

Bibliography, FINLAND

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Historical Perspectives and Milestones in the Research on Natural Forests

Aaltonen V.T. (1919): Natural regeneration of heath forests in Finnish Lapland. (Kangasmetsien luonnollisesta uudistumisesta Suomen Lapissa, I) Referat: Über die natürliche Verjüngung der Heidewälder im Finnischen Lappland, I. Communicationes ex Instituto Quaestionum Forestalium Finlandiae 1, 375 p.

Abstract: The natural regeneration of forests on mineral soils in Finnish Lapland was studied. The study concentrated on dry pine forests. The investigation consisted of different levels of sample plots. The results are shown mostly as graphical illustrations. Young seedlings were classified into different classes according to their quality. The regeneration ability is discussed based on vegetation, crown characteristics of seed trees, reindeer browsing, the effect of snow, freezing of soil, fungi and insects. It is proposed that Scots pine should be the main tree species on dry mineral soils. Forests should be relatively sparse because of the poor mineral conditions. Silvicultural methods are discussed but recommendations for the proper the time of thinning or for the amount of seed trees are not given.

Key-words: Scots pine, natural regeneration, ground vegetation, reindeer grazing, freezing

Aaltonen V.T. (1925): Selfthinning and growing space of trees in natural forests (Metsikön itseharventumisesta ja puiden kasvutilasta luonnonmetsissä). Referat: Über die Selbstabscheidung und den Wuchsraum der Bäume in Naturbeständen. Communicationes ex Instituto Quaestionum Forestalium Finlandiae 9: 20 p.

Abstract: The self-thinning of stands is discussed on the basis of Ilvessalo's growth and yield tables. The main feature is the number of stems on different forest site types and with different tree species. The number of stems is highest in spruce stands and lowest in pine stands: the higher this number is the poorer the forest site type. At old age the stem number decreases fastest in birch stands. It is shown that trees of the same size demand more living space the poorer the forest site type is. Spruce demands less living space than pine and pine less than birch.

Key-words: Self thinning, stem number, forest site type

Cajander A.K. (1909): Forest site types (Über Waldtypen). Acta Forestalia Fennica 1 (1), 175 p.

Abstract: This first research paper of the Finnish Society of Forest Science describes the classical study of A.K. Cajander of forest site types. It is based on literature and specially on field studies carried out in 1904-08 in Germany and in southern Finland as well as in northern Russia. The main part of the study describes different forest site types of Germany and their plant compositions. The experimental forest of Evo in southern Finland is described in detail.

According to this study, the competition between plants on living space, nutrients and light determines the composition of plant societies which are typical to different sites. The importance of forest site types for silviculture and forest management are discussed. The idea of growth and yield tables according to forest site types is presented. The aim of the study is to find an exact and objective method for forest site classification and to determine site classes which are independent on the tree species or geographic location of the site.

Key-words: Forest site type, site classification, competition, plant society, silviculture

Cajander A.K., Ilvessalo Y. (1921): Forest site types II (Über Waldtypen. II)

Acta Forestalia Fennica 20 (1), 77 p.

Abstract: The study consists of three parts. Cajander presents the basis for forest site type classification according to plant societies and describes clearly the fundamental principles of

forest site type classification. Altogether 15 forest site types are presented thoroughly by plant indicators.

Ilvessalo shows that forest site types can be used as a basis for growth and yield tables. Stem number, mean diameter, diameter distributions, dominant height and stand volume are used to show differences between forest site types. According to Ilvessalo, the variation in growth conditions within one forest site type is rather small but different forest site types vary so much that forest site types can easily be used for forest site classification, growth and yield studies and yield tables. Cajander summarizes shortly the different studies concerning forest site types during 1909-20.

Key-words: Forest site type, site classification, growth and yield table, stand characteristics

Heikinheimo O. (1915): The influence of shifting cultivation on forests in Finland (Kaskiviljelyn vaikutus Suomen metsiin). Referat: Der Einfluss der Brandwirtschaft auf die Wälder Finnlands. *Acta Forestalia Fennica* 4(2), 264 p.

Abstract: Slash-and-burn cultivation was the main method of agriculture in the 19th century and thus greatly affected the composition of forests in most of Finland. In eastern Finland it was estimated that over 75% of productive forest land had been under slash-and-burn cultivation before the year 1915.

Different slash-and-burn cultivation methods are discussed. The effect of slash-and-burn cultivation on the quality of forests is studied based on the seeding of the cultivation areas, their sprouting by tree species, and the effect of cattle on the reforestation of cultivation areas. The development of forests after slash-and-burn cultivation is analyzed by seed forests, coppices and the mixed alternatives of both seed forests and coppices. It is estimated that slash-and-burn cultivation has a positive effect on the quality of forests because pine and birch can regenerate easily after cultivation and form fully stocked even-aged forests. Some methods to improve the bad-quality forests after slash-and-burn cultivation are presented.

Key-words: Slash-and-burn cultivation, reforestation, sprouting, seeding

Kalliola R. (1966): The reduction of the area of forests in natural condition in Finland in light of some maps based upon national forest inventories. *Annales Botanici Fennici* 3, 442-448.

Abstract: The concept of forests in natural condition is discussed. Particularly the expansion of wood industry is seen to have led to an increasing utilization of forest resources and thus to the reduction of forests in natural condition. The proportion and location of forests in natural condition are analyzed based on the data from national forest inventories. The location of over-mature forests, number of dried-out standing trees (dbh > 20 cm) per hectare and number of windfalls (dbh > 20 cm) per hectare in the third national forest inventory (1951-53) are shown as maps. Most of the over-mature stands, dried-out trees and windfalls are located in northern Finland, in the eastern parts of the province of Kainuu, in the parts of Karelia located close to the border to Russia, and in the area of Suomenselkä.

The amount of the dried-out standing trees is regarded as the best indicator for forests in natural condition. The development of the amount of these trees is analyzed as time series from second to fourth national forest inventories. There seems to be no great differences between the second (1936-38) and third (1951-53) inventories. On the other hand, there is a very clear difference between the third and fourth (1960-63) inventories. This is due to the sharp increase in cutting activities during the 1950s and not least in eastern and northern Finland.

Key-words: National forest inventory, natural forest, disturbances, windthrow, dead wood

Kouki J. (ed.). (1994): Biodiversity in the Fennoscandian boreal forest: natural variation and its management.

Annales Zoologici Fennici 31 (1), 217 p.

Abstract: In Finland, most of the forested area is silviculturally managed for timber production,

and only a fraction of forests is set aside as reserves. Therefore forestry has a strong effect on animal and plant species in Finland. In terms of nature conservation and preservation of biodiversity, forests are probably the most significant habitat to be considered.

