react in quite different ways to variations in climatic conditions, incorporation of a growth index would have produced more problems than it would have solved.

The radial growth development of the sample trees in the data-group for Central Finland can be seen in Figure 2. The data is divided up into classes according to site type, distance to ditch, and height above ditch. The corresponding data for northern Ostrobothnia can be seen in Figures 3 and 4.

It is evident that the five-year radial growth of peatland trees (trees growing between the trap ditch and the mineral soil site) in all the classes has noticeably increased as a result of drainage, in most cases it has even doubled. The reduction in growth which occurs after the maximum growth is reached corresponds approximately with the normal radial growth development of similar aged trees. This may, however, be also due to the reduced efficiency of the trap ditch.

The radial growth of sample trees growing on mineral soil sites also appeared to have increased in a number of cases, especially of trees growing near to the ditch and at a height quite close to that of the ditch. Part of the increase in radial growth

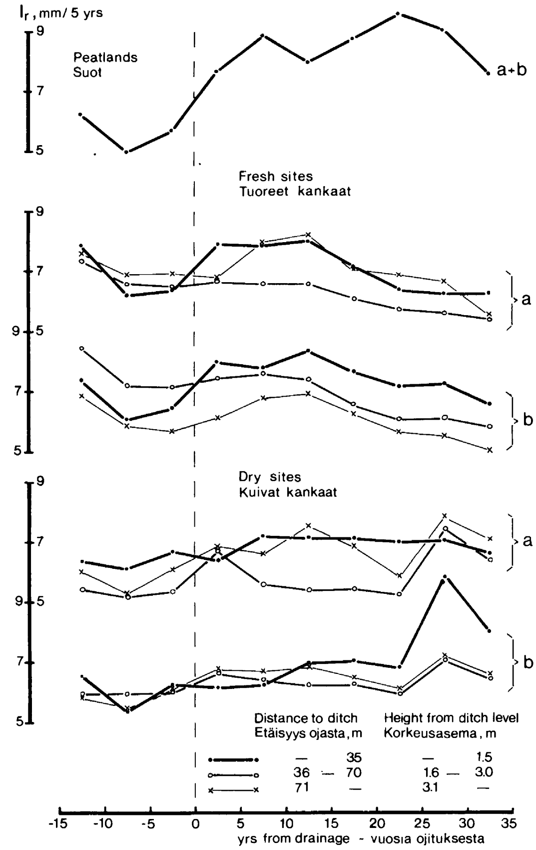

Fig. 2. Material for Central Finland. Radial growth development in different site quality classes, grouped according to height above ditch level (a) and distance to ditch (b).

Kuva 2. Keski-Suomen aineisto. Sädekasvun kehityksen aikasarjat eri kasvupaikkaryhmissä. Kuvaajat on laadittu erikseen korkeusaseman (a) ja ojaetäisyyden (b) mukaan ryhmiteltyinä.

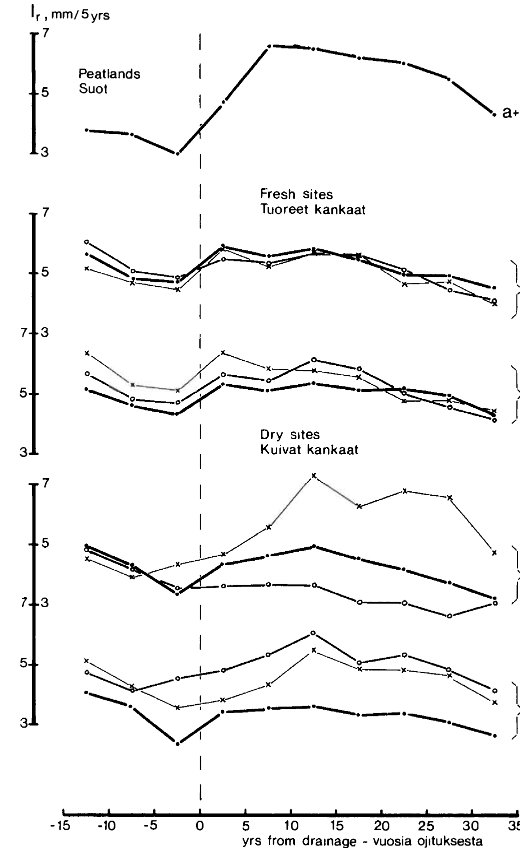

Fig. 3. Material for Ostrobothnia (measured in 1975). Radial growth development. See fig. 2. for explanations.

