

SUOMEN METSÄTIETEELLINEN SEURA — FINSKA FORSTSAMFUNDET

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ACTA FORESTALIA FENNICA. Sisältää etupäässä Suomen metsätaloutta ja sen perusteita käsitteleviä tieteellisiä tutkimuksia. Ilmestyy epäsäännöllisin väliajoin niteinä, joista kukin yleensä käsittää useampia tutkimuksia.

SILVA FENNICA. Sisältää etupäässä Suomen metsätaloutta ja sen perusteita käsitteleviä kirjoitelmia ja lyhyehköjä tutkimuksia. Ilmestyy neljästi vuodessa.

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SPORAL REGENERATION OF BRACKEN (PTERIDIUM
AQUILINUM (L.) KUHN.) IN FINLAND IN THE LIGHT
OF THE DIMENSIONS AND THE AGE OF ITS CLONES

EINO OINONEN

HELSINKI 1967

Preface

This investigation was started among the problems that remained unsolved after the completion of the preliminary study on the silvicultural ecology of bracken in 1946—48. The research carried out with the support of the Young Scientists' Grant which I received in 1952, did not lead to solving the problem of regeneration by spores, but gave some valuable hints for directing the continued investigations. Practical possibilities for extensions of the study did not exist to any great extent until 1962—65, when this opportunity was given by the *State Commission of Agriculture and Forestry*, for which I am greatly indebted. My special thanks are due to Professor YRJÖ ILVESSALO, former member of the Finnish Academy, and to Professor VALTER KELTIKANGAS for their sympathetic and favorable attitude towards my work. Most amiably, the Heads of the *Department of Silviculture, University of Helsinki*, Professor PEITSA MIKOLA and PAAVO YLI-VAKKURI, provided the working space and the equipment. In addition, they — and also Dr. ILMARI SCHALIN, who acted as temporary university Forester — suggested interesting sites for investigation. The Government Counsellor for the Conservation of Nature, Professor REINO KALLIOLA, provided me with a license that made investigations possible in some of the areas protected by the Law of Nature Conservation. For their kind help, I express my warmest thanks. In the field, Mr. REIJO MIETTINEN, B. For. (who was a student at that time), and Mr. SIMO PAKARINEN, Student of the Natural Sciences, were my good companions.

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Helsinki, December 10, 1965

Eino Oinonen

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1. Introduction

Questions concerning the life span of perennial plants have been extensively dealt with in woody plants. Abundant information is available in forestry and botanical literature on the average or maximum age of the stems and shoots of many tree, bush, and dwarf shrub species. This is especially so when age determination has been possible in a simple way — by counting the annual rings. The individuals for many tree species have only one stem which lives only once, and the age of the individual is the same as the age of the stem. Several tree species, however, are able to live, as individuals, beyond the maximum age of the original stem that developed from a seed. When the literature is searched for information on these questions of age, it can be seen that the problem has not been extensively studied (cf. PELTON 1953, SARVAS 1964). In tree species that regenerate and spread vegetatively, the determination or estimation of the age of individuals forming clones with several stems or those that have lived through several generations of stems is extremely difficult. In general, the view is held that the continuation of life vegetatively can theoretically be unlimited, but in some special cases — for instance, in the propagation of some poplars and rosebushes by grafting — a gradual weakening of vigor has been considered possible (MOLISH 1931, WOLTERECK 1941). The rate of distribution by suckers has been studied by KALELA (1961) in aspen (*Populus tremula*) and grey alder (*Alnus incana*) in afforested, formerly cultivated fields in the so-called Porkkala land-lease area.

Our knowledge of the age of the clones of bushes and dwarf shrubs is perhaps still more inadequate, not to mention many of the herbs, grasses, etc. of the ground vegetation in our forests (cf. e.g. PELTON 1953, BORNKAMM 1963). There is a considerably greater number of statements in the literature concerning the dimensions of the patches or stands of various plant species, but seldom are there, in these connections, allusions to the possible clonality of these patches, and in most cases no age determination has been made (e.g. MÖBIUS 1940, see also BURGESS 1960). In several plant species the elongation of aerial and underground shoots and its variation has been measured extensively, permitting estimates or prognoses of their age. This method, however, has not been adapted to practice to any significant degree, and doubtless the results would be rather rough. Age determination on the basis of the average length growth of shoots is employable only in estimating the minimum age (WHITFORD 1949, 1951).

It is obvious that the greatest difficulties in the determination of the dimensions or age of clones lie in the starting point, the marks of identification of individuals (cf. e.g. LINKOLA 1930, p. 164, GOODALL 1942, KERSHAW 1960). When references have been made to the clonality of the patches of some forest plant species, characteristics of a rather general kind have usually been used as a basis, such as an impression of their uniformity and homogeneity. Often the term, individual, is used for separate shoots, even if only a part of an individual be in question (see also GAMS 1918, p. 370, SKOTTSBERG 1929, p. 48 POORE 1955, p. 236). Although some plant species have already been described rather thoroughly — of forest plants, WITTRÖCK'S (1907) beautiful monograph on *Linnaea borealis* in Sweden can be mentioned as an example — the store of knowledge in the literature is still quite limited or rough in this respect. The highly developed methods of present-day plant taxonomy are, for their part, often too laborious for extensive use in the field. Even by using these methods it can sometimes be hard to obtain absolutely tenable data (BENSON 1962). It can be assumed that prejudice concerning these difficulties is the primary reason for the almost complete lack of investigations into the dimensions and age of forest plant clones. This is especially supported by WHITFORD'S (1950, p. 146) pessimistic statement concerning the possibilities of determining the limits of old fragmented clones. For this reason, he limited his investigations to the initial stages of the succession of forest vegetation, to selected forest stands at the prairie-forest border, where the clone patches were still clearly discernible, unbroken, detached, and relatively small in size.

Although this branch of research has long remained untouched, it has raised interest especially among plant sociologists. The question of vegetative spreading appears time and again in the written papers of several investigators. Especially in the latest literature, the importance of unravelling the problem of the time-size factor has been stressed more and more (DAWSON 1951, BURGESS 1960, KRAJINA 1960, etc.). At the same time it has been emphasized that detailed autecological studies concerning the most common plant species would be of great significance in this connection (CURTIS and MCINTOSH 1951, PELTON 1953, CLAPHAM 1956, etc.).

The object of the present study was to obtain information on the regeneration by spores of bracken (*Pteridium aquilinum* (L.) KUHN.), as well as on questions concerning the permanence and vegetative spreading of the clones. Widely varied views on these problems have been presented by different investigators. The possibilities of destroying bracken, which arrests forest regeneration (cf. e.g. DÖBNER 1858, NEY 1880, GRAEBNER 1909, BARTH 1938, KALELA 1945, TAYLOR 1945, SHANTZ 1947, EDLIN 1947, KÖSTLER 1950), both by biological and chemical means, can be fully seen only after we have a better knowledge of the most essential basic facts concerning the life cycle of the plant than are the various subjective views or conjectures which prevail at present. Destroying bracken is

rather expensive work (see also BRAID 1957, HODGSON 1964); for this reason, initiating such a project requires careful consideration based upon facts. When destroying is planned on a long range basis, it is important to know whether there is reason to try total destruction or whether a temporary weakening or partial destruction at the forest regeneration stage is satisfactory. It would also be useful to know how threatening the danger of bracken's becoming prevalent by spore regeneration is (cf. BRAID 1940), and to what extent this weed invades forest land by vegetative spreading.

2. Preliminary data concerning sporal regeneration

The search for bracken sporelings has everywhere given the result that they are extremely rare (CONWAY 1949, BRAID 1959). They have been found by BRITTEN (1881), FARROW (1915), LAURENT (1916), JEFFREYS (1917), BENSON and BLACKWELL (1926), FRITSCH (1927), WHITE (1930), LONG and FENTON (1938), LOUSLEY (1939, 1946), BRAID (1947, 1952, 1957; — he looked for them for more than 20 years without success), and CONWAY (1949). Most often young sporophytes of bracken have been found only singly, as curiosities. The most convincing are the discoveries made in England after the bomb attacks in World War II (London, Bristol, Clydebank, Greenock; cf. LOUSLEY 1946, BRAID 1947, and CONWAY 1949). There were plenty of young plants to be found in the ruins of burned buildings and bomb craters. In other cases, the following sites have been recorded: burned areas, sites of campfires, damp hollows and crevices in the ground, heaps of stones, the side of roads and paths, gardens, greenhouses, embankments, and cracks in stone walls. CONWAY (1949) succeeded in raising some prothalli by sowing spores on heat-sterilized patches of soil. Only one prothallus appeared on an unsterilized site, on the side of a tree stump. According to CONWAY (op.c.), the optimum pH-value of the medium ranges from 5.5 to 7.7. The best grown culture was obtained on a medium of pH 6.2. Bracken does not shun alkaline sites, which has been alluded to in the earlier literature (cf. BRAID 1939, 1957). DOCTERS VAN LEEUWEN (1936, p. 61) mentions that bracken appeared quickly in the cracks on the lava slopes of Krakatau. The plant was found there in an inspection three years after the explosion. It was also among the first plants to invade the volcano Rumoka, in Kongo, after an eruption. Krakatau is situated about 40 km from the island of Java, where the spores probably came from. The spore, which has the shape of a spherical tetrahedron, is light and small, with a diameter of 28—40 μ (WALDMANN 1928). BRAID (1959) states that a sterile site is one of the most important conditions required for regeneration by spores.

My own search, as well as my sowing experiments on different natural sites, was not successful. No young plants appeared on the humus and mineral soil

sites, moss covers, decayed wood, dung-patches in pastures and their sites, in the openings of mole- and worm-holes, ground pits, or along ditches, which were all dusted with spores. Also the campfire sites remained without plants. However, these experiments were rather made randomly than systematically. If the time of sowing and the weather conditions prevailing during the summer are of any decisive importance in the regeneration of bracken, the experiments, carried out in the same way only two and partly three times, are one-sided and too brief (1951—52 and 1958).

The spore material collected in the vicinity of Helsinki¹, in the region of Loppi—Riihimäki, and at Punkaharju had an excellent viability (according to random samples, 60—90 per cent germinated in about two weeks). Helsinki city water to which a small portion of ash was added was used as substrate. Also elsewhere, the viability has been generally proved to be quite high, 90—95 per cent (DÖPP 1927, WALDMANN 1928, ORTH 1936, CONWAY 1949). The spores have no period of dormancy, but according to the investigators mentioned above, germination occurs in about one week. The raising of prothalli usually turns out successfully in the laboratory, provided that the spore, protonema, and prothallium are protected against molds and microfauna (CONWAY 1949). In nature the development is also arrested by algae and moss protonemata (MOTTIER 1927, CONWAY 1949). The prothalli are relatively resistant to low temperatures — especially when covered by snow — but under these conditions they are particularly sensitive to drought. Also under other circumstances they are quite sensitive to drying winds and direct sunshine (CONWAY 1949, 1959). In conditions that are too warm only protonemata are formed (ROTTMANN 1939); which is also the case after an irradiation treatment and partly also as an effect of colchicine (ROSENDAHL 1940/41). Far from all protonemata in normal cultures develop into sexually mature prothalli (HOFMEISTER 1851, DÖPP 1936, CONWAY 1949, WILKIE 1963). The development from a spore to a sporophyte takes six weeks under favorable conditions (CONWAY 1949), but, according to LAGERBERG's (1907) experiments, it can be slower in unfavorable temperature conditions, taking up to several months. My own cultures (grown in the conditions of my apartment) were destroyed by moulds before any sporophytes had time to develop. It deserves to be mentioned that the spores collected in 1951—52 were not viable in 1958.

As spore shedding in Finland seldom occurs before the months of August and September, the time available before the beginning of the cold weather in the autumn is probably too short — if any regeneration at all takes place from indigenous spores. According to HARRIS (1955), the spores of bracken are transported by air currents over considerable distances. He found them in samples taken from guano 500 miles from the closest bracken site. Thus, the possibility

¹ The localities mentioned in this paper are communes (parishes), towns, and cities; where needed, the names of sublocalities are also given. See e.g. Suomi—Finland Yleiskartta 1: 400 000 Generalkarta. 1950. Maanmittaushallitus, Helsinki.

that our bracken vegetation may have developed from spore material of a more southern origin has to be taken into consideration. This explanation eliminates the hypothesis regarding the limiting influence of the short autumn period.

According to WALDMANN (1928), the spores of bracken retain their viability when stored for a period 2—2.5 years. CONWAY (1949) was able to get some, although poor, germination after twelve weeks in spores stored for as long as four years. According to BRAID (1952), one third had germinated. Spores collected one year previously showed 50 per cent germination within four weeks. Some germination already takes place at low temperatures of 1°—2° C, but it is quite slow. At temperatures between 8° C and 10° C, the germination rate is already near its maximum. Shed in Finland during August and September (also in the British Isles shedding sometimes occurs that late), the main part of the spores probably germinate in the autumn; however, they can also remain undamaged over the winter in a dry place and capable of germinating in the following spring, as is shown by CONWAY's experiments. It ought to be noted that where the young plants occur, the moisture conditions are usually so good that such postgermination hardly can be of any significance for the regeneration of bracken. As CONWAY (see also BRAID 1957) already considers the short duration and chilliness of the autumn in the temperate climate of the British Isles factors arresting the appearance of well-established sporophytes, such climatic factors can be considered much more important in the conditions prevailing in Finland.

It can be supposed that there are more prothalli and sporophytes in different stages of development in nature than the available data indicate. The identification of bracken prothalli is difficult (see also LAGERBERG 1908, KUJALA 1926 a, p. 55), and since they are small, they can easily remain unnoticed. On the basis of the marks of identification presented by LAGERBERG (op.c.), the determination of young, regularly shaped prothalli is possible, but the determination of the species in older multilobed and rosetted specimens (see MOTTIER 1927) is completely in the hands of the specialists. Because of the difficulties involved in the determination of prothalli, I collected them (and a small sample of the substratum) in vessels in order to be able to determine the individuals after they had grown into well-developed sporelings. — According to ORTH's (1938) drawings, the sporelings of bracken show quite distinct features and are readily distinguishable from other species (see also CONWAY 1949). — My search did not result in any bracken sporelings. The specimens, which for the most part were collected in wooded pastures resembling rich forest sites (in all prothalli collected in the spring and mid-summertime, the sporophytes had already begun their development), represented for their most part such species as *Athyrium filix femina*, *Dryopteris spinulosa*, and *Lastrea dryopteris* — or the same species of which further developed sporophytes were also found at the sites in question. It ought to be mentioned that the search was particularly concentrated on the surroundings of spore-shedding bracken stands. In grooves and cracks on the

side of rocks which, due to running water, were kept wet for long periods after rains, there were plenty of young sporophytes of *Polypodium vulgare* in different stages of development. Young prothalli were not encountered at all, which indicates that the sporophytes had probably wintered in the place (cf. LAGERBERG 1908). In the alluvial soil at a brook as well as at a site on decayed wood, there were abundant prothalli and sporelings of *Struthiopteris filicastrum* in later stages of development. These were located below and in the vicinity of an extensive stand of this species. On horse dung more than a year old, prothalli of *Dryopteris filix mas* (?) were encountered (determination by prothalli only according to LAGERBERG (1908), which makes the result slightly uncertain). When this dung site was checked one year later, no young sporophytes were found, although there had been tens of prothalli. The individuals of the nearby stand produced abundant spores, were big and probably also rather old. At the moment of study the prothalli had no young sporophytes and the bulk of them had developed to a longish heart-shape. As the investigation took place in the middle of September, it seems possible that the time was too late for further development. The young sporophytes of this species are probably rather rare on forest land, a conclusion supported by the fact that only a few specimens were encountered during the search (cf. LAGERBERG 1908, DÖPP 1939).

In bracken stands, great variation often occurs in the size and shape of the leaves. The longest leaf measured in connection with the present study was 2.1 m in length (Helsinki, Haltiavuori; the leaf was straightened out before measurement) and the smallest dwarf-leaves 3—5 cm (cf. BRAID 1957). The latter showed an »infantile» appearance — just as is characteristic of the leaves of young sporelings (BRAID and CONWAY 1943, CONWAY 1949). Such dwarf leaves are sometimes encountered at the edge of the stands proper, sometimes apparently independent, e.g. in road cuttings and on soil from ditches. In shady forests, especially in spruce (*Picea abies*) stands, they often occur in scattered groups or singly. Also in logging areas they can sometimes be found abundantly during the summers following cutting. The appearing of dwarfleaves in the first summer after the removal or thinning of the trees is either due to casual sowing just before the treatment or comes from latent forms of the plant in the area, the small leaves coming forth as the first signs of the revival of bracken. Dwarf leaves can be produced artificially by cutting the rhizomes — for instance with a spade — into small pieces (OINONEN 1958). The leaves were the smaller the shorter the pieces into which the rhizomes were cut (Fig. 1). Results of the same kind were obtained by cutting with a scythe (the stands were cut down 3—4 times during the summer): the leaves grew smaller year by year, until, by the end of the third summer, they measured only 10—20 cm in length and occurred only singly on the sample plots. Similar results have also been obtained by BRAID (1935, 1939, 1947) and STEPHENS (1953) as well as by several other investigators who have carried out experiments on the mechanical destruc-

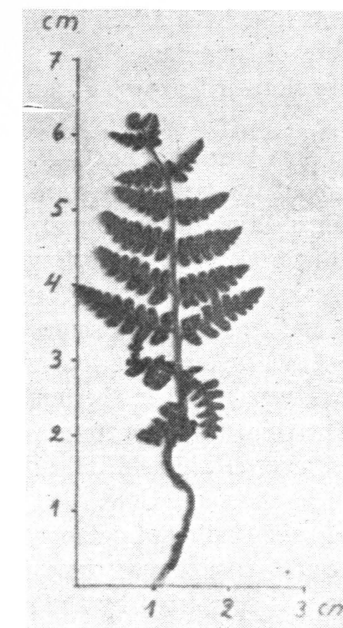


Fig. 1. Leaf sample from a sample plot where, in 1950, the rhizomes had been cut into pieces about 5 cm in length. Riihinäki, Hirvijärvi, 1951.

tion of bracken (see BRAID 1959). Thus, the occurrence of dwarf leaves (see also ANGST 1927 and WATT 1940) does not permit us to draw the conclusion that they are leaves of young bracken sporelings.

However, it can be assumed that there are, among the small bracken leaves, also some leaves of young sporelings. This is also supported by BRAID & CONWAY (1943). Excavations carried out to check this assumption indicated that the dwarf leaves often develop from rather thin rhizomes, the diameter of which is usually only 1/5—1/3 of that of ordinary long shoots. With a few exceptions these were blackish in colour, just like the normal rhizomes, and bore abundant leaf scars. The older parts of the rhizomes were usually in a state of decay. In the exceptional cases mentioned above, the thin rhizomes were light brown, had only one or two or no leaf-scars, and despite their thinness, grew well, resembling long shoots.

CONWAY (1949; see also BRAID 1952) states that the rhizomes of individuals regenerated by spores gradually attain their adult shape and thickness. On the whole, the young plant differs — according to e.g. BOWER (1923), LOUSLEY (1946), and BRAID (1959) — from the full-grown plant to a misleading extent. It remains unclear whether there are any essential differences in structure be-

tween the daughter specimens that have arisen from revived, stunted rhizomes and later the adolescent forms of sporelings.

These exceptionally light-colored rhizomes, 4—5 mm thick, as well as dwarf leaves, were found next to a rock (Hyvinkää, Kytäjä) at the moist and only slightly burned border of an area burned about 2—3 years earlier, in three different places in an area of about two ares. The same excavations, however, revealed thin, black rhizomes in addition to the normal. Whether the thin rhizomes were produced by young individuals or reviving fragments remained unsolved. Another discovery was made in a pine (*Pinus silvestris*) forest (Loppi, Sajanmäki) where the tree stand had been thinned some years earlier and the slash burned. At a distance of about two meters from the immediate site of a campfire, thin and pale brown rhizomes were found in the humuslayer — in addition, to some ordinary black ones. The third find was from a heap of soil pushed to the side of the road by a road scraper (Riihimäki, Hirvijärvi). Here also, pieces of normal rhizomes were found at the same time.

This search did not lead to the finding of detached, really independent samples of young forms, which could have proved the existence of sporal regeneration. This possibility, however, is supported by the exceptional nature and infrequency of the pale rhizomes. The places of occurrence, especially in the two first-mentioned cases also support this hypothesis — further support for it is found in the literature.

The next possibility was to study the regeneration from a reverse angle: *the dimensions of the clones*. As far as bracken is concerned, the question of size-age has remained totally disregarded in previous investigations. It is true that the possibilities of separating individual clones have been considered, but these have led to pessimistic results. Thus, for example, KUJALA (1926 a, p. 51) gives the following statement: »Die Art des Auftretens ist wahrscheinlich stets eine fleckenweise. An den zum Vorschein kommenden Blättern ist dies jedoch gewöhnlich nicht leicht zu konstatieren, da die Entfernungen zwischen den von demselben Stengel ausgehenden Blättern mehrere Meter betragen können.»

3. Characteristics of bracken individuals

Clear individual characteristics are the first prerequisites for the delimitation of the clones. As information on them was not found in the literature, they had to be looked for in the field. The starting basis was the study of the variation occurring in the structure of the fronds. Such observations led to the conclusion that there is great variation both in the structure and the phenological properties. Detached stands were found in which the variation was conspicuously small and a special characteristic in the structure or autumn color was repeated leaf by leaf. Another stand in the vicinity could be extremely variable, while a third

was quite homogeneous in appearance, exhibiting another conspicuous feature than the first-mentioned stand. — *These observations seemed to open up possibilities for continuing the investigation*. — In the variable stands there often was a clearly discernible form which could be traced quite easily from leaf to leaf. In the same way, the outer edge of the stand could be found and when it was marked out, the stands sometimes turned out to be *almost circular* in form. Some stands were also encountered, both detached and mixed, which markedly differed in characteristics from the normal range. *The working hypothesis was made that these homogeneous stands as well as those parts of the mixed growths, which, due to clear characteristics, could be separated, are clones*. Thus, clones (and the individual characteristics), as designated in this work, are to be considered temporary technical terms until the criteria used prove convincing.

Plant systematists have described and denominated some subforms of bracken (see e.g. CHRIST 1897, 1900, BRAUSE 1926, TRYON 1941). In this study, however, no attention was given to these divisions; the individuals were the sole object of study.

With the increasing of the number of observations, it became evident that bracken has a sufficient number of individual visual characteristics to enable the separation within certain limits, without special equipment, of the stands assumed to be clones. Microscopic and other more detailed examination would have taken so much time that its use would have been unreasonably slow or even impossible¹. There was no reason to deal with more complex mixed stands if there were no clearly discernible forms among them. Also simple cases are to be found in nature; searching for them seemed to give preliminary information on the problems of bracken regeneration and its natural durability.

The following description of the individual characteristics covers the subject in a random manner only. It represents only roughly the rich individual variability characteristic of this plant species.

The most distinct characteristic, on the basis of which the vegetation units can be divided into two groups, is the *color of the petiole*. In extreme cases it is either bright or pale green or dark, red-brownish, or blackish green. When the leaves turn yellow, the color changes in both cases: the green petioles turn straw-colored, while in the latter group the dark hue usually remains visible until the leaves are drying. Also, the *green color of the leaf blade* varies both between and within the different classes. Even *when the leaves are dry* and especially when soaked with rain, *the fronds of the same clone can be very clearly discernible from each other by their color*. The above-mentioned form with dark petioles seems — at least sporadically — to turn yellow later than the pale forms. It may still have its summer-green color when another, light-colored clone on the same site already has turned completely yellow or pale brown, or when it has dried to a greyish brown color. In the latest phase of fading, the leaves of the dark form

¹ After this first study they can be used, for instance, in control work and the development of methods

shine — especially when wet — in the sun with a bright orange-brown color. The light forms, on the other hand, are usually less bright in color: yellowish brown. Sometimes the color of the first-mentioned is slightly darker, reddish brown or with a touch of purple. *The tones of color are individual and hard to describe, and they change in the course of the autumn in a different manner in every individual.* There are individuals in which fading and drying has occurred almost one month earlier than in the hardiest ones on the same site. In the pale group, some extreme cases do not turn yellow in the proper sense of the word, but change instead from green into almost white, just as the leaves of stands treated with aminotriazole. When dried they have a dirty greyish tone. However, such stands have only been found in rather shady forests, for which reason it is possible that the whitening is partly due to environmental factors. In any case, the individual properties probably also influence this phenomenon, because other individuals on the same sites have been colored at the same time. Some stands located at the borders of pine swamps also had distinctive, pale autumn colors. Still, it ought to be mentioned that the color of the leaves also varies considerably from year to year. Thus, the leaves of bracken were very bright in 1964 in southern Finland, while in 1965 they were not.

The forms with dark petioles have been of decisive importance for the present investigation because they are much *more rare than the other forms*, i.e., the light forms and the phases intermediate between them and the dark forms.

It is self-evident that the autumn color when used as a characteristic has its limitations. Conclusions can be drawn on its basis only when the other characteristics do not show any differences. Extensive clones may cover several, variable sites at the same time, and with the site changes the autumn color of the leaves also — not arbitrarily, however, but according to an individual scheme. In such cases the different parts of the clones are at different stages of development and influenced by the varying growth factors. The color characteristics are most representative in homogeneous environments.

