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Predicting the need for ditch network maintenance in drained peatland sites in Finland

Kunnostusojitustarpeen ennustaminen ojitusalueilla

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Logistic regression models were developed to predict the condition of ditch networks in drained peatland sites in Finland. The data consisted of observations from two forest inventories in which the need for ditch network maintenance had been assessed in the field by classifying the condition of the ditches in the sample stands. In the analysis an indicator variable which referred to one of two condition categories (in need of repair – not in need of repair) was used as the response variable. According to the results, the probability of being in the poor condition category was higher in sites where the time elapsed since drainage was longer, the geographic location was more northern, peat thickness was greater, and plot inclination was smaller. At a probability level of 0.5, the models predicted the category correctly in 69% of the sites in the modeling data, on average. The models were applied to a growth simulator to study the effect of poor drainage conditions on stand-level growth forecasts.

Key words: ditch network maintenance, forest drainage, logistic regression, site

INTRODUCTION

Drained peatland is a labile mire ecosystem in the process of turning into a forest ecosystem: the draw-down of the groundwater table favors the growth of trees and various forest species in the ground vegetation. This development may be reversed as old ditches gradually lose their growth-stimulating effect as a result of, e.g., peat subsidence, the collapse of ditch banks, and growth of vegetation in ditches (Heikurainen 1957, Timonen 1983, Paavilainen & Päivänen 1995). As a consequence, the ground water table may rise, and the site become wetter.

Impairing site drainage has an influence on tree growth. According to Heikurainen (1980), declined radial growth of Scots pine (*Pinus sylvestris* L.) due to deteriorating ditch networks became apparent 15–20 years after drainage (c.f. Lukkala 1937). As indicated by several growth models derived for peatland trees, (Payandeh 1973, Hånell 1984, Hökkä et al. 1997) poor site water status is connected to decreased tree growth.

In order to maintain the timber productivity of the 4.7 million hectars of drained peatlands in Finland (Finnish Statistical Yearbook of Forestry 1998), a considerable proportion of the ditch networks need to be annually repaired by ditch cleaning or complementary ditching. This is even more important in areas subjected to commercial thinnings. Already in the 1980s it was estimated that ditch cleaning was needed in 10% of newly ditched peatlands (drained ca. 10 years ago) and in about 30% of the peatlands drained 30–50 years ago (Keltikangas et al. 1986). Furthermore, complementary ditching was suggested especially in northern Finland. However, the area of ditch network maintenance in the past 10 years has been clearly lower than the estimated annual need (Paavilainen & Päivänen 1995).

Ditch network maintenance has a positive effect on tree growth. According to Ahti and Päivänen (1997) and Hökkä (1997), the effect of improvement ditching on the growth of Scots pine in medium productive sites is relatively low. However, the effect on cumulative growth during a 15–20 year period may be considerable, thus making the measure economically profitable (Aarnio et al. 1997, Hytönen & Aarnio 1998).

The aim of the study was to construct a model that would describe how the condition of the ditch network is influenced by different site factors and time. This was done on the basis of systematic sample plot data collected from drained peatlands. The resulting model should be applicable to growth simulators and provide reliable predictions of temporal changes in the condition of the ditch network and site drainage.

MATERIAL AND METHODS

The study material consisted of two inventory data sets covering the area where forest drainage has been applied in practical forestry in Finland. For southern Finland and southern parts of northern Finland, the permanent sample plots of the 8th National Forest Inventory (NFI8) were used. For northern Finland, a special set of permanent growth plots (SINKA) was used (Penttilä & Honkanen 1986, Mielikäinen and Gustavsen 1993). For a more detailed description of the material, see Hökkä et al. (1997). Only plots where no previous ditch network maintenance had been carried out were accepted for this study resulting with 357 and 220 plots in the SINKA and NFI8 data sets, respectively. Most of the plots were classified as pine mires (67%).

Because site water status is complicated to observe directly, visual assessment of the condition of ditch networks into a few categories has been generally used as an indicator of site drainage (e.g., Hånell 1984, Hökkä et al. 1997). In the present study, the condition of site drainage was assessed in a similar manner in each sample stand by determining the need for different ditch network maintenance activities at the time of measurement and in the near future (next 5 years), based on average ditch depth, width, and general condition and spacing of the ditches. Categories referring to ditch cleaning or complementary ditching were then combined. Site drainage was considered to be poor in 159 and 56 stands in the SINKA and NFI8 data sets, respectively (Table 1).

