

Vascular flora of Inari Lapland. 2. Pinaceae and Cupressaceae

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Abstract

KALLIO, PAAVO, LAINE, UNTO & MÄKINEN, YRJÖ. (Botany Dept., Univ., Turku 50, Finland) Vascular Flora of Inari Lapland. 2. Pinaceae and Cupressaceae. REP KEVO SUBARCTIC RES STAT 8. 73—100. Illus. 1971. — The distribution, ecology, morphology and taxonomy of the three native conifers (*Picea abies*, *Pinus sylvestris*, *Juniperus communis*) are discussed, and the northern tree and forest lines of the spruce and the pine are mapped. In spite of the fact that in many places human activities have strongly affected the pine forest limit, it is one of the most important natural boundaries in Finland. The warm decades in the beginning of this century have not helped the pine to spread beyond this limit. Taxonomically, the variation of the pine is clinal, and no taxa can be separated. Of the spruce, ssp. *obovata* which is considered to be the dominating type in Kola peninsula rarely occurs pure in Inari Lapland. On the basis of cone scales and growth habit the variation of the spruce northwards is clinal and the Inari Lapland spruces mostly belong to transitional populations between ssp. *abies* and ssp. *obovata*. A variant form of the juniper with short and appressed leaves, known as var. *montana*, is recognized, but it is fairly rare. The age of the juniper may exceed 1000 years, growth being strongly dependent on local microclimatic factors.

1. Introduction

The first part of the vascular flora of Inari Lapland included a description of the area, the material and methods, and a list of the terms and abbreviations used (KALLIO et al. 1969: 46—52). For a map of the most important localities, see Fig. 19 in that study. A few additional remarks should be made.

Owing to the fact that the conifers of Lapland have been observed and studied much more thoroughly than the other plant species, they have been listed and mapped in a somewhat different way. For example, the maps have been supplemented with original data collected during the third General Forest Survey and

deposited in the Archives of the Forest Research Institute, Helsinki.

The distribution maps published by KALLIO et al. (1969) will be continuously supplemented with new records; copies of these maps are obtainable upon request.

1.1. Additional floristic excursions

During 1969 and 1970, a number of additional floristic excursions were arranged, mainly in the southern part of Inari Lapland, which was the area most poorly known (cf. KALLIO et al. 1969: Fig. 56, 58). In 1969, floristic data was mainly collected during trips from Angeli southwards via Vaskojoki—Poastajohka—Repojoki and Lisma to the Pokka road, from Rajajooseppi via Nangujärvi and Tsarmitunturit to Nellimö, from Kari-gasniemi via Muotkatunturit (Kaisavarri and Kourvikodds) to Aksujärvi, from the Kevo station to the southern Jeskadamtunturit, and via Njallatunturi to Harrematshikka at the Norwegian frontier. Many of the

islands in the southwestern part of Lake Inari were also studied eastwards from Inari up to Kaamasjärvi. In 1970, large areas of the Viipus-Maastatunturit field group (which had already been explored by KLOCKARS & LUTHER, 1938) were floristically inventoried by two groups of botanists. Additional excursions included one from Kalmankallio in Enontekiö via Peltotunturi, Korsatunturi, Ivalojoiki and Lisma to the Pokka road, and shorter trips around the village of Angeli and from Tsulloväddi at the Teno to Kaibmoaivi in the Paistunturit area. The southern archipelago in Lake Inari was studied east to Nellimö and Paatsvuono. Many new anthropochores were found during a survey of the roadside flora in Utsjoki and Ivalo.

The total number of observation points now amounts to 2856. Of these, 1111 are in Utsjoki and 1745 in Inari. 1234 are situated in the coniferous zone and 1621 in the alpine and birch belts. The distribution maps of *Pinus sylvestris* and *Juniperus communis* show the majority of the additional observations (cf. Fig. 58, KALLIO et al. 1969).

1.2. Floristic mapping of Finland (FMF)

In Finland a new biological mapping scheme was adopted in 1970 to be used in the cartographic presentation of all records of animal and plant taxa. The basis for this scheme is the uniform grid system (*yhdenäkökoordinaattisto* in Finnish); for further details see HEIKKINHEIMO & RAATIKAINEN 1971. The country is divided into 100 × 100 km squares, each of these into 10 × 10 km squares, and so on. Fig. 1 shows the 10 × 10 km squares in Inari Lapland; each of these squares bears a five-digit code number (e.g. 777: 51). The total number of such squares in our area is 229 (combined total of 191 whole squares and parts of 76 squares). Those marked with a cross have not been studied by us. The relative frequency of the squares in which the species has been found is given after FMF (for the whole of Inari Lapland). We suggest that the frequencies thus obtained could be effectively used in comparisons with other parts of Finland. Included in the upper left corner of the distribution maps is a small-scale map which gives the distribution in the FMF squares.

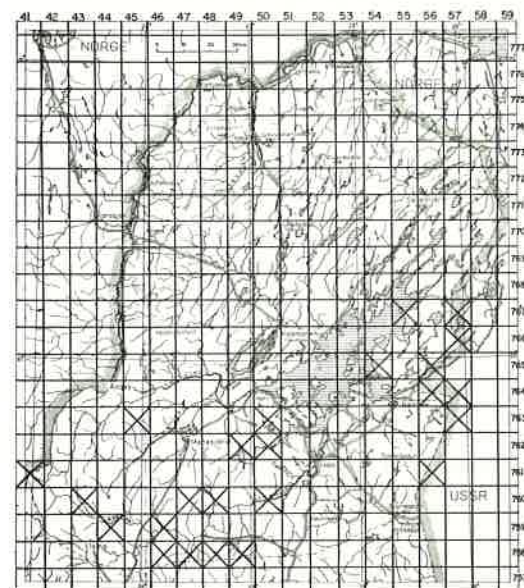


Fig. 1. The squares in the new Floristic Mapping of Finland scheme. The squares not studied by us are marked with a cross.

1.3. Coworkers during the excursions

We are especially indebted to Mr. JAAKKO NURMI, M.Sc., and Mr. ILMARI KAUSE, who in 1970 led separate floristic working groups in the Viipustunturit and Angeli areas, respectively. Persons who took part in the additional botanical excursions and who have not been mentioned by KALLIO et al. (1969: 45) include Pekka Ahlqvist, Matti Ahonen, Ullakaisa Alatalo, Leena Arola, Kurt Ekman, Jouko Hakala, Heikki Kallio, Tore Lindholm, Anja Niskanen (Vähämurto), Leena Nurmi (Viher-salo), Kaarlo Nygrén, Hannu Myrsky, Paula Paurola (Ahonen), Albert Pyysalo, Eila Seikkula, Christer Troberg, Merja Varjonen.

2. Cultivated conifers

In addition to the three native species, eight others are occasionally planted in Inari Lapland.

Abies balsamea Miller

Yard of the Ivalon Emäntäkoulu, 2 specimens planted in 1969, height ca. 50 cm, thriving well.

Abies sibirica Ledeb.

(1) According to PARVELA (1930: 223), planted in 1880 in the Toivoniemi park. In 1925 the trees were 7 m high, and 30 cm in circumference. In 1971 we counted 29 trees, many of them 2—3-branched at the base, 12—14 m high, very dense, diameter 10—40 cm, with abundant cones. (2) Yard of the Tepsell farm-house, E. shore of Vastusjärvi, 1 specimen. (3) Yard of the Ivalon Emäntäkoulu, 24 specimens planted in 1961, height 1—2 m, thriving well, flowering generally in the middle of June.

Larix kaempferi (Lamb.) Carrière (= *L. leptolepis* (Sieb. & Zucc.) Endl.)

Yard of the Ivalon Emäntäkoulu, 5 specimens planted in 1961. 3 specimens left in 1971, tallest ca. 1 m, but they thrive poorly and apparently are dying.

Larix russica (Endl.) Sabine (= *L. sibirica* Ledeb.)

(1) Mierasrova at Mierasjärvi along the Utsjoki highway, planted on a small area in 1960. (2) Aksujärvi along the Karigasniemi highway, planted on a small area in 1960. (3) At the Järvenpää farm-house at the NE end of Tsuolisjärvi, planted on an area of 100 m² in 1913. In 1971 there was a stand of about 15 trees, ca. 10 m high, vigorous and rising clearly above the surrounding birch forest. (4) At the Kyyneleiniemi farm-house, NE shore of Lake Inari, 6 specimens, 6—12 m, diameter 8—15 cm, and a few saplings. (5) In 1881 planted in the

Toivoniemi park by X. W. Nordling (NORDLING 1884; PARVELA 1928; 1930: 228; 1932). In 1926 the tallest tree was 9—10 m, and 53 cm in circumference. In 1971 three tall trees were left, about 10—12 m high, very dense and thriving well, about 45 cm in diameter, with abundant cones but avoid of seeds. (6) Yard of the Ahola cottage, S shore of Syrminiemi, 1 specimen in 1965, about 3—4 m high and at least 20 years old. (7) Koppelo, yard of the house owned by Armas Peltonen, a few specimens, about 50 years old, 16 m high, 40 cm in diameter; seeds have not germinated. (8) Veskonieni, 1 specimen, planted in 1916—17, 6—7 m high, 15—17 cm in diameter. (9) Ivalo, yard of the District Forester's Office, about 15—20 specimens, planted in 1960, 1.5—2.5 m high. (10) Ivalo, yard of the Ivalon Emäntäkoulu, 3 specimens, planted in 1961, about 2 m high.

Larix russica thrives very well in Inari Lapland up to the northern pine forest limit, and in favorable places its annual growth exceeds that of pine.

Pinus sibirica Du Tour

(1) Planted in Toivoniemi in 1883 (NORDLING 1884), but did not thrive, remaining low and shrubby. In 1923 they were no longer alive, but according to information by T. Itkonen there were slowly growing saplings somewhere else in Inari (PARVELA 1930: 230). (2) Yard of the Ahola cottage, S shore of Syrminiemi, 1 specimen, about 2 m high. (3) Inari, yard of the District Forester's Office, planted 6 specimens, 2 alive in 1971, height 70—100 cm. (4) Yard of an adjacent house to (3), 7 specimens, well thriving, highest 170 cm. (5) Ivalo, yard of the District Forester's Office, planted 8 specimens in 1960, 4 alive in 1971, height 30—40 cm. (6) Ivalo, at the entrance to the graveyard, 2 specimens, planted in 1931—32, height ca. 2 m. (7) Yard of the Ivalon Emäntäkoulu, 5 specimens, planted in 1961, highest 1 m.

Pinus mugo Turra

(1) Planted on the top of the Palovaara hill at Kaamanen in 1912 about 700 seedlings. In 1959 there was a small stand, fairly vigorous, still alive in 1971. (2) NE end of Tsuolisjärvi, close to the Järvenpää farm-house. (3) Yard of the Ivalon Emäntäkoulu, 8 specimens planted in 1968, thriving fairly poorly, 7 alive in 1971.

Pinus peuce Griseb.

Yard of the Ivalon Emäntäkoulu, 5 specimens planted in 1961 (?), thriving fairly poorly, height ca. 1 m in 1971.

Thuja occidentalis L.

Yard of the Ivalon Emäntäkoulu, 2 specimens planted in 1968, thriving very poorly.

PINACEAE

Picea abies (L.) Karst.

Picea excelsa (Lam.) Link

Indigenous, rare

Distribution. East-European — Central-Asiatic continental. Common over most of Fennoscandia, but almost totally absent or rare in southernmost Sweden, on the Atlantic coast and in the north (LINDQUIST 1948: 263; HULTÉN: 73—75; SARVAS 1964: 224). The northernmost localities in Fennoscandia are near Neiden and in the southern part of Rybachy Island at about 69°50' (DAHL: 237; LINDQUIST l.c.; HYLANDER 1953: 60; HUSTICH 1966: 14). The polar tree limit of the spruce along the Karasjohka and at the boundary between Inari and Utsjoki runs about 50—70 kilometers north of the forest limit of *Picea abies*. In the whole of Kola Peninsula there are only some outposts north of the spruce forest line (KIHLMAN 1890: 145, 146; SOLONEWITSCH 1938; LINDQUIST l.c.; Fl. Murm. I: map 35; KRYUKOV 1962; HUSTICH 1966: 14). Further east the distribution of spruce is continuous and extends north of latitude 72° in Chatanga, in the continental areas of Siberia (Fl. USSR I: 145; KRYLOV 1955: 73; POLUNIN 1959: 20; TOLMACHEV 1960: 68 and 1966: 198; HUSTICH 1966: 15; HÄMET-AHTI 1970: 264).

In Finnmark the spruce occurs in the valleys of the Anarjohka and Paatsjoki (e.g. KIHLMAN: 66; NORMAN: 1025; EIDE 1932; DAHL: 237; NORDHAGEN 1940: 26; LID 1963: 55). In Pechenga there are a few localities north of the Luttojoki (KUJALA 1929: 24; DAHL l.c.). In Kola there is a continuous spruce area in the southern and central parts (e.g. KIHLMAN 1890; Fl. Murm. I). In the Saariselkä district and along the Luttojoki spruce forests are fairly common (BORG 1904; TANNER 1913; ROIVAINEN; KUJALA 1929; PERTOLA), and also in most of Kemi Lapland (HJELT & HULT; HJELT 1838; WAINIO; HULT; HUSTICH 1937 a; MONTTELL; ULVINEN). In Enontekiö spruces grow in the SE and E parts (SANDBERG 1898; HUSTICH 1934; 1936 a; 1937 a; HARVIATINEN & al. 1968; FINNE 1970).