More detailed and persistent characteristics are often found in the *nectaries* of the plant. These, too, can be divided on the basis of their color into two extreme groups: *dark and light*. It is rather common that specimens with dark petioles have dark nectaries and light individuals light nectaries. However, this is no rule, and the color of the nectaries can be the contrary of that of the petiole. There are also individuals with a part of the nectaries dark — brownish or dark red-brown — and the rest light: green or yellowish green. Microscopic study may sometimes reveal some red-brown cells in nectaries pure green to the eye and likewise some green cells in dark nectaries. The color is also often arranged in *patterns*. The most common form seems to be one which resembles the moon's crescent or a sickle at the lower edge of the nectaries. This form, which occurs in different tones of brown or also other colors (reddish, purple-grey or blackish), can continue as a longitudinal stripe downwards from the nectary along the

main stalk or upwards along both the main petiole and the pinnule veins. The same form can usually be seen at least in the two — sometimes three — lowest pairs of nectaries (with differences in degree). In small and stunted leaves, this characteristic often shows poorly, and for the naked eye it is visible in the lowest pair of nectaries only. Sometimes black stripes and dots occur on the petiole close to the nectaries. The nectaries can also be surrounded by a dark ring which resembles a spectacle frame. In some cases this frame-stripe continues along the branches of the leaflets to the opposite side of the petiole, forming there a transversal stripe. In autumnal leaves this red-brown strip of colour is often very distinct. More exceptional have been those cases in which the »frame» is light and the middle of the nectaries consequently dark-spotted. Insect bites can sometimes cause a similar pattern (OINONEN 1963), but this damage usually shows as an irregular shape and can be readily distinguished by a magnifying glass.

In addition to differences in color, there are also *differences in the shape and size of the nectaries*: they can be circular, elliptic, or curved elliptic; they can continue far into the axil of the leaflets; they have more or less distinct borders; they are in-grown or projected, even or lenticular; and sometimes there is a nodular or cone-shaped protuberance in the middle of the nectary. Peculiar cases were seen in which the nectaries belonging to the same pair differ from each other so that while one of them is big the other is withered.

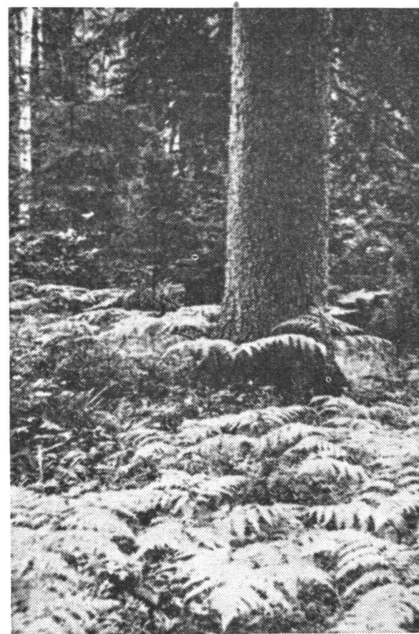


Fig. 2. Individual bracken stand with curved leaves. Riihimäki, Hirvijärvi, 1950.



Fig. 3. In this specimen the leaf blade projects levelly. Riihimäki, Hirvijärvi, 1950.

In the delimitation of a clone, there is reason to first look at the nectaries. However, they do not always — at least alone — provide sufficient characteristic, and other ways of identification have to be also used.

The shape of the leaf blades and leaflets often provide good marks of identification. One only has to get used to seeing them. In the beginning this is difficult in dense, mixed stands, but after some time of training, it becomes rather easy to follow some special forms (Figs. 2—4). Such are, for instance, individuals with wrinkled leaves (the specimens infected by the fungus *Cryptomyces Pteridis* (REBENT.) REHM., (cf. KILLIAN 1918), are readily distinguishable from them), and both folded or rough, and contrasting completely plane, straight, and even leaflets. In some individuals the tip of the leaf blade and the tips of the primary leaflets hang down. The whole leaf blade can also be evenly curved, and often simultaneously bent to the side, or even slightly twisted. The tips of the leaflets are sometimes bent slightly upwards while the edges are downwards, thus giving the leaf a rough appearance. The tips of the leaflets are evenly rounded in some individuals, while in others they taper more sharply. The breadth, likewise, varies. There are specimens with particularly narrow leaves, in which the primary leaflets resemble the leaves of *Polypodium vulgare*. The other extremity are the broad triangular forms which resemble the leaves of *Lastrea dryopteris*. The shape of the leaves is to some extent disturbed by environmental variation (cf. e.g., WOODHEAD 1906), but the differences due to this factor are generally only differences in degree. Difficulties in identification usually occur in connection with dwarfleaves and extremely lush giant leaves. An even environment is also best in connection with these characteristics.

Individual variation also occurs in the groove of the petiole, which sometimes is shallow, sometimes deep. At the axil of leaflets, it can even be almost overgrown. This place can also look swollen. The leaflets fork out from the petiole at different angles and usually they are almost opposite to each other, but in exceptional cases they can alternate at even 5—10 cm distances. As regards this characteristic, there is considerable inter-individual variation; however, there are also clones in which long-interval alternation occurs in all leaves. This phenomenon is sometimes connected with strong asymmetry in the pairs of nectaries. The form of a cross section of the petiole varies from elliptic to broad reniform. The leaflets may exceptionally fork in a slightly decurrent way, whereby the parts of the petiole below the nectaries are slightly folded in a longitudinal direction. The lowest leaflet forks from the petiole sometimes to the left and sometimes to the right. This characteristic is not, however, linked with the individual, but varies within the clones, and primarily depends on which side of the rhizome the leaf has grown from.

There are also differences in the glandular hairs of young fronds (crosiers) rising from the ground (see also LUERSSSEN 1889, p. 105). The color of the hairs varies individually, but also with their age. When the leaves mature, the hairs



Fig. 4. Specimen representing a type with rough leaves. Homogeneity is striking. Riihimäki, Hirvijärvi, 1950.

fall off (see also THEORIN 1907). As the leaves of the stands come out at varying times and as the closer examination of the glandular hairs requires microscopic studies, the characteristics constituted by these hairs were not generally employable within the framework of this investigation.

Examinations were not carried out on the individual variation in rootstocks, except in some exceptional cases. The long shoots were sometimes remarkably flat and sometimes elliptically rounded in their cross section. The pneumatophore-streak is sometimes broad and coarse, and sometimes very narrow, its color varying from a pale yellow to orange or reddish brown. It is not clear to what extent these differences are due to the site or the age of the rootstock, but they have also been encountered in comparisons concerning different individuals at the same site.

In the separation of individuals, one must learn to keep an eye on several characteristics at the same time. However, all characteristics are not visible at

the same time. The best picture of the individual is naturally obtained when it is studied in all its phases of development. In connection with the present investigation, this has been possible in a few exceptional cases only. Phenological characteristics ought to be studied during several years in the same growths. The concentration of disease and insect damage on a certain individual in a mixed stand, which is otherwise healthy, is also a phenomenon which requires study during a longer period of time. Some such odd cases are included in the present material.

Although rich individual variation occurs in bracken, individuals of similar appearance are frequently encountered. Sometimes they are near each other without, however, being possibly parts of the same clone due to, for instance, some obstacle in the terrain. Such individuals can also occur in the same stand, either side by side or overlapping. It is understandable that full certainty could not be obtained in all cases. The fact that the examined characteristics did not include distinct differences, is not sufficient evidence for mutual connection. However, on the basis of this we can draw the conclusion that connection possibilities exist. The permanence of the characteristics used had to be checked by other standards of criticism. Additional criteria had to be found.

As a kind of evaluation criterium of the objectivity and usability of the individual characteristics found, we probably can regard the fact that different persons got similar results by these characteristics in determining the dimensions of the clones. In connection with the present study, one experiment of this kind was carried out. After a week's training together, the research assistant was given the possibility of collecting material on his own, and for the portions in which comparison was possible, the results proved to be similar. It can be assumed that it is rather easy for anyone to get used to the identification of clones, when only the condition limits of this study are not crossed. It must always be remembered that the clone can be extensive. When this is not kept in mind, a fatal amount of uncertainty can creep in and interrupt the work. There are two kinds of suspicion at the same time: 1) the individual characteristics are not tenable, 2) the dimensions are fantastically large — we are not used to look upon things of this nature on such a scale. Nowhere can help be sought for criticising the work. One must break loose from prejudices.

4. Hypotheses and possibilities of comparison for explaining the size-age problem

Spreading caused by growth, and its consequence, the expansion of living space — one of the general characteristics of life (FRIEDERICHS 1930, THIENEMANN 1941) — occur schematically generally taking the form of a circle when

the plant branches out or divides in the same manner in all different directions. This requires, however, that growing conditions remain unchanged outside of the area. Unevenness in site quality and various physical barriers in the way of the spreading as well as destructive factors can cause form-changes in the vegetation units as well as their discontinuity. Thus, it cannot be expected that extensive clonal vegetation units are coherent and regular in shape in irregularly changing surroundings.

Bracken is a plant species which spreads centrifugally from its place of origin. On heathlands of even quality (British Isles), it develops characteristic circular zones around a common focus (WATT 1940, 1943 a and b, 1945, 1947 a and b, 1955, 1956). In other words, it spreads undisturbed in a circle. Together with the search for individual characteristics, this property was an important basis of evaluation, which enabled the work to be started. The most appropriate starting points were small detached stands in light and homogeneous pine forests on sites of poor or medium fertility.

The speed of growth of bracken's rhizomes varies considerably, depending on the site and environment. KUJALA (1926 a) states that the long shoots can grow 20—30 cm in length per year. According to WATT, the *stand* spreads quite slowly, only 3—4 in. per year, in a frontal direction on poor sites but 43 cm year on an average (WATT 1955, p. 497; in the British Isles) and CONWAY (1959) adds to this information that speed of growth is considerably greater on rich sites. Individuals planted when young spread, according to BRAID's and CONWAY's (1943) experiments, from April to July, forming patches of 1—2 ft. in diameter in July. According to *Nature* (1936), the stands spread about 1 yd. per year, thus yearly occupying a considerable area of new ground. WILLIS, FOLKES, HOPE-SIMPSON, and YEMM (1959) have recorded annual growth results of 30—90 cm, the average at their sample plots being 49 cm per year (in pasture areas in the British Isles). Still greater results have been recorded by JEFFREYS (1917), for instance. No records in the literature have been encountered on the speed of spreading of bracken stands in Finland or the northern countries.

By the information on the growth rate of the rhizomes, the estimation of their age is very uncertain. The accumulation of the error can cause considerable deviations from the correct age, especially when the clones are old and extensive. The growth rate might have varied at different ages of the stands due to variations in the site, and also changes in the structure of the tree stand and other factors. It must also be observed that a long shoot can form a short shoot at its tip and the latter, on the other hand, a long shoot at some stage of development, and both of them can form intermediary shoots (see also WATT 1940), in consequence of which the growth of shoots can sometimes go down to 2—15 cm per year. Leading shoots are not permanently leading, rather the leadership may shift from one branch to another. Thus, the growth rates of the long shoots easily give wrong information on the spreading rate of the stands. The rhizomes

do not grow straight forwards, rather they dodge about in both a horizontal and a vertical direction, even making large curves (see also WATT 1940). Uneven ground also causes such differences between the actual distance of advance and that measured on a straight line. Different obstacles to spreading, such as boulders, for instance, and the roots of growing trees, also force changes in direction. When the bracken rhizomes run across decayed roots of trees, they often enter the root channels, after which their direction of growth is dependent on the direction of the roots. Bracken circumlocutes wet depressions in the soil. The physiology of rhizome orientation has not been studied to any significant degree (see also ANDERSON 1961).

The data on the regeneration of bracken by spores in nature are scarce; however, both the literature and my own preliminary examinations indicate the importance of a sterile site for regeneration. The working hypothesis for the continuation of the present investigation is based upon this intimation. *The starting point is that bracken growths have mainly arisen under the conditions provided by wildfires and burning cultivation. The dimensions of the units assumed to be clones were thus to be compared to the time elapsed after the fire. Consistent parallelism, if encountered, would confirm, for its part, that the criteria used in identification were correct.*

Evidently, bracken regeneration by spores calls for the accumulation of favorable factors. On this basis it can be supposed that when conditions are favorable for regeneration, there would be several young plants to be found at the same time (as is also indicated by LOUSLEY'S (1939, 1946) records; cf. also BRAID 1952). *Thus, there could occur, in the area burnt by one fire, replication of clones of the dimensions corresponding to the time from the fire.* As all our forest lands have probably burned several times in their history — in some cases even rather frequently, according to fire scars in old trees — *it was also expected that gradation would occur according to the different dates of fire and that replicates would be encountered within the various size classes.* The basis for this hypothesis is the excellent fire-resistance of bracken, which is commonly known (see e.g. KUJALA 1926 a, INGRAM 1932, BRAID 1935, GAMS 1938, McCULLOCK 1942, SHANTZ 1947. SHANTZ terms such plants as empyrophytes). Naturally, the tolerance is only of a relative nature (see KUJALA 1926 b, p. 30), which, to the greatest extent, depends on the intensity of the fire and the quality of the substratum. Thus, irregularity was expected to be ever greater the older the vegetation. If regeneration is dependent on fires, it can also be assumed that *there do not occur, at least as replicates, clones which are smaller than those corresponding to the post-fire time.* Spreading barriers can prevent the growth of clones and strong shading by a dense spruce stand reduce the area occupied by the clone or break it up into fragments growing in glades; however, *same-sized replicates are not to be expected in such fragments, but, rather irregular variation.* The total

dimensions of the clones determined from such fragments, however, should approximately correspond to the time elapsed after the fire.

The basic hypotheses must also include the concept of *immortality of clones in a theoretical sense*. Due to the fire-resistance of bracken, one has to expect very extensive vegetation units to be encountered. There has been plenty of time available for spreading, and plenty of fires. Fires have probably been more extensive and more common during the past centuries than now. Some records of large fires in the past still exist, as well as on the usage of fire in wartime. Burning for crops goes far back in the past and this form of cultivation has been in use in places as late as at the beginning of this century (HEIKINHEIMO 1915). Charcoal has been burned for industrial use, in places even to a large degree. Likewise, tarburning has been an old and widely practiced means of earning a living (cf. e.g. KAILA 1931, E. LAITAKARI 1962 and A. LAITAKARI 1964). The possibilities for the fire to break loose are great under such circumstances. Due to the fact that fires probably occurred more frequently from the turn of the century backwards, *clones under 50 years in age should, considered from a relative standpoint, be rarer than older stands.* In village surroundings which have frequently been burned for crops, a more abundant aggregation of clones with small differences in size should be encountered than in outside areas or those unsuitable for cultivation, where, also, the size gradation should have greater intervals. Thus, uninhabited forest areas and the least fertile lands seemed to offer better possibilities of starting the work than the surroundings of inhabited areas where comparison with the time elapsed after fire is often difficult due to the scarcity of old, fire-scarred tree stands.

5. Area of study

The material of the present study was collected in southern and central Finland, the northern limit being the 64th parallel. To the north of this limit bracken is rather rare, occurring frequently only much farther to the south, on the southern side of the 63rd parallel (for closer information, see Fig. 6, p. 88, and KUJALA 1936, 1964). The bulk of this material is from south Finland.

In order to expedite the work, the search for clones was mostly carried out along highways and in their vicinity.

6. Delimitation of the individuals and method of measuring

In single vegetation units the permanence of individual characteristics was studied by moving crosswise through the units. Leaves taken from the starting point were carried along and additional leaf samples were collected at the oppo-

site edge and even in other parts of the supposed clone. When the stand had been investigated in this way, comparisons were made within the bundle of leaf samples. When the bracken stand included several individuals, these were studied one by one in an order determined by the distinctiveness of the individual characteristics. In large, mixed stands some clearly discernible individual form was first looked for. Its dimensions were studied in an arbitrary direction, and then, in a direction at right angles to the former, through the estimated center. When the clone was small all of its boundaries were often determined, but when it was very large, crosswise examination and sketchy confirmation of the boundaries in between-lying areas were considered sufficient. In broken terrain, measurements sometimes had to be carried out in several directions (for instance, when the clones occurred in depressions in rocky areas). Separating the clones of the area was sometimes continued as long as there were clearly discernible individuals. On several occasions, clones which were clearly separable at some of their borders had to be discarded because farther in the stands they were mixed up with other individuals of similar appearance. Special difficulties were also encountered, where the stands had partly spread over a very poor upland sites; here the specimen characteristics became gradually weaker, finally to such an extent that separating close forms was not possible with sufficient accuracy. In such cases phenological characteristics (in the autumn) would probably have been of great aid. It was by no means uncommon that individuals with similar characteristics occurred in groups (for instance, in areas formerly burned for crops or pastures) or in successive, string-like formations (for example, at the border of swamps or depressions in areas of low fertility). In these cases it is possible that the original stands have been broken up. On such occasions, the sub-stands were measured separately and together. Quite often it happened that extensive clones were bounded by some spreading barriers; such clones were either rejected or special notes occasioned by them were made in the records. The recorded clones in question are so extensive that the precise dimensions are, for their part, of secondary importance only, and could not be compared with any parallel occurrences.

The measurements were made along the ground surface with a stiff 2-m measure, a 4–5-m pole, or a 50-m tape, according to the special needs on each different occasion or the assistant situation. All these measuring devices have their own restrictions and sources of error; checking measurements, however, did not result in essential differences. Naturally, the accuracy of measuring is not as good in measuring along the ground as horizontally, but the latter method could cause considerable errors in uneven terrain. *The rhizomes of bracken grow along the ground surface, and it is just their distance of growth that is in question.* The measuring tape, which easily gets stuck in the ground vegetation, may sometimes have given slightly too great results for large clones, but this is probably of no practical importance. It was not possible to compare the dimensions of

large clones with data other than those obtained from accidental replicates of the same size.

The measurements for the smallest stands were recorded with an accuracy of 0.1–0.5 and 1.0 m. However, for the most extensive clones the accuracy was sometimes only 5–10 m, because the error in measuring could in those instances be of a magnitude of some meters. In the presentation of the results later in this study, the measurements obtained in this manner have been used as such, despite that they may not always be of the accuracy they indicate.

Measurements were first carried out crosswise, in the direction of the largest diameter of the clones and at right angles to this, through the center. Later on, the latter was often disregarded, because it seemed to express nothing special, except in some special cases. In rocky terrain and under dense spruce stands, measurements were sometimes carried out by means of a compass and a temporary middle point in the various directions in the star-shaped stands. In these cases the final measuring was made from the drawings. The first and last points of measuring were the bases of the outermost fronds. Bracken rhizomes can extend another half a meter beyond these, but for the purpose of the present investigation diggings did not seem necessary.

7. Dating the fires

Old trees with fire scars offer the best possibilities for the determination of the dates of fire. Nowadays, however, these trees are almost entirely being removed in connection with silvicultural cuttings, at least from ordinary mineral sites. At several places in south Finland such trees are only found on rocks and swamps, sites that are not favoured by bracken. Moreover, on rocky ground the size of the clones is generally determined by the dimensions of depressions and defiles. In connection with the present study, it was often necessary to take borings from trees with fire scars growing on rocks and swamps, because there were no other possibilities for comparison. Sometimes the trees were situated quite far from the bracken stand measured, however, on the basis of the assumption that fires, especially in the past, were usually extensive, this seemed better than rejecting the clone without closer investigation. In practice, these tests sometimes gave excellent results, and sometimes, on the other hand, they ended in difficult snarls, which required gathering more data to a quite considerable degree.

In some pure even-aged pine stands of which did not include any trees with fire scars, but which, judging by, for instance, resinous stumps seemed to have arisen in fire areas, the basis of comparison was the age of the oldest trees.

The age cores were studied by means of a microscope and it was attempted to date the fire to the closest year. However, in borings from trees growing on

rocks and swamps, the annual rings were partly so thin that such an accuracy could not be obtained in all cases.

The marks of fires in the series of annual rings are of a considerably varying nature (cf. MIKOLA 1950, p. 10). In the most distinct cases — on the edges of fire scars — there is usually black charring and tarring followed by a period of varying length with thin annual rings. In less damaged trees without a dead fire scar formation, but with longitudinal depressions at the butt, borings taken from the bottom of the depressions sometimes show similar borders between growth series as well as tarring. In forests untouched by fire, such butt depressions seem to be of rarer occurrence. In some trees the date of fire is only indicated by a sudden thin ring which sometimes does not include summerwood. If there are no trees with fire scars in the same place, the interpretation of the cause is impossible. A sudden change in growth can be the result of several other factors. In some sample plots the only basis of comparison for the dimensions of bracken clones were distinct borders between growth series at which, in addition, tarring occurred. Parallelism was often clear, but it cannot prove the occurrence of fire resulting in regeneration of bracken by spores without other bases of evaluation. Usually wildfires cause regeneration in the forests, in consequence of which the tree stands show gradation in age classes. This gradation often supported the conclusions drawn by the evidence provided by annual ring series bored out from the oldest trees on the sites in question.

8. Results

81. Grouping of the material

The material consists of about 1450 bracken units which have been interpreted as being clones. A considerable part of them, however, has remained unspecified as to time directly on the basis of burned annual rings or data on the age, either because of their size, or because of the lack of old trees with fire scars. The usability of such clones is minor within the frame-work of this study. The size of part of the clones was amenable to comparison only with annual ring readings from trees located far from them. The genuineness and provability of some clones determined from mixed bracken stands are somewhat vaguer than those from pure detached stands. In order to reduce the sources of error to a minimum, the numbered presentation below includes only the pure, detached stands and the clones of mixed stands, that exhibit specially distinct individual characteristics. For these comparison with the post-fire time is possible because it could be made in the same place.

In addition to these representative clones, a number of other stands are described, which, in the grouping of the material, have served somewhat as sup-

porting members. The determination with respect to size and time of these clones might include some errors of interpretation due to the lack of control methods. However, this group includes a number of vegetation units of equal value.

The possibilities of comparison offered by tree stands only in a few cases extend beyond a period of 250 years, and in some exceptional cases, beyond 300 years. As for older clones, other basis of comparison had to be found; however, in this connection their examination will be disregarded because of the partial incompleteness of the material. As it is intended to deal with the large occurrences of bracken later on, I have found it proper to restrict this presentation to clones under 100 m in extent. For solving of the size-age problem, young clones are better than older ones, which have been liable to outside disturbances, especially fires, for a longer time. Because of this fact comparison could even have been restricted to clones less than 50 m in extent.

With a view to later studies and verification of the material, the locations of the clones are mentioned in connection with their presentation. The first name after the number of the clones, indicates the commune (parish) where they are to be found. Because the search was carried out mainly along highways, only aided by rough road maps, indicating the precise names of places was not always possible. Instead, the road in question and the numbers on the nearest kilometer-post — where there were any posts — are given.

Fig. 5 (p. 72) shows the arrangement on coordinate axes of the measurements of the representative clones by their age and dimensions.

82. List of the clones

821. Size class 1—10 m

Representative clones

No. 1. Pohja; close to Hanko railway on its western side, about 2 km from Raasepori station in the direction of Kaskimaa.

Size of clone: 9×9 m (1965).

Age of tree stand: 22 years, according to the whorls.

The site is on a poor sandy VT¹ plain. According to the object of comparison offered by the surrounding area, the ground vegetation, which is dominated by lichens and dwarf shrubs, will probably gradually change with the increasing shade into moss-dwarf shrub vegetation. In the age core samples from the marginal trees of an outside stand, there is a dark pitchy border which has originated 25 years ago. Slight depressions occur at the base of the stems. The even-aged regeneration growing on this burnt area has partly originated by cultivation and partly a natural way. The clone is detached and the only bracken within the young tree stand.

¹ Forest (site) type; see p. 70.

No. 2. Pohja; Ekerö, about 1 km from the Raasepori railway station.

Size of clone: 9×9 m (1965).

Age of tree stand: about 20 years, according to the whorls.

The site is located at the border of a burnt area where the ground vegetation sharply changes from lichen vegetation into a moss cover with hummocks. A depression on a sandy VT plain. In core samples from the marginal trees, a limit at a point between two periods of different growth rates can be observed 25 years ago (a period with thin annual rings begins at this point; this is followed by a period with broad rings 21 years ago). The clone is solitary. In this young tree stand, several extensive but not very dense stands of bracken have been encountered. However, they are broken and weakened by fires.

No. 3. Pohja; Kaskimaa.

Size of clone: 9.5 m (1965).

Age of tree stand: about 30 years, according to the whorls.

The site, a VT-area between rocks. The even-aged tree stand has originated after a fire, which, on the basis of the rebuilt hills of *Formica rufa* L., coll. (OINONEN 1956), has been only light. The clone is solitary.

No. 4. Huittinen; Kevalava road junction on the highway between Helsinki and Pori (no. 2).

Size of clone: 9.5 m (1965).

Age of tree stand: thicket formed by broad-leaved tree species.

The site is an old place for timber barking, VT. The bordering trees are folded in their bases and 27 years ago a period of thin annual rings began. The spot has been burned. The clone is detached.

No. 5. Tohmajärvi; the road between Kaurila—Uusi Värtsilä (km-post 17-7).

Size of clone: 10 m (1965).

Age of tree stand: according to borings at the base of stems, 31 years.

The site is a moist area close to a roadside ditch in the vicinity of a brook. The pine stand growing at this place is of even age in a large area and has probably originated after a fire. The clone is detached (the only one in a large area).

No. 6. Sulkava; the road between Sulkava and Juva, km-post 13.

Size of clone: 10.5 m (1965).

Age of tree stand: 45 years + the age of the stump (borings carried out at the height of about 30 cm).

The site, a roadside area. In the annual ring series of the sample tree, a distinct limit between two different periods of growth occurs 31 years ago, at which time the area had burned. The clone is independent.

No. 7. Jämijärvi; the road between Kuninkaanlähde and Jämijärvi, about 5—6 km from the former.

Size of clone: 10.5 m (1965).

Age of tree stand: about 30 years, according to the whorls.

The site, a roadside area, VT. The young stand has originated in a burnt area. The clone is detached.

Other clones of the same size class

Tammisaari rural district; Källvik.