A common indicator variable was formed having value 0 for sites where no ditch network maintenance was suggested and value 1 for sites where ditch network maintenance had been recommended. This was done to summarize the essential information: whether or not the condition of the ditch network was acceptable from the forest management point of view. The indicator variable was used as the response variable in the analysis.

The logistic regression model was used as the method, because the response variable was binary and different continuos explanatory variables were used. Because normal errors do not correspond to a zero/one response, ordinary least squares was an inappropriate estimation method. The response variable (P) follows the Bernoulli's distribution:

$$P(Y = 1) = q,\ P(Y = 1) = 1 - q,\ 0 < q < 1 \qquad (1)$$

The so-called logistic transformation for Y's expectation is defined as follows:

$$\theta_i = \frac{e^{x_i b}}{1 + e^{x_i b}}$$

and $$1 - \theta_i = \frac{1}{1 + e^{x_i b}}, \quad i = 1,\ldots,n \qquad (2)$$

where x_i is $1 \times p$-vector of explanatory variables and b is $p \times 1$-vector of parameters. With simple transformation the model can be linearized:

$$\lambda_i = \ln \frac{\theta_i}{1 - \theta_i} = x_i b \qquad (3)$$

where the logit-function λ_i is the logarithm of the odds of success, i.e., the ratio of the probability for the poor condition of the ditch network (θ_i) to the probability for good condition of the ditch network ($1 - \theta_i$). The probability of stands belonging to either category was explained by variables which were related to site conditions and stand attributes. The model was estimated by applying the maximum likelihood-method using SAS-LOGISTIC procedure (SAS 1992).

The models' statistical evaluation was based on several criteria: change in the value of the likelihood function, as well the values of AIC (Akaike's Information Criterion) and SBIC (Schwartz's Bayesian Information Criterion) measures (McCullagh et al. 1989). A specific method was to plot ROC-curves (Receiver Operating Characteristic curve) (Murtaugh 1995). A curve's height indicated the goodness of fit of the model, because the area below the curve corresponded to the model's R^2 value.

Several models were developed because the time elapsed since drainage was determined differently in different data sets. In the SINKA data, time since drainage was recorded at a one-year accuracy, while in the NFI8 data the time elapsed was classified into larger categories (1–5, 6–10, 11–25, and more than 25 years, respectively). The mean drainage age in the SINKA data was 19 years. A model with a continuous time variable (Model 1) was constructed on the basis of the SINKA data. Models with a classified time variable were based on a combination of both the SINKA and the NFI8 (Models 3 and 3b). For comparison, a model with categorical time was also derived from the SINKA data (Model 2). In Model 3b, peat thickness was not used as an explanatory variable. The models were compared to find whether they gave similar results with similar value combinations of the predictor variables. With respect to time, probabilities were calculated for 5-year periods — as would be usually done in stand development simulations — and the mean values obtained from the combined data were given to other explanatory variables.

To test the applicability of the constructed models, they were elaborated into a simulation system which was based on basal area growth models and height-diameter models (Hökkä 1997), tree-level mortality models (Ojansuu et al. 1991), and stand-level self-thinning models (Hynynen 1993). The core of the system comprised tree-level growth models with the condition of ditch network as a dummy variable, among the other driving and restricting variables. The condition of ditch networks was evaluated at each 5-year simulation period by comparing the result of the chosen model to the given threshold value for the probability for poor condition of the ditch network.

Table 1. Minimum, mean and maximum values of some site and stand characteristics in the data sets.

Taulukko 1. Aineistojen kasvupaikka- ja metsikkötunnusten minimi-, keski- ja maksimiarvoja.