The report concentrates on ecological research related to conservation of boreal forests and their biota. The book is divided into six partly overlapping sections. It starts with an overview of biodiversity, the origin and conceptual domain of the term. The second section analyses the properties, structure and dynamics of the boreal forest habitats. Papers in the third section focus on large-scale or geographical patterns and variation in animal species richness. In the fourth section populations are analyzed from the local or regional point of view. In the fifth section the interaction between research and management is addressed more specifically. In the sixth section an overview of the present status of the knowledge as well as future research needs are discussed. As stressed there, the dynamical nature of boreal forests offers possibilities for changing timber production practices to promote conservation goals. There is probably no ultimate conflict between timber production and conservation in boreal forests.

Key-words: Biodiversity, species richness, boreal forest, forest management, forest dynamics

Poikajarvi H., Sepponen P., Varmola M. (eds.) (1989): Research activities on the nature conservation areas (Tutkimus luonnonsuojelualueilla). *Folia Forestalia* 736, 105 p.

Abstract: The information center of the Finnish Forest Research Institute in the Pallas-Ounastunturi National Park was the site of a research conference June 6-7, 1988. The theme of the conference was confined to research being carried out on nature conservation areas. This special theme was part of a celebration: the national parks run by the Research Institute turned 50.

The aim of the conference was to examine recent and current research in nature conservation areas around the country. With this in mind, the conference sought to assemble as representative a group of researchers as possible to present their findings.

The conference dealt with the significance of conservation areas for research, the need for research which their management occasions, and how such research has been organized in the various research stations. The results of numerous individual studies were presented. The papers brought out the unique position of conservation areas in basic research and in forest research. These areas are needed to study the rules of various changes in the environment and to furnish important bases of comparison with commercial forests. Research on the conservation areas yields opportunities for cooperation between the Research Institute and the universities.

In all, some 18 presentations were given, with topics ranging from basic cartography in the natural sciences to environmental economics.

Key-words: Nature conservation, multiple use, environmental economics

Sirén G. (1955): The development of spruce forest on raw humus sites in northern Finland and its ecology. (Lyhennelmä: Pohjois-Suomen paksusammalkankaiden kuusimetsien kehityksestä ja sen ekologiasta). *Acta Forestalia Fennica* 62 (4), 408 p.

Abstract: The development of spruce forests in Northern Finland was examined on the basis of 83 sample plots. The natural development of spruce forests and the ecological factors affecting on the development were the main aims of the study. Sample plots were laid out at stands where both natural development and some disturbance like forest fire, storm or other damage could be found. Stem number, mean diameter, diameter distribution, height, volume, natural mortality and natural regeneration were studied. The vegetation succession was examined and primary and secondary successions were described. The root development and the growth of raw humus layer were examined as well.

Many ecological measurements were made in one stand comprising of burned spruce forest where both primary (birch) and secondary (spruce) succession forest were present. Micrometeorological and soil variables were the main factors studied.

As a result, clear cutting, prescribed burning and direct sowing with pine was recommended as the suitable method to regenerate old spruce raw humus stands. Mixed tree composition of pine and birch was suggested to give best result.

Key-words: Norway spruce, ecological factors, natural disturbance, forest regeneration, direct sowing, prescribed burning, vegetation analysis

Stand structure research in natural forests

Cajanus W. (1914): The development of even aged forests. Statistical study I (Über die Entwicklung gleichaltriger Waldbestände. Eine statistische Studie I). Acta Forestalia Fennica. 3, 142 p.

Abstract: The development of even-aged stands of Scots pine and Norway spruce was examined on the basis of 94 sample plots. The site was described by five site index classes. The development of the mean diameter, dispersion, asymmetry, excess and stem number was studied. The mean diameter was expressed by site classes as a regression function where the dependent variable was the stand age. The diameter distribution was modeled by the different variables. With these models the development of a stand diameter distribution in different site classes could be expressed with the help of stand age as the dependent variable. The stem number was modeled as a function of stand age, too, for different site classes.

Key-words: Scots pine, Norway spruce, diameter distribution, site class, stand characteristics, dispersion, asymmetry

Havas P., Kubin E. (1983): Structure, growth and organic matter content in the vegetation cover of an old spruce forest in Northern Finland. Annales Botanici Fennici 20, 115–149.

A description is given of the vegetation, its growth, ecology and organic matter content in a spruce forest (*Picea abies* (L.) Karst) of the *Hylocomium* - *Myrtillus* type in Northern Finland (66° 22' N). A plot of 30*30 m was set aside for the description of the vegetation. The same area was used for the phytomass determinations, which were done by the harvesting method. The amount of litter was studied using small litter traps and also by extracting it from raw humus samples. Temperature measurements were obtained from a number of layers in the forest. Throughfall and free rainfall was measured using a small rain gauge.

The forest possesses a well-developed ground-layer vegetation consisting chiefly of dwarf shrubs and mosses. The major aerial biomasses among the dwarf shrubs were contributed by *Vaccinium myrtillus* (1.2 tonnes/ha) and *V. vitis-idaea* (1.3 tonnes/ha), while *Deschampsia flexuosa* attained the highest value (0.06 tonnes/ha) among the grasses and herbs. *Hylocomium splendens* (0.9 tonnes/ha) and *Pleurozium schreberi* (0.9 tonnes/ha) were virtually of equal importance among the mosses.

The calculated total phytomass of the forest was 139 tonnes/ha, of which 74 % was aerial phytomass and 26 % underground phytomass. The tree layer accounted for 95 % of the aerial phytomass and the ground-layer vegetation 5 %. The root systems comprised 20 % of the total tree biomass, and the roots and rhizomes of the ground-layer vegetation 70 % of its total biomass. The greatest part of the root material is contained in the humus layer (18 tonnes/ha). The mineral soil also proved to contain organic matter, the ignition loss for the eluvial and illuvial horizons together pointing to a figure of 209 tonnes/ha. The present determinations of growth and organic matter provide a basis for research into the nutrient cycle in the same forest.

Key-words: Boreal coniferous forest, phytomass, net primary production, ground-layer vegetation, spruce, litter, raw humus, organic matter, ecology

Iivessalo Y. (1920): Growth and yield tables for pine, spruce and birch in southern Finland (Kasvu- ja tuottotaulut Suomen eteläpuoliskon mänty- ja kuusi- ja koivumetsille) Referat: Ertragstafeln für die Kiefern-, Fichten- und Birkenbestände in der Südhälfte Finnlands. Acta Forestalia Fennica 15 (4), 96 p + 9 p.

Abstract: Forest site types were examined based on 467 sample plots from Southern and middle Finland. The examined stand characteristics were vegetation, mean diameter, dispersion, asymmetry, excess, stem number, diameter distribution, stand volume, stand basal area and mean height.