Size of clone: 1.2 m (1964).

Age of tree stand: park forest with trees of varying ages, the oldest trees being more than 300 years old.

The site is a depression at the edge of a tar-burning pit with an armful of greyed rye straw on its bottom. Evidently a camping place. At the moment of investigation, troops of soldiers were conducting manoeuvres in the area and traces of military activity from earlier times could also be found. In the vicinity another detached clone was encountered, which was 8 m in size, and near the sea shore, one which was 9 m. According to the rest of the data, these sizes correspond to an age of about 25 years, and at this time, war operations took place in the area. The following clone size encountered was 16—17 m and the clones found of this size totalled four. This size corresponds to an age of 45—50 years and recalls the event of the Finnish War of Independence. In the beginning of April, 1918, the German Baltic Division landed in Hanko and marched through Källvik.

If bracken, in its regeneration by spores, is dependent on sterilisation by fire, these stands have probably originated in campfire places.

Kuusjärvi; the road between Maarianvaara and Outokumpu (km-post 38-10).

Size of clone: 3.1 m (1965).

The site is a road embankment which, according to the numbers of whorls on some pine and spruce seedlings growing on top of it, was made at least 9 years ago. Judging by the individual characteristics this clone has arisen from a segment of a rhizome transferred to the place. The gravel used for the embankment has been taken from the upper slope of the ridge, when this was cut ned, from a place more than 100 m away, where there was a large clone (about 50 m). In a place of the embankment there are leaves with the same characteristics over a distance of 18 m. This stand has probably developed from several rhizomes which happened to come close together.

In this connection a similar find from Ormnäs in the Tammisaari camping area should be mentioned. Here, in the summer of 1965, the ground was levelled with soil brought from somewhere else in order to facilitate camping and to establish a lawn. There were dried rhizomes in places on the surface of the layer of soil spread out about a month earlier, and at one point there were two green leaves. There had been no previous bracken vegetation at this place. The leaves were not structurally young.

There are certain other observations of such transfer, generally from sites of gravel pits and railroad embankments. As an example of the latter, the 67 m continuous stand located on the Hanko railroad embankment at the Skogby junction, Lappohja, should be mentioned. Based on its individual characteristics, this stand appeared to be of the same clone (the characteristics are not, however, very good). The Hanko railroad was opened for traffic in 1873 (*Iso tietosanakirja*, 1963). This means that the embankment work was done somewhat earlier (in the forests at the side of the railway, fires occurred widely 94—113 years ago, but from this time backwards, the repetition of fires clearly diminishes). If the bracken stand in question has generated by spores, and assuming that it is of the same clone, its rhizomes have grown approximately 30 cm per year. This growth rate is not possible on a barren gravel embankment. The leaves of the stand also reflected the unfavorable nature of the site. The conclusion was drawn that gravel from the same gravel pit has been transported to the section of the embankment mentioned and that roughly there has been the original site of the clone.

A rather illustrative example of dislocation was provided by a find made at Porkkala, Kirkkonummi. In this instance a 13×11 m bracken clone had spread out on the top of a soil mound, also extending in part beyond its edge. The mound, which was located at the border of a forested field, was composed of left-over material from buildings, junk, and garden soil. The Porkkala area was leased to the Soviet Union in September, 1944, and it appeared as if the origin of the soil mound might be connected with the events of this period. According to

other data, bracken clones of 7—8 m correspond to this date. An 8×8 meter (1964) clone is also included in the data from the vicinity of the Porkkala customs station, a spruce-covered depression (MT) in which the patch of bracken had spread out from the place where a tent had apparently been. On the site there were several pieces of brick, tiles, and fragments of bottles. The previously mentioned 13×11 m clone is too extensive to correspond to the time indicated by the trash mound, and for this reason, the clone has probably found its way to this place from somewhere else.

Forested fields, which were given special attention in the beginning stages of this study, gave conflicting results apparently just because of the frequency of rhizome dislocation and their becoming rooted again in fields in connection with tillage of the soil. On the other hand, a factor contributing to confusion in these parts of the study have been the clones that already were on the site before the cultivation of the field or which regenerated in this connection and not at the period when the field was rejected. — I have also confirmed dislocations in connection with other plant species in former field areas.

Tervo; Tervo—Pielavesi highway, 37 km.

Size of clone: 5.5×5.2 m (1965).

Age of tree stand: estimated 40—45 years, oldest generation removed.

The site is the side of the highway, where rocks have been shoved to in connection with widening of the road. Judging from the bareness of the surface of the stones, the road work was done under 20 years ago. There has not been a fire during this time, but work-area fires are possible. The clone is independent.

Yläne; Palmusuo forest road, about 3—4 km.

Size of clone: 6 m (1965).

Age of tree stand: about 100 years.

The site is timber-barking place at the point where the road borders a pine swamp. Here is also a ditch which is clogged with bark. A stand of birch seedlings at the side of the road is 10—15 years old. There has been no wildfire, but campfires have most likely been burned at the place for barking. The clone is independent.

Lohja; Keskilohja, vicinity of the railroad.

Size of clone: 7 m (1965).

Age of tree stand: 22—23 years according to the whorls.

The site is a poor and even VT heath. The young stand has arisen in a burned spot. In the vicinity are extensive mixed stands.

Säkylä; Yläne—Säkylä highway, km 65—13.

Size of clone (3 pcs.): 7.6, 7.8, and 7.9 m (1965).

Age of tree stand: a forest of varying ages, subject to selected cutting.

The site is the side of the highway; there are traces of road widening work that was carried out several years ago. A branch of a forest road is in the vicinity. At the opposite side of the road is a young stand of pines, 30—40 years old. There has probably not been a wildfire during this time. All three clones are one next to the other at the side of the road and are at short distances from each other. The conditions prevailing at the time of their birth are not known, but the replicates point to the occurrence of sudden favorable conditions.

Vihti; Nummela.

Size of clone: 8 m (1964).

Age of tree stand: 35—50 years.

The site is a barren lichen-covered area on a heath. In the center of the patch is a straight-walled pit that has been dug with a shovel and in the pit is trash, apparently the left-overs from camping. The vicinity is not inhabited. The nearby Nummela airfield has been used during the last war, and judging from several signs, there were supply depots in the area surrounding the airfield. The clone is independent.

A 9-m independent clone is in same area on a clear-cut site (war time «compulsion cutting»?). Judging from rotted stumps, there has been a spruce stand at this place, VT-MT. There has been no wildfire. A patch of grass suggests a campfire. It remained unexplained whether the patch of bracken is only a fragment, stimulated by cutting, of a more extensive unit, or independent and arisen from spores. In spruce stands fragments of this sort are quite common.

Karjalohja; Härjänvatsa.

Size of clone: 9 m (1964).

Age of tree stand: 20- to 25-year-old grey alders.

The site is the bank of a brook, a rich forest area. The trees of the fruit orchard which occupied the site froze during the severely cold winter of 1939—40, after which the orchard was destroyed and the area cleared to be turned into a field. The clone is detached.

Snappertuna; vicinity of the Raasepori railway station.

Size of clone: 9 m (1965).

Age of tree stand: according to the branch whorls, about 25 years.

The site is an area of young forest beside a forest road, VT. The stand has apparently arisen in a burned spot. The region is used for army manoeuvres. The clone is detached.

Nurmijärvi; Palojoki.

Size of clone: 9 m (1964).

Age of tree stand: about 110 years.

The site is poor VT, a place for barking and storing timber, where unevenness is caused by windfall. There has not been a fire at a time corresponding to the size of the clone, but the workmen have probably used fires for keeping warm. It is possible that the stand is a reviving fragment of a more extensive entity that has been broken up after the formation of a dense generation of spruce. The barking place has been in use during the period when the undergrowth spruce stand was removed from the pine stand. The clone is detached.

Lappohja; Tvärminne, vicinity of large sand pits.

Size of clone: 9.2 m (1965).

The site is the border of a field, beside the highway. There is no tree stand. According to other data, the origin of this clone is probably connected with the events relating to the establishment of the Hanko area army base (1940).

Lohja; Ojamonkangas.

Size of clone: 9.5 m (1965).

Age of tree stand: about 90 years (forest treated with selective cuttings, of varying age).

The site is VT in the vicinity of the highway. Spruce has been removed by degrees from the pine-spruce mixed stand and the oldest stumps have rotted soft. There has been no wildfire. The clone is independent and in a cleared opening.

Somerniemi; Liesjärvi.

Size of clone: 9.5 m (1965).

Age of tree stand: about 40 years, an even-aged pine stand.

The site is VT, the side of the road. There has been no fire at a time corresponding to the size of the clone, but the tree stand has arisen after a fire. A detached patch. The stand may have been sectioned in connection with the widening of the road. There are also other observations of this sort on reduction. Thus at Ruovesi, in the vicinity of Ryövärinkuoppa, a stand about 20 m in length in 1947 that bordered the road was later reduced to such a degree due to road widening, that in 1964, all that remained was a patch some meters long. — Caution must be exercised in the measurement of stands on roadsides.

Säkylä; Yläne—Säkylä highway, km 66—12.

Size of clone: 9.5 m (1965).

Age of tree stand: a cut area where there is a seedling stand of varying age, 10—25 years old. The marginal stand is about 80 years old. In this stand a growth phase of wide rings began 32 years ago.

The site is VT, a possible fire area. Due to logging, the clone may be a reviving fragment of a more extensive entity. The patch is detached.

Sammatti; Luskala.

Size of clone: 9.5 m (1964).

Age of tree stand: about 100 years.

The site is on the top of an old tar pit. The surrounding area has been used as an out-of-doors area by the villagers and is strongly disturbed by human activity. There are abundant traces of this. The tar pit has also been studied. It is probable that no fire has occurred at this place at a time corresponding to the size of the clone; there has, however, been some logging. The clone is independent. In the vicinity is a 13-m independent clone which is at the elbow of a slope. The ground surface has been broken in several places on this slope.

Tenhola; Prästkulla—Tammisaari highway, km 7—7.

Size of clone: 10.5 m (1965).

Age of tree stand: about 30 years according to the branch whorls.

The site is the boundary between a rock formation and a pine swamp. There are abundant traces of a work site. The young stand has arisen in burned spot. Detached clone.

Lappohja; Tvärminne, a road junction in the vicinity of extensive sand pits.

Size of clone: 10.5 m (1965).

Age of tree stand: about 100 years.

The site is sandy soil. In the vicinity are trenches, barbed wire fence remains, and other marks of civilization. There was probably no fire at a time corresponding to the size of the clone, but there might have been camp-fires at this worn-out looking place. The clone is detached.

Pyhtää; the crossroads of Pyhtää communal center, beside the Loviisa—Kotka highway.

Size of clone: 10.7 m (1965).

Age of tree stand: about 33 years, based on the whorls.

The site is stony VT. Apparently a burned spot. The clone is detached.

822. Size class 11—20 m

Representative clones

No. 8. Säkylä; Yläne—Säkylä highway, km 61—17 (about ½ km from the boundary between the communes mentioned).

Size of clone: 11.5 m (1965).

Age of tree stand: about 35 years according to the whorls, (and 30+ years according to a boring taken at the height of 30 cm).

VT site. Independent clone. The tree stand has arisen in a fire area.

No. 9. Laukaa; Lievestuore—Toivakka highway, in the vicinity of the boundary between the communes of Laukaa and Toivakka.

Size of clone: 11.7 m (1965).

Age of tree stand: about 30—33 years according to the whorls.

A roadside site on poor VT. The clone is independent. There is not complete certainty about a fire. The origin of the clone, however, is connected with the date of logging or with the construction of the road. There are traces of digging in the ground.

No. 10. Vihti; Nummela, vicinity of the Vihti communal center—Ojakkala junction.

Size of clone: 13 m (1964).

Age of tree stand: 35+ years, from stumps.

The site is a forested field, MT. The clone is detached. Judging from that the stand extends a little beyond the field, it has probably originated after a wildfire. According to a core bored from a standard, a fire occurred 39 years ago. At the side of the field there is debris and marks of habitation.

No. 11. Pohja; vicinity of the railway overpass, beside the Koppskog—Åsenby road.

Size of clone: 13 m (1964).

Age of tree stand: 60+ years.

The site is on the top of an old tar pit and its surroundings, VT. A wildfire 38 years ago. The stand is alone at the side of the road. In the vicinity is a 21-m clone at a spot that was unburned in the last fire. This has probably developed after the fire that occurred 64—65 years ago.

No. 12. Karjalohja; Härjänvatsa, Sonnilampi.

Size of clone: 13 m (1965).

Age of tree stand: 39 years.

The site is a forested field (VT-MT) that has been discarded after a ploughing done in 1926. The clone has possibly been generated in this connection from a transported rhizome. There has been no fire. According to information from the owner, the field was cleared for cultivation in 1904. According to the stumps of marginal trees, this appears to have happened somewhat earlier, for an age of 64 years was read from the oldest stump. 2—3 years should probably be added to the age of the low stump so that the real age would be 66—67 years. The four 23.5—24.0-m clones in this field correspond to this age. One of these may be a fragment of a more extensive entity.

No. 13. Tohmajärvi; vicinity of the Petrovaara crossroads.

Size of clone: 13.3 m (1965).

Age of tree stand: about 55 years.

A roadside site where blasting work has been done (VT). Tarring and a limit between two different periods of growth occurs 43 years ago in trees at this site. This expresses the fact that fire has also been handled. The clone is independent.

No. 14. Padasjoki; the Vehkajärvi—Torittu roadside, km 12.

Size of clone: 13.3 m (1965).

Age of tree stand: an older generation 51+ years and a younger generation 37+ years according to stumps.

The site is a storage place for firewood located at the edge of a tree stand at the road (VT). The younger generation of pines has arisen after a fire and the clear-cutting which followed it. The clone is independent.

No. 15. Säkylä; Yläne—Säkylä highway, km 63—15.

Size of clone: 13.9 m (1965).

Age of tree stand: a clear-cut area in which there is a stand of small seedlings, marginal forest 66+ years old according to borings.

The site is VT. In the marginal trees there is an abrupt thin annual ring 38 years ago, a fact that points to a fire which occurred at this period. The clone is by itself at the edge of the road and may have been reduced in size in road widening operations.

No. 16. Pohja; vicinity of Raasepori railway station.

Size of clone: 14.5 m (1965).

Age of tree stand: about 35 years according to whorls, the marginal stand is 47 years, the samples have been bored at the root collar.

A roadside site at the edge of an extensive logging area, poor VT. The marginal stand has arisen in a fire area. There is a limit between two different periods of growth 40 years ago in the series of annual rings, but no certainty was obtained as to whether there was a fire at this time. The clone is detached. At the site there are abundant marks of camping and trenches of varying ages.

No. 17. Turku; Ruissalo.

Size of clone: 15 m (1965).

Age of tree stand: 30+ years.

The site is stony VT under a slope of rock. An old standard from the nearby rock has an especially thin annual ring 44 years ago. The stand has developed after a fire. The clone is detached. The petiole is brownish.

No. 18. Inkoo; Inkoo—Snappertuna highway, km 23—16.

Size of clone: 15.5 m (1965).

Age of tree stand: 48+ years.

The site is a partly rich forest-like depression between rocks at the junction of a forest path and the highway. Timber has also been handled here. It is possibly a burned spot. A period of growth of thin annual rings has begun 42 years ago in the sample trees. This individual with a brown petiole becomes mixed with other clones at one end.

No. 19. Oripää; the side of the Loimaa—Oripää road, about 2 km from the boundary between these two communes.

Size of clone: 15.5 m (1965).

Age of tree stand: a seedling stand of varying age, the oldest individuals of which are over 30 years old.

The site is barren lichen heath. Nearby, the age of the stand at the edge of this one is 52+ years; a tarred annual ring occurs 48 years ago in the core. In the vicinity of the clone is a monument to those who met their death at this place in 1918. The clone is detached, at the side of the road. A fire area.

No. 20. Kerimäki; Simanala—Savonlinna highway, km 12.

Size of clone: 16 m (1965).

Age of tree stand: 72+ years.

A roadside site, MT, which has apparently burned 43 years ago, at which time a growth period of thin annual rings suddenly begins in the trees. The clone is detached.

No. 21. Tammela; the area of Saari Public Park.

Size of clone: 17 m (1964).

Age of tree stand: 154+ years.

The site is the slope of a ridge, VT. According to fire-scarred trees, a blaze has occurred 51 years ago. Two other clones of the same magnitude (16 m) have been measured in the same area. The representative clone and one of the replicates are detached and independent, but the third unit is possibly a fragment of a more extensive one.

No. 22. Merimasku; Naantali—Askainen highway, vicinity of the Rymättylä crossroads.

Size of clone: 17 m (1965).

Age of tree stand: 48+ years.

The site is stony VT. The stand has arisen after a fire, which according to core from a standard on the nearby rock, has probably occurred 57 years ago. The clone is independent, near the highway.

No. 23. Keuruu; Keuruu—Petäjavesi highway, about 4 km from the church village.

Size of clone: 17 m (1965).

Age of tree stand: 66+ years.

VT site. A dump is in the vicinity. A slight fire has probably occurred 56 years ago, as is expressed by a limit between two different periods of growth in the annual ring series and by a change in direction. The clone is independent.

No. 24. Turku; Ruissalo Public Park.

Size of clone: 17 m (1965).

Age of tree stand: 46+ years.

The site is a field margin, beside a rock formation. This spot has probably been a field (burned for crops?) before the birth of the present stand. The vegetation is partly rich forest-like. The clone is detached. In the vicinity is a duplicate of the same size class; however, this is probably a fragment of an approx. 50 m unit.

No. 25. Kuhmoinen; Vehkajärvi—Torittu highway, km 10, in the vicinity of the Vesijako junction.

Size of clone: 17 m (1965).

Age of tree stand: 74+ years.

The site is the side of the road, VT. According to the evidence of borings, there was a slight fire 56 years ago. The clone is detached.

No. 26. Yläne; Yläne—Säkylä highway, about ½ km before the boundary between these communes.

Size of clone: 18 m (1965).

Age of tree stand: 40+ years, the oldest trees have probably been removed in thinning the stand.

The site is stony VT. The stand has regenerated after a fire. The clone is independent.

- No. 27. Säskylä; Yläne—Säskylä highway, km 63—15.
Size of clone: 18.5 m (1965).
Age of tree stand: 85+ years.
The site is the side of the road, VT. A fire occurred 54 years ago. The clone is independent.
- No. 28. Sauvo; Kemiö—Sauvo highway, about 1 km from the ferry.
Size of clone: 19 m (1965).
Age of tree stand: 48+ years.
VT site. The stand has arisen after a fire, which, according to cores from trees of the marginal forest, probably occurred 52 years ago. The clone is detached. At the same site is a 19 m duplicate which, however, is a fragment of a more extensive clone (see no. 163).
- No. 29. Kangaslampi; Kangaslampi—Heinävesi highway, km 6.
Size of clone: 19 m (1965).
Age of tree stand: 52+ years, read from a low stump.
The site is the edge of a paludifying depression, beside the highway (VT). The depression has developed in connection with the building of the road, at which time gravel was scooped from the place. The stand has arisen after a fire. The clone is independent.
- No. 30. Jäppilä; Jäppilä—Maavesi highway, about 11 km from the Jäppilä communal center.
Size of clone: 19 m (1965).
Age of tree stand: 73+ years.
The site is poor VT at the side of a gravel pit path. This place has also been a barking site. There apparently was a fire 60 years ago, at which time a period of growth of thin annual rings suddenly begins in the trees. The clone is independent.
- No. 31. Kuru; Vaskuu—Kuru highway, about 23 km, near the Pouru road fork.
Size of clone: 19 m (1965).
Age of tree stand: 67+ years.
A roadside site, VT. There apparently was a fire 56 years ago, at which time a distinct limit can be seen between two periods of different growth in the series of annual rings. The clone is detached, its petioles of a half-dark type.
- No. 32. Sauvo; Kemiö—Sauvo highway, km 15—23.
Size of clone: 19.5 m (1965).
Age of tree stand: 79+ years.
The site is VT. There was a fire 58 years ago, at which time a growth period of thin annual rings abruptly began in the sample trees. The clone is detached.
- No. 33. Somerniemi; Oinasjärvi, the road between Oinasjärvi and Kiikala airfield.
Size of clone: 20 m (1965).
Age of tree stand: 64+ years.
The site is VT, most likely a field formerly burned for crops. A period of thin annual rings began 58 years ago in the standards, and a corresponding phase occurs in the sample trees of a younger generation which was in the seedling stage at this time — this points to a fire or to burning for crops. The clone is detached. In the vicinity is a 21.5-m clone, the size of which corresponds to the age of the younger tree generation. A core from a tree indicated an age of 61 years.
- No. 34. Kesälahti; Kesälahti—Kerimäki road side, near the boundary between these communes.

- Size of clone: 20 m (1964).
Age of tree stand: 119+ years.
The site is a V-shaped ridge depression, VT. The stand has spread out in the direction of the bottom of the depression, following one slope, but has not climbed up the slope at the same rate. The diameter of the patch in this direction is 10 m. According to fire-scarred trees, there was a fire 59 years ago. The clone is detached.
- No. 35. Kaavi; Maarianvaara—Outokumpu highway, km 32—19.
Size of clone: 20.5 m (1965).
Age of tree stand: 60+ years from stumps.
A roadside site at the edge of a field, The stand at the other side of the road has arisen after a fire. The clone is independent.
- No. 36. Merimasku; Naantali—Askainen highway, about 0.5 km from the Rymättylä road junction.
Size of clone: 20.5 m (1965).
Age of tree stand: 50+ years.
VT site. The stand has regenerated after the fire, which, according to the sharp limit between two periods of different growth appearing in the series of annual rings of a nearby standard, occurred 57 years ago. The clone is independent.

Other clones of the same size class

- Lohja; Keskilohja, vicinity of the railroad.
Size of clone: 11.5 m (1965).
Age of tree stand: 69+ years.
VT site. The tarred annual rings in several trees point to a light fire 34—35 years ago, but complete certainty was not obtained. The clone is detached, and has possibly been reduced by dense spruce undergrowth which grew here earlier.
- Sammatti; Lohilampi, beside the nature reserve area.
Size of clone: 12 m (1965).
Age of tree stand: a left-over stand about 100 years old and a dispersed stand of seedlings of varying age.
The site is at the edge of the highway. The seedling stand is 20—30 years old. No fire has probably occurred at a time corresponding to the size of the clone. A site influenced by human activity.
- Pusula; Mäkkylä.
Size of clone: 13 m (1965).
Age of tree stand: 62+ years, counted from low stumps.
A roadside site, VT. An even-aged tree stand in the vicinity has been born after a wildfire that occurred 36 years ago. It remained uncertain, however, whether the wildfire had extended to the site of the clone. The stand has arisen after a fire which occurred 68 years ago. This is evidenced by the blackened fracture which occurs between the annual rings in the stumps of standards. At the side of the road there are diggings which point to road work. The clone is independent.

Honkilahti; Honkilahti—Yläne highway, km 9—11.

Size of clone: 13 m (1965).

Age of tree stand: 69+ years.

VT-MT site, an area formerly burned for crops. A period of thin annual rings began 36 years ago in a sample tree, but the reason for this remained unexplained. The clone is by itself at the side of the road.

Sammatti; Lohilampi.

Size of clone: 15 m (1965).

Age of tree stand: 43+ years, core from the root collar.

VT-MT site, the side of a path. Near a timber storage place. The stand has probably arisen in a fire area. The clone is independent.

Tammisaari Rural District; Källvik.

Size of clone; 15 m (1964).

Age of tree stand: 41+ years, boring from the root collar.

The site is a depression between rocks, VT. The even-aged stand of pines has probably arisen after a fire. Based on the uniformity of the individual characteristics of the bracken patch, it is probably a fragment of a more extensive entity (approx. 80 m), but it is, nevertheless, completely detached. Fires have occurred frequently in this area.

Kiikala; vicinity of the airfield.

Size of clone: 15.5 × 15.0 m (1965).

Age of stand: 66+ years.

The site is poor VT. In the center of the stand there is a pit that has caved in. Around this, in an area of several ars (ar = 100 sq. m), is a thicket of grey alder sprouts and a young stand of pine and spruce of varying ages (20—40 years). A possible camping place or spot burned by fire. The clone is mixed with other bracken vegetation, but it is easily distinguished from these by its brown nectaries and in the autumn also of the color of its leaves. The size of the clone points to the times of 1918 (cf. no. 19), which also left other traces in this area.

Lohja; vicinity of the race track work site.

Size of clone: 16 m (1964).

Age of stand: 39+ years.

The site is poor VT. Fires have frequented this area, but it has not been possible to determine their boundaries. In the older trees of the area, there are marks of fires which occurred 48, 51, and 54 years ago. Two 17-m clones have been measured in the same region. All of the clones which have been measured are detached, but they may be, at least in part, fragments of more extensive fire-shattered entities, which are abundant in this area.

Snappertuna; vicinity of the main highway to Turku and the junction of the road which leads to Raasepori.

Size of clone: 16 m (1965).

Age of tree stand: 69+ years.

VT site. In the cores there is charring and a limit between two different periods of growth 46 years ago, at which time there was probably a slight fire in the area. The clone is detached, but it may be a fragment of a more extensive entity. The area has burned frequently.

Somerniemi; Liesjärvi.

Size of clone: 17 × 15 m (1964).

Age of tree stand: 45+ years.

VT-MT site, which according to fire-scar trees, has burned most recently 51 years ago. The clone, under thick spruce undergrowth, has been broken up into a sparse stand, and is reviving after the thinning of the stand. The authenticity of the dimensions of such clones remains questionable. The nearest sample trees, from which the time of the fire was studied, are at a distance of over 100 m; thus, it was uncertain whether the clone site burned in connection with the fire mentioned or at another time. Fires have been frequent in the area. — The dimensions of the clone, however, correspond well to the time of the fire 51 years ago.