InL ref. The first map showing the northern forest limit of the spruce was by WAHLENBERG; Paatsjoenniska, Sulkesjok, the sources of Vaskojoki, at the Inarijoki near Jorgastak (FELLMAN); north of the spruce forest limit the species has been recorded in many places between Hammastunturi and Hammasuro, Mahlatti island, between Siintajoki (Tsiittijoki) and Nitsijärvi, Junnas, the lower course of the Kettujoki, Tirro, E of Vastusjärvi, Syrminiemi by Muddusjärvi, W of the mouth of Terstojoki, Karvaselkä, and Iso-Roiro island (KIHLMAN; some observations reported by inhabitants; not all finds have been localizable in our map); between Ivalo and Koppelo common, Veskonieni and Nautsisuvanto (WAINIO); e.g.

Kuodeveäiskaidi, Kuossavärri, Kuusivaara 15 km west of Mutusjärvi, Leägguaivi, by Aksujärvi, Syrminiemi, Jänkajärvi (Jäggijäyri) district, between Hammasjärvi and Vaasiljärvi, along Tsumujoki (SANDBERG 1898); SW of Vaijoki, between Vaijoki and Morgamjärvi, Morgammaras, Näättäselkä in the upper course of the Vaskojoki, between Äivihjärvi and Paadarjärvi (KLOCKARS & LUTHER); nearly the whole valley of the Ivalojoiki (KUJALA); Nierivaara, N of Paltsavaara, Autovaara on the lower course of the Vaskojoki (LAINE); Nukkumapää, Pasasjärvi and Akujärvi districts (FINNE 1970). For the forest limit of spruce and its occurrence in the area, see also HJELT 1897, HEIKINHEIMO 1920 a, 1920 b and 1921, LINDQUIST 1948, and HUSTICH 1952.

Rare (264; 0.028). Inari: II (264; 0.046). From the west the forest limit runs as follows: S side of Ivalojoiki — Lisma — Ivalon-Matti — Pokka road — Kynsileikkaamapää — S of Appistunturit — S end of Hammasjärvi — mouth of the Sotajoki — Tolonen — Ivalo — Koppelo — Laanila. From here the forest limit runs off the map in the south. The spruce "zone" reappears in the district of Tsarmitunturit. The following localities are north of lat. 68°55' and clearly on the northern side of the forementioned forest limit: 1) The valley of Inarijoki, Kuodeveäiskaidi (SANDBERG 1898, acc. to A. J. Castrén 5 trees. 2) Inarijoki, 2 km

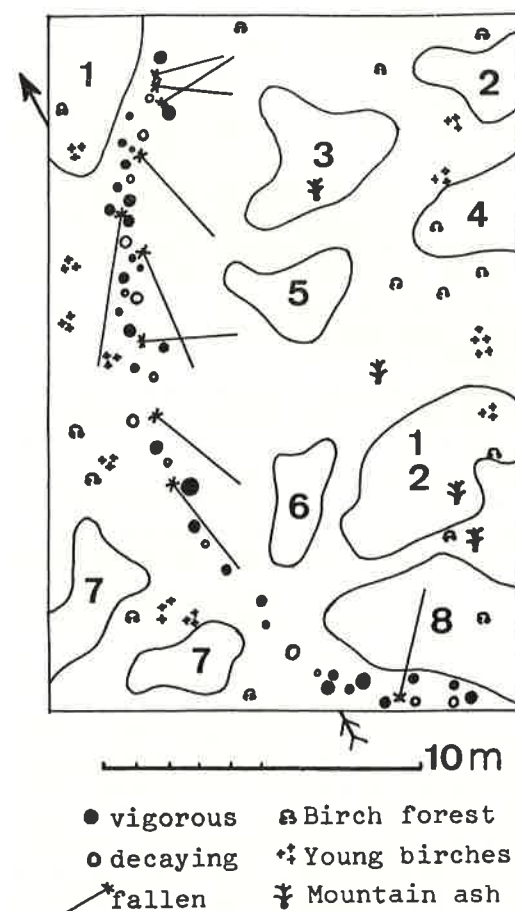


Fig. 2. Spruce stand on the Kuossavärri field. According to SANDBERG (1898). 1 = *Empetrum (hermaphroditum)*, 2 = *Phyllocladus caerulea*, 3 = *Pedicularis lapponica*, 4 = *Diphasium alpinum*, 5 = *Trientalis europaea*, 6 = *Cornus suecica*, 7 = *Vaccinium myrtillus*, 8 = *Vaccinium uliginosum*.

south of Ranttila farm one tree (acc. to Castrén). 3) The sources of Vuobmaveäijohka, Kuossavärri (HJELT 1897; SANDBERG 1898 (cf. Fig. 2), acc. to Castrén about 30 trees). 4) Muotkatunturit, between Pastapelltsokka and Äytjärvi (acc. to N. Ranttila and J. Sarre a few trees); within the pine forest limit. 5) SE of Verkkojärvi (acc. to Sarre; the number of trees not exactly known, but this locality may be the same as that mentioned by SANDBERG (1898): Kuusivaara, about 15 km west of Mutusjärvi, over a hundred trees). 6) SE of Meäskoavi, about 2.5 km south-southeast of Taidijärvi (acc. to SANDBERG l.c. 130 trees; also KOIVISTOINEN); N of the pine forest limit. 7) S side of Leägguaivi, the sources of Koske-

lojoki (HJELT l.c.; SANDBERG l.c.; at least 3 trees); N of the pine forest limit. 8) About 5 km west of the mouth of Terstojoki (KIHLMAN, a small forest). 9) W of Mutusjärvi, ESE side of Tuorbumoavi (acc. to Sarre a small stand). 10) The district of Aksujärvi, north of the Karigasniemi — Kaamanen road (one tree acc. to SANDBERG l.c.; 11) Mutusjärvi, Syrminiemi, W part of Kaunisvaara hill (KIHLMAN; acc. to K. Kyrö a small forest). 12) Kaamanen, W of Vastusjärvi (KIHLMAN; not mapped). 13) The district of Tirro (KIHLMAN, young trees; not mapped). 14) Inari Lake, Kaartassaaret, Kuusisaari (10 trees; cf. AUER 1927: plate VII). 15) Väylä, S shore of Ruohojärvi (number of trees uncertain, probably several hundreds). 16) Partakko, Venchakkaamavaara (one tree). 17) The upper course of Siuttajoki, N side of Jokiselkäjärvi (acc. H. Kallio 3 trees). 18) S of Paudijärvi, the ridge of Jänkajärvi (HJELT l.c.; SANDBERG l.c., 12 trees). 19) W of Nitsijärvi, between Ruohonvetämajärvi and Turvejärvi (one tree). 20) About 2 km southwest of the Kivikumpu summer camp between the mouth of Siuttajoki and Nitsijärvi (KIHLMAN, about 200 trees). 21) Nitsijärvi, Hammasjärvi, Palomajärvi district (acc. to A. Koivisto several trees). 22) Between Hammasjärvi and Vaasiljärvi (HJELT l.c.; SANDBERG l.c.; several trees). 23) Iso-Roiro island on N side of Sammakkonien (KIHLMAN; several big trees). 24) Kessivuono, Pitkäjärvi (many trees, acc. Y. Siitonen). 25) Between Majavajärvi and Laklemijärvet (several trees, acc. to Siitonen and the Virtaniemi Frontier Guard). 26) Between Korppikurujärvi and Kantojärvi (several trees, acc. to the Virtaniemi Frontier Guard). 27) Along Tsumujoki on S side of Vätsäri fjeld (SANDBERG l.c.; number of trees unknown). 28) E of Tsumujärvi, Surnupää (several trees, acc. Koivisto). 29) S of Tsumujärvi, Mellalompola (one tree, acc. to Koivisto). 30) Tsuolisvuono, Naudshusaari (one tree, acc. to Koivisto). 31) NE of Tsuolisjärvi (one tree, acc. to Koivisto). 32) Pakanaajoki, Jankkila (3 or 4 trees, acc. to Castrén); the northernmost spruces in Finland about 69°33'.

In fact, we have been able to map the spruce tree limit largely by means of the earlier literature and information given by foresters, Frontier Guards and several inhabitants. We have not even visited all the localities. It is more difficult to determine the forest limit of the

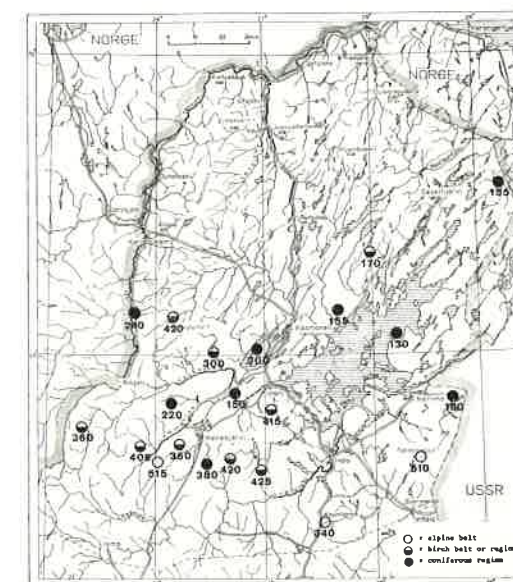


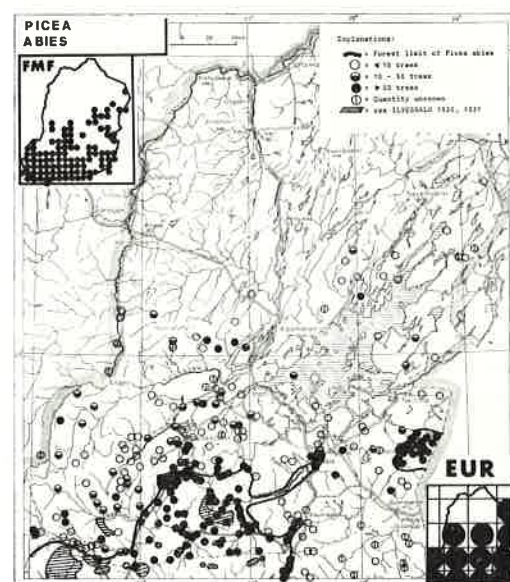
Fig. 3. The elevations of *Picea abies* in some localities in Inari Lapland.

spruce than that of the pine, because the number of forests and stands diminish gradually and not suddenly, as in the pine. *Southern continental*.

FMF 0.382.

Vertical distribution. c: II (0.049), ab: I (0.012) Difference***. Range 130 (Kuusisaari and Iso-Roiro islands) — 515 m (Morgam-Viibus). In alpine belt solitary bushlike individuals or seedlings in Morgam-Viibus, Akalauttapää and Kaunisää. In birch zone small stands or forests e.g. in Kuossavärri, Lauravaara and Kuusivaara, and between Roavveoavi and Stuurra Pogoavi. Among others, in Piehtarlavtašoavi some trees above the pine forest limit (KIHLMAN: 64). According to HUSTICH (1937 a: 60) ascends Ounas—Pallastunturit about 600 m, even above the birch belt. In Levitunturi in Kitilä the spruce forms the forest limit (AUER 1927: table 11). The outposts in N Finland are often met in groups in birch woods, where they generally have slender, cylindrical crowns (LINDQUIST 1948: 266). *Silvike*.

Ecology. Some ecological factors, such as moisture, illumination and the degree of podsolization of the soil differ clearly from those that as a rule dominate in spruce forests in Rovaniemi and Kuusamo districts. For instance, such vasculars as *Listera cordata*, *Melampyrum sylvaticum*, *Milium effusum*, *Moneses uniflora*,



Petasites frigidus, *Ranunculus lapponicus*, and *Thelypteris polypodioides* are not so typical of spruce forests in Inari as they are in Muonio district (MONTÉLL). Certainly, the above-mentioned species may occur in many spruce forests in Inari when these are eutrophic and springy enough. Vegetation dominated by *Geranium sylvaticum* and ferns is found, for example on the slopes of Tsarmitunturit, where the most important species in the field layer are *Carpogymnia dryopteris*, *Dactylorhiza maculata*, *Equisetum sylvaticum*, *Geranium sylvaticum*, *Luzula pilosa*, *Lycopodium annotinum* ssp. *annotinum*, *Melampyrum pratense*, and *Trollius europaeus* (e.g. KUJALA 1929: 28). In the spruce forest on the slope of Nukkumapää quite near the summit of the fjeld there is mesic vegetation (e.g. *Cornus suecica*, *Dactylorhiza maculata*, *Geranium sylvaticum*, and *Trollius europaeus*; FINNE 1970). In Kuusipää fjeld near Laanila the ground vegetation is composed of a poor community, containing *Empetrum hermaphroditum*, *Linnaea borealis*, *Luzula pilosa*, *Lycopodium annotinum*, *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*, and some mosses and lichens (*Pleurozium schreberi*, *Nephroma arcticum*; ERIKSSON & STRID 1969: 116). Maybe the most complete general view of the typical field layer of the spruce forests is to be seen in the area between Appesluobbal and N Kulpakkojärvi, where birch and spruce form mixed forests with the lowest parts clearly paludified: *Calamagrostis purpurea*, *Carex vaginata*, *Coeloglossum viride*, *Cornus suecica*, *Dactylorhiza maculata*, *Deschampsia flexuosa*, *Diphasium complanatum*, *Equisetum pratense*, *E. sylvaticum*, *Filipendula ulmaria*, *Geranium sylvaticum*, *Linnaea borealis*, *Listera cordata*, *Luzula pilosa*, *Lycopodium annotinum* ssp. *annotinum*, *Melampyrum pratense*, *Pedicularis lapponica*, *Rubus arcticus*, and *Vaccinium myrtillus*.