Each forest site type had its characteristics vegetation and the number of plants increased when forest site type became more fertile. Forest site types can be differed on the basis of plant vegetation. In all tree species the mean diameter was the larger the more fertile the forest site type was at the same age. Dispersion was the larger the better forest site type. Stem number was the bigger the poorer the forest site type. Theoretical diameter distributions can be calculated to different forest site types. Both stand volume, stand basal area mean height and dominant height at the same age were the larger the more fertile the forest site type was. It was concluded that forest site types suited well to be the basis for the classification of forest land, for all taxatoric studies, and for growth and yield tables.

Key-words: Forest site type, growth and yield table, stand characteristics, plant diversity

Ilvessalo Y., Ilvessalo M. (1975): The forest types of Finland in the light of natural development and yield capacity of forest stands (Suomen metsätyypit metsiköiden luontaisen kehitys- ja puuntuottokyvyn valossa). Acta Forestalia Fennica 144, 101 p.

Abstract: Since A.K. Cajander in 1909 had published his fundamental work on the theory of forest types, these have been the basis of the quality classification of forest sites in Finland. In this publication investigations on the growth and yield of naturally normal forest stands on different forest types carried out in five parts from south to north have been combined into a uniform study comprising the total mineral forest land of Finland. The study material consists of 1200 sample plots. The study shows that it is possible to work out uniform age-based development series for different stand characteristics in the case of the forest types. There is generally a clear difference in the development series of various stand characteristics between different forest types.

Key-words: Forest site type, site classification, natural forest, growth, yield

Lähde E., Laiho O., Norokorpi Y., Saksa, T. (1991): The structure of advanced virgin forests in Finland. Scandinavian Journal of Forest Research 6 (4), 11 p.

Abstract: The study deals with the structure of advanced virgin forests in Finland based on the national forest inventory carried out in the 1920s. At that time virgin forests covered 2/3 of the forested area of Finland. Stand structure was described in terms of the dbh distribution. The study material consisting of 10 x 50 m sample plots was grouped according to geographical region, site type and the age class of the overstorey. A stand was classified to be advanced if the age of the overstorey was at least half of the currently applied rotation age and if the stem volume exceeded 40 m³/hectare. About 60 % of all virgin forests were classified to be advanced. In the 1920s, the majority of advanced virgin forests were mixed stands with an all-sized structure. Trees of small diameter prevailed and the stem number diminished rather steadily with increasing dbh. Even-sized stands with a dbh range of 15 or 20 cm and a normally distributed diameter frequency accounted for only about one percent. The stand structures described in this study can be used as models when developing so-called natural silvicultural regimes. This concept includes methods for maintaining and developing the growing stock as a mixed stand all-sized in structure.

Key-words: Virgin, stand structure, even-sized trees, all-sized trees, diameter distribution, species composition

Lindholm T., Tuominen, S. (1993): Evaluation of naturalness of forest stand structure (Metsien puuston luonnontilaisuuden arviointi) Metsähallituksen luonnonsuojelujulkaisuja, Sarja A, No. 3, 40 p.

Abstract: The naturalness of tree stands is estimated, e.g., when planning the management of nature conservation areas. This paper gives background information and rules for the evaluation of naturalness based on tree characteristics. The evaluation of naturalness is difficult because the natural succession of Finnish forests is not well known. Naturalness is evaluated on the basis of structural characteristics of tree stands and the variables that have an effect on these characteristics. Naturalness is reduced by all variables that change the natural development of stands.

Evaluated factors are: living trees, their spatial variation, layers, stages and their characteristics, dead trees, amount of removed dead trees, previous tree generation, cuttings, ditching, and soil preparation.

A numerical scale is determined to each factor. Amount of living and dead trees have positive values, others negative. The total value of naturalness is the sum of different factors.

Key-words: Nature conservation, naturalness, forest succession

Lönnroth E. (1926): Inner structure and development of even-aged Scots pine stand based on material from Southern Finland (Untersuchungen über die innere Struktur und Entwicklung gleichaltriger Naturnormaler Kiefernbestände, basiert auf Material aus der Südhälfte Finnlands). Acta Forestalia Fennica 30, 269 p.

Abstract: The inner structure of even-aged natural normal Scots pine stands was examined on the basis of 30 sample plots in Southern Finland. The classification of trees to tree classes formed the basis for the study. The material was analyzed by mathematical-statistical formulas. The development of stem number, height, crown, breast height diameter, basal area and volume were presented graphically with smoothed curves as a function of stand age.

Key-words: Scots pine, even-aged forest, site fertility, diameter distribution, stand characteristics

Modelling the stand structure

Kolström T. (1992): Dynamics of uneven-aged stand of Norway spruce: a model approach.

Finnish Forest Research Institute, Research Papers 411, 75 p.

Abstract: The study presents the dynamics of uneven-aged Norway spruce (*Picea abies* (L.) Karst.) stands. The analysis of the stand dynamics is based on the theory of disturbances and patch dynamics. The stand dynamics is described using a transition matrix model. The effect of the spatial distribution on the growth of a Norway spruce stand is analyzed. In simulation studies the growth of the model stands clearly decreased with clustering, the maximum decrease was 40 % from the most regular pattern. The effect of the regeneration on the future development of an uneven-aged Norway spruce stand is studied. The calculations showed the primary importance of the ingrowth to the structure of an uneven-aged stand. Finally, the empirical parameters were estimated for the transition matrix model. The transition probabilities were based on 48 study plots and the regeneration parameters on 8 study plots in eastern Finland (about 62°N, 30°E, 100-120 m asl.). The simulations showed that the sustainable harvest proportion of 5 years varies between 7 and 20 % depending on the stand basal area. The variations of thinning interval and intensity showed the thinnings should be done often and be modest. The extension of the thinning interval from 5 to 10 years reduced the total removal slightly.

Key-words: Simulation, selection forestry, transition matrix, multicohort stand, disturbance

Hynynen J. (1993): Self-thinning models for even-aged stands of *Pinus sylvestris*, *Picea abies* and *Betula pendula*. Scandinavian Journal of Forest Research 8 (3), 326-336

Abstract: Self-thinning models were developed to describe the relationship between the stem number and mean diameter of even-aged and monospecific tree stands undergoing self-thinning. The models were developed separately for *Pinus sylvestris* L., *Picea abies* (L.) Karst. and *Betula pendula* Roth. stands. Data from 41 unthinned permanent sample plots were used. According to

Reincke's equation and the $-3/2$ power rule of self-thinning, a log-log plot of average tree size and stem density will give a straight self-thinning line of constant slope. According to this study, the slope of the line consistent with Reincke's equation varies for different tree species. Within tree species the intercept of the self-thinning line varies according to site index.