Honkilahti; Honkilahti—Yläne highway, km 8.

Size of clone: 18 m (1965).

Age of tree stand: 98+ years.

The site is the edge of the road. 54 years ago a growth period of thin rings has begun in a sample tree, indicating a fire at this time. The clone is independent.

Siuntio; Lohja—Siuntio highway, vicinity of Grönberga, in the border area between these communes.

Size of clone: 19 m (1964).

Age of tree stand: about 70 years.

The site is a depression in a rock formation, VT. There is tarring and a limit between two periods of different growth 58 years ago in the standards on the rock. Another 19-m detached clone has been measured in the nearby area. Wildfires, the boundaries of which remained indistinct, have occurred frequently in this region.

Savitaipale; Savitaipale—Suomenniemi highway, km 19.

Size of clone: 19 m (1965).

Age of tree stand: 62+ years, from a low stump.

The site is the edge of the highway. There have probably been no fires during the time of the present stand, but it has probably regenerated after one. The clone is detached.

Vihti; Nummela, vicinity of the Ojakkala road fork.

Size of clone: 19 m (1964).

Age of tree stand: 80+ years.

The site is the edge of a field, MT. In the stumps of trees, at a point 56 years ago, there is a break between the annual rings and a limit between two periods of different growth. This indicates a fire, but certainty was not obtained. The clone is detached.

Isojoki; Lauhanvuori.

Size of clone 20.5 m (1965).

Age of tree stand: 69+ years.

The site is the upper slope of the high ridge at this place, VT. A period of thin annual rings has begun 59 years ago in the sample trees, indicating a possible fire. The patch is detached. The ridge is apparently popular as a place for outings. In the vicinity is another detached patch of bracken 23.5 m in size, which approximately corresponds to the age of the tree stand. This stand is probably a fragment of a larger entity.

823. Size class 21—30 m

Representative clones

No. 37. Karttula; Lyytikälä—Karttula road, km 24—3.

Size of clone: 21 m (1965).

Age of tree stand: approx. 80 years.

The site is stony VT. Based on the evidence of borings from fire-damaged trees, there was a fire 65 years ago. The clone is independent.

No. 38. Honkilahti; Honkilahti—Yläne highway, km 3—17.

Size of clone: 21 m (1965).

Age of tree stand: 62+ years, read from a short stump.

The site is a VT-area at the side of the road. The stand has arisen after a fire. The clone is independent.

No. 39. Säskylä; Virttaa—Säskylä highway, about 2 km from the boundary of Oripää commune.

Size of clone: 21.5 m (1965).

Age of tree stand: 70+ years and younger.

The site is VT. A fire 66 years ago, at which time no summerwood was formed in the annual ring. This is followed by a growth period characterized by thin rings. The clone is independent.

No. 40. Lapua, Simsiönvuori.

Size of clone: 21.5 × 19.5 m (1965).

Age of tree stand: 56+ years.

The site is VT in rocky country. In the stumps of standards there is a break between the annual rings and a boundary between two different growth phases at a point 65 years ago, at which time a fire visited this place. The clone is detached.

No. 41. Snappertuna; the vicinity of Raasepori railway station.

Size of clone: 21.5 m (1965).

Age of tree stand: a three-cycle stand, the oldest part of which is 109+ years, the following 79+ years, and the youngest 60+ years.

The site is poor VT which has burned frequently. According to borings and stumps, the latest fires occurred 114, 84, and 65 years ago. The clone is detached. In the vicinity there is another clone, 20 m, located in part on bare sands at the border of a drying pine swamp.

No. 42. Lohja Rural District; Karkalinniemi.

Size of clone: 22 m (1965).

Age of tree stand: 64 years, the core was taken from the root collar.

The site is a former cleared and burned field, shady rich forest. In the vicinity are two 21.5-m clones, one of which is possibly a fragment. These clones are both very open in density. The oldest pines at the side of the field were probably born during the period of burning for crops.

No. 43. Iitti; Tillola, Kouvola—Lahti highway, in the vicinity of the Tillola battle monument.

Size of clone: 22 m (1965).

Age of tree stand: 74+ years.

The growing place is a stony and poor VT ridge, the elbow of a slope. A slight fire 67 years ago has caused tarring in the annual rings of a sample tree from this time backwards. The clone is independent.

No. 44. Pohja; at the Hanko railway, west side, about 2 km from Raasepori station in the direction of Kaskimaa.

Size of clone: 22.5 × 17 m (1965).

Age of tree stand: 113+ years.

The site is VT, the elbow of a slope. Frequent fires, the latest 64 years ago, at which time sharp boundary lines between different phases of growth were formed in the annual rings of a sample tree. The age of an adjacent stand is 53+ years old. This stand has regenerated after a fire. The clone is independent. In the center is an old *Formica rufa*-hill.

No. 45. Noormarkku; Noormarkku—Lavia highway, 12 km from Noormarkku.

Size of clone: 22.5 m (1965).

Age of tree stand: 84+ years.

The site is a depression in a stony VT-area. A sharp boundary between growth phases, tarring, and deformity in the annual rings of a sample tree are the signs of a light fire 65 years ago. The clone is independent, its leaves especially characteristic, finely lobated. A model clone for visiting.

No. 46. Säskylä; Oripää—Säskylä highway, km 16—1.

Size of clone: 22.5 m (1965).

Age of tree stand: 67+ years.

The site is VT-MT. There apparently was a fire 62 years ago, after which time a period of markedly thin annual rings are seen in the core of a sample tree. The clone is detached.

No. 47. Siuntio; Mustio, Stormora.

Size of clone: 23 m (1964).

Age of tree stand: 76+ and 60+ years.

The site is VT, the border of a spruce swamp. In a core from a spruce growing on the side of the swamp there is a blackened, rotten ring for the time 67 years ago, indicating a fire in the area. The clone is detached.

No. 48. Somerniemi; Liesjärvi.

Size of clone: 23 m (1964).

Age of tree stand: 139+ years.

The site is VT, and, according to the evidence of borings, it was burned in a wildfire 66 years ago. The clone is detached. In the same area there is a 52 × 22-m stand on a stony VT slope. The shorter diameter of this longish stand approximately corresponds to the time elapsed since the latest fire and the longer to the age of the tree stand. Similar cases also occur in the data from elsewhere.

No. 49. Punkaharju; Putikko, in the vicinity of the Lohikoski road junction.

Size of clone: 23 × 16 m (1964).

Age of tree stand: oldest generation 102+ years.

The site is VT. The area has burned frequently, and the most severely burned places are partly covered with lichens. The three most recent fires occurred 81, 67, and 48 years ago. In places there are stands which, in age, separately date from these fires, and in part the age classes intermingle. The clone's larger diameter corresponds to 67 years and the smaller one to an age of 48 years; thus, it is likely that the last blaze reduced the stand into a line-like strip 6—7 m in length. The 25 × 16-m and 26 × 25-m clones in the vicinity have probably been reduced in all directions or are slow-growing due to the poorness of the site. They have regenerated after a fire which occurred 81 years ago. A 28-m independent clone in the moss-covered part of the site which did not burn during the last fire nor possibly in the previous one either, also corresponds to this age. All vegetation units mentioned here, which have been interpreted as being clones, are detached.

No. 50. Enonkoski; Simanala—Savonlinna highway, in the vicinity of the borderline of Kerimäki commune.

Size of clone: 23 m (1965).

Age of tree stand: 96+ years.

The site is VT, and it probably burned 67 years ago, at which time a borderline was formed between two growth phases in the annual rings of a sample tree. The clone is detached.

No. 51. Ulvila; Kullaa—Harjunpää highway, about 1 km before the Ulvila road junction.

Size of clone: 23 m (1965).

Age of tree stand: 96+ years.

The site is the edge of a rock formation on the bank of a small pond beside the highway. Widening of the highway has possibly caused slicing of the growth. In the annual rings of a sample tree there is a distinct borderline between different growth phases at a point 75 years ago, marking the beginning of a period of thin rings, apparently caused by a fire. The clone is independent.

No. 52. Eura; Kauttua—Hinnerjoki highway, km 6—52.

Size of clone: 23.5 m (1965).

Age of tree stand: 80+ years.

The site is better than medium VT. In the age core there suddenly is narrow ring 67 years ago, and a period of poor growth began 63 years ago. The upland forest area on the opposite side of the highway has burned frequently. In the same area there is a sawmill with its stores. The clone is detached and broken up into small fragments.

No. 53. Askainen; Merimasku—Askainen highway, km 9—7.

Size of clone: 23.5 m (1965).

Age of tree stand: 73+ years.

The site is VT. A thin ring with undeveloped summerwood was suddenly formed in the sample tree 66 years ago. The cause is apparently a fire. The clone is independent.

No. 54. Lohja Rural District; Karkalinniemi.

Size of clone: 23.5 m (1965).

Age of tree stand: 101+ years.

The site is stony VT slope-land between rock formations. There are folded butts among the trees and tarring as well as the initial point of a period of poor growth 70 years ago in the cores. Evident earmarks of a light fire. The clone is independent, outstanding in its autumn colours, dark violet in hue, and differs from its neighbours most distinctively.

No. 55. Turku; Ruissalo.

Size of clone: 24 m (1965).

Age of tree stand: 128+ years, generation of hold-overs.

The site is VT. An especially thin annual ring appears suddenly in the cores 71 years ago. At that time there was probably an extensive fire in the area, because a similar thin ring was found in an old rock pine at a distance of ½ km. The clone is detached.

No. 56. Yläne; Yläne—Säkylä highway, km 58—20.

Size of clone: 24×22 m (1965).

Age of tree stand: trees left standing after logging 72+ years, dominant part 45—50 years.

The site is the side of the road (VT), on both sides, so that the road is probably a more recent development than the clone. In the cores there are thin rings 70 and 64 years ago, which points to sudden growth disturbances (fire) during these periods. The clone is detached.

No. 57. Inkoo; Stormossen.

Size of clone: 24×22 m (1964).

Age of tree stand: a stand of quite varying age on a rock site, characterized by the following samples: 235+, 175+, 76+ years and younger.

The site is a depression in a rock formation, VT. All of the old sample trees have fire scars, in the oldest, as the result of two different fires. These uniformly indicate a fire 70 years ago. The clone is independent.

No. 58. Pusula; Mäkkylä, Kaukela road junction.

Size of clone: 24 m (1964).

Age of tree stand: standards 165+ and 145+ years, dominant stand 60+ years old.

The site is VT, the elbow of a slope. According to borings and the examination of stumps, there was a fire 68 years ago. The younger generation of even-aged pines has arisen in the area of the fire. The clone is independent. Another 24-m clone has been measured in the same area, but this may be a fragment. The area has burned frequently.

No. 59. Siuntio; the area of Grönberga at the border of Lohja.

Size of clone: 24×23 m (1964).

Age of tree stand: 60+ years.

The site is a depression in a rock formation, VT. The old, fire-scarred pines in the surrounding area witness a fire 68 years ago. In all, 9 clones 24-m in magnitude have been measured in this area, a few of which may be fragments. Five 25—28 m stands were also found, possibly also fragments or individuals which have been reduced from their original size. A time of fire corresponding to their size has not been found in the cores. A part of the clones are independent and a part mixed. The representative is of a brown-stalked type.

No. 60. Lohja; in the vicinity of the trotting course work site.

Size of clone: 24 m (1964).

Age of tree stand: 65 years, based on a sample plot placard found in the stand (judging from the way that it has turned grey, the placard has been at this place for some years).

The site is the border area of an even-aged pine stand, MT-OMT. According to the stumps of standards, a fire occurred 70 years ago, and by the tarred rings and the borderline between growth phases of an old standard found farther away, it was 68 years ago. The clone is detached. In the nearby area further replicates of clones of the same size class have been measured as follows: 21 m (three), 22 m (four), 23 m (two), 24 m (three), and 25 m (two). A part of these may be fragments of more extensive entities. Several fires of varying patterns have occurred in the area, thus, a part of the clones may be in places burned by separate fires. Outlining the fire patterns was not possible, but the annual ring series in cores taken at different places exhibit divergences.

No. 61. Vehkalahti; in the vicinity of the Vilniemi road junction.

Size of clone: 25 m (1965).

Age of tree stand: 65+ years, read from stumps.

The site is VT. The stand has arisen after a fire, which, according to the core bored from a standard, was rampant 70 years ago. The clone is independent.

No. 62. Tammela; vicinity of Saari Public Park.

Size of clone: 25 m (1964).

Age of tree stand: 65+ years, read from stumps.

The site is VT. The stand has regenerated after a fire. The exact date of the fire was not revealed by the borings, but when 5 years are added to the age read from the stump, as has been customary in the estimation of age, we arrive at an age of 70 years. The clone is independent.

- No. 63. Kuusjärvi; Maarianvaara—Outokumpu highway, km 40—8.
Size of clone: 25 × 13 m (1965).
Age of tree stand: 92+ years.

The site is a depression in a barren heath, C1T-VT, at the edge of a patch of treeless swamp. The stand has spread along the edge of the swamp, its origin being at the border between the swamp and the heath. The latest fire occurred 81 years ago. The trees are damaged by fire. The clone is the only one in an extensive area.

- No. 64. Nurmes; Vieki—Haarakivi highway, about 2—3 km from the Pielisjärvi borderline.
Size of clone: 25 m (1965).
Age of tree stand: 60+ years.

The site is the border of a field beside the highway, on the slope of a tree-covered hill. The stand was born after a fire. The clone is independent.

- No. 65. Ilomantsi; Käenkoski—Särkkä ferry, near Huhus road junction.
Size of clone: 25 m (1965).
Age of tree stand: 82+ years.

The site is VT. A growth period of thin rings in the borings 75 years ago, possibly caused by fire. The clone is detached.

- No. 66. Tammisaari; Dragsvik.
Size of clone: 25.5 m (1965).
Age of tree stand: standards 205+, dominant stand 78+ years.

The site is poor VT, at the elbow of a slope. The younger tree generation dates from a fire which occurred 85 years ago. The area surrounding the bracken stand has been considerably disturbed by human activity, there are e.g. indications of the removal of stumps for tar burning. The clone is independent.

- No. 67. Tammisaari Rural District; Källvik.
Size of clone: 26 m (1964).
Age of tree stand: 195+ years.

The site is a defile between rocks, VT. A period of thin rings has uniformly begun 73 years ago in the annual ring series of sample trees, and there is a brown, rotted ring at the corresponding place in a spruce. These signs point to a light fire. Three other 26-m clones, all detached, have been measured in the nearby area.

- No. 68. Kiikala; the area between the airfield and Sakarjärvi.
Size of clone: 26 m (1964).
Age of tree stand: 66+ years.

The site is the border between lichen-covered forest land and a spruce swamp. This was also the limit of the latest forest fire. The area has been stamped by frequently recurring fires and the hummock cover at the edge of the spruce swamp has in places been sharply cut into. The transition zone is indefinite with regard to its forest site type and most nearly of *Vaccinium* type. The clone is detached. According to the borings in a wide area in the surroundings, the fire occurred probably 74 years ago.

- No. 69. Kiikala; area between the airfield and Metsänoja.
Size of clone: 26 m (1964).
Age of tree stand: standards 200+ years, following generation 109+, and youngest generation 66+ years.

The site is a gorge-like depression in firm forest land, VT. A fire visited this place 74 years ago. Five other clones of the same size class have been measured in the same area: four 25 m and one 26 m. In addition, there are some long strip-like growths in the folds between the level land and some of the ridge formations. The width of these strips varies in places with surprising uniformity between 22 and 26 m.

- No. 70. Kerimäki; Kaijansaari, vicinity of Mäkrä island bridge.
Size of clone: 26 × 24 m (1964).
Age of tree stand: 66+ years.

The site is a low VT hill in the vicinity of rich forest sites. On another VT site in the same area there is a 20 × 18-m clone which probably originated 58 years ago after either a wildfire or burning for crops. There is charring in the annual ring series of a pine in the vicinity at the point corresponding to this time. The representative clone is independent and was born after a fire.

- No. 71. Lohja; vicinity of the trotting course work site.
Size of clone: 26 m (1964).
Age of tree stand: 70+ years, read from a fresh stump.

The site is the border area of a tar pit, VT. In the annual rings of a nearby 175+-year old, fire-damaged standard, a sharp boundary between growth periods shows 72 years ago. This points to a fire at that time. The younger tree generation is likewise even-aged. The clone is independent.

- No. 72. Karjalohja; Härjänvatsa, Mustakorpi.
Size of clone: 26 m (1964).
Age of tree stand: 66+ years.

The site is a forested glade or an area formerly burned for crops, VT-MT. According to stumps and the cores bored from standards on the nearby pine swamps, 71 years have elapsed since the last fire. The clone is partly mixed, but since it is of an exceptional brown-stalked type, it stands out clearly from other bracken vegetation.

- No. 73. Suodenniemi; Vammala—Suodenniemi highway, km-post 26.
Size of clone: 26 m (1965).
Age of tree stand: 70+ years, read from stumps.
The site is VT-MT. The stand has regenerated after a fire. The clone is independent.

- No. 74. Sipoo; Spjutsund road, about 5 km from the Helsinki—Porvoo main highway.
Size of clone: 26 m (1965).
Age of tree stand: 62+ years.

The site is VT-MT, which, according to the core from a 117-year old standard, burned 73 years ago. There are depressions at the bases of the boles. The clone is detached, with dark petioles and nectaries.

- No. 75. Noormarkku; Noormarkku—Lavia, km 23.
Size of clone: 26.5 m (1965).
Age of tree stand: 62+ years, read from the tall stump of a spruce.

The site is a forested clearing next to a house (possibly a former field burned for crops) at side of the road, MT. Some of the farm's buildings are beside it. Independent clone.

No. 76. Kiikala; vicinity of Lamminjärvi, SW. of the airfield.

Size of clone: 27 m (1965).

Age of tree stand: 68+ years.

The site is a poor, low hill, VT. According to the cores from fire-damaged standards, the time of the fire was 77 years ago. The clone is independent.

No. 77. Karjalohja; Härjänvatsa, Vikkarainen.

Size of clone: 27 m (1963).

Age of tree stand: 73+ years, from a stump.

The site is a rich forest area at the foot of a rock that is located at the edge of a field. An even-aged stand has developed after a fire. The clone is in part mixed, but easily distinguishable, a rare brown type.

No. 78. Rantasalmi; Kolkonpää, near the Parkuinmäki—Mikkeli road junction.

Size of clone: 27 m (1965).

Age of tree stand: 64+ years.

The site is a stand which has arisen after burning for crops, MT. The clone is independent.

No. 79. Pyhtää; between the Kotka—Loviisa highway and Purola—Länsikylä road junction.

Size of clone: 27 m (1965).

Age of tree stand: 98+, 75+ years, and younger.

The site is a depression between rocks, VT. The area has burned 78 years ago. The clone is independent, of a brown type. In the same area at the edge of the road there is a 29-m clone which has probably been reduced by fire and road work.

No. 80. Sammatti; vicinity of Lohilampi.

Size of clone: 28×27 m (1964).

Age of tree stand: 67+ years.

The site is VT-MT. The stand has arisen after a fire. According to the boundary between growth periods which appears in the stumps and annual rings of the standards examined, the time of the fire was 81 years ago. The clone is detached.

No. 81. Pielisjärvi; Pankakoski—Inari highway, km-post 20—38.

Size of clone: 28 m (1965).

Age of tree stand: 107+ years.

The site is the side of the road, VT. There was a fire 85 years ago, one of the traces of which is a younger tree generation. In the annual rings of a sample tree, the summerwood remained undeveloped during the fire year. The clone is the only one in an extensive area.

No. 82. Karjalohja; Karkalinniemi nature park.

Size of clone: 28 m (1965).

Age of tree stand: 78+ years.

The site is a slope situated between rock formations, VT-MT. In the annual rings of a nearby 179+ year old standard, a distinct boundary between growth phases was formed 80 years ago and also 99 years ago. In both cases, a period of poor growth begins. The 78+ year-old tree generation has arisen after a fire. There are old fields burned for crops in the vicinity. The clone is detached.

No. 83. Jyväskylä Rural District; Jyväskylä—Kuopio highway, about km 4.

Size of clone: 28 m (1965).

Age of tree stand: 78+ years.

The site is VT. The stand has arisen after the fire which, according to the core from a 131+ year old standard, occurred 83 years ago. This tree is situated at the apparent borderline of the fire and a abrupt transition to good growth has occurred at that time. The material contains other similar cases. The clone is detached.

No. 84. Sääminki; Särkilahti—Lohikoski highway, km-post 46—15.

Size of clone: 29×27 m (1964).

Age of tree stand: 73+ years.

The site is VT, a pasture area. An even-aged stand of pines has probably arisen after a fire, but it has not been possible to determine the exact time. The clone is one of the most special encountered in this investigation. At the date of its discovery, August 12, 1964, the pointed parts of *all* of the leaves, about 1/5 of the leaf blade length, were lemon yellow and changed abruptly into the summer green of the other part of the leaf. The same sort of yellowing and withering can be seen in the last developed parts of leaves when they have been injured by frost, but in these cases, the change occurs leaf by leaf, resulting from different times of development as well as the unevenness of the frost effect in different parts of the stand. There was no frost damage in the neighboring vegetation units either. A curled-up shape is also connected with the yellowing of the tips of leaves damaged by insects, but the leaves of the clone in question were structurally normal from base to tip. The extensive stand in the vicinity were green, and only in the driest places were they in the initial phase of uneven yellowing.

To examine the permanence of this special color characteristic, a visit to the same place was paid a year later August 11, 1965. At this time the leaves of bracken everywhere in south and central Finland were generally of a less vivid color than in the previous year. The same feature was also confirmable in the stand which was the object of examination. The tip parts of the leaves were just beginning to turn yellow and among them were leaves which were completely green. Here and there, however, were leaves which were colored in the same fashion as in the previous summer. The color was but of a warmer hue. The leaves in other stands were almost fully green.

This interesting clone would deserve further study.

No. 85. Karttula; Lyytikälä—Karttula highway, km-post 15—12.

Size of clone: 29 m (1965).

Age of tree stand: 82+ years, from a stump.

The site is a pasture glade (MT), which has also been used for the storage of timber. It may have earlier been burned for crops. The even-aged stand of pines beside this place has arisen after a fire, but a more exact determination of the time of this occurrence is impossible. The clone is independent and the only one in an extensive area.

No. 86. Kitee communal center; vicinity of Kunonniemi road junction, km-post 72—77.

Size of clone: 29.5 m (1965).

Age of tree stand: approx. 50 years, standards 100+ years.

The site is VT, formerly burned for crops. There is a resinous ring in a standard's series of annual rings at 60 years ago and a sharp boundary between two periods of growth 84 years ago. The present tree stand has probably arisen after a more recent fire, while the bracken clone dates from a preceding older fire. The clone is independent.

- No. 87. Korpilahti; Ehikki—Korpilahti highway, vicinity of Korpiaho road junction.
Size of clone: 29.5 m (1965).
Age of tree stand: 118+ years, standards.
The site is VT. The period of thin rings in the borings 87 years ago may have been caused by a fire. The clone is independent and split by the highway.
- No. 88. Noormarkku; Pori—Noormarkku highway, about 10 km.
Size of clone: 29.5 m (1965).
Age of tree stand: 85+ years, from stumps.
The site is the edge of a swampy depression, a mixed pine and spruce forest on VT. The stand has arisen after a fire. The clone is independent and distinct in its individual characteristics: a light type with dark nectaries and streaks. A suitable place to visit.
- No. 89. Mynämäki; Hinnerjoki—Mynämäki highway, about 3 km.
Size of clone: 30 m (1965).
Age of tree stand: 105+ years.
The site is the side of the road, VT. A fire apparently occurred 89 years ago, at which time a thin ring suddenly formed in the series of annual rings of the sample tree. Detached clone.
- No. 90. Lohja; the area between the trotting course work site and the Hanko railway.
Size of clone: 30 m (1964).
Age of tree stand: 78+ years.
The site is VT. According to the borings of standards in the surroundings, there was a fire in the area 90 years ago. The stand is to a large extent even-aged. Three other 30-m clones have been measured in the same area.
- No. 91. Snappertuna; Lohja—Tammisaari highway, the border area between the Karjaa and Snappertuna communes.
Size of clone: 30 m (1965).
Age of tree stand: 80+ years.
The site is a rich forest depression. According to the borings of fire-damaged trees in the surrounding area and the examination of the stumps found at this site, the stand has arisen after a fire which apparently occurred 94 years ago. The clone is detached. In the vicinity there are three other stands of the same size class, 30, 32 and 36 m, but they may also be fragments of a more extensive entity. The distinguishing marks were not distinct.
- No. 92. Nummi; Leppäkorpi, Santsillanmäki—Sulittu.
Size of clone: 30 m (1965).
Age of tree stand: 139+ years, from a standard, dominant generation 72+ years.
The VT site is located between rocks. Based on tarring and a margin between growth phases in the annual rings of a standard, there was a fire 87 years ago. The clone is detached.

Other clones of the same size class

- Kiikala; Silva, the airfield road junction.
Size of clone: 22 m (1946).
Age of tree stand: 65+ years.
The site is on a sand bank of Varesjoki. A period of broad rings began 62 years ago in the core of a sample tree. It remained uncertain, however, whether or not a fire occurred at this

time. The same phase margin was encountered in swamp pines in the vicinity, and again at a distance of about 1 km. In these cases, however, the change between broad and narrow annual rings was the opposite of the former. One end of the bracken growth is on a steep precipice which has been dug up by animals, and here some stray leaves were found. It appeared as if they had broken off from the sharp point of the stand, and, therefore, the true size of the stand is not completely clear. The clone is independent.