Kuva 3. Pohjanmaan aineisto (mittaus 1975). Sädekasvun kehityksen aikasarjat. Selitykset kuten kuvassa 2.

may, however, be due to periodic variations in growth caused by climatic conditions. This is supported by the fact that changes in radial growth following drainage of the supplementary material representing the second drainage time collected in northern Ostrobothnia is smaller. Furthermore, cuttings have produced some irregularities in radial growth, especially in the material collected in summer 1975 from trees growing on dry mineral soil sites in Central Finland and northern Ostrobothnia.

Despite the earlier-mentioned interfering factors, it is evident that drainage has not decreased radial growth of any of the trees growing on mineral soil sites in any of the groups studied and that radial growth development during the subsequent decades has not decreased faster in any of the groups than the type of development which is normal for trees of such an age. In point of fact, radial growth has been slighly greater than normal because the radial growth of the sample trees in all the groups 15 years before drainage was close to the theoretical maximum for trees of a corresponding age. This is shown in Figure 5 where the relative radial growth time series for pine sample trees growing on sites of the *Vaccinium*-type in Central Finland are drawn.

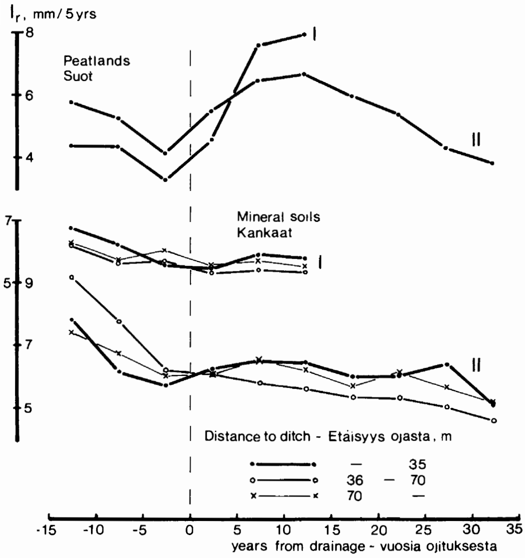

Fig. 4. Material for Ostrobothnia (measured in 1976). Radial growth development in sites drained 20 years ago (I) and 40 years ago (II). In both cases the material consists of pine sample trees only.

Kuva 4. Pohjanmaan aineisto (mittaus 1976). Sädekasvun kehityksen aikasarjat 20 vuotta (I) ja 40 vuotta (II) sitten ojitetuissa tapauksissa. Kumpikin aineisto sisältää vain mäntykoepuita.

The series used in this study have been made on the basis of dominant tree radial growth series drawn up by Ilvessalo (1920) (even-aged virgin *Vaccinium*-type stands) and Vuokila (1967) (regularly thinned *Vaccinium*-type pine stands) which have earlier been modified by Seppälä (1969).

If the radial growth development according to age of the sample trees would have been similar to the radial growth of either (a) natural or (b) thinned *Vaccinium*-type pine sample trees, then the values for the relative radial growth would be 100. On the other hand, however, it is not clear whether the apparent slight increase in the growth of the sample trees (examined according to height above ditch level or distance from ditch) found in this material, is due to an improvement in the water conditions as a result of drainage, heavier cuttings in the experimental than in those of the reference series or variations in growth caused by climatic conditions. Neither of these last two mentioned causes are very likely since heavily thinned stands were rejected right from the start (cf. study material p. 00). Furthermore, the climatic conditions prevailing during the 1950's and 1960's do not appear to be more favourable than those during the previous decades.

Similar results were obtained when corresponding calculations were made for the *Myrtillus*-type sample trees from Central Finland.

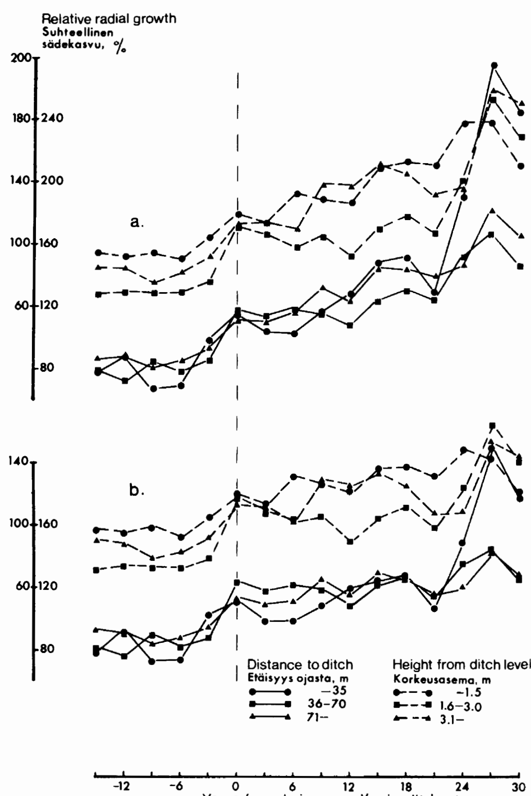

Fig. 5. Material for Central Finland. Relative radial growth development for *Vaccinium*-type pine trees. Development series of dominant trees of even aged, virgin *Vaccinium*-type pine stands according to ILVESSALO (a) and of regularly thinned *Vaccinium*-type pine stands according to VUOKILA (b) used as reference levels.