Characteristics	Data set — *Aineisto*											
Tunnus	SINKA				NFI8- VMI8				Combined — *Yhdistetty*			
	min	mean	max	std	min	mean	max	std	min	mean	max	std
N coord (km)	7 044	7 227	7 504	117	6 715	7 017	7 306	142	6 715	7 151	7 504	164
E coord (km)	324	451	646	70	213	457	709	125	213	455	709	95
Ts (dd)	735	971	1 070	76	830	1 075	1 330	98.5	735	1 008	1 330	101
Peat (cm)	8	57	100	31	2	70	100	33.3	2	62	100	33
Poor ditch condition	–	159	–	–	–	56	–	–	–	215	–	–
G (m^2 ha^{-1})	0.7	13.2	33	7.3	0.1	9.8	35.8	7.5	0.1	11.8	35.8	7.5

N coord = north coordinate — *pohjoiskoordinaatti.*
E coord = east coordinate — *itäkoordinaatti.*
Ts = temperature sum, day degrees with threshold value + 5 °C — *lämpösumma kynnysarvolla +5°C.*
Peat = peat thickness, measured down to 1 m depth — *turpeen paksuus, mitattu 1 m:n syvyyteen saakka.*
Poor ditch condition = number of sample plots, which were in the need of ditch network maintenance — *niiden koealojen lukumäärä, joissa on todettu kunnostusojitustarvetta.*
G = stand basal area — *metsikön pohjapinta-ala.*

RESULTS

Models

The time elapsed since drainage was the most important factor in explaining whether the condition of the ditch network was poor or not (Table 2). The coefficients of other explanatory variables were of the same magnitude in different models although time since drainage was expressed differently. The difference between these models was that in the young drainage age classes Model 2 gave higher probability for the poor condition of ditch network than Model 3. Using continuous values for time instead of categorical values improved the model fit (Models 1 and 2 in Table 2).

In Model 1, sample plot inclination, expressed as a dummy variable for plots where the slope was greater or equal to 3%, significantly decreased the probability for poor condition of the ditch network (Table 2). For all models, the probability was higher in more northern locations. Average temperature sum was tried alternatively, but the north coordinate resulted with a better fit. Also in sites where the peat layer was thick the probability for poor condition of the ditch network was higher. Different categorical variables related to site quality according to Huikari (1974), i.e., main site groups (spruce mire, pine mire), site quality classes, as well as the supplementary definitions were tested, but they proved to be insignificant. In fact, the distribution of the sample plots into the poor and good categories was almost the same for spruce mires and pine mires in the combined data. The effect of stand basal area was insignificant as a single variable or through any interactive effects with other explanatory variables.

Model comparisons

Of the final models, Model 1 had the highest ROC-curve and it fitted best with the data, while others showed a somewhat poorer fit. When using probability level 0.5 as the threshold to separate the two condition classes, different models predicted 69% of the entries to either class correctly in the modelling data, on average.

Due to the categorical variables that were used for time in Models 2 and 3, their predictions were less accurate: considerable change in probability for poor condition of ditches occurred between 15–25 years after the drainage and the models assumed a constant value for the whole period (Fig. 1). The difference in the predicted probabil-

Table 2. Models for predicting the need of improvement ditching. Standard errors are given in parentheses.

Taulukko 2. Mallit kunnostusojitustarpeen ennustamiseksi. Keskivirheet ilmoitettu suluissa.

Variable	Model 1 (SINKA) *Malli 1 (SINKA)*	Model 2(SINKA) *Malli 2 (SINKA)*	Model 3 (Combined) *Malli 3 (Yhdistetty)*	Model 3b (Combined) *Malli 3b (Yhdistetty)*
Constant —*vakio*	– 26.1614 (7.4965)	– 16.6645 (7.0906)	– 16.722 (4.3549)	– 13.5728 (4.1176)
N coord	+ 0.00321 (0.00104)	+ 0.00237 (0.00099)	+ 0.00237 (0.0006)	+ 0.00201 (0.00057)
Peat	+ 0.0124 (0.00384)	+ 0.0115 (0.00366)	+ 0.0115 (0.00297)	
Inclination[1]	– 1.0191 (0.4877)			
Time[2](cont.)	+0.1109 (0.0173)			
Time[3]1–5		– 2.9051 (0.829)	– 3.3828 (0.8008)	– 3.2307 (0.7929)
Time[3]6–10		– 2.1835 (0.4915)	– 2.6047 (0.4569)	– 2.513 (0.4473)
Time[3]11–25		– 1.3776 (0.3182)	– 1.4739 (0.3047)	– 1.3532 (0.2976)
– 2*LOG(L)	415.799	446.268	683.553	710.462
AIC	425.799	458.268	695.553	720.460
SBIC	445.187	481.268	721.700	742.329