Yläne; Vaskijärvi, at the boundary of the nature park area.

Size of clone: 22 m (1964).

Age of tree stand: an ocular estimate, approx. 50 years.

The site is a spruce swamp, which probably burned before the birth of the present stand. The time of the fire occurrence remains unexplained.¹ The clone is independent.

Snappertuna; Lohja—Tammisaari main highway in the vicinity of the border of Karjaa commune.

Size of clone: 23 m (1964).

Age of tree stand: 80+ years.

The site is poor VT at the border of a spruce swamp. The pattern of a cross-section of the tree stumps is like gingerbread. This form began to develop 64 years ago, at which time a boundary between growth phases also took form. The stumps of trees felled a few years before the study show a break between the rings at this point. The extent of the bracken stand, according to other data, corresponds exactly to the 64-year age. The clone is detached, but it may be a fragment of a more extensive entity. The identification characteristics are weakly discernible in the stunted leaves.

Säkylä; Yläne—Säkylä highway, km-post 64—14.

Size of clone: 24 m (1964).

Age of tree stand: 128+ years, chequered with younger trees.

The site is VT at the border of a pine swamp. The upland forest area has burned frequently, according to the borings, most recently 67 years ago. On the basis of the individual characteristics, this detached bracken clone is either a fragment of a 52-m stand, or else there happen to be side by side two clones possessing the same individual characteristics. The 52-m size links up rather well with the age of the trees left standing after logging when the height of the boring and the addition for the regeneration period are taken into consideration in the reading of the 128-year age. On the other hand, it should be taken into account that a more extensive entity has possibly been reduced in fires, in which case the size is perhaps not at all authentic. Checking this requires other criteria, for which, in this connection, sufficient possibilities do not exist. Problems of the same nature generally arise in connection with the study of the dimensions of large clones. Ideal cases, in which replicates of the same size furnish strong support for determining the situation are comparatively rare. *The next possibility is then to compensate for the lacking replicates by substitutes: the possible parallel cases.*

Halikko; Marttila—Salo highway, km-post 10—1.

Size of clone: 25 m (1965).

Age of tree stand: 74+ years.

The site is pasture land, VT-MT. In a core, a period of poor growth can be seen 67 years ago, but there is no certainty of a fire. The place has previously been burned for crops. The clone is independent, at the junction of the highway and a household road.

¹ Boring in 1965 dated the fire 66 years ago.

Lapua; Simsiönvuori.

Size of clone: 26 × 24.5 m (1965).

Age of tree stand: 56+ years.

The site is a defile in a rock formation, VT. As the stand has been treated with selection cutting, it remained unclear whether or not the oldest sample tree represents the oldest of its generation. In the area of this rock formation fires have apparently occurred 65 and 77 years ago, partly on different sites, but it proved to be an overwhelming task to outline their limits. The clone is detached.

Kirkkonummi; Porkkala, vicinity of the relay station.

Size of clone: 26 m (1965).

Age of tree stand: a rock forest of varying age, oldest tree 206+ years, following generation 112+ to 103+ and younger.

The site is on an MT slope located on the lower slope of a rock formation. Fires have been frequent in the area and the sample trees, which are quite close to each other, yielded conflicting boring results. The following alternatives are mainly relevant: 67, 72, and 83 years ago. Clone in mixed stand.

Pielisjärvi; Koli, experimental forest of the Forest Research Institute.

Extent of clone: 27 m (1965).

Age of tree stand: 47+ years.

The site is an OMT slope which has been burned for crops. It was not possible to determine the time of burning or of a wildfire. The clone is by itself at the road junction of the experimental station.

Säkylä; Yläne—Säkylä highway, km-post 66—12.

Size of clone: 28 m (1965).

Age of tree stand: a clear-cut area with seedlings, around which the stand is 73+ years old.

The site is VT. Although the forested portion of the upland area has arisen after a fire, it was not found out whether the same wildfire visited the clear-cut area. Here there are also other stands, partly very open and fragments, the characteristics of which are weak due to the stunted growth of the leaves. The characteristics of the leaves of this clone are, nevertheless, the same throughout, so that it appears possible that its birth is connected with the same fire which has caused the regeneration of the neighboring forest.

Sulkava; Linnavuori road, vicinity of the terminal point.

Size of clone: 29 m (1965).

Age of tree stand: 65+ years.

The site is a former field burned for crops surrounded by a stand treated with selection cutting. The time of a wildfire or of the burning for crops is unknown. The clone is independent; thus, its minimum age is approx. 75 years.

824. Size class 31—40 m

Representative clones

No. 93. Karjalohja; Härjänvatsa.

Size of clone: 31 m (1963).

Age of tree stand: 80+ years.

The site is the transition zone between an OMT depression and a VT area mixed forest of spruce, pine and birch treated with selection cutting. An area formerly burned for crops, treated as a complex of small patches rather than a larger entity. The age reading is from the stump of a spruce which was felled some years earlier, thus the tree may have arisen about 90 years ago after a wildfire or burning for crops. Afterwards there has been no wildfire at this place. The clone is of an exceptional brown type, the patch detached, fragmented.

No. 94. Pusula; Mäkkylä, vicinity of Kaukela fork.

Size of clone: 31 m (1965).

Age of tree stand: 71+ years.

The site is VT, the border area of a gravel pit. The present stand has arisen after a wildfire which occurred 79 years ago. According to the cores from standards in the vicinity, the previous fire visited the area 93 years ago. The clone is independent.

No. 95. Sulkava; vicinity of Linnavuori.

Size of clone: 31 m (1965).

Age of tree stand: 113+ years.

The site is VT. There was a fire apparently 91 years ago, at which time a thin ring was suddenly formed in the series of annual rings of a sample tree. The unit is situated at the edge of a tree stand, outside of which are younger stands. An area formerly burned for crops. The clone is detached.

No. 96. Kiihtelysvaara; Huhtilampi—Kiihtelysvaara highway, km-post 30—42.

Size of clone: 31 m (1965).

Age of tree stand: 70+ years.

The site is situated between the highway and the bank of a pond. Forest of varying age and treated with selection cuttings is on the other side of the road. The oldest trees have probably been selected and cut. The clone is independent.

No. 97. Keikyä; Keikyä—Huittinen highway, about 1 km.

Size of clone: 31.5 m (1965).

Age of tree stand: 81+ years.

The site is the margin of a rock formation and a spruce swamp, VT. The stand has arisen after a fire, but the exact time of the fire was not determined because there was nothing left of the older stand. Independent clone.

No. 98. Sipoo; Spjutsund road, about 5 km from the Helsinki—Porvoo main highway.

Size of clone: 31.5 m (1965).

Age of tree stand: 117+ years, young generation 62+ years.

The site is VT-MT. There apparently was a fire 94 years ago, at which time a period of growth characterized by thin rings began in the sample trees. The clone is detached.

No. 99. Kuru; Kuru—Kihniö highway, about 3 km.

Size of clone: 32 m (1965).

Age of tree stand: 80+ years.

The site is a slope formerly burned for crops, MT. It was not possible to determine the exact time of a fire or of burning for crops. The clone is detached.

No. 100. Somerniemi; Liesjärvi, National Park.

Size of clone: 32 m (1964).

Age of tree stand: the oldest trees left standing after cutting 312—322+ years, the following generation 160—176+ years, the rest 139+ and younger.

The site is VT in a depression of a rock formation. A wildfire 92 years ago. A duplicate is located on the opposite side of a narrow pine swamp (another 32-m clone measured in 1965); in fire-damaged trees, there is a period of poor growth 92 years ago. Both clones are detached.

No. 101. Karjalohja; Lönnhammar.

Size of clone: 32 m (1964).

Age of tree stand: 119+ years.

The site is a depression in a VT area. According to fire-scarred trees, there was a fire 93 years ago. In individuals with slightly folded butts, tarring and a boundary between different growth phases occur at the same point. The clone is detached.

No. 102. Tammela; the vicinity of Saari Public Park.

Size of clone: 32 m (1964).

Age of tree stand: 154+ years and younger.

The site is VT, which, according to the bored, damaged trees, and the stumps, burned 92 years ago. An exactly same-sized replicate of this clone was measured in the area. The smaller diameter of a 35-m fragment is also 32 m.

No. 103. Lohja; vicinity of the trotting course work site.

Size of clone: 32×31 m (1964).

Age of tree stand: 78+ years.

The site is VT. According to some cores from fire-damaged standards nearby, the even-aged stand has arisen after a fire which visited this place 95 years ago. The clone is detached.

No. 104. Somerniemi; Oinasjärvi.

Size of clone: 32 m (1965).

Age of tree stand: 109+ years and younger.

The site is VT-MT. According to the fire-damaged trees, there was a fire 93 years ago, at which time a growth period of thin rings began. The clone is detached. In the same area there are three other 32-m clones, one of which is possibly a fragment of a more extensive entity.

No. 105. Sulkava; Sulkava—Puumala highway, km-post 35.

Size of clone: 33 m (1965).

Age of tree stand: 82+ years.

The site is the edge of the highway. The clone grows there in the form of a semicircle. The clone is independent. The exact time of the blaze was not revealed.

No. 106. Lapua; Simsiönvuori.

Size of clone: 34.5 m (1965).

Age of tree stand: 90+ years.

The site is an OMT depression between rock formations. The exact time of the fire could not be determined. The clone is detached.

No. 107. Tohmajärvi; Uusi Värtsilä—Tuupovaara highway, km-post 5—27.

Size of clone: 35 m (1965).

Age of tree stand: 94+ years.

The site is the side of the road, an OMT rock gully. The stand has arisen after a fire. The clone is independent.

No. 108. Punkaharju; Laukansaari, experimental forest of the Forest Research Institute, the so-called *Montell's* larch stand.

Size of clone: 35×30 m (1964).

Age of tree stand: 87 years, according to the posted table of the sample plot.

The site is an OMT bank of mineral soil. The larch stand was, according to HEIKINHEIMO (1958), founded in 1877 on a field burned for crops. There is no mention in this description of the time the field was burned. The clone's smaller diameter corresponds, judging by the other data, exactly to the age of 87 years, while the larger one implies birth about 100 years ago. It is a suitable clone to visit, although the clone's individual characteristics are very commonplace. The clone is detached, situated behind the posted table of the sample plot. The other clones examined in this area are quite extensive, for the most part mixed and difficult to delimit. In the vicinity, at Seppälänmäki, there is, however, an especially dark-stalked clone which is fragmented, but whose limits are easy to determine (90 m).

No. 109. Juupajoki; Hyytiälä, Sudenkytö.

Size of clone: 35×30 m (1964).

Age of tree stand: standards 276+ years.

This clone is from the material collected by REIJO MIETTINEN, a forestry student, who acted as research assistant. The site is the edge of a spruce swamp, which, according to the evidence of borings from fire-scarred trees (charring, tarring, and a period of growth of especially thin rings), burned 103 years ago. Independent clone.

No. 110. Sammatti; vicinity of Lohilampi.

Size of clone: 36 m (1965).

Age of tree stand: 105+ years.

The site is VT. According to the results of borings of butt-folded and fire-scarred standards on the rock formation beside this place (tarred, rings, charring, and a period of growth of thin rings), the area burned 110 years ago. Detached clone.

No. 111. Pohja; vicinity of Raasepori railway station.

Size of clone: 36 m (1965).

Age of tree stand: 89+ years.

The site is VT. According to the evidence of borings from fire-scarred standards in the vicinity, the area burned 109 years ago. The clone is detached. Nearby, another 37-m clone has been measured, which has especially good individual characteristics (brown petiole). It may, however, be a fragment of a more extensive entity which has been shattered into several parts. Also, near this clone there are old, fire-damaged rock trees, in the annual rings of which there is a distinct margin between growth periods at 109 years ago. These areas have burned frequently.

No. 112. Tammissaari; Hagen park.

Size of clone: 36 m (1965).

Age of tree stand: 134+ years.

The site is a herbaceous forest slope. According to the borings of butt-folded trees, there apparently was a wildfire 108 years ago. The clone is detached, of a type which is very light in color. In the same area there is a 38-m clone.

No. 113. Tenhola; Prästkulla road, km-post 7—7.

Size of clone: 36 m (1965).

Age of tree stand: standards 178+ years.

The site is the side of the road, VT. The area has burned frequently, probably 98 or 109

years ago, as well as later on. The boring evidence is from trees on the rock beside this place. The clone is partly mixed.

No. 114. Tammela; vicinity of Saari Public Park.

Size of clone: 36 m (1964).

Age of tree stand: hold-overs 147+ years, dominant generation 105+ years.

The site is VT. According to the borings of fire-scarred trees, there was a fire 108 years ago. The clone is detached. Two other 36-m clones and a 38-m clone have been measured in the area.

No. 115. Kaavi; Sivakkavaara—Kaavi highway, km-post 65—3.

Size of clone: 37.5 m (1965).

Age of tree stand: hold-overs 116+ years, and younger trees.

The site is the border of an upland area and a spruce swamp, pasture land, VT-MT. According to the borings, there was a wildfire or a period of burning for crops 111 years ago. Independent clone.

No. 116. Kirkkonummi; Obbnäs.

Size of clone: 37.5 m (1965).

Age of tree stand: 152+, 96+, and 58+ years.

The site is a defile in a rock formation, VT. Judging by resinous rings and a margin between growth periods, there was a fire 111 years ago. The clone is independent.

No. 117. Tenhola; Tenhola—Perniö highway, km-post 25—87.

Size of clone: 37.5 m (1965).

Age of tree stand: hold-overs 200+, 121+, dominant generation about 30 years.

The site is sandy, poor VT. The area has burned frequently according to the borings of the standards, for instance, 114 and 85 years ago. The clone is independent. In a depression in the same area, there is a 34.5-m independent clone which may be reduced from larger unit.

No. 118. Loviisa; Fort Rosen.

Size of clone: 38 m (1965).

Age of tree stand: 90+ years, from stumps of the oldest trees.

The site is a stony hill beside the wall of the fort, OMT. The size of the clone points to the time of the Loviisa fire (1855). Another unit of the same size class, 36 m, has been measured in the vicinity. The stand is 90+ years old at this place, too. Both clones are detached.

No. 119. Sauvo; Kemiö—Sauvo highway, about 1 km from the ferry.

Size of clone: 38 m (1965).

Age of tree stand: the old stand 141+ years, the young generation 48+ years.

The site is VT and has burned frequently, for example, 113 years ago. The clone is detached.

No. 120. Tammissaari Rural District; Källvik.

Size of clone: 38 m (1964).

Age of tree stand: 208+, 130+ years and younger.

The site is a VT slope situated between rock formations. According to the cores from fire-damaged trees, there was a fire in the area 114 years ago. The clone is detached. Two other 38-m clones have been measured in the area.

No. 121. Siuntio; the Grönberga area at the borderline of the commune of Lohja.

Size of clone: 38×34 m (1964).

Age of tree stand: 94+, 60+, and older hold-overs of varying ages on the surrounding rock formations.

The site is VT. According to the borings at various places in the surrounding area, there apparently was a fire 112 years ago. In the area there is one replicate (38×27 m), and there are also two 38-m occurrences which probably are fragments of a larger entity.

No. 122. Kirkkonummi; Porkkala.

Size of clone: 39 m (1965).

Age of tree stand: 112+ years.

The site is a VT-MT slope. According to boring from a standard (206+ years) in the nearby area, there apparently was a fire 116 years ago. The clone is detached.

No. 123. Ilomantsi; Ilomantsi—Nehvonniemi highway, km-post 8—13.

Size of clone: 39.5 m (1965).

Age of tree stand: 140+ years and younger.

The site is VT-MT. According to cores, it burned 119 years ago. Independent clone.

No. 124. Kiiikala; Iso-Kolasiinjärvi.

Size of clone: 40 m (1965).

Age of tree stand: 110+ years.

The site is a musty gully, VT-MT. According to the boring of a 129-year old standard, a wildfire visited this place 119 years ago. Limited by the shore of the lake, the clone may be to some extent unauthentic in size. The unit is detached.

No. 125. Somerniemi; Oinasjärvi.

Size of clone: 40 m (1965).

Age of tree stand: 109+ years.

The site is VT. The even-aged stand has arisen after a fire. It was not possible to determine the exact time. The clone is detached.

No. 126. Pohja; Ekerö, vicinity of Raasepori railway station.

Size of clone: 40 m (1965).

Age of tree stand: 161+, 105+, and 81+ years.

The site is VT, at the boundary of a former fire area. Judging by borings both here and at several other places in the surrounding area, there was a rather extensive wildfire 114 years ago. The clone is independent.

No. 127. Viitasaari; Suovanlahti.

Size of clone: 40 m (1965).

Age of tree stand: 166+ and 102+ years.

The site is VT. According to borings, there was a fire 117 years ago. The clone is detached. In the same area is a 46×45-m clone whose birth may be connected with a fire that occurred 135 years ago. This clone is also detached.

No. 128. Kuhmoinen; Kuhmoinen—Puukkonen highway, about 8 km.

Size of clone: 40 m (1965).

Age of tree stand: 100+ years.

The site is on a side of the road. The even-aged stand probably regenerated after a fire, the exact time of which could not be determined. The clone is detached.

Other clones of the same size class

Inkoo; Mustio, Stormora.

Size of clone: 32 m (1964).

Age of tree stand: 78+ years.

The site is MT. The even-aged stand probably arose after a fire 93 years ago. Independent clone.

Karjaa; Kaskimaa.

Size of clone: 32 m (1965).

Age of tree stand: approx. 35 years.

The site is VT. The present stand has arisen after a fire. Judging by borings from different points in the surroundings, there may have been a fire before this, 94 or 98 years ago. The clone is independent.

Lappee; Ylämaa—Lappee highway, about 15 km from the Ylämaa borderline.

Size of clone: 33.5 m (1965).

Age of tree stand: 77+ years.

The site is VT. The even-aged stand probably arose after a fire. It was not possible to determine the exact time of this. The clone is detached.

Rantasalmi; Tammenlahti.

Size of clone: 34 m (1965).

Age of tree stand: 76+ years.

The site is an OMT area which has formerly been burned for crops. It was not possible to determine the exact time of the wildfire or of the burning for crops. The clone is detached.

Somerniemi; Liesjärvi.

Size of clone: 35 m (1965).

Age of tree stand: 36+ years.

The site is VT-MT. According to borings in the surroundings, a wildfire may also have visited this place 95—97 years ago. The clone is independent.

Sauvo; Kemiö—Sauvo highway, km-post 15—23.

Size of clone: 35 m (1965).

Age of tree stand: 79+ years.

The site is VT-MT. The stand has arisen after a fire. The time of this is undetermined. The clone is mixed.

Inkoo; Stormossen.

Size of clone: 36 m (1965).

Age of tree stand: 127+ years.

The site is a depression in a rock formation, VT. There was possibly a fire 100 years ago, at which time a margin between growth periods formed in the series of annual rings of the sample trees. The stand is limited by the rock formation, so the authenticity of its size cannot be considered certain. The clone is independent.

Ruovesi; Ruhala-Mänttä highway, about 16 km.

Size of clone: 37 m (1965).

Age of tree stand: 87+ years.

The site is VT. The stand may have arisen after a fire. Time undetermined. The clone is detached.

Viljakkala; Kuru road junction, about 6 km from the communal center.

Size of clone: 37 m (1965).

Age of tree stand: 84+ years.

The site is the edge of a forest at the border of a field and the highway. The stand probably arose after a fire, but it was not possible to determine the exact time of this. The clone is independent, clear in its individual characteristics.

Pyhtää; Kotka—Loviisa highway, about 2 km from Pyhtää communal center road junction in the direction of Loviisa.

Size of clone: 38 m (1965).

Age of tree stand: 85+ years.

The site is VT. Judging by charred stumps, the stand has arisen after a fire. It was not possible to determine the exact time of the fire. The clone is independent.

Somerniemi; Liesjärvi, National Park.

Size of clone: 38 m (1964).

Age of tree stand: 139+ years.

The site is VT. There are also two 36-m clones in the vicinity. These are all close to a field which has probably been burned for crops at its earliest stage. In the core bored from a nearby sample tree, there is a margin between growth phases at a point 103 years ago, but it is not clear whether this is the result of a fire. This margin does not exist in the cores from fire-scarred trees at a greater distance; instead, there is a margin at 111 years ago, which in certain trees indicates a marked decrease of growth, while in neighboring trees (at the edge of a pine swamp) some tens of meters away, an opposite change in growth was observed. Whether the fire 111 years ago extended to the site of the clones cannot be decided on the basis of the sample material at hand. In the light of other data, the 38-m size corresponds well to the time that has elapsed since this fire.

Kuhmoinen; Vehkajärvi—Torittu highway, 10 km.

Size of clone: 38.5 m (1965).

Age of tree stand: 88+ years.

The site in VT. The tree stand has arisen after a fire but it has not been possible to determine the exact time of occurrence. The clone is detached.

Pyhämaa; Tuorlahti, about 13 km from Uusikaupunki.

Size of clone: 39 m (1965).

Age of tree stand: 92+ years.

The site is a forested glade at the side of the road. It was not possible to determine the time of a fire or of burning for crops. The clone is independent.

Kuusjärvi; Varislahti—Rikkaranta—Outokumpu highway, Rikkaranta village.

Size of clone: 40 m (1965).

Age of tree stand: estimated approx. 50 years.

The site is a field burned for crops that has become forested. It was not possible to find links to this burning or to a time of a fire. An especially distinct independent unit in its individual characteristics.

825. Size class 41—50 m

Representative clones

- No. 129. Lohja; Keskilohja, vicinity of the railway.
Size of clone: 41 × 35 m (1965).
Age of tree stand: 87+ years.
The site is VT-MT. According to cores taken from standards at different places in the surrounding, the area probably burned 114 years ago. The clone is independent. In the same stand there is a 40-m duplicate, also independent.
- No. 130. Kuusjärvi; Outokumpu.
Size of clone: 41 m (1965).
Age of tree stand: hold-overs 111+ years, dominant generation 70+ years.
The growing place is the bank of a pond, VT-MT. According to the borings, the last fire occurred 74 years ago, but it was not possible to date fires earlier than this one with any precision. The clone is independent.
- No. 131. Somerniemi; Marttila—Somerniemi highway, km 23.
Size of clone: 41 m (1965).
Age of tree stand: 100+ years and younger (the stand has been cut selectively).
The site is MT. The place has been burned for crops, but the time of burning or of a wild-fire could not be determined. The clone is independent.
- No. 132. Säskylä; Oripää—Säskylä highway, km-post 16—1.
Size of clone: 41 m (1965).
Age of tree stand: 108+ years.
The site is VT on poor and stony ground. The tree stand has probably arisen after a fire, but the exact time of this occurrence could not be determined. The clone is independent.
- No. 133. Valkeala; the road between Harju and Multahovi at the borderline of Valkeala and Kuusankoski.
Size of clone: 42 m (1965).
Age of tree stand: 130+ years.
The growing place is the side of the road. The last fire occurred 121 years ago. The clone is independent.
- No. 134. Sulkava; the area of Scout training center.
Size of clone: 42 m (1965).
Age of tree stand: 111+ years.
The site is VT. The tree stand has arisen after a fire. The clone is independent.
- No. 135. Hamina; Vilniemi, in the vicinity of the city beach.
Size of clone: 42 m (1965).
Age of tree stand: approx. 130 years (disintegrated sample).
The site is poor VT. Judging by resin formation and a boundary in the annual ring series, there was apparently a fire 119 years ago. The clone is independent.
- No. 136. Turku; Ruissalo.
Size of clone: 42 m (1965).

- Age of tree stand: hold-overs in the immediate surroundings are 128+ years. The dominant generation is roughly 30 years old.
The clone grows at the edge of a field. The OMT site has been burned for crops. A fire apparently took place 119 years ago, at which time the tree stand on the nearby rock was damaged. The clone is independent. In the public park area, a 43-m clone has been found which is especially distinct in its identifying characteristics; however, this could not be exactly linked to time. The oldest trees on the site are 99+ years old.
- No. 137. Lohja; Ojamonkangas.
Size of clone: 43 m (1965).
Age of tree stand: 118+ years.
The growing place is the elbow of a ridge and the site VT. A tree stand of even age has arisen after a fire. In the vicinity, fires have occurred 120, 127, and 129 years ago; however, the determination of the boundaries between them was not possible. The clone is detached.
- No. 138. Vehkalahti; vicinity of the Vilniemi road junction.
Size of clone: 43 m (1965).
Age of tree stand: 137+ years and younger.
The site is VT-MT which burned 119 years ago. The clone is detached.
- No. 139. Vihti; Nummela, the vicinity of the airfield.
Size of clone: 43 × 39 m (1965).
Age of tree stand: 146+ years and younger.
The growing place is the slope of a ridge, the site, poor VT. According to the cores taken from trees damaged by fire, there was a wildfire in the area 126 years ago, and again 110 years ago. In the vicinity there are two replicates in the same size-class: 38 and 40 m. The clones are detached.
- No. 140. Ruovesi; Siikakangas, Moskulanmäki.
Size of clone: 44 × 40 m (1964).
Age of tree stand: hold-overs 165+, 137+, 116+ years and younger.
The site is VT. According to the cores from fire-scarred trees in the nearby area, there was a fire here 123 years ago. The clone is detached. This clone is from the data collected by REIJO MIETTINEN.
- No. 141. Jyväskylä Rural Commune; Jyväskylä—Kuopio highway about 4 km from Jyväskylä.
Size of clone: 44 m (1965).
Age of tree stand: 115+ years.
The site is VT. The area has burned in the earliest stages of the stand's development. The clone is detached.
- No. 142. Kiihala; Nummenharju.
Size of clone: 44 m (1965).
Age of tree stand: 117+ years.
The site is VT. The stand has arisen after a fire which occurred 125 years ago, according to the cores from fire-damaged pines located in the nearby pine swamp. The clone is independent. In the same area there is a 42-m unit (independent), and the shorter diameter of a larger clone is 45 m.