Key-words: Scots pine, Norway spruce, birch, self-thinning, prediction

Gap dynamics research

Kalela E. K. (1937): Studies on the development of spruce-grey alder mixed forests (Tutkimuksia kuusi-harmaaleppä-sekametsiköiden kehityksestä) Referat: Untersuchungen über die Entwicklungen der Fichten-Weisserlen-Mischbestände in Ostfinnland. Acta Forestalia Fennica 44, 198 p.

Abstract: After the slash-and-burn cultivation Norway spruce decreases and grey alder takes place as a pioneer tree species. The development of mixed spruce-alder stands was examined on the basis of 196 sample plots in Eastern Finland. Stem number, mean diameter, dominant height, mean height, and basal area are studied separately for both tree species and also as total stand variables. Special attention is paid to the description of root formation and competition of both alder and spruce. The tending of mixed stands is discussed.

Key-words: Norway spruce, grey alder, mixed forest, slash-and-burn cultivation, regeneration, stand characteristics

Kuuluvainen T. (1994): Gap disturbance, ground microtopography, and the regeneration dynamics of boreal coniferous forest in Finland: a review. Annales Zoologici Fennici 31 (1), 35–51

Abstract: The reviewed studies indicate that small-scale gap disturbance and gap regeneration can be common in boreal forests that have escaped catastrophic fire disturbance for prolonged time periods. Tree regeneration in gaps is enhanced by fine-scale heterogeneity at the forest floor created by soil disturbance and woody debris, which create favorable microsites for seed germination and seedling establishment. The significance of specific microsites for seedling establishment varies among forest types, being smallest in dry Scots pine dominated forests with scanty understorey vegetation and thin humus layer, and greatest in moist Norway spruce dominated forests with abundant understory vegetation and thick humus layer. In a gap the survival, growth and recruitment of tree seedlings is determined by gap size and long-term below- and above-ground interferences between tree seedlings, understory vegetation and adjacent large trees. Gap disturbance contributes to the structural, functional and species diversity of the boreal forest both at local and areal levels. At the local level, gap disturbance increases fine-scale variation in soil properties and microtopography. At the areal scale, gap disturbance creates horizontally and vertically heterogeneous forest structures and contributes to the coexistence of coniferous and broad-leaved tree species.

Key-words: Gap disturbance, boreal coniferous forest, forest regeneration, tree species coexistence, ecological diversity

Successional development, disturbances

Haapanen A., Siitonen P. (1978): Forest fires in Ulvinsalo strict nature reserve (Kulojen esiintyminen Ulvinsalon luonnonpuistossa). Summary: Silva Fennica 12 (3), 187–200

Abstract: This study is the first report of a larger project concerning fire ecology in the Finnish boreal forests. Ulvinsalo strict nature reserve (63° 55' N 30° 24' E, area 2 500 hectares), where modern forestry has never been practiced, represents in this project an area, where forest fires have been uncommon because of its mosaic of mineral and peat soils and site types. The forest stands are mostly Norway spruce (*Picea abies*) dominated with Scots pine (*Pinus sylvestris*) often as the oldest trees of a stand. Forest fires have been aged by counting annual rings from

cambium to the fire scar in pines. Wood samples were got by boring wood cylinders.

73 stands covering 1207 hectares were surveyed of over 80 % of stands on mineral soil. 50 % of the areas surveyed were burned at least once during the life time of the present old pine trees. 48 different forest fires were found. The first has been in 1712 and the last in 1969. In the stands where fire scars were found the average time elapse between fires was about 82 ± 43 years, range 18-219 years. It is assumed that the stands where no fire scars were found, have, however, regenerated after fires but there have been no fires since then. In these cases the time elapse between forest fires was 191 ± 59 years. In all stands surveyed, the average time elapse between fires has been 120 years and range 18-372 years. In the latter part of the 19th century, 21 forest fires were dated, in other half centuries 4-9 (Table 2). The increased human activity in the late 19th century may be seen in this fire peak. The mean area burned at a time has been at the most 24 hectares. The fire rotation of the area is 280 years. The spruce is almost the only tree species, which can regenerate in the present situations.

Key-words: Norway spruce, Scots pine, fire frequency, fire ecology, boreal forest, strict nature reserve

Heikinheimo O. (1920): The snow damage areas and their forests in Finland (Suomen lumituhoalueet ja niiden metsät) Referat: Die Schneeschadengebiete in Finnland und ihre Wälder. Communicationes ex Instituto Quaestionum Forestalium Finlandiae 3, 151 p.

Abstract: The snow damage areas of Finland, specially in the North Finland, were analyzed in 38 spruce dominated forests. The reasons for snow damage were listed as follows: snow depth and water content of snow, snow content in tree crowns, climatic variation between winters, the elevation of the forests, west-east location, and the altitude. The quality of snow damage was divided into mechanical, physiological, rotten, and fungi damage. The snow damage areas of Finland was estimated to ca. 500000 ha. Spruce forests were more susceptible to snow damage than pine forests. Snow damage was analyzed to be an important factor affecting the altitude of timber line in the mountain area in North Finland.

Key-words: Norway spruce, snow damage, timber line

Hyvärinen V., Sepponen P. (1988): Tree species history and local forest fires in Kivalo area of Northern Finland (Kivalon alueen paksusammalkuusikoiden puulaji- ja metsäpalohistoriaa). Summary. Folia Forestalia 720, 26 p.

Abstract: The aim of the study was to describe the history of the tree species present in a spruce forest of the *Hylocomium myrtillus* type by palynological methods and at the same time to trace the incidence of forest fires in the area. Cores for the construction of pollen diagrams were taken from small peat deposits, and microscopic charcoal particle counts were made from the same samples for the identification of forest fires.

Pollen stratigraphies from three sites show spruce *Picea abies* to have spread to the Kivalo area around 4000-3200 B.P., prior to which the hilltops had been covered by a mixed *Betula-Pinus* forest. Widespread *Picea abies* forest existed in the area by 3200 B.P. at the latest, the species having spread at the expense of first birch, *Betula* sp, and later gradually also pine, *Pinus sylvestris*.

Forest fires would seem to have been rare in the area with definite evidence of only four such events within the last 1700 years to be seen on the top of the hill of Kumpukivalo. These fires would seem to have led to the major destruction of the *Picea abies* stands and to a consequent increase in the abundance of *Betula* in the forests. The resulting *Betula* forests, nevertheless, gradually reverted to *Picea* forests via intermediate *Betula-Picea* stages. *Pinus sylvestris* did not feature, to any essential degree, in the succession which followed these forest fires, at least in the case of the last such event.

Key-words: Forest history, succession, forest fire, silvicultural conversion

Kauhanen H. (1989): Inventory of the windthrow area of Jauru Valley in the Urho Kekkonen National Park (Jaurujokilaakson tuulenkaatoalueen inventointi Urho Kekkosen kansallispuistossa). Summary. *Folia Forestalia* 736, 59–66

Abstract: Natural disturbances play an important role in the dynamics of virgin forests. In the past, both fire and storm were rejuvenating factors in the boreal forest ecosystem. Due to efficient fire suppression during this century, the role of wild fire has sharply decreased. At present storms are the most important disturbance in virgin boreal forests in Finland.