In the whole of Peräpohjola county there are typical HMT spruce stands with poor growth (LAKARI 1920; SIRÉN 1955). This forest type dominated by a thick moss carpet and blueberry seems to be rare in Inari Lapland. However, KUJALA mentions its occurrence at the Ivalojoiki (cf. also AALTONEN 1919: 27). According to HEIKINHEIMO (1920 b: 36, 37), the extensive spruce area in the Repokaira district consists partly of paludified heaths, partly of drier *Empetrum-Cladina* heaths.

The spruce thrives quite well on drier soils, too, but in such sites it generally occurs scattered. SANDBERG (1898) gives descriptions of some of the northernmost localities (e.g. a sketch made of the stand consisting of over 30 trees on the SW slope of Kuossavärri fjeld; Fig. 2). The spruce forests mixed with pines and birches between the mouth of the Siuttajoki river and Nitsijärvi lake is the largest to the north of Lake Inari. In that habitat there are a few signs of nemoral vegetation (*Cornus*, *Geranium*), but vasculars (e.g. *Eriophorum vaginatum*, *Equisetum sylvaticum*, *Rubus chamaemorus*, and *Vaccinium microcarpum*) are abundant, giving peculiar, more oligotrophic and paludified heath forests.

As we have stated above, the plants especially characteristic of spruce forests (restricting within such habits) are almost totally absent from Inari Lapland. Thus, it may be futile attempt to search for the following species in the spruce stands, even though the vasculars are not uncommon in our area: *Athyrium filix-femina*, *Carex loliacea*, *Stellaria longifolia*, *Ptilium crista-castrensis*, and *Rhytidadelphus triquetrus*. The habitats of the last-mentioned plants seem to concentrate along brooksides and riversides (except those of *Ptilium*).

Fungi and epiphytes. The northernmost occurrences of the following fungi seem to be at the northern boundary of the spruce forests, and in certain years they may even be common in the spruce area of Ivalo: *Clitocybe inversa*, *Hygrophorus olivaceoalbus*, *Micromphale perforans*, *Mitrella abietis*, and *Tricholoma imoenum*. On the other hand, we can state that some macromycetes, e.g. *Camarophyllus caprinus*, *Hygrophorus piceae*, and *Lactarius scrobiculatus*, usually considered as species of spruce forests only occur as far as the pine district of the Utsjoki valley (KALLIO & KANKAINEN 1964, 1966). Many of the spruces with dry tops which seem to be afflicted with rot are surprisingly sound. The annoying *Fomes annosus*, found generally in S and Central Finland, does not occur here, but, unfortunately, is replaced by the equally dangerous *Phellinus pini* var. *abietis*. Other parasitic fungi destructive to forests are *Abortiporus* (*Spongipellus*) *borealis*, *Fomitopsis pinicola*, and *Polystictus circinatus* var. *triqueter* (= *Inonotus triqueter*). Cf. JØRSTAD & JUUL 1939; ERIKSSON 1958; ERIKSSON & STRID 1969. According to KUJALA

(1950: 99), not a single example of *Pucciniastrum padi* has been found anywhere in N Finland, but in 1970 it grew on old fallen cones of spruces in Ivalo. In certain years *Chrysomyxa ledi* is very conspicuous in the landscape.

The local inhabitants say that the Lappish spruces are often very "hairy". What they mean is that their branches, twigs and trunks are thickly clad with lichens. Especially the *Alectoria* species (*A. fremontii*, *jubata* and *simplicior*) may be almost as common on pines and spruces growing close to each other. In the Ivalo district, which is climatically moister than many other habitats of the spruce in our area, *Ramalina dilacerata* is found exclusively on spruces (ÄHLNER 1937 and 1948: map 22). Trivial constituents of epiphytic lichens are *Hypogymnia physodes*, *Parmelia sulcata*, *Parmeliopsis ambigua*, and *P. hyperopta*.

Sexual and asexual reproduction. The present forest limit of spruce gives the impression of being unchangeable. Good seed years on the northern boundary are rare and thus seedlings are almost totally lacking (cf. SARVAS 1970 b). Further, much seed has been destroyed by insects of the *Cecidomyia* group (HEIKINHEIMO 1921: 17) and, for example in 1920 over 50 per cent proved empty. In 1970 seeds of high quality seem to have developed for the first time after a long interval. Of the material collected at Ivalo 32 per cent, at Koppelo 30 per cent and at Vuomaselkä in N Sodankylä 69 per cent germinated in the Department of Botany, University of Turku. On the other hand, seeds taken at Kaunisvaara by Mutusjärvi germinated very poorly (only 3 per cent).



Fig. 4. *Picea abies* on Jänkajärvi ridge south of Paudi-järvi lake (ca. 69°22') in Inari Lapland. 12. 7. 1959 Rauno Tenovuori.



Fig. 5. A solitary spruce in the subalpine belt on the Pieni Joenkielinen fjeld south of the Lenmenjoki river, in Inari. 10. 7. 1970 Jaakko Nurmi.

According to MIKOLA (1952: 27) spruce tolerates at its northern limit extreme climatic alterations better than pine. However, its reproduction is small. This is according to MIKOLA (l.c.: 25) mainly due to the unfavorable ground conditions for the seedlings. Further south, at least, in the so-called HMT forests, the seedlings can not grow through the thick moss cover (cf. HUSTICH 1954: 39; SIRÉN 1955). In our area the widespread mineral soils, which are readily pervious to water, are also unfavorable for hygrophilous seedlings. In the open peatlands the seedlings are sensitive to frost. Furthermore, they appear to be unable to grow in burned areas. Solitary seedlings are to be found on barren soil at the base of spruces and by roadsides (AALTONEN 1919: 310). On the other hand, the fact that lower branches have the ability to form adventitious roots guarantees that the spruce will persist even in its most northerly habitats (cf. NORMAN: 1025; HUSTICH 1951: 176; SAARNIJOKI 1963). For example, many of the spruce groups on the upper courses

of the Lemmenjoki and Vaskojoki rivers are clones developed from one or more mother trunks (cf. DEUBER & FARRAR 1940).

Age and growth. In many of their northernmost localities spruces may grow fairly tall (Fig. 4 and 5) and often their crowns rise above those of birches and pines. The biggest trees hardly reach twenty meters in height and often not even fifteen meters. SANDBERG (1898: 186) estimated the ages of the oldest trees at 210 years and 195 years in Kuusivaara hill near Verkkojärvi lake. About the ages of the spruces in Kuusipää (Laanila) SAARNIJOKI (1963) writes (original text): "Owing to the medullary decay the corresponding number of the annual rings of the trunk cannot, however, have been counted quite to the pith, but since we have to add to the number of the preserved 166 annual rings some 40 or 50 ones we see that there have been on breast height in the said trunk more than 200 annual rings all". Different results were obtained at different heights: at breast height there were 67 and 93 whole annual rings in two trees measured, but 126 and 138 near the base. Thus the addition of 50 to the number of annual rings measured at breast height would raise the ages of a couple of trees (255 and 258 annual rings at breast height) to over 300 years. In general, the diameter at breast height is under 20 centimeters, but in some specimens it is over 0.5 m. A relatively thick base rapidly tapering towards the top is typical of Lappish spruces. Crowns with many tops are common

owing to storm or/and snow damage. It is very important, however, that even the lower branches of trees with dry tops remain vigorous and send down roots and gradually grow independent in favorable moisture, e.g. under the snow cover.

Taxonomy, morphology and variation. The area of distribution of the spruce is relatively continuous and limited, the variation range being considerable. As regards Fennoscandia the most important races are ssp. *abies* and ssp. *obovata* (Ledeb.) Hult. (Fl. SSSR I; LINDQUIST 1948; Fl. Eur. I; TOLMACHEV 1966; HÄMET-AHTI 1970). The area of distribution of ssp. *obovata* is considered to continue through N Russia as far as the Kola Peninsula and the northern parts of Scandinavia (HULTÉN 1949 and 1950: maps 74, 75; Fl. Eur. I), while that of ssp. *abies* includes Central, Eastern and Northern Europe (LINDQUIST 1948; MEZERA spruces. Crowns with many tops are very 1939). After the Ice Age the two advancing fronts spreading from the south and south-east evidently joined each other (cf. AUER 1929; HYYPPÄ 1936; VASARI 1962; AARTOLAHTI 1966; MOE 1970), at any rate in the northern part of Fennoscandia. The question of different races of the spruce is at present still very critical north of the 66th latitude. Ssp. *obovata* is considered to be the dominating type in the southern and central parts of the Kola Peninsula (FELLMAN 1869; Fl. Murm. I; HYLANDER 1953), but ssp. *abies* also occurs there (KIHLMAN

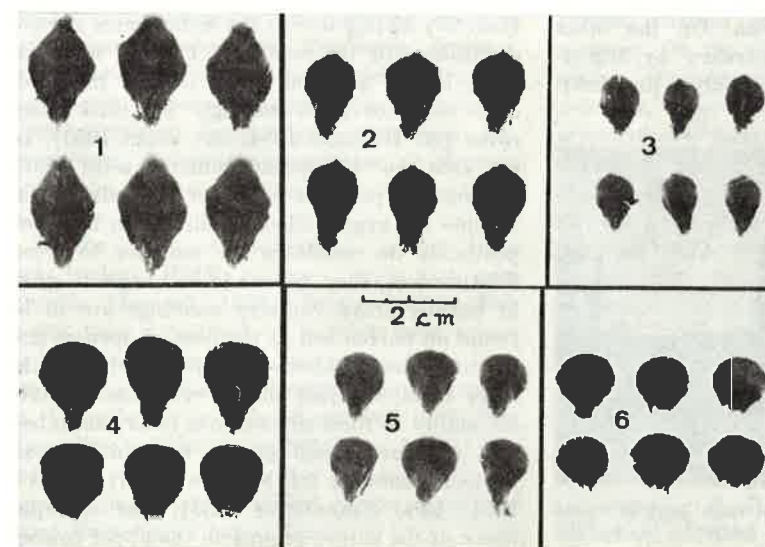
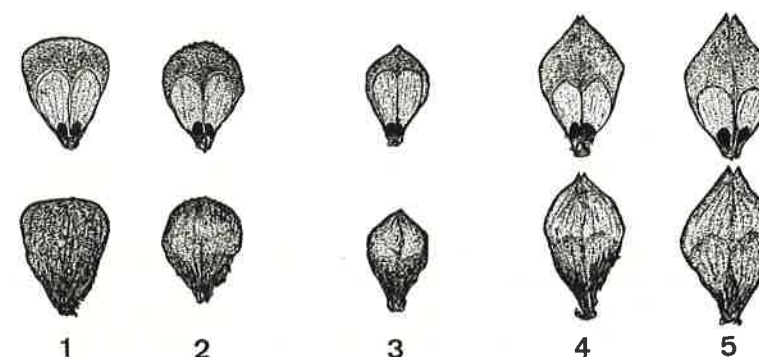


Fig. 6. Cone scale types of *Picea abies* s.lat. 1 = Yläne (S Finland), 2 = Ivalo village, 3 = Ivalo, Hoikkaniemi farm, 4 = Mutusjärvi, Kuusivaara district, 5 = Lemmenjoki, Hukkaselkä hill, 6 = Siberia, at the river Lena. Photo K. Alho.

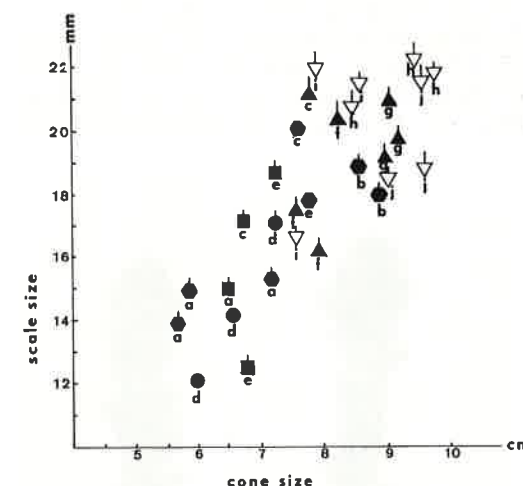
Fig. 7. Cone scale model of *Picea abies*. 1 = *obovata* type (Siberia, Lena district); 2 = *obovata* ("fennica") type (Inari, Jänkajärven harju); 3 = intermediate type (Inari, Mudusjärvi); 4 = *abies* ("europaea") type (Sodankylä, Vuomaselkä); 5 = *abies* ("acuminata") type (Yläne, Elijärvi).