No. 143. Sauvo; Kemiö—Sauvo highway, km-post 12—23.

Size of clone: 46 m (1965).

Age of tree stand: 141+, 48+ years.

The site is MT and lies at the border of a field. According borings, there was a fire 126 years ago. The clone is detached.

No. 144. Kirkkonummi; Porkkala, in the vicinity of the relay station.

Size of clone: 46 m (1965).

Age of tree stand: 112+ years.

The site is VT-MT and the clone is in a defile between rocks. In the cores from standards on the nearby rocks, there is resin formation and a phase margin at 126 years ago. The clone is detached.

No. 145. Somerniemi; Oinasjärvi.

Size of clone: 46 m (1965).

Age of tree stand: 146+, 131+, and 71+ years.

The site is VT. The area burned 128 years ago in a wildfire extending over a wide area. The clone is independent. In the vicinity is a 46-m stand, which might, nevertheless, be a fragment of a greater entity.

No. 146. Tammisaari Rural Commune; vicinity of Källvik.

Size of clone: 47 m (1964).

Age of tree stand: 208+ years and younger.

The site is VT-MT. According to borings, there was a fire 129 years ago. The clone is detached.

No. 147. Heinola Rural Commune; Vierumäki—Heinola highway, about 2 km from Vierumäki Sports Institute.

Size of clone: 47×46 m (1965).

Age of tree stand: the oldest standard in the immediate area is 119+ years old, the dominant generation is younger.

The growing place is the slope of a ridge. VT. The area has burned before the birth of the oldest tree generation. The clone is independent.

No. 148. Pohja; Ekerö.

Size of clone: 48 m (1965).

Age of tree stand: 90+ years.

The site is a MT slope. According to the annual ring material bored out of trees at different places in the surroundings, a very extensive fire occurred in the area 134 years ago. The clone is detached.

No. 149. Yläne; the region between Eljjärvi and Vaskijärvi.

Size of clone: 50 m (1964).

Age of tree stand: 206+, 108+ years.

The site is poor VT situated on a rocky slope. According to the cores from fire-damaged trees, there was a fire in the area 146 years ago. The clone is independent.

No. 150. Sammatti; the vicinity of Lohilampi.

Size of clone: 50 m (1965).

Age of tree stand: standards 186+ years, the dominant stand 72+ years and younger.

The site is MT located at the base of a ridge. At this spot tar has been burned, the area has been burned for crops and probably also used as pasture. In its identifying characteristics, the clone is distinct with brown petioles. According to the borings of standards, fires have been frequent in the area and the determination of their boundaries is not possible. The samples examined from different places indicated, for their part, different times of occurrence. The nearest possibilities are the following: 137, 143, and 154 years ago. The middle figure is apparently correct because it has been obtained from the standards closest to the site in question. This was in a limited area, as its marks have not come forth elsewhere in the surroundings. At the same place there are two other units of the same size: 51×50 and 50 m.

No. 151. Pohja; vicinity of Raasepori railway station.

Size of clone: 50×33 m (1965).

Age of tree stand: standards 189+ years, dominant generation approx. 70 years.

The site is CIT-VT. The area was visited 164 years ago by a fire which also darted over the bracken site. The tree stand on the site is fire-scarred. The bracken probably arose after an earlier fire. The clone is independent. This area has burned frequently, probably also 141 and 94 years ago. The smaller diameter of the clone corresponds to the later time, and the larger one may also be reduced.

Other clones of the same size class

Kiikala; Hidaisenpyöli.

Size of clone: 41 m (1964).

Age of tree stand: standards 119+ years, there are also younger trees in the area.

The site is VT. The clone has become stunted under spruce undergrowth and broken up into fragments and open, dispersed units. It is reviving after thinnings carried out in the tree stand. The clone is detached. The last fires appeared 75 and 110 years ago. No information was gained on earlier fires, but the current standards probably arose after one of them.

Sippola; Utti—Hirvelä highway, about 12 km.

Size of clone: 44 m (1965).

Age of tree stand: 121+ years.

The growing place is a damp-bottomed depression at the side of a road. The site is VT-MT. The tree stand arose after a fire, but it was not possible to determine the date with precision. It is possible that this bracken stand is a fragment of a more extensive entity. The distinguishing marks on the stunted leaves are only weakly discernible.

Tammela; the area of Saari Public Park.

Size of clone: 46 m (1964).

Age of tree stand: estimated approx. 150 years and younger.

The site is an OMT gully. There are no boring samples available from this place. The annual ring series of the nearest sample trees indicate the possibility of fires 129 and 136 years ago. The clone is mixed. A 45-m clone has been measured in the same gully.

Kiikala; vicinity of Lamminjärvi.

Size of clone: 45 m (1964).

Age of tree stand: 86+ years and younger.

The site is VT and lies on the border between a narrow strip of spruce swamp and the firm land. According to the nearest fire-damaged standards, the following are possible dates of fires: 129 and 134 years ago. The clone is detached.

Tammisaari Rural Commune; Källvik.

Size of clone: 46 × 34 m (1964).

Age of tree stand: an old stand composed of trees of varying ages, 200—300 years.

The site is VT. There are no borings for this place. There was a fire nearby 129 years ago, and this could have extended to the site in question. The clone is independent and distinct in its autumnal coloring.

Pusula; Mäkkylä.

Size of clone: 46 m (1964).

Age of tree stand: 68 years (the stand arose after a fire that time ago).

The site is VT. There are no cores available for this place; however, a time of fire 132 years ago was obtained from a fire-damaged individual (165+ years old) in a group of standards situated in the area of the last fire, about ½ km from the clone. In the basis of other data, this time corresponds nicely to the 46-m diameter of the bracken unit. The clone is independent.

Kitee; stand of larches, the Forest Research Institute's experimental forest.

Size of clone: 48 m (1965).

Age of tree stand: 123 years (the stand was planted in 1842 or 1843, cf. PALOSUO 1938).

The site is VT and was probably burned for crops before the larch stand was established. According to other material, the burning was probably 135—145 years ago. This clone is the smallest measured in the stand.

Kiikala; area between the airfield and Varesjoki.

Size of clone: 50 m (1964).

Age of tree stand: 149+ years and younger.

The growing place is the margin of a slope and the floor of a funnel-shaped valley, VT. According to the borings of fire-scarred standards, there was a fire in the area 143 years ago (distinct charring). The sample tree is not near enough to the bracken stand, and because fires have occurred frequently and in chequered pattern in the vicinity, it is important that the determinations are taken on exactly the same spot. The clone is independent.

Kerimäki; Mäkrä island, the Forest Research Institute's experimental forest.

Size of the clone: 50 m (1962).

Age of tree stand: estimated approx. 130 years, a younger generation about 90 years old.

The growing place is the border between a narrow strip of spruce swamp and firm VT-MT forest land. According to SARVAS' (1962, p. 10, Table 1, sample plot XXXIII) studies on the even-aged pine stand on the opposite side of this narrow depression, it was 143 years old in 1959 (i.e., 146 years old in 1962). The tree stand has arisen after a fire. It is possible that this fire also extended to the depression in question. The clone is detached. At the same place a duplicate (approx. 50 m) has been delimited from a stand of mixed clones. Also, the shorter diameter of a 58-m unit is 50 m. In 1964 R. MIETTINEN, who served as assistant, independently recorded a 57-m clone at the extreme end of the same depression. The area has been burned for crops and used as pasture.

826. Size class 51—60 m

Representative clones

No. 152. Karjaa; Kaskimaa.

Size of clone: 51 m (1965).

Age of tree stand: standards 182+, 133+, 120+ years, the dominant generation approx. 100 years and younger.

The site is VT situated between rocks. According to the cores from fire-damaged trees, there was a wildfire at this place 143 years ago. The clone is independent.

No. 153. Kangaslampi; Varkaus—Kangaslampi highway, about 6 km.

Size of clone: 51 m (1965).

Age of tree stand: standards 148+, dominant generation 110+ years old.

The site is VT. The clone is divided by the highway. It is a distinct specimen in its characteristics of identification, the petiole is an intermediate between dark and light in color. The clone is independent.

No. 154. Siuntio; vicinity of Grönberga at the border of Lohja commune.

Size of clone: 51 × 46 m (1964).

Age of tree stand: standards 214+, 201+, 170+, 139+ years, dominant generation 79+ years and younger.

The site is a VT-MT area surrounded by rocks. There have been forest fires frequently in the area; for instance, judging by the uniform evidence of the cores of fire-damaged trees at different spots, 145—7 years ago. The annual rings are tarred and so thin and vague that it was not possible to determine the exact year from the cores even with a microscope. The clone is detached. Four other 50—51-m clones have been measured in the same area, one of which is of the brown-stalked type. A part of these may be fragments of a larger entity.

No. 155. Vehkalahti; vicinity of the Vilniemi road junction.

Size of clone: 51 m (1965).

Age of tree stand: standards 137+ years, dominant generation 65+ years old.

The site is VT-MT. Judging by the evenness of age, the old stand probably arose after a fire. The clone is detached.

No. 156. Säskylä; Yläne—Säskylä highway, km-post 64—14.

Size of clone: 52 m (1965).

Age of tree stand: standards 128+ years old, dominant generation under 100 years old.

The site is VT, the edge of a pine swamp. The older stand has, with the exception of a few individuals, been thinned out by selecting, so that the remaining trees perhaps do not represent the oldest part of the forest generation in question. It was not possible to determine the time of the fire. The clone is independent and split up into fragments and open, dispersed vegetation units.

No. 157. Pohja; vicinity of the railway overpass at the side of the Koppskog—Åsenby road.

Size of clone: 52 m (1964).

Age of tree stand: 60+ years.

The site is at the border between a pine swamp and an upland forest area covered by lichens (VT). The cores from standards both in the upland stand and on the pine swamp con-

sistently indicate a fire 147 years ago. The bracken has been protected by the moisture at the edge of the swamp also in later fires, the most recent of which happened 38 years ago, but it was destroyed on the sandy heath, where it again appears to be spreading. The clone is detached.

No. 158. Somerniemi; Oinasjärvi.

Size of clone: 52 m (1965).

Age of tree stand: clear-cut area on the margins of which are standards 164+ and 131+ years old.

The site is sandy VT. There has been a fire in the area 155—157 years ago. The clone is independent and broken up because it has grown under a spruce stand. The wildfire was probably extensive because its traces were seen at a distance of several kilometers, as far as the regions of Kiiikala airfield and Johannislund. In the area between those places a number of 50—59-m clones have been measured, which nevertheless, have not been linked with time by borings from the same places.

No. 159. Anjala; Anjala—Kotka highway, Huruksela.

Size of clone: 52 m (1965).

Age of tree stand: the oldest part is 156+ years.

The site is barren VT underlain by rock. The stand has arisen after a forest fire. It has not been possible to determine the date of this occurrence. The clone is independent and broken up into fragments and sparse units.

No. 160. Luvia; Luvia—Pori highway, about 7 km.

Size of clone: 54 × 43 m (1965).

Age of tree stand: 157+ years.

The site is a damp depression on VT. The highway divides the stand. The old tree stand has probably arisen after a fire. The clone is detached and clear in its individual characteristics. A special feature are the projecting, droplike nectaries. A suitable clone for visiting.

No. 161. Pyhtää; Purola—Länsikylä road junction.

Size of clone: 54 m (1965).

Age of tree stand: standards 139+ years, younger stand 53+ years.

The site is VT and has probably burned at the birth of the old stand. The clone is detached.

No. 162. Turku; Ruissalo, the area of the invalid-home road junction.

Size of clone: 55 m (1965).

Age of tree stand: 128+ years and younger.

The site is VT at the foot of a rock. According to the core bored from a tree on the rock (169+ years), there was a fire in the area 157—158 years ago. The clone is independent and distinct in its individual characteristics: the petiole is brown, the puffed-up nectaries lighter in color than the petiole, and the leaf blade regular, levelly projecting. In the vicinity on an OMT site there is another unit of the same magnitude, 56 m. This one is also especially good in its individual characteristics: the petiole is light yellowish-brown and the nectaries are dark. The clone becomes mixed at one end with another, rather extensive clone of a light-colored type. Suitable for visiting.

No. 163. Sauvo; Kemiö—Sauvo highway, about 1 km from the ferry.

Size of clone: 55 m (1965).

Age of tree stand: 48+ years.

The site is VT. An old stand in the surroundings, 141+ years old, has probably arisen after a forest fire. The clone is detached, a form with a not very dense leaf structure. Subsequent fire have broken the clone into fragments (cf. no. 28).

No. 164. Yläne; Lautpaltta—Vaskijärvi forest road.

Size of clone: 58 m (1965).

Age of tree stand: 209+, 162+ years and younger.

The site is poor VT, which, according to the fire-scarred trees, has burned about 170 years ago (charring and discontinuity in the series of annual rings; exact determination of the year of occurrence was not possible). The clone is independent and in part broken up into a sparse vegetation unit. It should also be mentioned that two other 58-m clones have been measured at the side of Palmusuo forest road in the same commune. However, it has not been possible to make comparisons with the phases of development of the stand because all the old trees had been removed from this area.

No. 165. Sippola; Utti—Hirvelä highway, about 6 km.

Size of clone: 59 m (1965).

Age of tree stand: 150+ years.

The site is a VT-MT slope. Judging by its evenness of age, the stand has arisen after a wildfire. It was not possible to determine the time of the fire. The clone is independent.

No. 166. Ruovesi; Ruhala—Mänttä highway, about 8 km.

Size of clone: 60 m (1965).

Age of tree stand: 151+ years.

The site is VT, which has probably burned at the birth of the stand. It was not possible to determine the time of the fire. The clone is independent.

Other clones of the same size class

Sammatti; vicinity of Lohilampi nature reserve.

Size of clone: 51 m (1965).

Age of tree stand: approx. 35+ years old.

The site is VT-MT, which has probably burned at the birth of the even-aged pine stand (143—148+ years) in the Lohilampi nature reserve, in other words, at the time of the war for Finland (1808—09). According to the borings from damaged trees (tarring, charring, and a marked growth phase margin 155—157 years ago), the rock formations in the vicinity have also been touched by fire during this period. The clone was delimited from a mixed growth. Before the present tree generation, a forest dominated by spruce grew on this site. It should be mentioned that 50—53 m clones have been measured separately in the forests at the side of the road at a distance of about 4 km from here in the Sammatti—Karjalohja border area.

Tammela; the vicinity of Saari Public Park.

Size of clone: 51 × 50 m (1964).

Age of tree stand: 147+ years.

The site is a funnel-shaped depression in a VT area. The area has probably burned before the birth of the old even-aged stand, i.e., presumably during the war for Finland (1808—1809). The clone is independent. Two replicates are of the same size, 51 and 50 m; one of these is detached, the other mixed.

Tammisaari Rural District; Källvik.

Size of clone: 52 m (1964).

Age of tree stand: 264+ years and younger.

The site is a defile in a rock formation, VT. A fire probably occurred 158 years ago. Another 52-m clone has been measured in the area; in its vicinity, the time of the fire was estimated as 152 years ago. Both clones are detached. In the course of time, there have been so many disturbing cultural factors (e.g., tar burning) at work in the area, that the estimates are uncertain. Many of the most clearly damaged trees have been removed in cuttings, and, consequently, the determination of the fire time is affected by oscillations in growth due to other causes.

Yläne; Lautpaltta—Vaskijärvi forest road.

Size of clone: 53 m (1965).

Age of tree stand: standards 162+ years, and younger.

The site is an MT depression, apparently an area formerly burned for crops. There was probably a fire in the area 146 years ago, at which time a marked boundary between periods of growth was formed in the annual rings of a sample tree. From this time a period of especially thin rings begins. The stand older than the now dominant generation (approx. 70 years) has been almost completely removed in cuttings, so that its distribution among age classes at this place does not afford any help for the estimates. The clone is independent.

827. Size class 61—70 m

Representative clones

No. 167. Siuntio; Grönberga at the Lohja borderline.

Size of clone: 61 m (1964).

Age of tree stand: 70+ years.

The site is an area formerly burned for crops, located between rock formations, VT-MT. A 60 m replicate grows at the same place. Both are detached units. In the vicinity there is also a 58-m unit which is broken up into fragments. According to the borings of trees growing on the rocks on both sides of the defile, there was a fire in the area 170 years ago.

No. 168. Tammisaari Rural District; vicinity of Källvik, beside the Hanko railway.

Size of clone: 62 m (1964).

Age of tree stand: 247+, 208+ years, and younger.

The site is the border zone between a spruce swamp and a rock formation, VT-MT. Judging by the consistent growth periodicity of increment cores bored from several sample trees, there was a fire in the area 174 years ago. The clone is independent.

No. 169. Kiiikala; vicinity of Lamminjärvi.

Size of clone: 63 m (1965).

Age of tree stand: 170+ and 68+ years.

The site is on the border of a swampy depression and a poor VT area. The old, even-aged stand has arisen after a forest fire, possibly 180 years ago. The cores from trees of the older age class primarily point to this year. The clone is detached.

No. 170. Pohja; vicinity of Raasepori railway station.

Size of clone: 63 m (1965).

Age of tree stand: 200+, 183+, 143+ years and younger.

The site is the juncture of a steep, barren, lichen-covered slope of an embankment, slightly swampy due to a spring, situated lower down. The cores, taken from fire-damaged trees on the same site and the immediate vicinity consistently indicate a fire 176 years ago. In a sample tree which was a 10—15 year old seedling at the time of the fire, there is also distinct charring in the core at this point. The fire occurred during a war, the war of Gustaf III 1788—90 (large numbers of troops were moved through the area of the commune, cf. EKMAN 1900). There are other clones of the same size class in the immediate area, e.g., a 61-m clone near the Raasepori railway station, a 61-m individual at the margin of a pine swamp situated alongside the village road between Ekerö and Kaskimaa, as well as clones measuring 57 (of a darkish type) and 58 m located in the area between the Raasepori station and Gebbelby. All these are independent or detached occurrences. A 64-m unit delimited from a mixed stand in the vicinity of the representative clone constitutes an equivocal case in that the individual characteristics differ but slightly from each another on that barren site. The clone may, therefore, be somewhat larger.

Both the representative clone and its replicates nearby may, on the basis of their size, date from the birth of the over 183 year old part of the stand, apparently born after quite an extensive fire in the area.

No. 171. Pernaja; at the borderline of Loviisa, by the side of the highway.

Size of clone: 66 m (1965).

Age of tree stand: old trees in the area 177+ years, younger ones about 90 years.

The site is an MT gully in a barren and stony VT area. The old stand most likely sprang up after a fire, roughly 185 years ago. A 56-m clone has been measured in the vicinity (and a 55 m one at the Pohjois-Sarvilahti road junction), but the stand offered no possibilities for comparison. According to other data, this size points to the time of the War of Finland 1808—09. Both clones are detached.

No. 172. Yläne; Lautpaltta—Vaskijärvi forest road.

Size of clone: 66 m (1965).

Age of tree stand: oldest standard 209+ years, succeeding generation 162+ years.

The site is VT. There has been a fire in the area 190 years ago. At this point, in the stumps of the old trees, there is a distinct margin between growth periods, in a stump, blackening and a fissure between the annual rings were discovered. The clone is detached.

No. 173. Lammi; vicinity of Evo.

Size of clone: 68 m (1965).

Age of tree stand: 128+ years.

The site is VT-MT. In a 320-year-old standard on the nearby pine swamp (at the edge of the upland area) there is a marked boundary between growth phases at 190 and, especially, 210 years ago. A distinct fire scar developed about 236 years ago. According to other data the size of the clone best corresponds to an age of 190—210 years. The clone is independent and the highway divides it into two parts. The dominant stand has probably arisen after a fire which occurred 138 years ago or after a period of burning for crops.

No. 174. Siuntio; vicinity of Grönberga at the Lohja borderline.

Size of clone: 70 m (1964).

Age of tree stand: oldest standards 214+, succeeding generation 170—185+ years, and younger.

The site is a defile in a rock formation, VT. The oldest trees are damaged by fires at their butts and they have a sharp bend at a height of 1—2 m. According to the borings, there was

a fire on the rock formation 194 years ago. Judging by the even age, the oldest stand arose in due course after a forest fire. At the edge of a pine swamp in the vicinity is another clone of the same size class, 69 m.

828. Size class 71—80 m

Representative clones

No. 175. Säskylä; Yläne—Säskylä highway, km 65—13.

Size of clone: 71 m.

Age of tree stand: the old stand 247+ years.

The site is on the border of a swamp and an upland area (VT). According to boring, there probably was a fire 198 years ago, at which time a succession of markedly thin annual rings began. The clone is independent.

No. 176. Kiiikala; beside the junction of the Johannislund road to the airport.

Size of clone: 74 m (1965).

Age of tree stand: approx. 70 years.

The site is the side of the road, VT. The clone does not cross the road but has spread out in an arc from its edge. The identifying characteristics of the individual are exemplarily distinct: light petiole, dark nectaries, striations on the petiole running upwards and downwards from the nectaries; the hair-covering of the young, unopened leaves which rise from the ground is greyish. The clone is independent. The oldest stand has been removed, but from fresh stumps, an age of 195—200+ years was read. Some standards of the same age are to be found one by one over a relatively large area, quite an extensive wildfire has probably preceeded their birth. A 74-m clone has also been measured about one kilometer away, in the area half way between the Johannislund road junction and the airport, on the slope of a gorge-like, funnel-shaped valley. In its individual characteristics, it is also of a clear, brown-stalked type. The age of the oldest existing trees here (fire-scarred, but no clones correspond to the time of the fire) is 149+ years. A 59-m clone near the representative one corresponds to this age, but there are no traces of corresponding trees.

No. 177. Siuntio; Grönberga near the Lohja borderline.

Size of clone: 74 m (1964).

The site is a field formerly burned for crops, MT. The age of the stand on the nearby rocks is somewhat evenly 185—201+ years; here and there are also lone individuals about 220—230+ years old; the oldest trees found are 253+ and 280+ years old. According to the cores taken from these oldsters, there probably was a fire in the area 206 years ago. At this point there is a sharp borderline between growth phases, occurring consistently. In some trees, this is followed four years later by a series of unusually broad annual rings. The clone is detached. The shorter diameter of a more extensive clone in the area is 76 m.

No. 178. Kalanti; Laitila—Uusikaupunki highway, about 10 km.

Size of clone: 76 m (1965).

Age of tree stand: old stand 225+ years.

The site is VT in a rocky area. The old stand may have arisen after a fire. Independent clone.

No. 179. Tammisaari Rural District; Källvik.

Size of clone: 76 m (1964).

Age of tree stand: 247+ years.

The site is VT, which probably burned widely 225 years ago. The fact that there is a uniformly 209+ years old stand in the neighboring area also indicates this. On the rock formation, where traces of this fire are also to be found, is a 73 m clone, one of the extremities of which is limited by rock. Both units are detached.

No. 180. Yläne; Lautpaltta—Vaskijärvi forest road.

Size of clone: 77 m (1965).

Age of tree stand: oldest stand 209+ years.

The site is VT situated between rocks. The old stand has probably arisen after a fire. The clone is independent.

No. 181. Karjalohja; Härjänvatsa heath.

Size of clone: 78×75 m (1963).

Age of tree stand: approx. 70 years.

The site is a VT slope, burned for crops in the past. Tar burning has been carried on in many places in the vicinity. The age of the stand on the nearby rock formations is 210+ years, and an individual in the pine swamp beside this place is 238+ years old. The next class is 208—216+ years. According to boring, there was a forest fire in the area 220 years ago (charring and fracturing, as well as marked tarring). The clone designated as representative is especially well-defined in its individual characteristics: it has dark brown petioles and nectary axils which are marked with strong black scores. The clone is partly mixed. In the same area there are two replicates, 75 and 74 m. In its individual characteristics, the former of these is exemplarily distinct. It has narrow leaves, which remind the leaves of *Polypodium vulgare* in their leaflet structure. Phenologically this clone also clearly differs from the other clones in the vicinity, being noticeably later than its neighbors in yellowing. In 1964 this individual did not turn yellow until about the middle of September; the earliest clone of the vicinity had already turned brown and shriveled up a month earlier. The sites, however, are rather similar (VT), both on a border between sandy heath and spruce swamp. This 75-m clone is independent. The 74-m clone at the edge of the same area is pure stand with rather commonplace characteristics.

No. 182. Kiiikala; area between the airfield and Metsänoja.

Size of clone: 80×66 m (1964).

Age of tree stand: oldest generation 200+ years.

VT site. The oldest stand has probably arisen after a wildfire. In the vicinity, there is another clone of the same size class, 78 m. The former is detached, the latter partly mixed. Clones of the same magnitude have also been measured north of the airfield at a distance of about 1—2 km: 82 m (2 clones) and 84 m. There were no possibilities for comparisons with the phases of development of the tree stand. There are still more clones of the same magnitude, on the Somerniemi side of this extensive and uniform area in the vicinity of Oinasjärvi (4 clones, 82—88 m, were measured). There is no old stand left here either.

No. 183. Yläne; Vaskijärvi, the western border-area of the nature park.

Size of clone: 80 m (1964).

Age of tree stand: 125+, 99+ years, and younger.

The site is the border zone of an upland area and a spruce swamp which is drying, due to drainage. The old trees in a pine swamp beside this place are 205+ years old and have appar-

ently been born after a fire. It was not possible to determine the date of this occurrence. The clone is independent, broken up under a spruce stand, into sparse stands and, in places, into fragments, but it is now reviving and uniting again after logging. Wildfires have also occurred later on, and bracken has in places survived only when sheltered by a damp inflammable hummock cover. A 78-m unit of the same magnitude was measured at the opposite side of this pine swamp, in the area between Vaskijärvi and Elijärvi on a VT site. This clone, too, has been fragmented in later wildfires, and perhaps also partly under the spruce invading the area. The old stand is 206+ years old.