[1] a dummy variable referring to sites, with inclination ≥ 3% — *dummy-muuttuja kasvupaikoille, joilla maanpinnan kaltevuus ≥ 3%.*

[2] time since drainage, years — *aika ojituksesta, vuotta.*

[3] time since drainage category, range in years — *aika ojituksesta, numerot viittaavat vuosiluokan ylä- ja alarajaan.*

ity was more than 0.1 units when 10–15 years, 20–25 years, and more than 35 years had passed since the drainage. In old drainage areas the probability for poor condition of the ditch networks was systematically underestimated by Models 2 and 3. However, Models 1 and 3 gave rather similar average results up to 35 years since drainage, while Model 2 gave higher probabilities for poor condition of the ditch networks in young drainage areas.

The predictions of Models 1 and 3 were further compared with respect to other explanatory variables by fixing one variable to correspond to the mean value of the combined data, and giving minimum, mean and maximum values for the other variable (Fig. 2a–c). Model 1 predicted constantly higher probability for poor condition of the ditch network in the north and lower in the south than Model 3. The difference was more evident in northern Finland. This was due to the greater coefficient for the north co-ordinate in Model 1. With respect to peat thickness, all models gave very similar responses. As a conclusion, Model 3 predicted lower probabilities for poor condition of ditch networks in northern Finland and old drainage areas than Model 1.

Application

The example stand used in simulations representing meso-oligotrophic pine mire sites (RhSR) in northern Finland had the following site and stand characteristics: elevation 40 m.a.s.l., temperature sum 950 degree days, density 1397 pine stems ha^{-1}, basal area 1.6 m^{2}ha^{-1}, and dominant height 3.6 m. The stand was drained at the beginning of the simulation period, and the basal area growth was simulated for a 50-year period using each of the Models 1–3b and a fixed threshold value 0.5 for the probability for poor condition of the ditch networks. All models reached the chosen level after 25 years of simulation (Fig. 3a). As the condition of the ditch network changed to poor, ca. 15% reduction in the 5-year net basal area increment resulted (Fig. 3b). With this example data and threshold level of 0.5, there were no differences between the constructed probability models. With a lower value for the threshold probability, Model 3b would have suggested poor ditch condition earlier than Model 1.

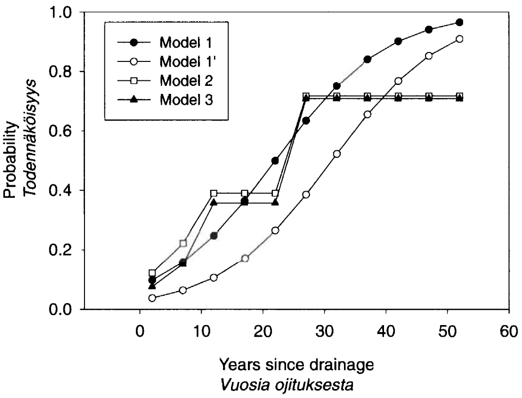

Fig. 1. The probability for the poor condition of ditch networks as a function of drainage age, as predicted by Models 1–3. Mean values were given for the north coordinate (7 150 km) and peat thickness (62 cm). Model 1' gives predictions for sites where inclination is ≥ 3%.

Kuva 1. Kunnostusojitustarpeen todennäköisyys ojituksen-iän funktiona mallien 1–3 mukaan. Pohjoiskoordinaatille ja turpeen paksuudelle annettu aineiston keskiarvot (7 150 km ja 62 cm). Malli 1' antaa ennusteen kasvupaikoille, joilla maanpinnan kaltevuus on ≥ 3%.

DISCUSSION

Inventory data were used to develop logistic regression models for the probability of poor condition of ditch networks in drained peatland sites. The data had a wide geographical coverage, but were however concentrated in northern Finland, which limited the modeling work and model applicability.