MAN 1890; TOLMACHEV 1960). According to LID (1963) and HYLANDER (1953), the spruces in Finnmark belong to the Siberian race (cf. also DAHL: 237). Older phytogeographical studies often lay stress on the great variation of cone scales, e.g. in the Luttojoki district (ROIVAINEN), in N Sodankylä (HULT: 5), in Muonio (MONTELL), and in the valley of the Ivalojoiki (KIHLMAN; WAINIO: 86). Partly the spruces with the intermediate forms of cone scales belong to the types called *fennica* and *medioxima* (e.g. AALTONEN 1919: 33; DANILOV 1943). From this we can conclude that transitional populations often occur in Inari Lapland. SAARNIJOKI (1965), in studying his material of cone scales, states that the scales become broader and more obovate towards the north. Some authentic cone samples from Siberia in H have broadly obovate scales with faintly indented — entire front margins (cf. Fig. 6). The material is too scanty, however, to permit any conclusions. When investigating critical taxa in the field, we try, as is known, to choose the most typical specimens. LINDQUIST (1948: 295) is also of the opinion that the variety in the type *obovata* would be greater than one would be led to expect from a perusal of literature.

As we know very little about the true amplitude of ssp. *obovata*, we are obliged to make a model of interpretation of our own. As the normal type of ssp. *abies* we selected the scale which is broadest in the nearly middle of the scale. The scale of the type ssp. *obovata* is broadest close to its edge (Fig. 6 and 7; cf. also SAARNIJOKI 1965). In a scatter diagram (Fig. 8) each scale type is the average value of five scales detached from the middle part of the

scale. Each of the cones examined was taken from a different tree. The cone size of ssp. *obovata* is stated to be clearly smaller than that of ssp. *abies* (Fl. Eur. I; Fl. USSR I). The mean length of the cones collected in Ivalo is 5.77 ± 0.11 (n. = 24; cf. KIHLMAN 1890: 146)



explanations:

- = type 1 (*obovata*)
- = type 2 (*obovata*)
- = type 3 (*abies* ≤ *obovata*)
- ▲ = type 4 (*abies*)
- ▼ = type 5 (*abies*)
- scale margin:
no bar = entire
short bar = serrate
long bar = dentate

white = southern population (3 samples)
black = northern population (3 samples)

a = Ivalo, Koppelo; b = Mudusjärvi, Syrjäniemi;
c = Ivalo, along Ivalojoiki; d = Lemmenjoki, Hukkaselkä; e = Sodankylä, Vuomaselkä; f = Sodankylä, Vuotso; g = Sodankylä, Petkula; h = Yläne, Elijärvi; i = Piikkiö, Harvaluoto; j = Lokalahti

Fig. 8. Scatter diagram of cone scale types of *Picea abies* in Inari Lapland (a—d), Kemi Lapland (e—g), and SW Finland (h—j) in E Fennoscandia. See Fig. 6 and 7.

and in Yläne in Southern Finland 8.68 ± 0.25 ($n = 24$).

By examining a comprehensive material LINDQUIST (1948) established that the hairiness of the annual shoots of spruces increases towards the north. The number of glandular hairs also tends to increase in the same direction. Yet types with glabrous shoots occur in the fjeld districts of Scandinavia, with outposts in the area of the Nuortijoki and in the eastern part of the Kola Peninsula (cf. LINDQUIST l.c.: 304; HULTÉN: 74). From Finland LINDQUIST had no records of this type. Later on, however, SAARNIJOKI (1965) reported that this "race" occurs in the northern parts of our country. Our material from the Appesluobbal district (N of the Ivalojoiki) contains at least one sample with glabrous shoots, most of the shoots of nearby trees being extremely pubescent (Fig. 9). LINDQUIST (l.c.) regards this type, which he called var. *arctica*, as a race that has possibly survived in refuges.

In describing ssp. *obovata* the floras mention the dense brown hairiness of the annual shoots (Fl. USSR I; Fl. Murm. I; Fl. Eur. I). There are also individuals of this kind in Inari Lapland, but the degree of pubescence varies



Fig. 9. Young annual shoots of *Picea abies* from the vicinity of Appesluobbal, southeast of Menesjärvi. Photo K. Alho.

greatly. However, we do not regard this feature as suitable for determination of individual cases, although it is of course of importance when a population sample is examined.

On account of the short branches (especially the lower ones), the general habit of the spruce in N Finland and Lapland is very narrow. However, this is not a feature of taxonomic significance, but an ecotype resulting from extreme circumstances. The narrow habit is not correlated either with the type of cone scales or with the pubescence of the young shoots. As regards the length of needles, there is no great difference between the southern and northern Finnish materials, though individuals with long needles are more often found in S Finland. The size of the needles varies greatly in shoots of different ages, even on the same branch. Further, the position of the leaves in northern specimens is rather irregular, not comblike, as in S Finland. A characteristic of the spruces in Inari Lapland is the presence of falcate needles even on the lower branches.

Dependence on culture (human influence). It is most likely that the number of spruce forests has decreased in some degree during the last hundred years. Disastrous forest fires are an important factor stopping the spread of spruce forests (KAIRAMO: 257; KUJALA 1926). In a table SANDBERG (1898: 153) presents a list of 76 forest fires in Inari in 1865—1892, careless people being mostly responsible for fires. The total burned area was estimated roughly at 52,000 hectares. It is possible that in the whole of Inari only a few districts were spared from forest fires. And the spruce, as well known, is one of the most sensitive trees to fire. In general, according to foresters, the spruce forests in Inari have not recently been destroyed by forest fires.

The northernmost forests, stands and solitary trees of spruce belong to the Utsjoki reserve, where all the trees are protected from timber cutting. But the situation is different in the Inari reserve, because spruces in vast areas have been cut down, even in recent years, and seedlings of pine have been planted instead. However, the reforestation has been unsuccessful. HEIKINHEIMO (1920a: 63) reported that the Lappish spruce forests were of bad quality and thus of no value, a forester's point of view. On account of their small cubic capacity, the spruces are not very suitable for firewood.

Further, it is not easy to cut them down, because of the dense branches and twigs. KUJALA mentions that poles at the Ivalojoiki are mainly made of spruce. In general, we can state that timber cutting and other economic uses have not lowered the present tree and forest limits of spruce. In Utsjoki we have only twice seen planted spruces (at Puksala and Haukiniemi farms) but these trees were not vigorous.

Pinus sylvestris L.

Indigenous (partly planted), *frequent*.

Distribution. Boreal Eurasian (from Scandinavia almost to the Sea of Okhotsk). The northern limit descends from $70^{\circ}18'N$ (Stabbursdalen, Porsangerfjord, Norway) to about 60° in Eastern Siberia (HUSTICH 1966: 18). East of Pechenga it is no longer important as a forest tundra conifer. Common throughout Fennoscandia, the fjeld areas and the outermost archipelago excluded (HULTÉN: 71; HYLANDER 1953; also SKULT 1956; TENOVUO 1956). In Troms mostly in the interior of the long valleys (fjords) but only reaches the seashore in very few places. Often it forms mixed forests with birch. Pure pine forests mostly occur on burns and as plantations (BRNUM: 82). JUUL (1925) and DAHL extensively mapped the distribution in Finnmark. The long fjords with their continental character harbour many isolated pine forests (e.g. Alta, Lakselv and Porsangerfjord). Along the river Teno, on the Norwegian side (cf. RYVARDEN 1969) there are isolated trees from Polmak as far north as the Laevvajohka (there are ca. 40 trees), and from there towards the south small stands and sparse forests occur as far as the mouth of the Karasjohka, beyond which continuous pine forests dominate. Southwards in the Inarijoki and Kietsimäjoiki valleys there are poorly developed forests, mostly isolated trees. In Pechenga continuous pine forest extends northwards along the Paatsioki valley to ca. 20 km south of Kirkenes. Around Tuulijärvi (Petsamojoki and Lammasjoki), there is an isolated pine area the northernmost trees being at $69^{\circ}37'N$ (KUJALA 1929); to the east of Pechenga the pine forest line descends to $69^{\circ}N$. In Kola pine avoids the shore and the eastern part of the peninsula (here the forest tundra with some isolated pines is also wider than in Finland; cf. KIHLMAN 1890; Fl. Murm. I: 36).

In L. ref. WAHLENBERG drew the northern pine forest limit south of Näätämojoki (where the continuous pine forest extends further north than anywhere else in the world), and south of Iijärvi; at the present Utsjoki highway his limit ran north of both Säytjärvi and Savujärvi (Syysjärvi?) up to "Betsekojaure". This is of importance, as this is the only place in Inari where WAHLENBERG personally observed the northern pine limit; obviously at this point the forest limit has receded southwards about 10 km. West of the highway the boundary ran as at present (through the mouth of the Peltojoki). In the Inarijoki valley the pine forest reached the mouth of the Karasjohka. The isolated pine forest of Utsjoki—Kevo was noted. KIHLMAN presented a more detailed map; in

subsequent publications (e.g. BORG 1904; RENVALL 1919; HEIKINHEIMO 1921) nothing essentially new has been reported.

In the economic forest maps prepared by the National Board of Forestry ("Yleissilmäyskartta Utsjoen hoitoalueesta"; 1943, completed 1956) the limit of the continuous pine forest and that of the isolated pine forests are drawn separately. The latter coincides better with the pine forest limit presented by the authors mentioned above and with that given in our map. In the maps of HUSTICH (1958; 1966; 1969) the generalized northern limit of "more or less closed pine forests", and "a belt with pine stands and trees among dominant low birch forests" is indicated and north of these limits, isolated trees and seedlings. Our additions for these maps cannot be very important. Other papers of HUSTICH (1940; 1942a; 1944; 1947; 1948; 1956; 1958) which deal mainly with the ecology and plant geography of the pine also contain local distributional data.

In collecting the data for the distribution map in addition to our floristic lists and literature (KALLIO & MÄKINEN; LAINE 1964; LAINE & al.; HÄMET-AHTI 1963; WAINIO), we consulted the following sources:

a) Information obtained from the Lapp farmers and foresters, and from the frontier guard, mostly verified afterwards.

b) The pine forest limit in the Saariselkä area is taken from the tourist map (1:50 000) published in 1967, based on aerial photographs.

c) Aerial observations and photographs by the authors (1966, 1968, 1971).

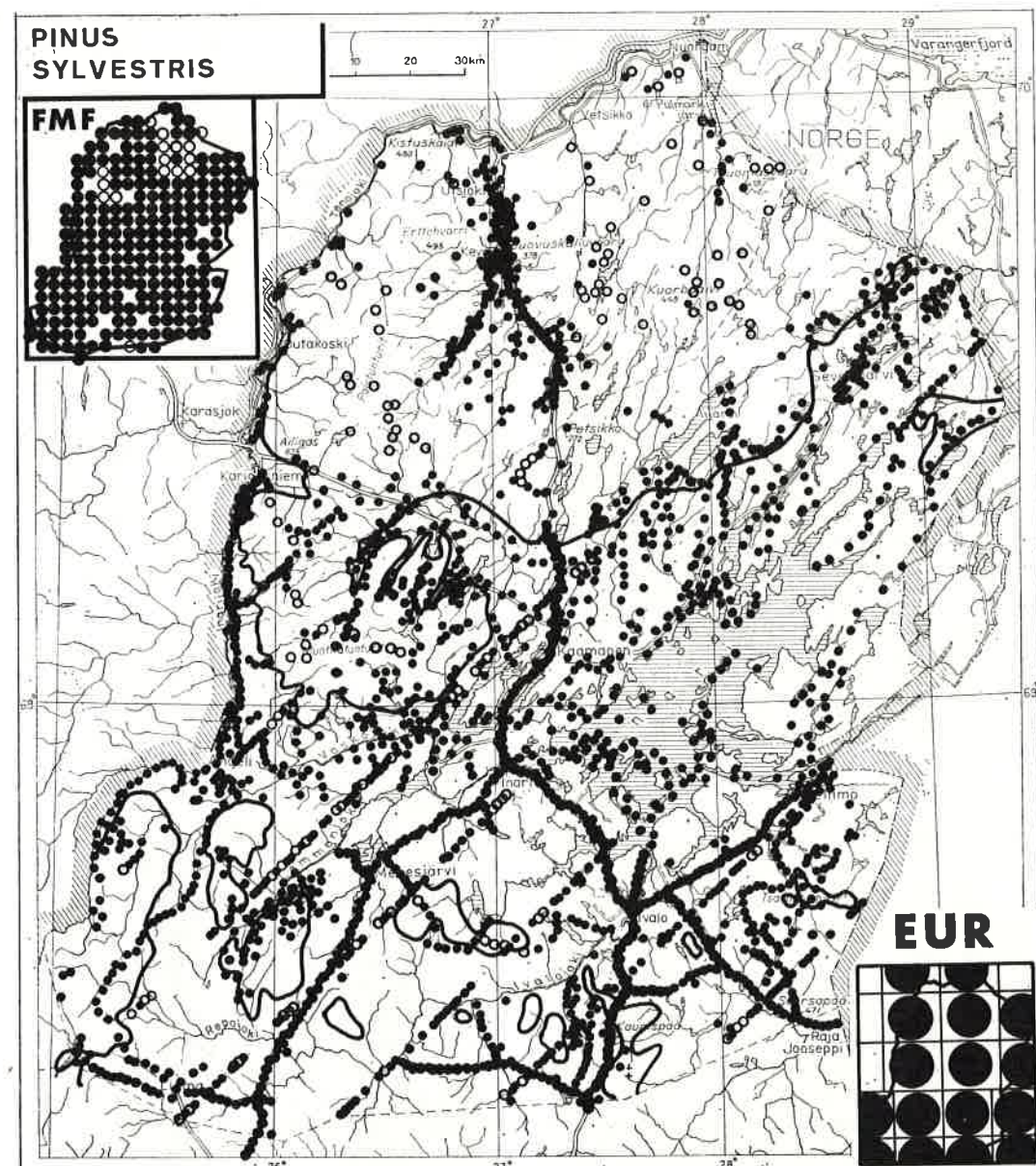
The old dead fallen pines mostly lie so close to the living trees or forest that it is only in rare cases possible to indicate them separately.