829. Size class 81—100 m

Representative clones

No. 184. Sammatti; Oino.

Size of clone: 88 m (1963).

Age of tree stand: about 90 years.

The MT-OMT site is a former field burned for crops, the border area of a pine swamp. The oldest trees of the pine swamp, 243+ years, have probably regenerated after a fire. In its individual characteristics, the clone is of an especially distinct, brown-stalked type, growing detached.

No. 185. Karjalohja; Härjänvatsa heath.

Size of clone: 88 × 60 m (1963).

Age of tree stand: 70+ years.

The site is an isthmus between two swamps. The oldest trees of the swamps are 238+ and 244+ years old and have probably arisen after the same fire. The clone is detached. The following replicates have been measured in the same heath area (1963—64): 84 × 62 m, 86 m, and approx. 90 m.

No. 186. Tammisaari Rural District; Källvik.

Size of clone: 88 m (1964).

Age of tree stand: 238 — 247+ years, forming an independent generation.

The site is VT. According to a core from the oldest tree (303+ years), there may have been a fire in the area 250 years ago, at which time a sharp limit between two periods of different growth in the series of annual rings. The clone is detached. Three replicates have been measured in the same area: 86, 87, and 88 m.

No. 187. Yläne; the area between Vaskijärvi and Elijärvi.

Size of clone: 88 m (1964).

Age of tree stand: The oldest trees of the pine swamp beside this place are 230+ years.

VT site. The clone is independent, circular. Tar has been burned in the area.

No. 188. Siuntio; Grönberga at the boundary of Lohja.

Size of clone: approx. 100 m (1964).

Age of tree stand: oldest tree 280+ years.

The site is the border between a steep rock slope and a skirting VT-MT slope. The old pine mentioned is at the border of a rock precipice and a more gently sloping summit area at a distance of some tens of meters from the bracken growth. The clone is detached.

83. Summary of the representative clones

The numbered clones of the list have been summarized in table 1. Where the determination of the fire-date is based on readings of the stand, the compensating addition required by the stump or boring height is five years to the age of the former and ten years to the age of the latter. Although the estimated age figures cannot be exact (cf. YLI-VAKKURI, 1961, pp. 45—46), they nevertheless provide the minimum age with tolerable precision. The hypothesis is that regeneration occurred immediately after the fire and that the sample trees are among the oldest individuals of this forest generation.

9. Discussion

91. The relation between the size of representative clones and the date of fire

The correlation between the size of clones in the most reliable part of the presented material and the data on their age is visualized by Fig. 5. The graph shows a quite definitely rectilinear parallelism between the size of clones and the length of the post-fire period. Despite variations in site fertility, no great size deviations are revealed. Although the graph includes the clones measured in the northernmost parts of the geographical distribution area of bracken, even the deviations of these are in the general range of variation. It is thus obvious that the populations spread at a fairly even rate, contrary to the expectations on the basis of the information on the large range of variation in the rhizome growth rate.

This holds true, especially, when the maximum spreading rate is studied. When replicates of the same magnitude were recorded on a sample plot, the largest clone was chosen as a representative. Were all these replicates included in the graph, the points would have been dispersed to a greater extent. This is also seen from the diameters measured crosswise. Usually they vary, only in a few cases have they been identical. Completely circular bracken stands are extreme rarities. All directions of spreading from the site of germination are not equal for the rhizomes or the stands; some direction is usually better than the others. Except for some extreme cases on the poorest sites, this most favorable direction is, as evidenced by the bulk of the data, almost equal in value throughout the study area and irrespective of the site, i.e., the differences are so small and become clearly distinct only at such a considerable age of the stands that the reasons of variation are not distinctly connected with site fertility; the differences of some meters might rather have been caused to a considerable extent by other environmental factors. Because these factors cannot be separated and

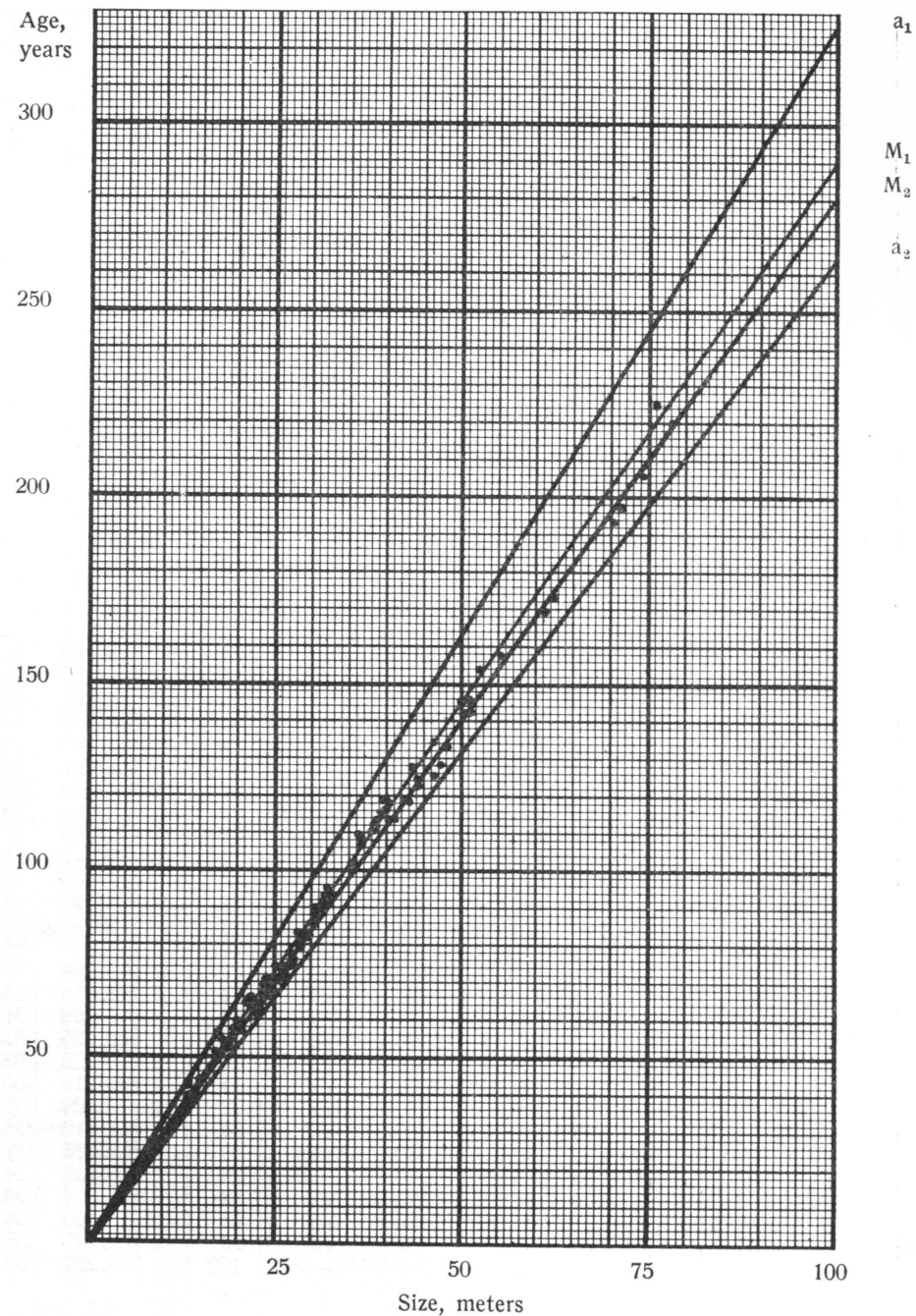


Fig. 5. The relationship between the size of the representative clones and the time elapsed after the fire.

- a_1, a_2 = 95 per cent confidence limits (all sites)
 M_1 = mean, all sites
 M_2 = » VT—MT sites

classified, there is no reason for discussing the data in the framework of CAJANDER'S (1949) forest type classification. The bulk of the material represents an average fertility of bracken sites (VT—MT) and only this part is extensive enough to allow the calculation of averages and variation. However, the data originating from the poorest and the most fertile sites indicates, to a certain degree, the extreme limits of variation. It also ought to be taken into consideration that, especially in the areas covered by extensive clones, variation, sometimes extreme, in the quality of the sites has often occurred. Part of a bracken stand might have grown in a highly fertile depression, part in barren lichen-covered area; a part might have grown under a dense, strongly shadowing spruce stand, and another in open, sun-exposed places; furthermore, one part of a stand might have grown in a spot covered with boulders, another on heath, etc. Thus, it is understandable that the largest clones do not nearly always show distinct differences in spreading rates according to the fertility classification. The dimensions of smaller clones, for their part, may be influenced more by other factors regulating growth and spreading than fertility. Furthermore, it ought to be born in mind that the errors made in measuring stands in rough terrain might, in the worst cases, be of some meters' magnitude for each 100 meters measured. The magnitude of these possible errors cannot be assessed, but if the total variation could be ascribed to them only, the errors would not exceed an approximate ± 3.5 m in populations of 100 years of age. As, however, the date of fire often corresponds nicely to the metrical result obtained by measuring the clones, the errors cannot be granted but accidental significance.

On average sites (VT—MT; the poorest VT sites were disregarded) bracken stands spread, as calculated by 104 cases, at a rate of 35.84 ± 2.13 cm per year. Thus, the progress made by the front is about 17.9 cm annually, which is slightly less than the annual rate of rhizome growth. Due to the lack of exact data, however, the reducing effect of the randomness of the growth direction cannot be calculated. It can be estimated, however, that rhizome growth exceeds 20 cm per year, which agrees with the figures presented by KUJALA (1926). The diameter of populations 100 years in age is about the same as the height of the tallest pines in Finland, namely 32—35.5 m (SARVAS 1964, p. 379).

According to the evidence from seven sample plots (nos. 13, 22, 23, 25, 51, 63, and 151), the minimum spreading achievement of bracken on the poorest sites is about 30.5 cm per year. The rate for the slowest-grown of these stands is 29.8 cm per year. On the best sites spreading has been about 37 cm per year, the highest record being 37.2 cm per year (no. 20). Consequently, the progress of the front has been at least about 15 cm per year and at its best about 18.5 cm per year. This range of variation covers all the forest site types from *Cladina* site to herbaceous forests. Because of the scarcity of data from these extreme sites, the actual range of variation may be somewhat wider. According to calculations for 122 cases, the 95 per cent confidence limits are 30.5—38.2 cm per

year, and the mean 34.3 cm per year. It should, however, be kept in mind, that only the largest among the replicates for a size class, growing on a single sample plot, were considered. The actual minimum spreading rate cannot be calculated from these data.

In these calculations as well as in the graphic compilation, only those cases were taken into consideration for which the date of the fire was determined from borings. A considerable part of the representative clones, however, are such that their size could be compared with the age of the growing stock only. As previously mentioned, the age borings of trees arisen after a fire can only provide a basis for estimates, and the age of the stump and the time needed for regeneration must be added to this (cf. YLI-VAKKURI 1961, pp. 45—46). Because there are 46 such estimates among the representatives and a number also among the unnumbered clones, there is reason to discuss, how they agree with the rest of the data. On experiment, this cluster of points proved to harmonize rather well with the rest of the material, when the required additions had been made. Only in a few cases, these corrections pushed the points a little beyond the cluster of other points and gave too high growth values. The results obtained from the representatives are supported somewhat unevenly by the unnumbered material, but there are also some eloquent coincidences. For their part, they provide an estimate of the minimum age limit.

Variation in the relative growth rate seems to be greater in small than in large clones. This is quite logical; small clones are more clearly influenced by the heterogeneity of the sites, favorably or unfavorably, while, for the part of the large clones, these opposite effects have had more time to reach a state of balance. If there were no such balance, the angle of dispersion of the points in the graph would perhaps be wider.

92. The consistence of the mass of data as evidence for clonality and the individual characteristics

The linearity of the points in the graph can hardly be explained otherwise than that *the stands chosen as representatives are of clones*. This conclusion is also confirmed by the occurrence of replicates of the same magnitude, recorded from several sample plots (nos. 12, 21, 41, 42, 59, 60, 67, 69, 90, 91, 100, 102, 104, 111, 112, 114, 117, 118, 120, 121, 129, 139, 142, 150, 154, 162, 167, 170, 174, 176, 179, 181, 182, 183, 185, and 186 as well as among those without a number). Consequently, the *individual characteristics*, which in the preceding context were given a hypothetical status only, *have proved to hold true*. Although the number of accepted representatives could possibly include some erroneous interpretations of the age or the size, the number of watertight cases and replicates is so great that the results obtained can hardly be undermined to any essential degree by

accidental errors. The material also includes some vegetation units the size of which was fixed to time otherwise than by interpreting the life history of the growing stock; also in these cases the results were convergent. There is reason to return to comparing the size of bracken clones and the dates provided by written historical documents in later investigations on the subject.

93. Regeneration by spores and the permanence of the stands

The presented graphic compilation is a time table for the spreading of bracken clones, wherefrom the minimum or probable age can be read for clones measured in the field. In this way it can also be used in estimating the date of fire. Especially when there are replicates of bracken clones in the same size class in a sampling area, it is evident that a wildfire or burning for crops has preceded the appearing of bracken in the area. For some sample plots the size of the replicates was expressed by the same metrical figure, or the deviation was only a few meters (nos. 167, 170, 174, 176, 179, 181, 182, and 186). Replicates particularly occur on the sites of large clones, and they show the excellence of bracken as a chronometric device in optimal conditions.

The data of the present investigation revealed no certain cases of successful sporal regeneration without any aid from fire. An ultimate answer for this question was thus not received. Some of the small clones in the material, on the sites of which no wildfire has occurred during their lifetime, are all from the sphere of human action, primarily from the vicinity of roads and working sites where fire has probably been used. The traces of such fires, however, disappear in 20—30 years, often even more quickly. In one case only were replicates encountered among these small stands in settled areas (road-side stands, see p. 28). Except from road-side areas, small clones were searched from by criss-crossing fairly large forest areas systematically. The clones were found from land burned in wildfires, from sites used for timber storage or barking and from other work sites, occasionally along paths, etc. (cf. FRITSCH 1927 and HOPKINSON 1927), and once from the site of a winter logging road (Pusula, Mäkkylä, a completely independent clone measuring 2.5 m).

If bracken were able to easily regenerate without the help of fire, on, for instance, appropriate sites otherwise uncovered, sporelings and variable-sized young stands would be common on sites where the surface of the humus layer or the mineral soil are abundant and recently uncovered. Innumerable ditches and borders of fields are to be found everywhere in settled areas, as are also new and old road-cuttings, -terracing, and -ditches, and gravel-pits. All these sites were carefully searched during a long period of time in connection with the present study. During the last two seasons of field work, more than 30 000 km of road-sides were studied in south and central Finland, and despite that about 90 per cent

of the existing small detached stands were recorded, the number found was small. *Only 15 clones under 11 m in size and 53 stands in the 11—20 m class were accumulated.* It can be considered possible that bracken occasionally regenerates without the aid of fire, but such occasions must really be rare.

The material does not give a correct idea of the relative frequency in the size classes of bracken clones because special attention in the search was paid to the smallest stands. In spite of this, *not more than 20 representative clones under 50 years of age were found; the number of those between 50 and 100 years was more than four times that, 85.* This considerable difference speaks for itself. Burning for crops has been almost completely abandoned during the last 50 years, and forest fires have become rarer. Especially, extensive wildfires have become less frequent. The number of 100- to 200-year-old representative clones is again relatively smaller in the material than that of 50—100 years, but this phenomenon is due to the lack of old tree stands and not to the lack of clones. Comparison to time was not possible; therefore a part of the clones measured had to be disregarded. There are also sample plots on which no clones under 200 years of age were recorded, while older ones were quite numerous. One of the hardest draw-backs of the investigation was the rapid disappearing of old tree stands, in this respect the material of the present study was collected at the last moment. Several previously chosen sites for sampling became unsuitable for the present purpose during the last two years.

The close correlation shown by the investigation between the size of clones and the post-fire time indicates that bracken regenerates after fire during a very short period of time. Often, a size gradation according to fire periods was also discovered (nos. 1 and 44; 21, 62, 102 and 114; 48 and 100; 49, 59, 121, 154, 174 and 177; 67, 120, 146, 179 and 186; 69 and 182; 74 and 198; 83 and 141; 58 and 94; 80 and 110; 28, 119 and 163; 104 and 125; 138 and 155; 164, 172 and 180; 76 and 169; and 185). There are also sample plots for which fires at times corresponding to the size of the clones could not be shown. Such contradiction was found in areas of intermittent fires which left a variegated pattern on the sites they frequented. However, it does not witness against the connection of generation with fire. It should be noted that this contradiction between the size of clones and the length of the post-fire period occurs primarily in stands which have arisen after fires preceding the last one. Fire may also fragment bracken stands as is indicated by the differences in the cross-diameters of some clones. In some cases the shorter diameter may correspond to the length of the post-fire period while the greater one is connected to earlier wildfires (e.g., nos. 49 and 151). The stands may, of course, be reduced by fire in an irregular manner; in these cases the correlation described is not encountered.

In the special cases in which the diameters measured crosswise indicate different wildfires, the stands often occur at the edge of swamps, in moist depressions of a longish shape, or along the elbows or ledges of slopes. Such tape-

formed stands are quite common and occasionally of surprising length and uniform width. If this even rate of spreading were supposed to result from the even, tape-like variation of the site, the agreement between the width of the tape-formed stands and the length of the post-fire time would remain as a peculiarity. The frequency of this phenomenon was greater than can be expected as a result of mere accidental factors. The mineral sites on which tape-formed stands were recorded were usually scorched by fire; the humus layer was extremely thin, and there was a distinct layer of charcoal on top of the mineral soil; small circular patches of other plant species also occurred, and the ant-hills were small in their basal diameter. The spots where bracken had managed to survive fire also appeared to have served as a refuge for other plant species, the patches of which were larger in those places. Sometimes the ant-hills found in such places are quite big; either they have not been touched by fire in the last wildfire or they have been rebuilt after less severe fires, which gives them a terraced appearance. Sometimes there are individual trees left from the preceding forest generation, which, although still alive, are marked by fire scars and inter-stem tarring as well as sudden changes in the rate of growth. Some spruces can be the only individuals of that species in the vicinity, perhaps indicating that spruce was more common in the areas during the preceding tree generation. Hence, the fire resistance of bracken is relative, not absolute (see also SUMMERHAYES and WILLIAMS 1926). On light-exposed, warm, and well-drained sites bracken rhizomes often grow rather deep in the mineral soil, thus they may be able to resist even strong fires (cf. e.g. BEWS 1916, SKUTCH 1929, and McCULLOCK 1942). In moist and shaded forests, on the other hand, the rhizomes grow closer to the surface, mainly in the humus layer, and in the most shadowed sites they hardly ever penetrate into the mineral soil. In spruce swamps bracken rhizomes likewise grow in the organic layer and in pine swamps — a somewhat unusual site for bracken — they are found almost exclusively at the border between peat and mud, i.e., the whole rhizome net is flattish and avoids the ground water (cf. also OLBERG 1956, WILLIS, FOLKES, HOPE-SIMPSON, and YEMM 1959, and POEL 1961). In shaded, moist, cold, and hard soils bracken is extremely susceptible to fires that scorch the site, and the whole stand can be destroyed. The clones weakened and fragmented under dense spruce stands are also extremely susceptible to fire. These sparse clones, when larger than expected by the age of the spruce stand may be remnants of older regeneration which have suffered from fires before the birth of the present forest generation (cf. e.g. FRITSCH 1927). A similar explanation has been given by McMINN (1951; see also INGRAM 1932, LEACH 1933, and McCULLOCK 1942) in a forest stand description. Consequently, the present tree stand is only partly responsible for the weakened state of the bracken stand. This hypothesis is supported by a number of observations, according to which some bracken clones that grow in spruce stands and that have arisen after the last fire are quite vigorous. Neither have all large clones lost their vigor in

spruce stands: especially in glades they may sometimes be even rather lush in appearance.

It can be conceived that bracken, for some special reason, could be bound to sites where it already occurs. Its coherent and in places huge stands may consist of a countless number of clones. However, the study of extensive stands did not show this to be the case; even the large stands often consisted of either on a single clone or a few mixed individuals, sometimes exhibiting complex patterns where the chain-like or net-formed clones pervaded each other. In general, a mixture of clones is found primarily in the vicinity of settlements, especially on lands previously burned over for crops. However, small clones proved to be rare here, too. No evidence was obtained of self-regeneration so that a part would die out and be replaced by new parts through continuous and vigorous regeneration.

Of bracken, KUJALA (1964, p. 27) mentions the following (original in Finnish): »The share of bracken in the forest vegetation in south and central Finland is considerable, but its occurrence is regulated in the same way as, for instance, that of heather, by cultural factors. It is not permanent in nearly all vegetation communities in which it occurs. It is rather trivial, but not a species of as poor sites as heather. Regionally, bracken is of great importance and silvicultural significance.»

In part, the results obtained here do not agree with those of KUJALA's studies. Comparing to heather is surprising because heather regeneration by seeds takes place quite readily, in burned sites and also in unburned areas bared or unvegetated for other reasons, Heather is also very quick in invading cut forest areas (see also KUJALA, *op.c.*). It is not bound, like bracken, to narrow requirements for regeneration, and for this reason, the dimensions of the homogeneous patches of heather vary from young seedlings to as large stands as permitted by the time elapsed after the catastrophe, the series being almost continual. The fire tolerance of heather is weak compared to that of bracken (see also LEACH 1933); it can, however, survive a fire, but more or less reduced (see also GIMINGHAM 1960, p. 469). On forest land only slightly touched by fire there sometimes are even considerably larger pure heather stands than the circular ones arisen after a fire. Thus, the gradation of size classes is also seen for heather, but it is not as common and distinct as for bracken. Heather can in no conditions survive in an area scorched bare by fire. On burned sites, the vegetative reproduction of heather is poor in comparison with that on sites covered by a moist moss cover, where the branches of heather are readily rooted.

The present study has probably offered several examples of the permanence of bracken. There is also a number of examples of the breaking up of stands into fragments as well as their partial destruction, especially due to fire. Dense tree stands, particularly those of spruce (see also BRAID 1959), and among these especially stands which have grown spruce for several tree generations, are able

to weaken and shatter the bracken stands and gradually perhaps even to eradicate the species completely from the site. The paludification or water-logging of the site can also lead to the destruction of stands (cf. KUJALA 1964, p. 27, BRAID 1957, see also POEL 1961). Flooding has even been utilized in prevention. A beautiful example of the incapability of bracken to spread across water-logged areas is provided by a clone 4.5 m in diameter which was measured at Källvik, Tammisaari rural district. The plant had entirely occupied a high tussock at the base of an black alder, but flood water prevented it from spreading to other tussocks. The age of the growing stock was here clearly higher than would have been expected by the size of the bracken clone.

Young and small-sized bracken clones are naturally more at the mercy of possible damaging factors than the large ones, which can cover a large variety of sites, and in the area of growth of which the environmental factors are liable to vary from one extreme to another. KUJALA (*op.c.*, p. 27) mentions that bracken cannot stand frost. As a matter of fact, the leaves are easily damaged by frost, but they are replaced by new ones, and the stand quickly recovers. Frost does not destroy the stands, which means that bracken is very resistant to frost. The minute significance of losing a set of leaves has been clearly brought out in several experiments in which attempts were made to destroy bracken by mechanical means (for details, see BRAID 1959). By mowing once in the summer, at the physiologically most critical moment, destruction has been accomplished only after 7—9 years according to BRAID (1947). On some sample plots, mowing did not give any results in the course of 13 years. By cutting the leaves continuously twice a week, BRAID managed to destroy a stand in three years. Similar results have also been obtained by other investigators (e.g. OINONEN 1958). It is clear that the results are somewhat different case by case, depending on the vitality of the stands. In a regressive phase of development, the stands are more vulnerable than in their high season of life. Bracken rhizomes develop a great number of buds in different stages of development which, after damage, develop into leaves — one here and one there — and after the first destruction there is a manifold number of them in reserve (see also STEPHENS 1953).

The frost resistance of bracken rhizomes has been particularly studied in the British Isles, and the conclusion has been drawn that frost might cause gaps in the stands (WATT 1950, 1954). BRAID (1957), however, considers this of quite small significance because part of the rhizomes are deep in the ground and, consequently, well protected. In Finland, bracken commonly occurs as extensive clones even on sites exposed to frost, which indicates that the possible damage does not threaten the survival of the plant. Some observations made in connection with the present investigation show that the rhizomes can sometimes be highly resistant against cold. Thus, in one case, healthy bracken rhizomes were discovered grown into a pit formerly used for storing potatoes; they hung down along the walls protected only by a shingle-roof in bad repair. They were

estimated to have been hanging there for three winters exposed to frosts; nevertheless, they were in good condition, the growing points included. Similarly, a number of rhizomes 30—70 cm in length were found hanging down from the wall of another pit with board cover; despite that they had been exposed to frost for one or two winters, they were in perfect condition. This pit was under a dense spruce stand and, consequently, covered in wintertime by a thin snow layer only. — Bracken rhizomes break easily when bent and may therefore be damaged in soils heaved by frost.

If the disappearing of bracken were common, remnants of clones of varying irregularly in size should be found here and there on our forest lands. However, the number of small clones encountered is low, although special attention was given to them in the search. If we suppose that a part of the discovered clones represent disappearing remnants, we are led to the conclusion that regeneration by spores is still rarer than indicated by the material of the present study. There are several insects (FRANK 1896, NIELSEN and HENRIKSEN 1915, HERING 1926, MEIKLE 1937) as well as fungi (and also bacteria and a virus) (BRAID 1934, GREGOR 1938, ANGUS 1957) which cause damages to bracken, but none of them threaten the survival of the species and can therefore not be utilized in biological control.