On October 16th, 1985, an exceptionally severe storm blew across the Urho Kekkonen National Park and felled a large number of trees in the most remote part of the park. The windfall area in Jauru Valley afforded a unique opportunity to start a long-term survey dealing with the regeneration of virgin forests.

In 1986 and 1987, permanent sample plots were established. Both windthrown and standing trees were measured, and a number of site factors estimated. Before the storm stand density ranged between 200–600 stems/ha in most cases. Stem volume ranged between 27–226 m³/ha, mean height between 9.1–18.4 m and mean diameter between 15.1–30.0 cm.

Among the 1390 trees measured in the plots, 55.3 % were intact and 44.7 % damaged by the storm. Damage was characterized by a high proportion (93.2 %) of uprooted trees. Only 1.4 % of the damaged trees had snapped. The rest were tilted or left leaning against other trees. The storm did not fell all trees at any site but reduced stand density more or less. The number of trees declined 50–70 % in most of the plots investigated.

Topography played an important role in the occurrence of windthrow. The most extensive and heaviest damage was found on windward, middle slopes. Severe damage but smaller in area were common also on hilltops and even on the valley floor. The proportion of windthrown trees increased significantly with an increase in height.

Key-words: Scots pine, windthrow, national park, topography, damage

Lehtonen H. (1997): Forest fire history in North Karelia: dendroecological approach. University of Joensuu, Faculty of Forestry, Research Notes 59, 23 p.

Abstract: Dendrochronological dating of fire scars is used to determine the history of forest fires in eastern Finland and the effects of these and of slash-and-burn cultivation on forest structure are studied. The fire history spans about five hundred years. Forest fires increased towards the end of the 17th century and again towards the end of the 18th century, but decreased markedly in the middle of the 19th century. Before the period of pronounced human influence, the mean fire interval was about 60 years in *Vaccinium*-type forests and about 50 years in *Calluna*-type forests, while during the most intensive slash-and-burn cultivation period (1750–1850) the figure was 30–40 years for all forest site types. The mean fire interval became longer with increasing distance from slash-and-burn cultivation areas and hilltop forests have burned more frequently. The changes in fire history reflect changes in the population of North Karelia and the extent of slash-and-burn cultivation. Most fires were of low or moderate intensity. The average area burned was 130 ha.

The old forest survey maps used to reconstruct the forest structure after the cessation of slash-and-burn cultivation and forest fires showed that the forests were mostly young (50–100 years), with old forests (over 200 years) making up about 20 % of the area. The proportions of young forest and of deciduous trees decreased with increasing distance from the slash-and-burn cultivation areas.

The results show that dendroecological methods can be used to determine past fire history despite extensive land use and cutting in the past. It also becomes clear that forest fires were a very important factor in the forest succession in North Karelia in the past and that the forest fire history of the region has been greatly affected by slash-and-burn cultivation. The results also indicate that these two factors have largely controlled the forest structure in the region for hundreds of years.

Key-words: Dendrochronology, dendroecology, fire history, forest fire, forest structure, slash-and-burn cultivation

Sarvas R. (1938): Natural regeneration on prescribed burning areas in Northern Finland. Ecological study on the dry heaths in Northern Finland (Kuloalojen luontaisesta metsittymisestä. Pohjois-Suomen kuivilla kankailla suoritettu metsäbiologinen tutkielma) Referat: Über die natürliche Bewaldung der Waldbrandflächen. Eine waldbiologische Untersuchung auf den trockenen Heideböden Nordfinnlands. Acta Forestalia Fennica 46 (1), 146 p.

Abstract: The natural reforestation after forest fires was examined in the middle of Finnish Lapland. The material consisted of 77 burned areas, mostly on dry Scots pine heaths. The characteristics of forest fire, the damage, reforestation process, development of Scots pine seedling stands, and the sprouting of birches were examined.

Scots pine is the most persistent tree species against forest fires. Birch will regenerate by seed but also by sprouts which are the first trees to grow after a forest fire. Norway spruce usually totally dies in a fire. A sufficient amount of pine seed trees should be left on a burned area. On dry heaths, there should not be more than 60-80 seed trees/ha. Artificial sowing can be used if the amount of seed trees is minor. The best sowing time is two-three years after a forest fire. Removal of birches is the most important cleaning operation.

Key-words: Scots pine, Norway spruce, fire frequency, forest regeneration, seedling stand, sprouting, reforestation, silviculture

Tolonen K. (1983): The post-glacial fire record. In: Wein R.W., MacLean O. A' (eds.): The role of fire in Northern circumpolar ecosystems. John Wiley & Sons Ltd. p. 21-44.

Abstract: Knowledge of the post-glacial fire history helps in understanding ecological questions, such as succession and stability of the vegetation mosaic, the dependence of flora on fire, and ecological consequences of fires to lakes and bogs. This information is incorporated in peat and lake deposits as fossil macroscopic and microscopic charcoal particles. Palaeoecological fire records have not been systematically collected or examined, except for a few recent lake sediment studies. Peat and other soil profiles register the location of ancient fires but these are usually difficult to date and give too low frequencies when compared with dendrochronological and historical data. Improved modern methods of charcoal analysis from lake sediments allow temporal and spatial comparisons through millennia. Results from boreal North America and Finland have revealed remarkable differences between post-glacial climatic periods and different forest types. Stratigraphical studies have shown that neither historical nor prehistorical man can be eliminated as a potential source of ignition in any region with combustible vegetation cover. The past fire regimes during different forest-historical stages appear to be related to corresponding differences in the fire frequency within the present-day vegetation zones.

Key-words: Norway spruce, fire frequency, lake sediment, charcoal, peat

Biodiversity aspects, dead wood component related to stand structure

Haila Y., Niemelä P., Kouki J. (1994): Effects of management on the ecological diversity of boreal forests (Metsätalouden ekologiset vaikutukset boreaalisissa havumetsissä) Finnish Forest Research Institute, Research Papers 482, 123 p.

Abstract: A seminar called "Effects of management on the ecological diversity of boreal forests" was held in 1993 in Lammi Biological Station of Helsinki University. The aim of the seminar was to get together scientists who have made research on the effects of forestry on nature biodiversity. The main idea was to discuss the up-to-date results of research and the challenges of future research based on opinions of scientists from different research areas. The seminar showed that much research is available of the relationship between forestry and forest biodiversity. The actual challenge is to move towards the applications in forestry, to increase

cooperation between natural scientists and forest researchers and to get forest managers into the cooperation. Altogether 15 papers were presented, grouped to 1) boreal forests, their structure and biodiversity and 2) forest stand treatments and their effects on biodiversity.