Frequent (1804; 0.464). *Utsjoki*: V (341: 0.274), *Inari*: VII (1463; 0.584). Difference***.

The pine forest limit in our map corresponds to the northern limit in the maps of the Board of Forestry and of HUSTICH. In some places, e.g. along the Utsjoki highway at Syysjärvi, where it coincides with the southern margin of a bog area, the limit is sharp, only a few pines occurring north of it. In some places between Paudijärvi and Apukasjärvi the limit is more gradual and therefore perhaps different interpretations are possible.

Fig. 10, 14, 17 and 19 give examples of the appearance of the pine forest limit (see also KALLIO et al. 1969: Fig. 39). It is important to note that in form and size the pines are not dwarfed even in the northernmost habitats, although the pines growing isolated are smaller than those in closed forests (cf. RENVALL 1919: 23).

In our research area the prostrate and table-shaped trees common in the forest limit e.g. in



North of the continuous pine forest limit, dots indicate isolated trees, open circles seedlings only (below 2 m in height). The dots in rows derive from the results of the 3rd General Forest Survey.

Kola and Siberia (cf. TIKHOMIROV 1970) are absent. Even if the trees are smaller (maximum height 10 m), the stem is thick and the crown is well developed, often asymmetrical, roundish and rather dense (cf. RENVALL 1919). At the upper vertical limits the trees may sometimes show features of "Krummholz" (e.g. the highest

pine on Jesnalvaara at Kevojärvi, at an altitude of almost 300 m).

In the mountain region of the Muotkatunturit fjelds the forest stretches along the valleys of the rivers and brooks deep into the fjeld area. In the Inarijoki-Teno valley the continuous pine forest reaches Outakoski up to



- >8
- 6-8
- 4-6
- 2-4
- <2

Fig. 10. Distribution of *Pinus sylvestris* around the Kevo Subarctic Research Station, according to aerial color pictures from 1965. The sizes of the dots indicate the heights of the trees. From LASSILA (1966).

Fig. 11. Plantations of the Scots pine in the Utsjoki valley. The origins and the planting years are (from north to south; data of the District Forester's Office): 2. Muonio (1940), Ylike (1950), Ylike (1951), 1. Kolari (1926), Raudanjärvi (1936), Kemijärvi (1948), 20. Kemijärvi (1928), Raudanjärvi (1936, 1938), 19. Kolari (1926, 1929, 1924, 1925), 19a. Kolari (1929), 12. Kemijärvi (1942), Kitinen (1942), Inari (1952), Kolari (1953, 1954), 13. Kolari (1925), 18. Kemijärvi (1928), 6. Raudanjoki (1938), Kitinen (1939), Inari and Muonio (1939-1940).

Jeägelveäddji, and isolated small stands and trees extend to the mouth of the Utsjoki. In the Teno valley between Utsjoki and Nuorgam there are only a few pine trees, perhaps relics of an ancient pine forest (RENVALL 1919; JUUL 1925). Because SANDBERG (1898) knows only one pine near Ailigas and a few seedlings near Vetsijoki and no pines between Vetsijoki and the Polmak river, it is clear that no essential change has taken place in this area in the last 80 years. An isolated and vigorous pine forest exists in the Utsjoki and Kevojoki valleys, thoroughly studied by RENVALL (1919). The map of LASSILA (Fig. 10) shows the distribution of the pine around the Kevo Station. In this area pure pine forests prevail with a dense tree cover and typical pine forest undervegetation. A further, smaller isolated pine forest extends along the Pulmankijoki, just south of Pulmankijärvi (only a few hectares), but until the last century it was much more extensive (cf. SANDBERG 1898: 138; RENVALL 1919).

Southern.

FMF 0.891

Vertical distribution. *c*: VII (0.709), *ab*: V (0.276). Difference***. Range 25–450 m (tree)–539 m (seedling). KIHLMAN gives the following data of the vertical distribution: S. slope of Piehtarlavttasoaivi, forest limit 368 m, isolated trees 396 m; Hammasurotunturi forest limit

368 m, a small isolated, bushy pine 473 m; Tuarpumoaivi, isolated trees between 278 and 324 m; Kolšanoaivi (Kudossuvannonpää), forest limit 274 m, scattered trees 322 m; Ailigas, forest limit 293 m, isolated trees 335 m. For Muotkatunturit SANDBERG (1898) gave upper limits for pines between 320 and 420 m. In the Lemmenjoki area the pine forest limit is at Morgammaras between 340–360 m (isolated trees up to 450 m), and at Morgam-Viibus 360–380 m. HEIKINHEIMO (1921:9) gives the values 270–285 m for the forest limit and 290–355 m for the tree line in the Hammas-Maarestatunturit area.

At the southernmost border and partly south of our area in eastern Saariselkä the forest limits, as measured from the topographic 1:50 000 map (1966), are south of Lurojärvi, Vesipää, S. slope of Rovapää, Kaarnepää and Lupukkapää about 400 m, Peuranampumapää and Hirvaspää about 370 m. In some places south of Sokosti the spruce extends to higher altitudes than the pine. In Laanila the forest limit is at 340–360 m (Kaunispää, Palopää, Kivipää). HULT (1898: 108) recorded the pine limit in the Raututunturit as 367–428 m.

In Inari Lapland the upper limit of the pine descends towards the north. From the southern border up to the Ivalojoiki region this change is about 30 m (cf. HULT 1898: 108).

The continuous pine forest limit runs mainly between altitudes of 150 and 200 meters on the northern border of the Lake Inari basin (cf. KALLIO et al.: Fig. 41), solitary trees and seedlings extend about 100 m higher, e.g. in Karigasnjarga Ailigas in 293 m (KIHLMAN).

In the Utsjoki-Kevojoki pine forest area the pine limit is at a height of about 250 m, but is slightly lower around Kevojärvi. The top of Tsarsjokskaidi (over 240 m) is devoid of pines, and on the eastern side of Kevojärvi there are only solitary trees over 250 m. On the other hand, a southern slope of Puksalskaidi, 1 km SSE of Kotkapahta still houses a pine stand at a height of 250–260 m. In the Kevojoki valley the pine forests extend as far south as the upper Njaggajärvi, and the vertical limit at Madjokskaidi lies at about 250 m. Isolated pines grow up to the Fiello Falls. Solitary small trees (more than 50 years old) are found above the birch forests on the slope of Tuolba Njanguoivi at a height of about 400 m (LAINE 1970). North of Kevo the pines do not generally

extend to altitudes higher than 200 m (e.g. near Mantojärvi). In the Polmak river area (at 69° 53') the upper limit of pine is between 200 and 240 m (SANDBERG 1898: 166) and at Potsuväärri (69° 54') 210 m. In the southern part of the research area the pine may form the upper forest limit (e.g. on Stuurra Rivttušvarri), but in the north, birch forest always extends beyond it. *Silvike.*

Ecology. At its northernmost limit the pine is no longer totally adapted to the prevailing environmental conditions. In this marginal zone it is more dependent on the most favorable habitats and for reproduction, on favorable years (cf. RENVALL 1919; SARVAS 1970). There is also evidence that genetically the pine is much less variable here than in the more southern areas. The northernmost localities are characterized by a relatively warm local summer climate and dry soil (cf. KIHLMAN 1884: 185; HULT 1898: 41–43; KUJALA 1929: 21). On the other hand, the low winter temperatures are apparently without significance (e.g. in winter 1939–40 with unusually low temperatures; cf. HUSTICH 1942: 228). Thus the pine grows in the deep valleys of the Utsjoki and Kevo, where the temperature minima in winter may be nearly 20° lower than in the surrounding fjelds but where the summer temperature is higher than in the mountains (according to the meteorologic observations at Tsieskulvaara and in Tsieskula farm yard). The soil on the best pine forests of Utsjoki-Kevo is glacial sand and gravel with a vegetation of *Cladina* and dwarf shrubs (*Empetrum hermaphroditum*, *Vaccinium vitis-idaea* and *Arctostaphylos uva-ursi*). The same features of the habitat also prevail in the Pulmankijoki valley. In Inari *Empetrum nigrum* is typical of warm (pine forest) soil. At its northern limit, pine rarely grows on bogs. The gravelly slopes of the mountains, particularly those with a southern exposure, are typical habitats of pine in the valleys of the rivers Teno, Inarijoki and Kaamasjoki and their tributaries. The soil pH is mostly 4–5, and podsolization is rather well developed; in the Kevo IBP site the A layer is very thin, 4 cm, and at Angeli it averages 4.5–5 cm.

Age and growth. The pine forest grows slowly here — the annual growth in the research area has been estimated as 0.8 m³/ha in southern Inari and 0.4 m³/ha near the forest limit



Fig. 13. Young pines at the Kevo Station. Note the uppermost, very short annual shoots of the year 1969. 1970 Matti Sulkinoja.

(ILVESSALO 1957; MIKOLA 1970) and the timber volume from 53 to 15 m³/ha. The radial increment of the pine is correlated with the temperature prevailing during the growing season (RENVALL 1912; HUSTICH 1940; 1941; 1944; 1947; 1948; 1956; 1969; MIKOLA 1952; SIRÉN 1961; LEIKOLA 1969: 116, and the literature cited there). At the outermost pine forest limit the average width of the annual ring was 0.46 mm in the years 1851–1900, but in 1930–1939 it was 0.90 mm. In the southern part of N. Finland the difference is less pronounced (MIKOLA 1952: 11). The growth of about 60 first years for the seedlings is very slow (RENVALL 1919). The length of the annual shoots in the pine is closely correlated with the temperature of the previous year (HUSTICH 1969). The pine grows slowly and may reach a great age in the research area, although the growth of length ends at the age of about 150 years. The oldest pines in the vicinity of the station are about 450 years old, but trees more than 800 years old are known from Inari Lapland (STRÉN 1961). Storms have often felled pines in the research area where in many places



Fig. 12. Isolated, badly damaged pine from Joenkielinen, Inari. Elev. about 450 m. 9. 7. 1970 Jaakko Nurmi.



Fig. 14. A view from Ravaspää, Inari. There is no birch belt above the pine forest. 10. 7. 1970 Jaakko Nurmi.

there are trees that have all fallen in the same direction (cf. SANDBERG 1898), mostly towards the south or southeast. In October 21 and 22, 1965 a heavy storm (21 m/sec) felled about 4000 pines in the Kevo forests. The prevailing northern winds may also cause an excentric growth of the stem (RENVALL 1923: 13). Although normally the winter temperature seems not to be a factor limiting growth of pine, after too short a summer the severe cold may cause severe catastrophes; such a catastrophe took place in 1902 (cf. MIKOLA 1950). Another occurred in winter 1968—1969; the September was very cold, having a mean temperature of only $+3.4^{\circ}$, the minimum night temperature fell below 0° on 19 nights; the mean temperature for June–September was only 7.4° C. During the winter 15–20 % of the young pines in the Kevojoki valley were very badly damaged, and 80–90 % of the pines grown from seeds collected in Kolari — in the plantation near Utsjoki church. Similar damage was seen everywhere in Inari Lapland, even in the southernmost parts. In the more favorable summer of 1969 (mean temperature 9.2°) the damaged shoots lost their needles. In a few shoots the apical bud remained alive and the growth of the shoot continued, but mostly branching of the stem resulted.