Kuva 5. Keski-Suomen aineisto. VT-mäntyjen suhteellisten sädekasvujen aikasarjojen kuvaajat. Perustasoina ILVESSALON luonnonnormaalien VT-männiköiden (a) ja VUOKILAN harvennettujen VT-männiköiden valtapuiden kehityssarjat (b).

CONCLUSIONS

As the earlier discussed radial growth series may include a certain amount of periodic and annual variation caused by climatic conditions, the effect of cuttings and other possible factors, interpretation of the results is rather uncertain. Furthermore, the relatively small size of the sample tree material will only serve to accentuate the importance of possible random factors.

However, all of the calculated series show unanimously that drainage has not reduced the radial growth of stands growing on mineral soil sites bordering drainage areas. On the contrary, even the radial growth of trees situated near to the trap ditch which are classified as growing on mineral soil sites has increased.

This study thus shows that under the humid climatic conditions prevailing in Finland, normal drainage does not reduce the production capacity of the surrounding mineral soil stands. However, if changes occur in the water conditions, such changes would rather have a positive effect on the growth of trees.

These observations are in good agreement with those Сабо (1974) has found under corresponding macro-climatic conditions in the northern parts of the Soviet Union.

This does not mean that cases cannot be found where drainage will produce or has produced negative changes in the growth conditions, although such cases are hardly common.

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SELOSTE:

PUIDEN SÄDEKASVUN KEHITYS OJITUSALUEESEEN RAJOITTUVISSA KANGASMAAMETSIKÖISSÄ

Artikkelissa tarkastellaan yhteensä noin 700 koepuuta käsittävän aineiston perusteella, miten ojitus on vaikuttanut vallitsevan latvuskerroksen puiden sädekasvun kehitykseen ojitusalueeseen rajoittuvissa kangasmaametsiköissä.

Aineisto on kerätty vv. 1973—76 kahdelta erilliseltä osa-alueelta, joista toinen sijaitsee Pohjois-Hämeen ja Keski-Suomen rajamailla, toinen käsittää puolestaan Pohjois-Pohjanmaan rannikkoalueen. Aineiston perusjoukkona pidettiin Kml Tapion ja Metsähallituksen toteuttamia ojitushankkeita, joista peruskarttojen avulla poimittiin ojastoiltaan ja kaltevuussuhteiltaan soveliaat kohteet. Niistä puolestaan maastossa mitattiin koealat häiriöttä kehittyneihin, joko harventamattomiin tai lievin harvennuksin käsiteltyihin havupuuvaltaisiin varttuneisiin kasvatusmetsiköihin. Koealan sijoitus maastoon esitetään kuvassa 1 (s. 69).

Aineistosta saadut päätulokset nähdään kuvista 2, 3 ja 4 (ss. 71 ja 72), joissa on esitetty koepuiden sädekasvun keskiarvoinen kehitys ennen ojitusta ja sen jälkeen viisivuotiskausin laskettuina summina ja jaettuna aineisto kasvupaikkaryhmien, ojaetäisyyden ja ojan reunasta määritetyn korkeusaseman perusteella muodostettuihin ositteisiin.

Tulokset osoittavat, että koepuiden sädekasvu on suoksi luokitetulla niskaojan ja kankaan välivyöhykkeellä kaikissa osa-aineistoissa selvästi suurentunut. Varsinaisiksi kangasmaiksi luokitetuilla kohdin ei myöskään missään ryhmässä näy ojituksen aiheuttamaa sädekasvun pienentymistä, vaan usein lievää suurenemista, erityisesti, jos otetaan huomioon puiden sädekasvun normaali iänmukainen kehitys (kuva 5). Vaikuttaa siis mahdolliselta, että joissakin tapauksissa suon ojitus jopa parantaa kasvuolosuhteita ympäröivillä kangasmailla.

Vastaavissa suurilmastollisissa oloissa on Neuvostoliitossa saatu jokseenkin edellisten kanssa yhdenmukaisia tuloksia (esim. Сабо 1974).