Key-words: Boreal forests, structure, biodiversity, silviculture, forest management

Norokorpi Y. (1979): Old Norway spruce stands, amount of decay and decay-causing microbes in Northern Finland (Seloste: Peräpohjolan vanhat kuusikot, niiden lahoisuus ja lahottajat). *Communicationes Instituti Forestalis Fenniae* 97 (6), 77 p.

Abstract: Decay damage was studied in a total of 6 275 living spruce trees from nine Norway spruce stands that were more than 150 years old and located in northern Finland (northern boreal vegetation zone, N 65j - N 68j). Of these trees 30 % were damaged by decay. Decayed and discolored wood comprised 4.9 % of the underbark volume. Decay advanced slowly so the average length of the butt-rot column was only 107 cm. Decay frequency and volume of the decay column depended on the age and size of the growing stock.

Thirty species of *Basidiomycotina*, two species of *Ascomycotina* and 22 species of *Deuteromycotina* were isolated from the decay columns. Bacteria were found in ca. 50 % of the columns. The most common species of *Basidiomycotina*, were *Coniophora arida*, *C. olivacea*, *Inonotus triqueter*, *Phellinus chrysoloma* and *Haematostereum sanguinolentum*. *Ascocoryne sarcoides* and *Phialographium* sp. were the most common *Ascomycotina* and *Deuteromycotina* species. *Heterobasidion annosum* occurred in only one tree near the southern border of the northern boreal zone.

The average butt-rot and wound-decay columns caused by *P. chrysoloma* were the longest and had the greatest volume. The butt-rot columns caused by *Haematostereum sanguinolentum* and *Peniophora pithya* were also longer than average. The butt-rot columns from which basidiomycetes were isolated were, on an average, longer and had a larger diameter and volume than those from which only other microbes were isolated.

Key-words: Norway spruce, old forest, fungi, decaying wood

Siitonen J. (1994): Decaying wood and saproxylic *Coleoptera* in two old spruce forest: A comparison of two sampling methods. *Annales Zoologici Fennici* 31, 89-95.

Abstract: The saproxylic beetle fauna was compared in two old spruce dominated forests in northern Finland. The volume of decaying wood in the forests was 32 m³ and 8 m³ per hectare. The beetles were sampled by carefully peeling the bark off all the dead trees within twenty circular sample plots of 100 m², and by window flight trapping. The pooled sample comprised 7184 individuals of 207 saproxylic species. According to both sampling methods, common generalist species were equally abundant in both forests, whereas specialists living either on decaying spruce or birch were more abundant in the forest with a larger supply of decaying wood. The set of dominant species was, however, almost completely different with the two methods. Bark peeling yielded mostly sub-corticolous species. Window flight trapping yielded, in addition, many species living inside decaying trees, on microfungi on dead trees or on polyporous fungi. The amount of decaying wood around the traps did not affect the number of species or specimens caught.

Key-words: Norway spruce, old forest, decaying wood, saproxylics

Siitonen J., Martikainen P., Punttila P., Rauh, J. (1996): Amount and quality of decaying wood in old managed and natural spruce forests in southern Finland. In: Second International Workshop on Disturbance Dynamics in Boreal Forests. Workshop Abstracts. Université du Québec. p. 226-227.

Abstract: Decaying wood plays a substantial role in several ecological processes in boreal forests. Coarse woody debris greatly affects the amount of organic material, carbon budget and nutrient cycles in forest soils. Decomposing logs act as seed beds and are important for

regeneration in certain forest types. Decaying wood is a key factor for biodiversity in boreal forests and hosts a vast number of epixylic bryophytes and lichens, polyporous and other fungi and invertebrates.

The aim of the study was to compare the amount and structure of decaying wood in old managed, over-aged and natural forests. We established 30 one hectare (100 x 100 m) sample plots in mesic *Vaccinium myrtillus* type spruce (*Picea abies*) dominated forests in southern Finland. The main difference among the stands was the intensity of previous management in the form of selective logging or thinning. The level of cutting was estimated by counting the number of cut stumps > 10 cm in diameter per hectare. We tentatively classified the forests in three categories, ten forests in each category, on the basis of the stand age and occurrence of cut stumps: (1) old managed, (2) formerly managed, over-aged (dominating trees > 120 years old, cut stumps present) and (3) natural old-growth forests (dominating trees > 160 years old, no cut stumps).

The average volume of living trees was 293 m³/ha in old managed forests, 332 m³/ha in over-aged and 378 m³/ha in old-growth forests. The average volume of decaying wood was 11 m³/ha in managed (range 2-25 m³/ha), 25 m³/ha in over-aged (range 11-38 m³/ha) and 108 m³/ha (range 60-194 m³/ha) in old-growth forests. The proportion of decaying wood of total timber volume varied between 0.6-7 % in managed, 4-13 % in over-aged and 14-44 % in old-growth forests.

In the old-growth stands, about 70 % of the dead trees were logs, 23 % entire standing trees and 7 % snags and stubs. Most of the volume of decaying wood belonged to the diameter classes 20-29 and 30-39 cm, but there were also large logs > 40 cm in all the old-growth plots. In the managed stands, about 50 % of the decaying wood was manmade and consisted of ca. even amounts of cut stumps, logging residue and cut bolts left in the forest. In many cases, large proportion of decaying wood belonged to small diameter classes 5-9 and 10-19 cm. Large logs > 40 cm occurred only on two plots, and large deciduous logs were completely missing. Dead trees in old-growth plots were on the average more decayed than in the managed or over-aged plots.

Key-words: Norway spruce, coarse woody debris, biodiversity, boreal forest, decaying wood, managed forest, over-aged forest, natural forest

Väisänen R., Biström O., Heliövaara K. (1993): Sub-cortical *Coleoptera* in dead pines and spruces: is primeval species composition maintained in managed forests? *Biodiversity and Conservation* 2, 95-113

Abstract: The sub-cortical beetle fauna of dead Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) trunks was compared in primeval forests and managed forests in central Finland. The numbers of both individuals and species were higher in the managed forest in spite of the smaller trunk surface area examined. The proportion of rare species was higher in the primeval forest. Although most species occurred both in primeval and managed forests, there were striking differences in the abundance relations: there was only once species (*Pydlo depressus*) in common among the ten most abundant species. The proportion of bark beetles (*Scolytidae*) was more than 50 % in the managed forests and less than 5 % in the primeval forests. The number of species per site was associated with observation date, occurrence of snails and trunk position (standing or lying) in the primeval forest and with trunk diameter in the managed forests. The occurrence of rare beetle species in dead conifer trunks was related to man's effects on the forest. Although many sub-cortical species live in managed forests the fauna differs drastically from that of primeval forests.