The young pines in the fjelds are in most cases very badly damaged, with branched stems, and show clear ruination in all probability caused by freeze-drying (cf. EICHE 1966) and mechanically by reindeer or (as was verified at the Kietsimäjoki and Peltojoki areas) by elk. The disturbance caused by reindeers is at Kevo as it was for 50 years ago when 90 % of all

pine seedlings were more or less damaged (RENVALL 1919). Local counts made at Stuuravdsi on the Muotkatunturit, indicated that the mean age of 12 pine seedlings in the alpine belt, the lengths of which varied from 20 to 36 cm, was 31 ± 4 years. The seedlings of the pines from many different favorable years in this century (cf. HUSTICH's papers cited; SIRÉN 1961) have not led to a northward expansion of the pine forest limit. There are, however, many seedlings at this limit (particularly in the Kevojoki-Utsjoki area but much less than in the northwest corner of Inari), and this means at the very most that the favorable years help to retain the present position of the forest line.

The high temperature over 20° C, required by the pine for optimal net photosynthesis at Kevo (UNGERSON & SCHERDIN 1968: 420), which is higher than that of the typical subarctic plants (*Betula tortuosa*, *Arctostaphylos alpina* etc., UNGERSON & SCHERDIN 1962), does not indicate very good adaptation of the pine in its northernmost extension. The yearly inactive phase is apparently more rigid than in southern Finland. In January a temperature of 5° C during 3 days is needed to produce a net gain from photosynthesis, or 15° C during one day. The minimum temperature for respiration is -17° to -18° C (UNGERSON 1968). The chlorophyll content shows a yearly rhythm (Fig. 18). The very yellow autumn color is typical of the Lapp pine (cf. WRIGHT & BULL 1963).

Reproduction. Up to this century the reproduction of pine has been very weak, as clearly

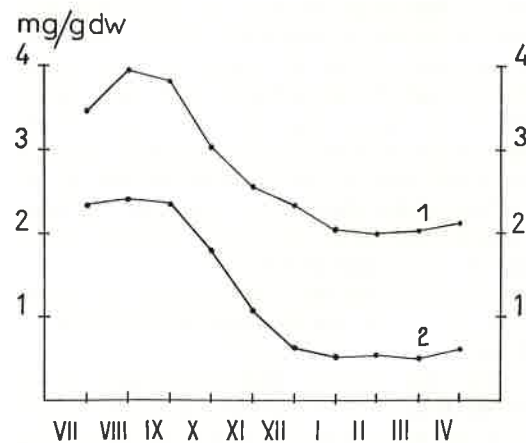


Fig. 15. Variation of the chlorophyll (1) and carotenoid (2) content of *Pinus sylvestris* in 1969 at Kevo.

indicated in the studies of RENVALL (1912; 1919). In this century, on the other hand, many rather favorable years for seed production have occurred, as HUSTICH (1940; 1942; 1944; 1947; 1948; 1956; 1958), MIKOLA (1952; 1959; 1971) and SIRÉN (1961) have shown. Around Kevo young pines of several age classes between 5 and 50 years are common. Mostly they are around seed trees, but even in the birch forest may be seedlings some hundreds of meters from pine trees. In the Inari fjelds seedlings are also common in the alpine belt. In 1965, a count was made at Rovapää near Kietsimäjoki, and about 400 pines per square kilometer, 30–40 years old, and mostly branched and badly damaged if not totally dead were found in the lower alpine belt over a wide area. In the alpine zone of Stuuravdsi in the Muotkatunturit fjelds about 700 young but very badly damaged seedlings per square kilometer were counted in 1966. The age classes vary, but one contingent is from the last years of the 1930s (perhaps from the warm summer of 1937). In the Saariselkä, pine seedlings are not uncommon in the alpine region (cf. BLÜTHGEN 1970: Kaunisää). In the alpine region of Toaresoivi several young pines have reached a height of about two meters (hence they originated during the first warm summers of this century). On Puurihroaivi, Muotkatunturit, (539 m) a pine seedling was observed right at the top! In SW Inari, e.g. near Poastajohka, dense stands of pine seedlings (18–25 years; more than $10/m^2$) in some places even form a hindrance to walking.

In the Kevojoki and Utsjoki valleys pine seedlings are rarely found outside of the pine forest area (cf., however, SIRÉN 1960; 1960 b; 1970. Between Paavalvaara and Juovvaskallovarri there are some young pines originating from the years 1945–1947. From the early years of the 1950s however there are quite isolated seedlings to as far north as Kuorboavi, as well as some totally dead ones from the 1930s. Around Vetsijärvi the frequency of pine seedlings is apparently highest in the NE fjeld area of Utsjoki. But these examples show that here the pine seedlings are of no significance for the expansion of the pine forest in this direction.

Still more important than for vegetative development is the limiting effect of low temperature on sexual propagation. The mean

summer temperature (June–September) is one parameter which gives good correlations for seed formation (HAGEM 1917; HEIKINHEIMO 1921; KUJALA 1927; SIRÉN 1961; MIKOLA 1970), but apparently the thermal sum gives a still better correlation (SARVAS 1962; 1970). In the 1960s the mean temperature of June–September never reached 10.5° C, which has been regarded as a lower limit for (minimum) seed production. From the earlier decades (in the literature cited) there is ample evidence that many good seed years have occurred at the pine forest limit even in this century. On the other hand, in the year 1970 the summer mean temperature was 11.3° , which is enough to permit adequate seed formation (cf. KUJALA 1927). The effective thermal sum in such a rather average year as 1966 at Kevo was 550 d.d. (= degree days summed for days over $+5^{\circ}$) and in 1965 605 (YLI-MATILTA 1967). In such thermal conditions, the pine is mostly able to produce only empty seeds. Even in the closed forests of Inari average seed formation per unit area is low as compared with that of southern Finland, and the average number of viable seeds may be only 10 % of the total seed count (cf. SARVAS 1962: 151). In the research area the thermal sum declines steeply from south to north. In Inari the d.d. in the last decade (1961–1970) was, according to MIKOLA (1971), 664 and 800 d.d. is first able to ensure a weak seed formation (VALTANEN 1968). When calculated in the same way at Kevo it is only 586 (in 1962–1970). The value is the lowest mean in Inari in this century (cf. also VALTANEN 1968, dealing the Sodankylä area) and makes it understandable that conditions are by no means promising the northward expansion of the forests.

The pine forest limit. There is much evidence that the pine forest limit has receded in Northern Fennoscandia owing to deterioration of the climate. Confirmation is forthcoming from Utsjoki where some pine trunks have been found in lakes and ponds now situated north of on above the present pine area. Two such places mentioned by SANDBERG (1898: 140) are: "Skadtjanjargalompola", 10 km from the mouth of the Utsjoki at the Tenojoki river, and Ailigasjäyri.

It is apparent that the pine forest limit irrespective of whether it has receded to its present position or not and whether or not it is



Fig. 16. Old pine at the Stuuravdäsi river. 1965 Paavo Kallio.

affected by human activity, is the most natural phytogeographic limit in Inari Lapland. The pine forest limit coincides with the northern distributional (absolute or relative) limits of many plants, e.g. *Picea abies*, *Juncus stygius*, *Scirpus palustris*, *Carex globularis*, *Phragmites communis*, *Scheuchzeria palustris*, *Betula pendula*, *Salix xerophila*, *S. pentandra*, *Moneses uniflora*, *Empetrum nigrum*, *Vaccinium oxycoccos*, *Drosera anglica*, *D. rotundifolia* and with the southern limit of common occurrence for some alpine species, e.g. *Phyllodoce caerulea* and *Loiseleuria procumbens* (cf. KALLIO et al. 1969: Figs. 40 and 42). Even if the pine is disregarded, this limit is the sharpest distributional limit and apparently is correlated with the temperature and with the maritimity (e.g. dependent on elevation).

Fungi and epiphytes. The pine limit is the distributional limit of several mycorrhizal fungi, or at least the limit for the formation of their fruiting bodies (KALLIO & KANKAINEN 1964). The typical mycorrhizal fungi (common in the whole boreal coniferous zone in Finland) distributed up to the tree limit of the pine are:

Suillus bovinus (up to Käsäjärvä in the Utsjoki valley)
S. luteus (Kevo and Pulmanki, also around some isolated pines north of the forest line)
S. variegatus (as the previous species)
Boletus edulis var. *pinicola* (up to Kevo)
B. vulpinus Watling (as the previous species)
Amanita porphyria as far north as Kevo and Laevva-johka)
Tricholoma pessundatum, *T. virgatum*, *Collybia putilla* (Kevo)

There are still other apparently mycorrhizal species which in Finland are more abundant in

the northern pine forests than in those of the south. *Armillaria focalis* is typical of the Kevo-joki valley (the species also grows at the easternmost margin of the range of pine i.e. in Yakutia, where the author Kallio collected it in 1967). *A. goliath* is another typical fungus of northern pine forests.

The various diseases of the pine that are common in the south also occur in Lapland; in addition, some northern species are apparently very important. Most of the dangerous species of Polyporaceae extend as far north as Inari Lapland, although isolated trees apparently are not so susceptible to these fungi as those in closed forests. For example *Fomitopsis pinicola* is rare in the timberline area (KALLIO & KANKAINEN 1964; ERIKSSON & STRID 1969). Such more or less parasitic microfungi as *Cenangium ferruginosum*, *Cronartium peridermipini*, *Lachnellula suecica*, *Lophodermium pinastri*, *Phacidium infestans* and *Scleroderma lagerbergii* are common in the area, at least in some years (e.g. 1969). All these are also collected in the Kevo area.

The epiphytic lichens, which are typical of the closed pine forests up to the main forest limit (e.g. near Syysjärvi) — *Alectoria fremontii*, *A. jubata*, *A. simplicior* — are much rarer in the isolated pine areas of Utsjoki. *A. fremontii* is totally lacking in the Kevo area and in Pulmanki, although in the Utsjoki valley

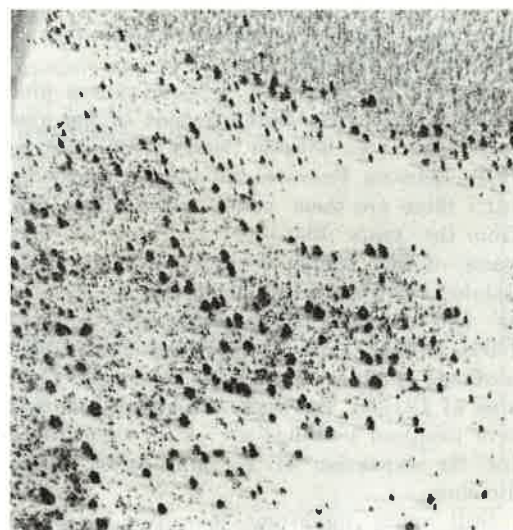


Fig. 17. Mixed birch-pine forest near the pine forest limit between Syysjärvi and Sammutjärvi. 1966 Paavo Kallio.



Fig. 18. Pines near the pine forest limit, southwest of Iijärvi. 1970 Heikki Kallio.

there are rather abundant epiphytic *Alectorias* at Korretoja. On the other hand, *Parmelia olivacea* (found particularly on birch but also on pine) seems to be commoner north of the continuous pine forests.

Dependence on culture. The rivers in the research area that run to Norway — the Teno with its tributaries and the Näätämöjoki have been routes for timber floating, and it is apparently human influence that has given rise to the pure birch forests e.g. along the lower course of the Teno, which was earlier covered by mixed pine forests up to the Arctic Ocean (SANDBERG 1898; JUUL 1925: 376; MIKOLA 1959). In other parts, too, particularly north of Saariselkä, human influence has affected the pine forest limit (KIHLMAN 1884; RENVALL 1919; ILVESSALO 1942; HUSTICH 1944; SIRÉN 1958). Apparently the forest fires have had the most effect on the withdraw of forest limit but the tree felling particularly along Utsjoki, Näätämöjoki and Pulmankijoki have been also very important. On the other hand, even the "bark bread" (the common emergency food) use (until 1880) has alone been able to affect the forest limit (RENVALL 1919: 56). Possibly the retreat of the limit north of Syysjärvi may be an example of the effects of human influence (see p. 83); this, then must have taken place in the period between WAHLENBERG's (1802) and KIHLMAN's (1880) expeditions (cf. KIHLMAN: 29). On the other hand, in the area east of Syysjärvi there is no evidence to support the view that recession of the forest is dependent on felling. In this area settlements have apparently always concentrated on the shore of Lake Inari — the Sevettijärvi line (cf. NICKUL 1952), about 20 km south of the pine forest limit. Neither have the routes of the

people from Pohjanmaa and Inari to the Arctic Ocean (cf. KIHLMAN, 29) followed the forest line. Even here however, forest fires have evidently affected the forest line (SIRÉN 1956; 1960).

Only very rarely do young pine seedlings occur outside the pine forests in a group. One such locality is not far from Selsjärvi (south of Kuorboarvi). Because there have been no seed trees in the vicinity, the occurrence is possibly anthropochorous: an old reindeer route passed this way from Inari to Polmak (according to Juhani Nuorgam), and the Lapps lined their reindeer sledges with pine twigs (cf. also HUSTICH 1958).

Reforestation in areas near the pine forest limit started at Harrisuvanto near Näätämöjoki in 1911 and was later practiced at Pakanajoki, Pulmankijärvi and at many places in the Utsjoki valley (cf. Fig. 11).