The response variable, indicating need for ditch network maintenance, served as an indicator of the real variable, site water status, which is problematic to measure directly, especially in a way that it would correlate to the variation of short-term growth (annual, 5-year) of trees. Depending on weather conditions, site moisture may vary considerably from year to year and within a growing season. While the response variable had only two classes, it includes lots of error in measuring site drainage. Consequently, the causality of the relationships obtained in this analysis should be interpreted with care.

The number of years since drainage was the most important factor that affected the condition of ditch networks. This has been noted in several

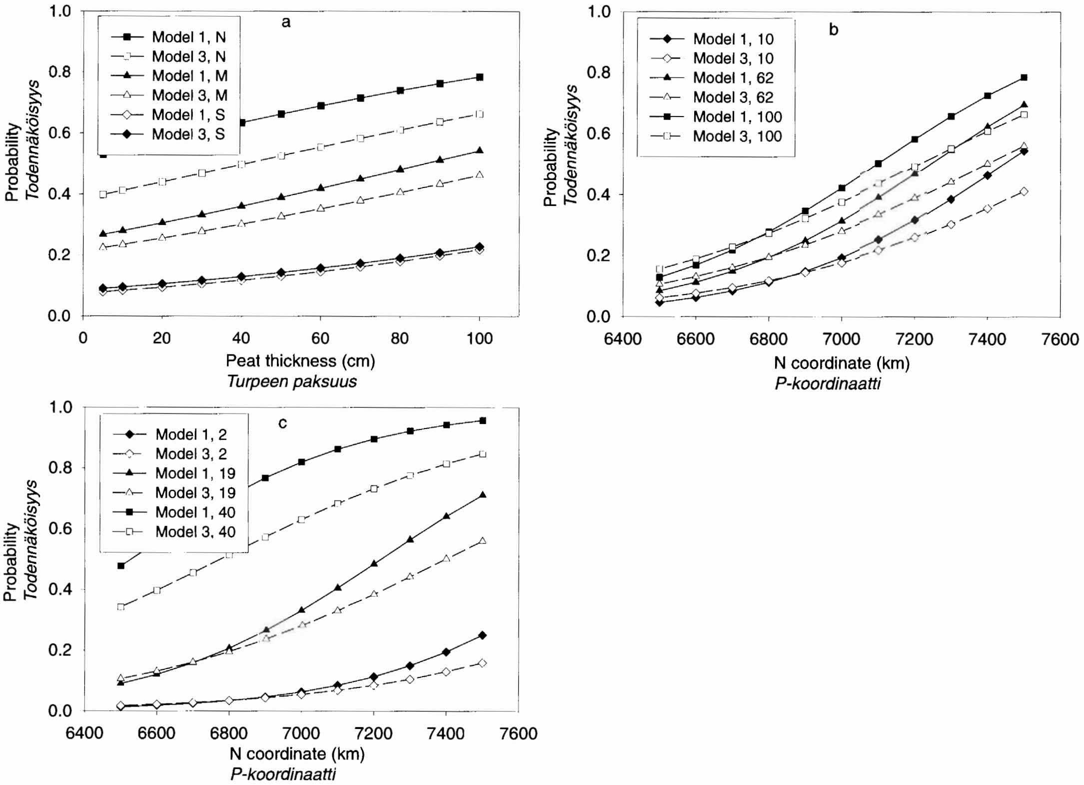

Fig. 2 (a–c). The probability for the poor condition of ditch networks as a function of latitude (a), peat thickness (b) and time (c) predicted by Models 1 and 3. In 2a, values 7 500 (S, south), 7 150 (M, middle), and 6 700 (N, north) were given to the latitude. In Fig. 2b, 10, 62 and 100 cm were given for peat thickness. In 2c, 2, 19, and 40 years were given for the drainage age. In 2a and 2b, drainage age was 18 years, and in 2c, peat thickness was 62 cm. For Model 1, the inclination was < 3%.