Key-words: Silviculture, saproxylics, boreal forest, endangered species, insects

Virkkala R. (1987): Effects of forest management on birds breeding in northern Finland. *Annales Zoologici Fennici* 24, 281-294

Abstract: The effects of forest thinning and fragmentation on bird species were studied in northern Finland in 1982-1985. Based on line transect censuses bird communities of virgin and

thinned pine forests, and contiguous and fragmented spruce forests were compared. There were no statistically significant differences in total bird densities in virgin and thinned pine forests, nor in uniform and fragmented spruce forests. The structure of bird communities was, however, different both in pine and spruce forests. The densities of the generalist species *Phylloscopus trochilus*, *Carduelis flammea* and *Turdus iliacus* and the marsh-nesting *Motacilla flava* were higher, and those of *Parus cinctus*, *Perisoreus infaustus* and *Phoenicurus phoenicurus* were lower in thinned forests than in virgin pine forests. Forest fragmentation had a positive effect on the densities of *Ph. trochilus*, *T. iliacus* and *C. flammea*, and a negative effect on the group of northern taiga species (*Tetrao urogallus*, *Picoides tridactylus*, *Parus cinctus*, *Perisoreus infaustus*, *Pinicola enucleator*, and *Emberiza rustica*).

Line transect censuses had been carried out in the vicinity of the study area already in the 1940s and 1950s. Densities of the most common species in virgin forests were compared using the 1940-50 censuses and the present results. *Fringilla montifringilla* had increased fivefold from the 1940-50 period to the 1980s, but this was probably due to a collapse, caused by several cold winters in the 1940s. Densities of species preferring old forests, such as *P. cinctus*, *Ph. phoenicurus*, and *P. infaustus*, had remained nearly the same in the study area from the 1940-50s to the 1980s, although these species have drastically declined in the whole of northern Finland due to silvicultural practices. In the study area the densities probably remained almost unchanged as, even today, there are large, virgin forests left. The importance of these forests in the conservation of declining northern bird species is emphasized.

Key-words: Fragmentation, virgin forest, thinning, silviculture, birds

Comparisons between natural forests/managed forests

Kuuluvainen T., Penttinen A., Leinonen K., Nygren M. (1996): Statistical opportunities for comparing stand structural heterogeneity in managed and primeval forests: an example from boreal spruce forest in southern Finland. *Silva Fennica* 30 (2-3), 315-328

Abstract: The horizontal and vertical stand structure of living trees was examined in a managed and in a primeval spruce-dominated forest in southern Finland. Tree size distributions (dbhs, tree heights) were compared using frequency histograms. The vertical distribution of tree heights was illustrated as tree height plots and quantified as the tree height diversity. The horizontal spatial pattern of trees was described with stem maps and quantified with Ripley's K-function. The spatial autocorrelation of tree sizes was examined with semivariogram analysis. In the managed forest the dbh and height distributions of trees were bimodal indicating a two-layered vertical structure with a single dominant tree layer and abundant regeneration in the understory. The primeval forest had a much higher total number of trees which were rather evenly distributed in different diameter and tree height classes. The K-function summaries for trees taller than 15 m indicated that the primeval stand was close to complete random pattern. The managed stand was regular at small distances (up to 4 m). The semivariograms of tree sizes (dbh, tree height) showed that the managed forest had a clear spatial dependence in tree sizes up to inter-tree distances of about 12 meters. In contrast, the primeval spruce forest had a variance peak at very short inter-tree distances (< 1 m) and only weak spatial autocorrelation at short inter-tree distances (1-5 m). Excluding the understory trees (h < 15 m) from the analysis drastically changed the spatial structure of the forest as revealed by semivariograms. In general the structure of the primeval forest was both horizontally and vertically more variable and heterogeneous compared to the managed forest.

Key-words: Norway spruce, boreal forests, spatial analysis, K-function, semivariance, structural variation, biodiversity

Nyyssönen A. (1950): Comparative observations on the structure and development of tended and natural pine stands (Vertailevia havaintoja hoidettujen ja luonnontilaisten männiköiden rakenteesta ja kehityksestä). Summary. *Silva Fennica* 68, 48 p.

On the initiative of the Finnish Forest Research Institute, methodical thinning experiments have been carried out since 1924. To this end, hundreds of permanent sample plots have been established, and thinning and measurements affected on them; hence, on the majority of them, for over 20 years now.

On the basis of tree classification, e.g. in heavy thinning from below, 3rd and 4th crown storeys are removed in their entirety, and of diseased, injured and poorly formed trees of the 1st and 2nd crown storey the best only are left. Of the material in question, three pairs of sample plots have been included in the study.

In the stands in natural condition approximately half belong to the 1st crown storey, and of the stand volume, generally at least 3/4. The proportional amounts of other crown storeys usually follow in numerical order diminishing towards the lowest storey. Owing to heavy thinnings from below and particularly owing to interlocations, the proportional amount of the 1st crown storey has grown considerably, whereas dominated crown storeys have remained of practically no significance.

In pine stands in natural condition the most slender individuals are generally beaten in the struggle between the trees, both in the entire stand and, with occasional exceptions, in the different crown storeys as well. In all cuttings trees have been removed which were of a smaller average diameter than those left standing. This fact, and the diameter increment increasing as a result of the cuttings, are responsible for the fact that the mean diameter of the stand and its different crown storeys, in the last measurements of stands treated by intermediate cuttings, are regularly larger than in stands in natural condition.

The tree stand, by means of intermediate cuttings, has acquired more even diameter relations, and the number of trees in the large diameter classes has become relatively greater. In pine stands in natural state, the volume increment per stem is largest in the 1st crown storey and diminishes strongly towards lower crown storeys.

Key-words: Scots pine, crown storey, thinning, low thinning, diameter distribution

Uuttera J., Maltamo M., Hotanen J.-P. (1997): The structure of forest stands in virgin and managed peatlands: a comparison between Finnish and Russian Karelia. *Forest Ecology and Management* 96, 125–138

Abstract: This study investigated the changes caused by management, including drainage and thinnings, in peatland forest stand structure. Drained peatland sites in Finnish North Karelia were compared within the same type groups and nutrient status levels of virgin peatlands in the Republic of Karelia, the Russian Federation. The variables studied, which depict stand structure variation, included: (1) the diameter of the median tree; (2) the range of sampled diameters; (3) the basal area of the stand; (4) the estimated number of tree storeys; and (5) the number of the tree species. The number of tree storeys was determined through non-parametric Kernel estimation.