The seedlings of northern provenience have survived, although their growth is very slow (KALELA 1937; NUORTEVA 1948; MIKOLA 1952; 1959). However the cold years, e.g. 1968—1969, caused severe damage, as described earlier (cf. also HOLTMEIER 1971). Although it now sounds somewhat too optimistic to say that "probably the whole fell-birch region could be converted into coniferous forests" (MIKOLA 1952: 35), some reforestation activity will presumably continue.

Human influence in recent years has been most felt over wide areas because of timber felling and many doubts have been expressed concerning the success of reforestation in these



Fig. 19. Aerial view of the pine forest limit south of Palloaivi, Inari. 9. 4. 1971 Saini Heinonen.

areas (cf. MIKOLA 1971). For example felling has been fairly extensive between the Virtanien and Rajajoosppi roads, and also in SW Inari, mainly south of Ivalojoiki, and new temporary roads are continuously being built deeper into the still primeval pine forest areas. As is obvious even to a casual visitor, this felling has radically changed the whole landscape. Apparently, the amelioration of the summer temperature in the 1930s has also caused pressure against the protection-forest act since 1950 (MIKOLA 1971) before the deterioration of the climate had affected the planning.

Taxonomy and variation. In the Flora Europaea the Lapp pine is named var. *lapponica* Fr. HYLANDER (1953) and BENUM use this name at subspecific level. The taxon has also been accorded the rank of a species (*P. lapponica* Mayr and *P. frieseana* Asch.). In the history of its taxonomy, the Scots pine has acquired at least 144 names for geographic and morphologic variants (cf. CARLISLE 1958). However, from the studies of LANGLET (1936), WRIGHT et al. (1958), etc., the clinal nature of *lapponica* is evident. Perhaps the "ecotype A" of WRIGHT & BULL (1963) is identical with *lapponica*. We can thus give no nomenclatural status to the Lapp pine.

The young Lapp pine, with its relatively thick and straight stem, is narrow with short horizontal twigs and short needles lasting from 4 to 6 years. The ash content of the needles is high. The color of the cones is mostly of a somewhat more yellowish brown shade than that of the more southern representatives. Apparently, all the northernmost pine populations are rather uniform and physiologically specialized (cf. SARVAS 1970 a, b). Particularly the long distances over which pollen is dispersed (cf. KOSKI 1970) and the small chance that viable seeds will be obtained from self pollination are responsible for the fact that for example the two northernmost pine forest exclaves (Utsjoki — Kevo and Pulmanki) differ very little genetically. There are, however, slight but significant differences in the morphology of the cones as well as in the thickness of the hypoderm (KOSKI, private communication). Because responses to different environmental conditions in the Kevo and Pulmanki areas may be involved, it is only by growing the trees in identical condition that

the real relations of the two populations can finally be unraveled. The distance of about 50 km separating the pine exclaves apparently dates from the Subboreal age (cf. RUUHIJÄRVI 1962); the time may be long enough to cause some small differences.

In 1969 it was easy to see that the planted pine populations (Utsjoki church and Mierasjärvi) grown from seed brought from Kolari, which has proved to be one of the most favorable provenience for transplantations in forest limit (cf. KALELA 1937), and from Sodankylä (Mjelkkijoki) clearly differ from the local strains in their adaptation to the yearly rhythm of activity and the response to the situation caused by the very early onset of winter.

CUPRESSACEAE

Juniperus communis L.

Indigenous, very frequent

Distribution. Boreal circumpolar; the only almost completely circumpolar conifer (HULTÉN 1962: 75; HUSTICH 1967). Common throughout Fennoscandia (HULTÉN: 69). Common in Troms (BENUM: 82), in Finnmark ((DAHL: 237) e.g. in the Rastigaissa area (RYVARDEN 1969), in Pechenga and in Kola (ROIVAINEN; VALLE 1933a; SÖYRINKI: 1; Fl. Murm. I: 96). Common in the whole of northern Finland (HJELT & HULT: 155; HULT: 179; HJELT 1888: 70; LINDÉN; MONTELL; PERTOLA; KUJALA 1964) in both lowland and mountain areas.

InL ref. Common — very common (KIHLMAN; WAINIO; MIKKOLA MS; KLOCKARS & LUTHER; LAINE et al.; KUJALA; KALLIO & MÄKINEN; LAINE).

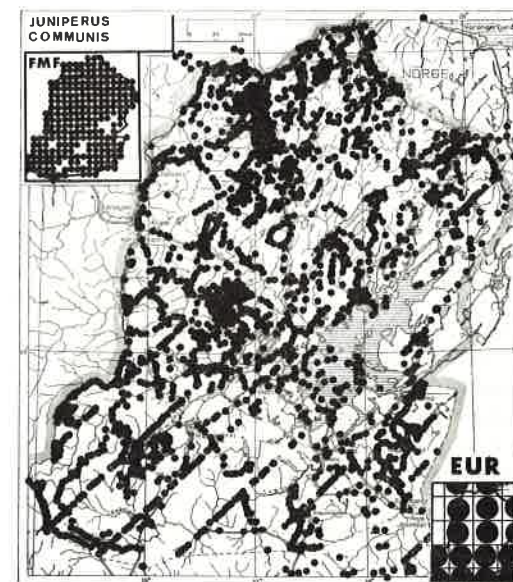
Very frequent (2312; 0.758). *Utsjoki*: VII (838; 0.755); *Inari*: VII (1474; 0.759). Fairly evenly distributed over the whole area. However, there is a slight concentration in the eastern and southern parts which is not obvious from the distribution maps. For the southern areas, this is detected if the relative frequencies are plotted against the geographical latitude at 5° intervals, and a rank correlation test made between frequency and latitude. This gives $r = 0.22$, which denotes a correlation significant at the 3.5 per cent level. According to KUJALA (1964: map 20), the conifer forest areas in Lapland form a zone where the juniper is very frequent. In the Lake Inari area, the juniper occurs on the larger islands (but is not very abundant), is often totally lacking on the medium-sized islands, and again becomes common on the small skerries, but then as a prostate

form instead of the shrubby ecotype which grows on the larger islands. *Whole area*.

FMF 0.910.

Vertical distribution. *c*: VII (0.737), *ab*: VII (0.772). Difference***. Recorded range 13 — 620 m (SW slope of Kaibmoaivi); SE slope of Peldoaiivi 550 m (KIHLMAN). Common in the conifer region and in the birch belt; still fairly common in the alpine belt but becoming rare and local on the highest tops. Finnm. 722 m, Troms 1024 m, EnL 884 m; Vuomapää in Sodankylä 634 m (HULT: 179). *Vertical ubiquitous*.

Ecology. Moisture requirements. Although the juniper is one of the commonest vasculars in Inari Lapland, it has distinct ecologic requirements as to both soil and climate. Solitary shrubs occur scattered in every type of community, but there are no stands of any size on the dry heaths which form the main vegetation type in the area. This statement is valid both for the pine region and for the birch and alpine belts. According to KALLIOLA: 209, it is one of the species characteristic of the mesophilous Phyllocladeto — Vaccinium myrtillion but absent from the xerophilous Loiseleurieto — Arctostaphylio. In the heath areas the juniper occurs almost without exception along brooks and rivers, usually in places which are inundated during the spring, often with such associates as *Cirsium heterophyllum*, *Geranium sylvaticum*, *Carpogymnia dryopteris* and *Saussurea alpina*; according to KONTUNEMI (1932: 43), the juniper is strikingly common and abundant in the Dryopteris — Myrtillus sociations. Along the riversides it usually forms continuous stands. In the birch belt the juniper also commonly occurs at the margins of bogs, often forming a narrow belt between the wet bog and the drier ground, and in depressions and other places which remain long inundated. Later during the summer the habitats may dry out considerably but in the habitats of the juniper the ground water level is always fairly near the surface, and it should be remembered that the root system reaches deep into the soil (LEMBERG 1933: 94; KUJALA 1958). On inundated riversides the juniper also forms large and continuous stands on sandy soil; typical examples are the Lohiniemensaaret islands in the Teno river, where almost pure juniper stands dominate an area of about 3 hectares.



Similar stands occur elsewhere, e.g. along the Polmakelven, Luobmošjohka and Ivalojoiki. These alluvial stands apparently correspond to the dune habitats in S Finland (LEMBERG 1933: 94).

As well as along the rivers, the juniper also forms dense stands on moist, usually birch-covered hill-sides, particularly on the lower slopes, where the ground water is nearest to the surface. In the alpine belt it forms very extensive stands in many places, especially in the Paistunturit and Jeskadamtunturit area, e.g. at the sources of the Madjohka at Koddigvarri and by the Nuvvusjohka west of Kirjeeädna (see also MIKKOLA MS). Similar large stands occur on the S and SW slopes of Akšojunni and on Seppeheikkavaara in the Muotkatunturit area; SÖYRINKI: 1 mentions that on the N slope of Kiilopää it forms a zone about 50 — 100 m wide just at the upper birch limit. The other large juniper stands are also usually found at this altitude; maybe their presence there is partly linked with the calamities to the birch caused by *Oporinia*; in places which are moist enough the juniper certainly benefits from the killing of the birches.

Our concept of the moisture requirements of the juniper is somewhat at variance with the views of DAHL: 237 and BENUM: 82, who both stress that it occurs in dry sites. This difference may be due to three factors: (1) the climate

of N Norway is more humid than that of N Finland, and thus the juniper may thrive on drier grounds there; (2) Troms and Finnmark are more alpine and maritime, and this leads to a greater abundance of low and appressed types, which generally occur on drier ground; (3) there is much calcareous substrate in N Norway, and this seems to compensate (at least partly) for moisture.

Edaphic and microclimatic requirements. To a certain degree *Juniperus communis* is also edaphically exacting. For example, in the Kevojoki valley it is clearly concentrated on the narrow amphibolite areas which traverse the valley. These requirements — besides the need for a humid soil — may partly explain its preference for brooksides. According to BENUM: 82, it is very abundant on dry calcareous hills, and we have observed the same preference in several localities in Finnmark. There are no equivalent habitats in Inari Lapland, but on the ultrabasic serpentine rocks the juniper is one of the most characteristic species. According to KUJALA, it is especially frequent on eutrophic fens along the Ivalojoiki, and AHTE & HÄMET-AHTI (1970) also stress its abundance in "eutrophic fens and moist forests".

To some extent the juniper also shows southern characters here; the largest stands especially are confined to the southern slopes of the hills and fjelds. This has also been pointed out by DAHL: 237, BENUM: 82 and T. LAINE. Especially large and vigorous stands characterize slopes which provide all the various conditions required by the juniper: soil moisture, basic soil, and southern slope. Typical examples of such stands are the southern lower slope of Tsuomasvaara, where its associates include *Athyrium filix-femina*, *Cirsium heterophyllum*, *Geranium sylvaticum* and *Milium effusum*, and a hillside slope west of Uusipää, Tsarmitunturit area, where, for example, *Athyrium filix-femina*, *Galium triflorum*, *Geranium sylvaticum*, *Goodyera repens*, *Luzula pilosa*, *Melica nutans*, *Milium effusum* and *Rubus saxatilis* grow among the juniper shrubs.

Probably the most typical sites of the juniper in steep river valleys are talus slopes and ground at the foot of cliffs. In the Kevojoki valley the juniper stands on these sites are often so numerous and extensive that we can speak of a "juniper belt". The associates of the juniper in these habitats are chiefly species

which prefer a microclimatically warm southern exposure, e.g. *Chamaenerion angustifolium*, *Hackelia deflexa*, *Melica nutans*, *Poa glauca*, *P. nemoralis*, *Ribes spicatum*, *Rubus saxatilis*. LUNDQVIST (1968: e.g. 89—92) thoroughly investigated the ecology of such juniper scrubs and pointed out that special microclimatic conditions develop within these very closed juniper stands, and that there is also a change in the quality of the soil.

Age and growth. Junipers may reach a considerable age in Inari Lapland. The oldest known specimen was one studied by G. SIRÉN in the Lemmenjoki area, Pellinen (1070 years; personal comm.). The oldest observed by us showed exactly 900 annual rings, to which about 40 years should be added, giving a total age of about 940 years (mouth of the Puordnajohka by the Kamajohka, upper birch belt). Numerous other samples have proved to be 300—400 years old. According to KIHLMAN (1890), the juniper in Kola may reach 230—544 years. It may be mentioned that the oldest juniper on record grew in Livonia, circumference 2.75 meters and estimated age 2000 years (KANNGIESSER 1909).

Long ago, SANDBERG (1898: 195) pointed out that part of the stem may continue to grow even though other parts are dead. This has very often been observed in the junipers studied by us; Fig. 20 shows an example of a very asymmetrical old juniper stem. It is evident that certain microclimatic factors are responsible for the one-sided growth of such junipers. The most important of these is probably the wind, which molds the form of the crown and thus also affects the growth of the stem, and which, during snow- and ice-storms, injures the windward side. These factors also include such local topographic features as big stones and adjacent slopes which raise the temperature in the microclimate.