Kuva 2 (a–c). Kunnostusojitustarpeen todennäköisyys pohjoiskoordinaatin (a), turpeen paksuuden (b) ja ajan (c) funktiona mallien 1 ja 3 mukaan. Kuvassa 2a pohjoiskoordinaatille annettu arvot 7 500 (S, etelä), 7 150 (M, keski) ja 6 700 (N, pohjoinen). Kuvassa 2b turpeen paksuudelle annettu arvot 10, 62 ja 100 cm. Kuvassa 2c ojitusiät olivat 2, 19 ja 40 vuotta. Kuvissa 2a ja 2b ojitusikä oli 18 vuotta, ja kuvassa 2c turpeen paksuus 62 cm. Mallissa 1 maanpinnan kaltevuus oli < 3%.

previous studies as well (Heikurainen 1957, Timonen 1983, Keltikangas et al. 1986, Isoaho et al. 1993), and is related to the gradual deterioration of ditches with time. Keltikangas et al. (1986) concluded that the proportion of sites where ditch cleaning should be done was more than 10% at 11 years after ditching. In this study, the probability for poor condition of the ditch networks at 10 years after drainage was already 0.20. In plots drained more than 30 years ago, the probability was 0.7–1.0, which was clearly higher than the corresponding 30% proportion in the study of Keltikangas et al. (1986). The difference may partly be explained by the fact that sites with the need for additional ditching were not included in the figures given by Keltikangas et al. (1986).

It was shown that the condition of ditch networks was poorer in more northern locations. Keltikangas et al. (1986) found that the need of ditch cleaning in southern Finland was greater than in northern Finland on the basis of the regional calculations. In this study, the effect of the north coordinate on the probability was analyzed simultaneously with other factors and was found to be similar and significant in both of the independent data sets. The effect of the north coordinate was even greater when site inclination was accounted for in Model 1. The effect may be due to the differences in climate. It is also possible that a greater proportion of the ditches in northern Finland have been made by plough thus resulting in a faster rate of deterioration (Lauhanen et al. 1998) in the north. However, information on ditching methods – available only from the SINKA data – did not support this assumption.

Greater peat thickness increased the probability for poor drainage condition in this study. It has been observed in previous studies that the shallowing of ditches is fastest in originally wet peatlands with a thick peat layer (Heikurainen 1957, Timonen 1983). This is mostly due to the subsidence of the surface peat, which takes place within a few years after the drainage. The wetter the site and thicker the peat layer, the greater the rate of subsidence may be (Lukkala 1949, Minkkinen and Laine 1998). In this study, the peat thickness was measured only to a depth of 1 m. With observations of thicker peat layers, the coefficient of peat thickness in the models could have been different.

Greater inclination (≥ 3%) of the sample plot decreased the probability of poor drainage condition. This relates to the faster running water which cleans the ditches but may also cause erosion (Paavilainen and Päivänen 1995).

In drained peatlands, a stand may contribute to site drainage to such an extent that a positive effect on tree growth rate can be detected (Penner et al. 1995). However, a well-growing stand does not influence the condition of the ditches even though it may keep the site dry. If the ditches are poor, improvement ditching will be suggested anyway.

According to the present guidelines for practical ditch network maintenance in Finland, no measures are suggested before 20 years have passed since drainage (Luonnonläheinen metsänhoito 1994). At 20 years drainage age and 62 cm peat thickness (mean in the combined data), the probabilities for poor ditch condition were 0.15, 0.30 and 0.60 in southern, middle and northern Finland, respectively, indicating high geographical variation (Fig. 2). In southern Finland the same level of probability will be achieved 25–30 years later than in northern Finland. Consequently, in northern Finland in a thick-peated site, the probability of being in the poor condition category may be relatively high even before 20 years have elapsed since the original drainage. This suggests that the same 20-year threshold may not be proper for the whole country.