Over a long duration, management smoothes the natural multi-modal structure of virgin peatland stocking by decreasing the variation in size-distribution. Management also changes the natural tree species dynamics on peatland sites by providing the competitive advantage to the tree species, which adjust best to the changed growing conditions. These species begin to dominate the habitat and reduce the species diversity. The effect of recent thinnings and cleaning cuttings on the forest structure is dependent upon fertility of the site and the stage of the forest stock at the moment of silvicultural operation. Cleaning cuttings may have also an increasing effect on the structural diversity of peatland forest stand.

Key-words: Drainage, thinning, virgin forest, peatland, species dynamics

Uuttera J., Maltamo M., Kuusela K. (1996): Impact of forest management history on the state of forests in relation to natural forest succession. Comparative study, North Karelia, Finland vs. Republic of Karelia, Russian Federation. *Forest Ecology and Management* 83, 71–85

The purpose of this study was to examine the impact of recent history of forest management on the state and structure of forests. Comparisons were made between test areas in the south-eastern part of North Karelia, Finland, and the western part of the Republic of Karelia, Russian Federation. The test areas are located in the same climatic region, but their history of forest management has been considerably different during the past 50 years. They therefore also provide possibilities for wider international observations.

The total biodiversity of a large forest area consists of the existence and area distribution of the forest succession stages. Within these stages the stand structure reflects the processes of the small natural vegetation succession cycle of boreal coniferous forests. Considering the factors that maintain potential forest biodiversity, it is clearly seen that the forests in the Republic of Karelia are in a more natural state than those of North Karelia. However, considering the natural fire ecology of the region, both test areas have a paucity of old forests. When examining the stand characteristics reflecting the small succession cycle within habitats, the forests in the Republic of Karelia have more of the crucial factors typical for species classified as threatened in Finland.

If mimicking the natural dynamics of boreal coniferous forests is taken as a goal of forest management, the desired habitat diversity can be achieved only by maintaining all stages of the large vegetation succession cycle. Within the succession stages of young, middle-aged and mature stands, structural variation and variation of tree species composition should be increased. This can be achieved by means of forest management and forestry operations, but these policies, on the other hand, may decrease wood production.

Key-words: Biodiversity, forest succession, boreal coniferous forest, fire ecology

Vuokila Y. (1962): On growth and its variations in thinned and unthinned Scots pine stands (Männyn kasvusta ja sen vaihteluista harventaen käsitellyissä ja luonnontilaisissa metsiköissä). Summary: *Communicationes Instituti Forestalis Fenniae* 52 (7), 38 p.

Abstract: The paper deals with the variations in tree growth expressed as radial growth at breast height and at fixed heights in stands treated with heavy thinnings from below and in stands in natural condition. The material consists of 5 permanent sample plot pairs located in homogeneous even-aged Scots pine stands in southernmost part of Finland.

Absolute and relative variations in radial growth at breast height were rather similar in thinned and unthinned stands. The effect of thinning on the growth appeared to a major extent during the first year after thinning. The fluctuation due to climatic reasons exceeded the effect of thinning. The absolute variation of growth at different heights of the stem was most marked along the lowest third of the stem after thinning. In the top section thinning could even reduce growth. In natural stands, climatic variation can be studied from borings at breast height but in thinned stands borings should be done higher along the stem.

Key-words: Scots pine, growth variation, radial growth, thinning, natural forest, stem form

Vuokila Y, Laasasenaho J., Ihalaenen A. (1984): The accuracy of stem taper curve functions for natural trees in spruce plantations. (Luonnonmetsien puiden runkokäyrämallien tarkkuus viljelykuusikoissa). *Folia Forestalia* 596, 16 p.

Abstract: This report deals with the possibility of applying the stem taper curve functions for natural stands to estimate the cubic volume of trees in spruce plantations. The comparison is based on 1022 spruce sample trees with known diameters at nine relative heights of the stem. Sample materials to be compared have been collected mainly from southern Finland.

On average, the tree volume calculation functions based on sample material from natural stands, proved to be quite accurate in spruce plantations. The mean of the tree volume estimates was

found to be 1.38 % (standard deviation 6.19 %) higher than the true mean when using a function with two independent variables (d, h) and 0.40 % (standard deviation 3.44 %) higher with three variables (d, d6, h). The estimate for the pooled volume of sample trees involved was found to be only 0.18 % too high when using a function with two variables and 0.37 % too small with three variables.

The greatest differences were found at the base of the tree, at relative heights of 1-2 % of tree height. Because of the overestimation of diameters along the lowest 5 % of the stem, an average error of 1.0 % was added to the volume of the whole stem, this error being greater than that encountered along the remaining 95 % of the stem.

The greatest error in the application of stem taper curve functions was encountered in young stands with a function of two independent variables. In spruce plantations under 40 years of age, the function gave an average overestimation of 3 %.

Key-words: Taper curve, Norway spruce, model accuracy, spruce plantation

Applications for silviculture

Kalela E.K. (1948): Natural-like management of forests (Luonnonmukainen metsien käsittely) 2nd edition 1986. Kirjayhtymä. Mäntän kirjapaino. Mänttä, 45 p.

Abstract: The principles of natural-like forest management are described in this short book which, first published in 1949, laid out the basis for the modern silviculture and treatment of forests in Finland. In this book, the dynamics of virgin forests is described separately for monocultures and mixed forests. In the dynamic process, selfthinning and regeneration phases are separated and discussed more thoroughly. Intermediate thinnings are described in both monocultures and mixed forests. Different phases of regeneration cuttings are presented and special attention is paid to the regeneration of „unsatisfied,, forests like those after selection cuttings. The basic idea of these guidelines is to strive the treatments in a forest for always keeping the best and most valuable part of a stand as evenly spaced and with as good growing conditions as possible.

Key-words: Natural-like silviculture, natural forests, mixed forests, regeneration cutting, thinning

Parviainen J., Seppänen P. (1994): The ecological sustainability of forests and different forest management alternatives (Metsien ekologinen kestävyys ja metsänkasvatusvaihtoehdot). Finnish Forest Research Institute, Research Papers 551, 110 p. + 6 p.

Abstract: The concept of sustainable forestry and the characteristics of natural and production forests are described in the study. Alternatives of forest management which take into account environmental and biodiversity aspects are presented on the basis of recent research information. The ecological sustainability of forests means that the timber production and utilisation of other forest products should not threaten the preservation of biodiversity, growing capacity, health and ecological function of forests. The usage of forests should not make any harm to other ecosystems like lakes or streams.

Forest management can essentially affect the natural-like development of biodiversity in production forests without any remarkable loss of timber production. Natural-like forest management leads to longer rotation ages and more variable structure of forests. The development of silviculture in production forests does not decrease the need to preserve rare, old natural forests because they are home to their own specialized organisms. Alternative calculations of different forest management practices are needed before the wide application of new forest management methods.

Key-words: Silviculture, biodiversity, natural forest, forest succession, environmental effects, forest regeneration, forest management