The leaves of bracken are certainly trivial in many places, but there are still several, even extensive sites and areas which meet the requirements for the growth and regeneration of the species, but where it does not occur. Thus, it varies unexpectedly in its occurrence. This fact has also been referred to in the literature, and LINKOLA (1921, p. 166) chose his words well: »Recht launisch in ihrem Auftreten: fehlt oft dort, wo man sie erwarten konnte und kommt wieder ganz unerwartet vor». Bracken occurs in all the forest site types, from the poorest lichen-covered soils to the most luxuriant herbaceous forest sites. For this reason, it has not been given the status of indicator plant, on the contrary, its unfitness has been emphasized (ILVASSALO 1929, 1944, p. 126). Neither does it occur in all forests touched by fire, and where it occurs, clones cannot be found corresponding to each fire. In some sampling areas, only very extensive clones have been encountered, sometimes even in areas which are continuously and intensively influenced by human activity (for instance, the tourist-haunted areas at Punkaharju). This gives an idea of the rareness of bracken regeneration by spores. As long as the degree of the triviality of bracken is estimated on the basis of clone entities, the conclusion has to be drawn that bracken is not a particularly trivial plant as is, for instance, heather.

The fact that bracken occurs on all different forest sites and otherwise under quite varying environmental conditions, points to the accidentality of the regeneration by spores and to the decisive importance of this accidental factor. SUKATŠEV (1960, pp. 48—49) also paid attention to this circumstance when dealing with the problem of the patchy distribution of bracken (see also FARROW

1915). He brings the factor forth as a possible explanation and especially if bracken stands will prove to be permanent. In this connection it ought to be said that bracken has not been, at least on the basis of clear evidence or research data, shown to be a species of varying occurrence resulting from sudden regeneration and disappearance. The cases in which the author has been able to follow the development of some stands in the course of about 20 years, exhibited a high degree of permanency. Information from a small number of land-owners was also quite congruous.

For the regeneration of bracken, the macro-environment is of no particularly great significance. The plant individual is born in a minute spot, and favorable sites of this size can occur in almost any area. Observations on the sites and birth centers of bracken clones revealed that the plant is not very selective, but that the birth sites vary considerably. There are clones growing on sandy heaths where they were born without protection against the sun or drying winds. However, these are extreme and rare instances. It is more common that clones growing on heaths have originated in places with some moisture and cover to be found: in slight depressions, sheltered by stones or stumps, in holes, at the border of rocks or the edge of swamps from where the stands have encroached upon the heath in due time. Very often the clones have originated on spots which have not been too strongly damaged by fire, so that a part of the humus layer is left. It is difficult to determine, in such cases, whether the presence of humus is the import factor or whether these spots are moister than the surrounding areas and therefore favorable for bracken. The moist spots, of course, are also seldom scorched bare by fire. Sometimes, the place of birth is the side of a brook, the surroundings of a spring, the shore of a lake or the sea, where the moisture conditions are clearly excellent. The endotrophic mycorrhiza of bracken, encountered only sporadically in old individuals, but never in young specimens (CONWAY and ARBUTHNOTT 1949), is of no importance for the regeneration.

When, in a sample area, a certain size class of bracken clones was represented by replicates, the units seldom grew very close to each other. Only in exceptional instances were two different clones shown to have almost exactly the same spot of birth. Quite often the replicates were at distances of some tens or even hundreds of meters from each other. Along the roads in some areas, replicates with still greater distances between them (several kilometers) can be encountered. The size class including such replicates varies by regions, however, some occur more frequently than others. In the northernmost parts of the distribution area of bracken, replicates become gradually rarer and the clones more often detached. The extensive stands growing by the hill villages are mostly independent or they consist of only a few clones. Bracken is able to regenerate, even nowadays, in these northernmost areas of its distribution, as is shown by some small clones encountered. Even the northern data show no correlation between the regeneration of bracken and, for instance, periods of warmer climate,

at least on the basis of the material of the present study. Thus, it seems that the regeneration of bracken by spores is a phenomenon which takes place more rarely in the northern parts of its area than in the southern regions. Evidently, the northern areas receive spores in smaller numbers than the southern ones.

It is still unclear to what extent the northern areas produce spores. Probably the production is lower than in the southern parts of the country. In the summer of 1965, no spore production was recorded for the northern occurrences and even the stands on the most favorable sites in the south dusted only weakly in the end of August. In southern Finland abundant dusting in bracken is quite infrequent and takes place during particularly warm summers only, then the spores are also shed earlier than normally. This periodicity in the abundance of spores shed did not show in the study material. Perhaps the intervals between the periods are too short to become visible in the dimensions of the clones. The data on the variation of the years of fire do not show a smooth gliding year by year, but there are also periods of subsequent years during which bracken clones have been born. Two possible explanations can be given for this: either the marginal between fire and regeneration covers more than one year or spores are carried by the wind from the south, from countries with a warmer climate. When the rarity of the regeneration by spores is taken into consideration, the former alternative seems improbable. The sterility of the sites does not last long. Algae, the worst competitors of bracken at this critical stage (CONWAY 1949), probably come first (JAAG 1945), and in burned humus-covered areas the invasion of mosses, for example, can often be seen already in the following year after fire (see also SARVAS 1937, UGGLA 1958). The latter alternative, viz. the foreign origin of the spores, seems to be more reasonable. In connection with the present investigation, the surroundings and inner parts of several detached clones bearing spores were searched for smaller clones, however, without any positive result. In vegetation units several hundreds of years in age, in some cases overrun by many fires, the absence of regeneration seems peculiar. It can hardly be ascribed to the lack of spores or suitable substrata for regeneration. As the spores have also been proved viable, despite that they did not produce any regeneration in sowing experiments carried out in the field at the spore-shedding time, the presumption that the spores are of foreign origin becomes more likely.

The transfer of spores to Finland from regions located further to the south could be studied by means of traps before the shedding of vernacular spores. Judging by the fact that replicates of the same magnitude are relatively rare even in extensive areas burned in the same fire, the results of such an experiment may be meager if it is not carried out on a broad scale. Perhaps the spores do not arrive in clouds, but scatteredly. The most promising period for spore sowing experiments seems to be in the beginning of the summer, before spore-shedding in the indigenous stands. By such means, the solution of this problem can probably be found.

94. Silvicultural aspects

The possibility and necessity of bracken control in forestry has often been discussed in seminars, in papers, and in studies both in Finland and in other countries concerned with forestry. The results of the present investigation show that bracken regeneration by spores is very rare in Finland and takes place almost exclusively in connection with fire. Consequently, the areas in danger of infection are those of wildfires or those burned for silvicultural purposes, as well as work sites, where open fires are used. This danger can not however, be considered very great, but rather accidental. The development of a bracken clone at a spot where fire has been used once is a coincidence of quite miraculous nature.

Once brought into existence, bracken stands are extremely permanent and spread out centrifugally from their point of generation at an annual rate of about 17—18 cm. With this radial increment, the new territory invaded annually is considerable. Although the basis for calculations is lacking, the estimate for the total area of new land invaded annually in Finland would be very large. The map of distribution (Fig. 6) prepared by KUJALA (1964) gives a good general view of the present situation as well as its probable future development.

Bracken can be controlled and destroyed by the weedicides currently available. However, a single treatment is usually not sufficient, at least for the most vigorous stands, when the purpose is their total destruction. The rhizomes dormant at the time of the first treatment (see, e.g., BÜSGEN 1915, BRAID 1935) must be destroyed by reapplications, as they will become active and bear leaves. Possible over-looking in the first treatment may also necessitate reapplications for satisfactory results (according to experiments in 1958—62). Similar results have been obtained by, for instance, CONWAY and FORREST (1961). However, the cost of this method is high (cf. HODGSON 1964). For this reason it is not economically feasible to try the sudden destruction of large-sized stands. These can be temporarily weakened by chemicals to such a degree that the tree seedlings planted can be helped through the dense canopy of leaves. Planting has to be carried out as soon as possible after cutting the old tree stand (see also MACINTYRE 1946). Under densely grown tree stands (particularly spruce stands), bracken gradually weakens and is at its weakest when the tree stand is at its most shading stage of development. At this stage the destruction of bracken becomes timely. If nothing is done, a new period of a dense bracken stand is to be expected during the following period of regenerating the tree stand. It remains to be decided whether it is advisable to wait for the difficulties to recur at the beginning of each rotation or to effect the permanent eradication of bracken. From a financial standpoint, the best stands to eradicate are the physiologically subsiding, sparsely-grown and fragmented ones as well as the vigorous, when they are still small and detached (cf. BRAID 1957). Because of the rarity

of bracken regeneration by spores and because the plant is quite harmful from a silvicultural standpoint, there is, theoretically, sufficient reason for its complete destruction even in large areas. A similar conclusion has been drawn by the editors of *Outlook on Agriculture* in a paper published in 1959.

10. Abstract

After the search for bracken sporelings and the experiments on sowing spores had turned out to be unsuccessful, the investigations on the problem of regeneration in this plant species were continued from a reverse angle, the size of the clones. The starting point was provided by the implication in the literature and in my own preliminary studies that one of the most important prerequisites for regeneration is the sterility of the site. It was established that one of the primary sterilizing factors are the natural wildfires that have occurred in Finland and that sterilizing has also been effected by burning for crops which has been practised far back in the time from the beginning of this century.

If the fires have been central factors of regeneration in bracken, the size of its clones should be directly proportional to the length of the post-fire period. In areas burned by the same wildfire replicates of a certain clone size could also occur. Due to the fire tolerance of bracken, it was expected that the clone material would show gradation according to the periods of fire and that the different steps would also be represented by replicates. If there are no replicates of a smaller size than is provided by the time elapsed after the last wildfire, the sterility of the site is probably of considerable importance, and if no such smaller clones occur, the correlation must be considered as nearly perfect. The hypotheses also include the immortality of the clones in a theoretical sense.

In the first phase of work, the individual variation in bracken had to be studied and as permanent as possible marks of identification, the individual characteristics (pp. 12—18), had to be fixed. It was thought that if a correlation could be found to exist between the stands or parts of the stands delimited according to these characteristics, and the length of the post-fire period, the characteristics would prove to be correct and the delimited stands to constitute clones. Thus, the whole material collected would serve as evidence. In the second phase of work, sample plots were searched, in which the date of fire could be determined by boring the trees. Special attention was paid to the smallest clones; they were measured whenever they were encountered. The study of the sites of such stands offered the best possibilities to find out whether bracken regeneration also takes place independently of fire. In the last phase of the work, bracken clones were measured throughout its area of commonness without choosing the environment, the distinctivity of the individual characteristics being of decisive importance for the choice of units to be measured. Principal attention was given

to detached, solitary, and pure clones. A great part of these stands were, however, so extensive that they could not be compared with the age of the trees or with the length of the postfire period as interpreted by these.

To find a solution to the size-age problem, the most reliable cases (188 in all) were selected from the material and presented as a numbered list (pp. 25—68). In addition, a number of other units were described, for which the interpretation was slightly uncertain in some way or another. This presentation was restricted to a maximum clone size of one hundred meters because material for comparing to the growing stock was not available for larger bracken stands. Clones measuring more than one hundred meters in diameter will be dealt with in extensions of this study.

The summaries of the material (Table 1, p. 70 and Fig. 5, p. 72) reveal that the correlation prevailing between the stands delimited and interpreted as clones and the length of the post-fire period is consistently clear and fixed. It can thus be concluded that the stands in question are clones and that their delimitation was effected on the basis of actual individual characteristics. The research assistants easily learned to use these individual characteristics in the delimitation of individuals, especially in the most distinct cases. One of the two assistants collected material by himself using them, and the results agree in their comparable parts.

On average sites (VT-MT), the spreading rate of bracken stands averages 35.8 ± 2.1 cm annually, or about 17.9 cm annually in the frontal direction. From the most fertile (OMT-Lh) and the poorest (CIT and poor VT) sites, the extreme values of 29.8 and 37.2 cm per year have been recorded for the total rate of spreading, or 15—18.5 cm per year in radial direction. This implies that the growth rate of the rhizomes is somewhat greater, at its maximum probably a little more than 20 cm annually. On the basis of these figures, the minimum age of bracken clones can be estimated with a relatively great accuracy.

The present material, in the collection of which special attention was given to small, and above all small detached clones, indicates that bracken regeneration by spores is very rare in Finland and that it has been rarer during the last 50 years than the preceding half-century. The search in road-side areas in southern and central Finland and their marginal forests over more than 30 000 km only resulted in 15 clones under 11 m in size and 53 clones ranging between 11 and 20 m, for which the date of birth could also be established. The number of clones under 50 years of age was only 20, and of those 50—100 years old, 85, or more than four-fold. Clones older and larger than these occur more frequently, but this is not apparent from the present material which includes only such stands for which the age could be compared with that of old tree stands or with the dates of fire expressed by the trees. For the time being, there are few old forests, and old fire-scarred trees are rare even in them. On the other hand, bracken does

not occur in all old forests. That bracken regeneration by spores becomes rarer is probably due to the end of the practice of burning for crops at the last turn of the century, the decrease in the number of wildfires, and the decrease in the size of the forest areas damaged by fires. According to the material of the present study, regeneration by spores, during the last 50-year period, has taken place mainly in fire-areas and regions subject to strong human influence, and in places where fire almost certainly has been dealt with.

The even spreading rate of bracken clones and, on the other hand, the regeneration in connection with fire are illustrated by replicates of the same size in several sample areas. Gradation according to fire periods and replicates for the same stages were also recorded. Among the small clones encountered in settled areas, replicates were recorded only in a few exceptional cases and, except for some accidental occurrences, no clones were found on forest land proper, which were smaller in size than provided by the time of the last fire occurrence. Discrepancy between the size of clones and the date of fire was noticed quite frequently in cases, where the clones were older than the last fire, e.g., among the stands that have survived the last wildfires. Except for irregularity in their dimensions, peculiar regularity was also recorded. In many of these cases the larger diameter of the clone corresponds to the fire preceding the last one, or even to earlier ones, while the smallest diameter corresponds to the time elapsed since the last fire. Usually such stands grew in longish depressions or at verging points of slopes as well as at the edge of swamps, all of which were moist enough to have remained untouched by fire or only slightly burned, while the surrounding areas have been scorched bare. Fragments of large clones are also frequently encountered, and among them, replicates of sizes representing various fire periods can sometimes be found. The fact that the fragments belong to the large clone entities was indicated by the distinct individual characteristics, which were encountered in all parts of the entity. Only a phenomenal chance could distribute such peculiarities in groups. »Empty» gaps can sometimes be of tens of meters in width. — Such discrepancies and peculiarities were observed to a particular degree in forest areas which had burned frequently and severely. The minimum diameter of the fragments, which usually corresponds to the time elapsed after the last disturbance, indicates that the fragments have originated from undamaged rhizome segments and, in some cases, from remnants of the stand, which have been stripelike in form (for example, at the edge of swamps).

The immortality of bracken clones in a theoretical sense is clearly indicated by the large clones which will be dealt with later. They include vegetation units so unusual individual characteristics that there is hardly any room for doubts. They also include homogeneous detached clones. The present data reveal that the relation between the size and the age is fairly consistent in clones up to 300 years old if no catastrophe or physical barrier has interfered. One may ask, why would spreading not be the same for longer periods. There has been much time

for vegetative spreading. Why would there, accordingly, be no giants among the bracken clones in Finland? We can expect them on large uniform sites.

Especially in its northern areas of distribution, bracken is connected with settlements and the ancient sites of burning for crops. In uninhabited, extensive forest areas between villages, bracken is often absent, according to the surveys carried out along all the roads of some large forest areas (for instance, the unsettled areas between Ilomantsi and Kuhmo, the areas of Pohjaslahti—Multia—Petäjävesi—Koskenpää—Mänttä—Keuruu, and the communes to the west of the lake Pielisjärvi). In Ostrobothnia, the species is absent from very large regions or it is so rare in some areas that no bracken was recorded in spite of the tens and even hundreds of kilometers covered. The sporadic northern populations offer an interesting possibility to compare the size of clones with the history of settlement.

Regeneration by spores in the northern distribution areas of bracken also occurs nowadays, although it is clearly less frequent than in the southern parts of the country. The abundance of small clones is, according to the present material, greatest in the southern coastal areas and in southwestern Finland. Because the bulk of the investigations were in fact carried out in these areas, the results obtained may be somewhat biased.

KUJALA (1964, p. 27) mentions that the northern border of the area of the even distribution of bracken is quite clear-cut, which also becomes apparent from the distribution map in his paper. The search carried out in connection with the present work also lead to a similar impression; the problem was studied within the possibilities offered by the road net in such a manner that this border area, within a zone measuring about 200 km in width, was crossed several times along a zig-zag line reaching from the western shore to the eastern border of the country. As cited on p. 78, KUJALA ascribes an important regional significance to bracken. In the northern border areas of its distribution, bracken is most often reported from settled areas as well as sites on the slopes and tops of hills formerly burned for crops. This indicates that cultural factors are of especially great importance for the regeneration of bracken (this is also emphasized by KUJALA) in this part of the country. In the large uninhabited areas between Tohmajärvi and Kuhmo in the vicinity of the eastern frontier, bracken is clearly rarer than at corresponding latitudes in the more densely settled central parts of the country, the Pieksämäki—Iisalmi area. In the northern sites, the clones are usually quite large, which gives a rather erroneous picture of the frequency of the species. Bracken is also very persistent in its northern areas of occurrence. It can be mentioned that a stand, recorded in 1946, from the area of Nurmes, (Petäiskylä, at the rapid of Kolkonkoski), was encountered at its former site when checked in 1965. Only the forest was completely changed due to clearcutting done some years earlier. In the western coastal area, bracken already becomes suddenly rarer in the vicinity of Uusikaupunki. According to

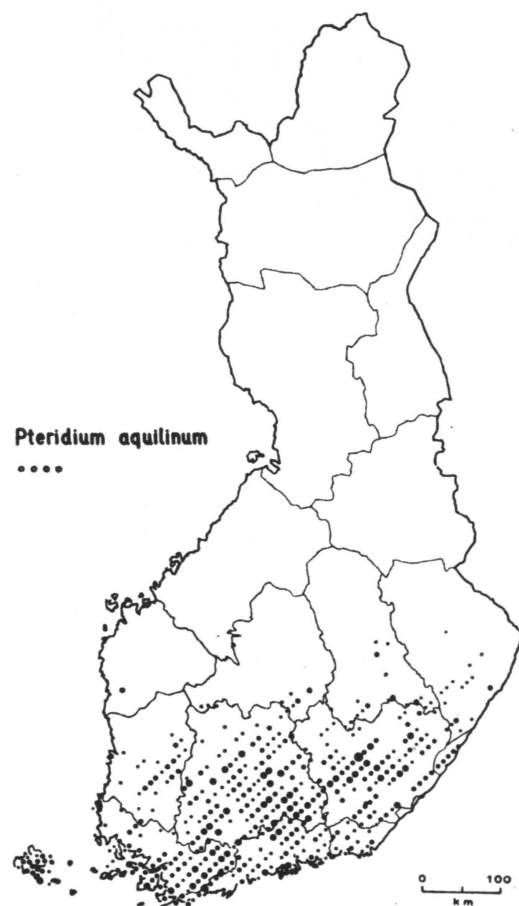


Fig. 6. Distribution and frequency of bracken on forest land in Finland according to KUJALA (1964). Cf. Fig. 7.

KUJALA (1964, cf. Fig. 6), this takes place in the area of Pori so that the northern border of even occurrence drops peculiarly to the south in this region.

Many facts point to the possibility that regeneration by spores takes place in Finland from spores of foreign origin. The period of the maturing and the shedding of spores comes so late in our country that the time for the development of prothalli capable of wintering might be too brief. No progeny developed in experiments on spore sowing at the time of natural spore-shedding, irrespective of the good germinative capacity of the spores used. No young clones were encountered inside or in the vicinity of detached large-sized clones, although these stands bear spores at present and probably have been in the same state

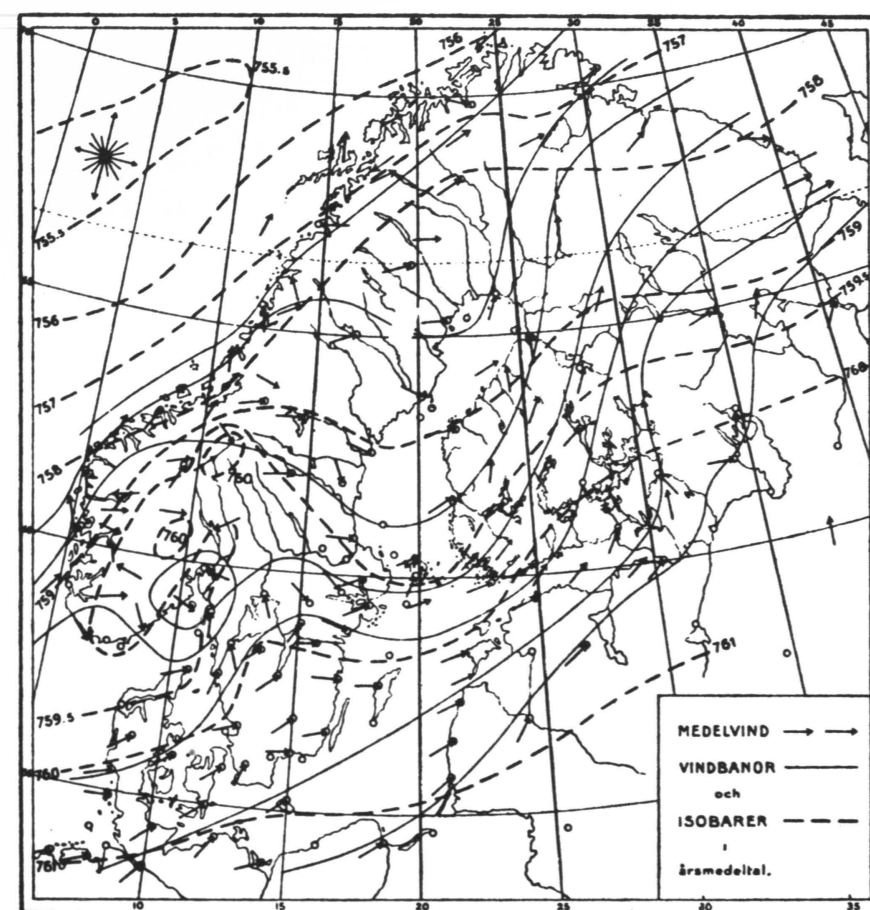


Fig. 7. General directions of air currents in Scandinavia according to JOHANSSON (1914). Cf. *Suomen kartasto — Atlas of Finland 1925—28*, which indicates that the direction of winds prevailing in the summer is somewhat more westerly on the Finnish coast of the Gulf of Bothnia.

several times during their existence which covers hundreds of years. Usually, they have also survived a varying number of wildfires, after which suitable birth sites have probably been abundant. As mentioned earlier, HARRIS (1955) found bracken spores from his guano samples taken from a distance of 500 miles from the nearest vegetation unit, a spectacular proof of the flying ability of the spores. When we consider that spores have been found from samples with a relatively small surface area at the distance mentioned, it can be supposed that individual flights of spores might cover even greater distances. They might reach Finland from the southern parts of Sweden, the Baltic countries, and even areas still farther to the south. This transport of spores is favored by

the southern and southwestern winds prevailing in summertime (see *Suomen kartasto — Atlas of Finland 1925—28*, JOHANSSON 1914, KERÄNEN and KORHONEN 1951). The fact that there are, even in large fire areas, only relatively few replicates of the same size class and that these are only seldom located close to each other, indicates that the spores fly scattered. They have probably not originated from the stands in the vicinity, which, during favourable summers, can produce spores in masses. The strong decrease in the number of bracken units — and the increasing proportion of detached clones in them — in the coastal areas of the Gulf of Bothnia and to the north from the vicinity of Uusi-kaupunki might be dependent on the westerly winds prevailing in these areas (JOHANSSON 1914, KERÄNEN and KORHONEN 1951, see Fig. 7). Still farther to the north, northwesterly winds become prevailing. If these westerly and northwesterly winds transfer bracken spores, they bring them from regions with about the same conditions prevailing as those, which regulate spore formation here. If the air currents transport spores from more southern areas, where the maturing of the spores takes place earlier than in Finland, the shortness of the autumn will not prevent the development of sporelings and their becoming established. The assumption of the southern or southwestern origin of the spore material might be somewhat contradictory to the conception expressed by BURSHEL and RÖHRIG (1960, p. 17) that the bulk of the Finnish and Scandinavian bracken population is of an eastern type and that an essentially stronger type is found in the western parts of Europe and in Norway. These investigators, however, consider the border between these two forms uncertain, both in its structure and location.

Bracken clones have regenerated on quite varying sites, which indicates that the species cannot be considered very demanding in this respect. The site of birth is of minute size and such sites are probably abundant in fire areas. As sporelings have still been everywhere born rather sparsely, the scarcity of spores, the narrow regeneration requirements, and the abundance of destructive factors seem to be the limiting factors.

From the silvicultural point of view, it has to be considered that bracken, by spreading vegetatively annually invades large forest areas in its distribution area. The species is extremely persistent on the sites where it occurs and its regeneration is of an accidental nature. Due to these facts, there might be reason to consider, in places, the permanent destruction of the plant. The areas mainly threatened by spore regeneration are those of forest fires and of prescribed burning, and the work sites where fire is used. This threat can not, however, be considered very serious.

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