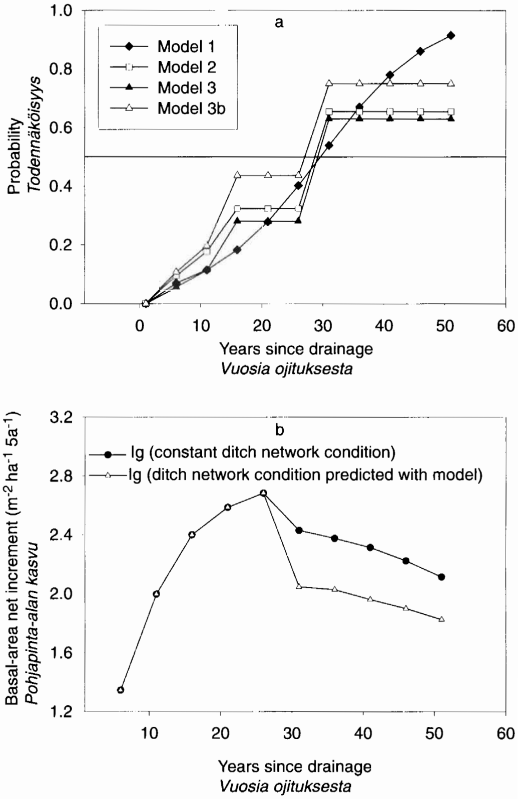

Fig. 3 (a–b). Results from an example simulation: probability for the poor condition of ditch network as predicted by Models 1–3b (a), and the net basal area increment when poor ditch network condition is accounted for or not (b).

Kuva 3 (a–b). Tulokset simuloinnista esimerkkimetsiköllä: kunnostusojitustarpeen todennäköisyys mallien 1–3b mukaan (a), ja pohjapinta-alan nettokasvu kun ojituksen kunto on otettu (avoin kolmio) tai ei ole otettu (täytetty ympyrä) huomioon (b).

Several factors that have been shown to affect the condition of ditch networks were however not used in the models. Lauhanen et al. (1998) suggested that ditches on pine mires and spruce mires would deteriorate at different rates. Such difference was not found to be significant in this study. However, it is likely that site quality has some effect, which may have partly been accounted for by, e.g., peat thickness and inclination. The explanatory variables used in the models are only those which were commonly measured in forest inventories, and thus can be used as input in growth models. Ditch spacing, digging technique, peat composition, quality of the mineral subsoil, etc. have been shown to affect the deterioration rate of drainage ditches (Timonen 1983, Heikurainen 1957, Isoaho et al. 1993). It should be considered whether these factors also need to be assessed in future inventories to provide more information for predicting site conditions.

The comparison of Models 1 and 3 suggested that if Model 1 is used to predict the condition of ditch networks in the whole country, it will give a similar response in relation to time, but higher probabilities in the north than Model 3. The difference varied from 0 to 0.2 units. Based on the difference, Model 1 may not be proper for predicting the condition of ditch networks in the whole country.

The models developed here were designated to be used in combination with the basal area growth models constructed by Hökkä et al. (1997) for trees on drained peatlands in Finland. The growth models included the condition of ditch network as an explanatory dummy variable, but its use in long-term forecasts was problematic, due to difficulties in predicting how these conditions changed with time (Hökkä 1997). The simultaneous use of the growth and probability models made it possible to utilize information on site drainage in predicting the future stand development. Predictions of higher probability than 0.5 (threshold) for poor condition of the ditch network resulted in lower basal area growth. Compared to situations when site drainage is not accounted for, the use of the probability models is expected to improve the accuracy of long-term stand simulations.

Ditch network maintenance is a necessary option in the management of drained peatland sites. It should thus be considered in long-term stand forecasts to provide relevant management schedules and more accurate estimates on stand development (Hökkä 1997). As demonstrated, the constructed models can be used to predict when the ditch network is in poor condition. It is also possible to incorporate the models into expert systems to support decision-making in peatland forest management (see Kangas et al. 1996). By giving different probability values, i.e., when it is appropriate to implement ditch network maintenance, varying management schedules can be produced and compared.

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TIIVISTELMÄ

Kunnostusojitustarpeen ennustaminen ojitusalueilla

Kunnostusojitus on ojitusalueiden metsien hoidossa tarpeellinen toimenpide, jolla voidaan välttää ojitusaluemetsikön kasvun taantuma ja mahdollinen tuhoutuminen kuivatuksen ajan myötä heikentyessä. Käytännön kunnostusojitussuoritteet ovat kuitenkin jääneet jälkeen arvioiduista tarpeista (Paavilainen & Päivänen 1995). Heikolla kuivatustilanteella on todettu olevan negatiivinen (Hånell 1984, Payendeh 1973) ja kunnostusojituksen tekemisellä positiivinen (Ahti & Päivänen 1997, Hökkä ym. 1997, Hökkä 1997) vaikutus puiden kasvuun. Tässä tutkimuksessa pyrittiin laatimaan malli, jolla voitaisiin ennustaa metsikön kunnostusojitustarvetta kasvupaikkamuuttujien

avulla.

Aineisto koostui kahdesta invetointiaineistosta: 1) SINKA (Penttilä & Honkanen 1986), joka käsitti Pohjois-Suomen alueen ja 2) VMI8:n pysyvät koealat (Mielikäinen & Gustavsen 1993), jotka yhdessä kattoivat koko maan. Niissä koealan kunnostusojitustarvetta oli arvioitu maastossa (Taulukko 1). Tämän arvion perusteella metsiköt jaettiin kahteen luokkaan sen mukaan oliko tarvetta ojien kunnostukseen vai ei. Binääriselle vastemuuttujalle laadittiin logistinen regressiomalli SINKA-aineistossa sekä yhdistetyssä aineistossa. SINKA-aineistosta estimoidun mallin mukaan todennäköisyyttä ojituksen huonolle kunnolle lisäsi ojituksesta kulunut aika, metsikön pohjoinen sijainti ja turpeen paksuuntuminen (Taulukko 2). Maaston suuri kaltevuus taas vähensi todennäköisyyttä ojituksen huonolle kunnolle. Koska VMI8-aineistossa ojituksen ikä oli luokiteltu (0–5, 6–10, 11–25 ja > 25 vuotta), yhdistetystä aineistosta laskettiin koko maan alueelle tarkoitettu malli, jossa selittäjinä olivat aikaluokat, pohjoiskoordinaatti ja turpeen paksuus. Myös SINKAsta laskettiin malli, jossa ojituksesta kulunut aika oli luokiteltu. Keskimäärin koko aineistossa todennäköisyys ylitti 0,5, kun ojituksesta oli kulunut 25 vuotta (Kuva 1).

Eri aineistoista estimoitujen mallien parametrit olivat suunnilleen samaa suuruusluokkaa. Käytettäessä luokiteltua aikaa selittäjänä (malli 3) saattoi ennuste poiketa yli 0,1 yksikköä siitä, mitä jatkuvaa aikamuuttujaa käyttävä malli 1 ennusti. Toisaalta malli 1 tuotti Pohjois-Suomessa selvästi korkeamman todennäköisyyden kunnostusojitustarpeelle kuin malli 3 (Kuva 2 a–c).

Kaikki laaditut mallit liitettiin metsikkösimulaattoriin, joka koostui pohjapinta-alan kasvumalleista ja pituusmalleista (Hökkä 1997), sekä kuolemis- (Ojansuu ym. 1991) ja itseharvenemismalleista (Hynynen 1993). Esimerkkimetsikössä kaikki todenäköisyysmallit ennustivat todennäköisyyden ojituksen huonolle kunnolle ylittävän määrätyn raja-arvon 0,5 samalla 5-vuotisjaksolla (25 v. ojituksesta) (Kuva 3a). Ojituksen huono kunto alensi pohjapinta-alan kasvua n. 15% (Kuva 3b).

Mallien selittäjät olivat pääosin samoja kuin ne tekijät, joiden on aikaisemmissa tutkimuksissa todettu vaikuttavan mm. ojien kuntoon (Heikurainen 1957, Timonen 1983, Lauhanen et al. 1998). Kunnostusojitustarve vaikutti lisääntyvän nopeammin ajan mukana kuin Keltikankaan ym. (1986) tutkimuksessa. Tässä tutkimuksessa korpien ja rämeiden välillä ei voitu havaita eroa kunnostusojitustarpeen suhteen (vrt. Lauhanen ym. 1998). Malleja voidaan soveltaa ojitusaluemetsien kehitysennusteiden laskentaan käyttämällä todenäköisyysmalleilla saatua ennustetta kasvupaikan tilasta kasvumalleissa syötteenä ja siten korjata metsikön kasvuennustetta tehtäessä pitkän ajan metsikkösimulointeja.

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