Fig. 21 shows the growth of juniper according to 13 samples, collected in various parts of the Paistunturit area in the upper birch belt or in the lower alpine belt. As a rule, initially the growth has been fairly slow; according to KUJALA (1958), growth is most rapid between the ages of 5 and 20 years but it should be noted that in our specimens these very first years are always missing. During the recent years growth has been fairly rapid, and generally steadily increased during the last



Fig. 20. A very asymmetric old juniper stem, age 900 + 40 years (mouth of the Puordnajohka by the Kamajohka. Scale 5 cm, Photo K. Alho.

150—200 years. Short-term fluctuations in the climate are not apparent in the annual growth of juniper; obviously microclimatic factors largely mask the general macroclimatic features. The radial increment ranges yearly from ca. 0.16 to 0.55 mm, the grand mean of all the annual growth rings measured being 0.31 ± 0.03 mm. Very similar results were obtained by KIHLMAN (1890), who reported the radial growth to be 0.15—0.39 mm per annum.

Reproduction. In southern Finland juniper seedlings are fairly common (KUJALA 1926: 113), and because berry production is high, conditions are favorable for sexual reproduction. In Lapland, however, it seems that the importance of asexual reproduction increases. In Pechenga SÖYRINKI: 1 has only rarely found seedlings in the alpine belt, and KONTUNEMI (1932: 43) found none in the subalpine belt. In Utsjoki, seedlings have been found at least on the sandy bank of the Teno close to the Utsjoki Frontier Guard Station. In Lapland especially, the boughs are capable of forming adventitious roots and thus the juniper may spread vegetatively (SÖYRINKI: 1; KUJALA 1958; LEMBERG 1933: 95; SARVAS (1964: 493)

mentions that a vegetatively spreading juniper may form stands covering tens of square meters, and that in suitable habitats reproduction is predominantly vegetative. Probably, however, the capacity to form adventitious roots is intimately correlated with edaphic conditions, especially with moisture, and thus extensive juniper stands only develop in the edaphically most suitable habitats.

The parasites and epiphytes. *Gymnosporangium cornutum* is very common in Inari Lapland on *Sorbus aucuparia* (MÄKINEN 1964b) but has only once been found on juniper leaves (Kotkapahta by the Kevojoki). Other parasitic fungi found in our area include *Lophodermium juniperinum* and *Sphaerella juniperi*.

The commonest epiphytic lichens are *Parmeliopsis pallescens*, *P. ambigua* and *Cetraria juniperina*, and in the southernmost parts also *C. caperata*. — *Amphicline*.

Morphology. *Table junipers.* In exposed localities in the lower alpine belt the juniper may form a single and usually very thick (about 10—25 cm) stem ca. 0.8—1.5 m high. The

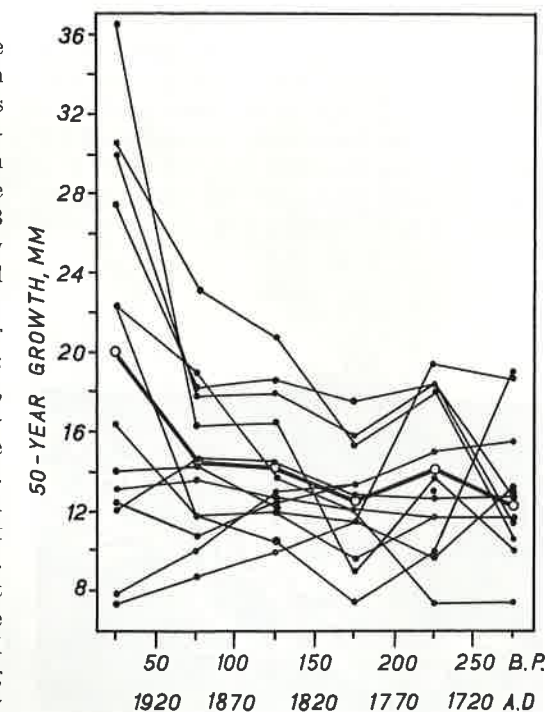


Fig. 21. Growth of juniper stem as a mean of 13 samples (thick line; thin lines indicate the growth of individual specimens).

branches are very densely crowded in the crown, which is clearly flattened and 1–3.5 m wide, so that the whole plant acquires a table-like form. SANDBERG (1898: 195) describes such junipers and mentions that the crown may reach a diameter of 3.5 m, the same maximum value which has also been found by us. The question is one of adaptation to the winter snow and wind conditions; only very few of the outermost tips of the branches extend above the protective snow cover. These conditions also modify the form of the birch, and they are also clear in the lack of branches in those spruces which grow at the upper forest limit in the zone immediately above the snow (in N Canada this phenomenon is very clear in black spruce and white spruce, see e.g. HARE 1971: Fig. 9). According to our observations, such table junipers are totally lacking in the eastern part of Utsjoki; typical table junipers occur e.g. at Kirjeeädna by the Nuvvusjohka, on the E slope of Nuvvusaittevarri (also one-stemmed birches), in the whole bog and heath area immediately E of the Paistunturit (e.g. at the mouth of Puordnajohka), and between Puurihroaivi and Portstšohkka in the Muotkatunturit area. The saddle between the two tops of Nuvvusvarri is characterized by dead single-stemmed birches and dead or dying table junipers; on the E slope of the same fjeld three-quarters of the large table juniper stand has died. The trees described by SÖYRINKI: 1 in Kilopää were also evidently table junipers (height up to 1.5 meters). Fig. 22 shows a very



Fig. 22. A very old (age not determined) table juniper, already partly collapsed and decayed (sources of the Stuuravdši river). 1965 Paavo Kallio.

old table juniper, which is partly decayed and has collapsed on the ground but is still partly alive.

Size. The size of juniper shrubs does not normally exceed 1 m. Table junipers, however, generally exceed this limit (see above). MIKKOLA (MS) mentions a juniper stand on the W slope of the Paistunturit, in which most of the plants had stems 1–1.3 m high and 20–30 cm thick. According to SÖYRINKI: 1, the juniper may exceed 1 m even in Pechenga; on the Nattastunturit fjelds in Sodankylä the thickness of the stem was 25 cm. Between Puurihroaivi and Portstšohkka the height of the 39 tallest table junipers ranged from 1.1 to 1.65 m (at the upper birch limit), the mean being 1.37 m. The thickest stem that we have measured is 22.5 cm in diameter (Kamajohka at the mouth of the Puordnajohka), but one specimen (Fig. 20) collected in the same locality had a radius of 20.6 cm, although its growth was strongly one-sided. The 1070 years old juniper recorded by G. SIRÉN was almost 40 cm in diameter. According to SÖYRINKI: 1, prostrate specimens in the Petsamontunturit area may reach a length of 320 cm.

Taxonomy and variation. Numerous authors have mentioned that var. *montana* Ait. (var. *nana* (Willd.) Loud., ssp. *nana* Syme, *J. nana* Willd., *J. sibirica* Burgsd.) occurs on the highest fjelds and on other open and exposed localities, e.g. in N Finland and on outer islands of the archipelago as a plant of the seashore rocks. In Finland, intermediate types have been called var. *subnana* Sael. According to AHTI & HÄMET-AHTI (1970), the junipers on hemerobe habitats in Kuusamo approach var. *montana*. In the Soviet Arctic, only *J. sibirica* is mentioned (TOLMACHEV 1960: 74); according to Fl. Murm. I: map 37, *J. communis* hardly occurs at all in Kola, but we strongly suspect that there it must have a wide distribution, and in our opinion should also occur in the Soviet Subarctic elsewhere.

Unfortunately, exact notes have not usually been made on the occurrence of var. *montana* in our area. However, our observations strongly suggest that this variety is extremely rare in the forest belts (KUJALA mentions one locality along the Ivalojoiki) and fairly rare even in the alpine belt, the situation being very much the same as in Troms; BENUM: 82 mentions that prostrate specimens of both races occur in the

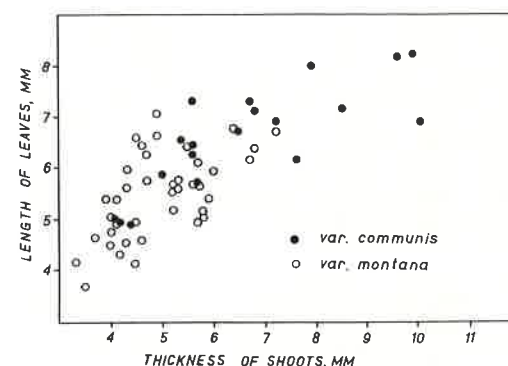


Fig. 24. Variation in the length of the leaves and in the breadth of the one year old shoots in the Lapp specimens of *Juniperus communis* (deposited in H and TUR). The dots indicate var. *communis*, the open circles var. *montana*.

alpine belt (but also in the lowlands), and pure ssp. *nana* is confined to the alpine belt but even there is rather infrequent or rare. We believe that in our area var. *montana* is still rarer in the alpine belt than in N Norway. Numerous authors mention that var. *montana* is the only race occurring in the alpine areas, but the form

in question may equally well be prostrate specimens of var. *communis*. At least in our area, most of the prostrate types in the alpine belt clearly belong to the main variety. Generally, the prostrate types seem to occur on drier ground than the erect shrubby types. Whether there is difference in this respect between var. *montana* and prostrate types of var. *communis* remains to be studied.

Apparently no-one has ever made any population analyses or transplantation experiments to clarify how far the variation in the juniper is hereditary and how far due to environmental influences. It seems obvious that in our area the differences between ecotypes are due to both causes, at least in the case of var. *communis*.

According to Fl. Eur. I: 38, the most important differences between var. *communis* and var. *montana* (there called ssp. *nana*) are the following: (1) growth habit (prostrate in *montana*, erect in *communis*); (2) length of the leaves (10–15 mm in *montana*, 20 mm in *communis*); (3) form of the leaves (acute to obtuse in *montana*, acuminate-subulate in *com-*

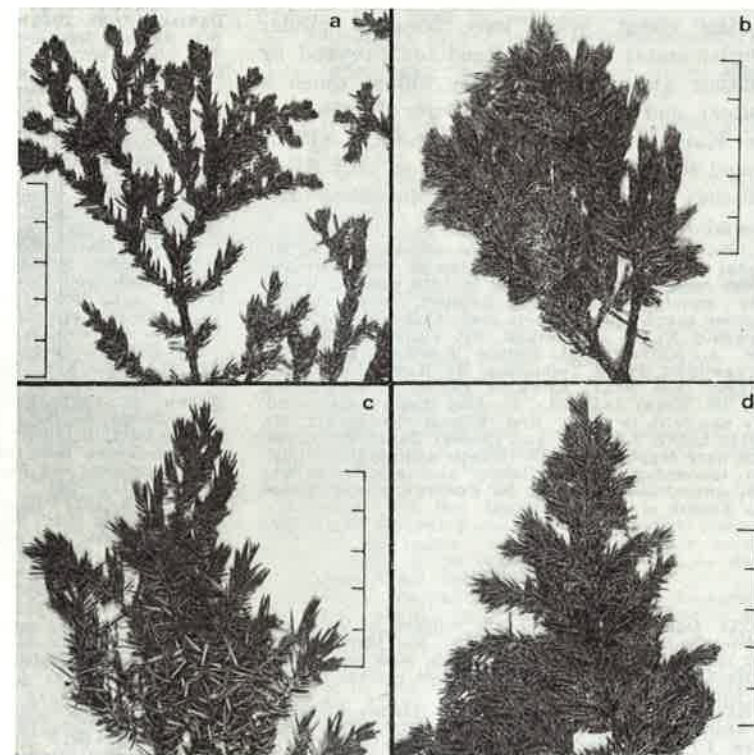


Fig. 23. Representatives of (a) and (b) *Juniperus communis* var. *nana*, and (c) and (d), var. *communis*. (a) Ahvenanmaa (Åland), Kökar, Bergskär, rocky seashore slope, June 19 1955 Y. Mäkinen; (b) Inari, Laanila, Kaunis-pää, subalpine belt, 28. 6 1931 Lauri E. Kari (TUR 157.850); (c) Utsjoki, Kevo, Tsarsjoki valley, sandy riverside bank, 23. 7. 1964 Unto Laine (TUR 130.581); (d) Inari, Lake Inari, Pietarinlaassa, creeping ecotype on a rocky slope, 7. 8. 1970 Yrjö Mäkinen 70–1337. Scale 5 cm. Photo K. Alho.

munis); (4) position of the leaves (closely set and upcurved in *montana*, spreading in *communis*). Fig. 24 shows the variation in the Lapp specimens of *Juniperus communis* according to the length of the needles, and the thickness of the one year old shoots, measured from the specimens in H and TUR. It is evident that the variation is fairly continuous, thus not allowing sharp delimitation of the two varieties, at least not on this basis. It should be noted that specimens exactly similar to the Lapp *montana* are known in the southern archipelago; see Fig. 23 for typical representatives of var. *montana* and var. *communis*. (A good picture of both is given in Fl. Murm. I: 97). Detailed morphologic and ecologic studies are needed to clarify the taxonomic rank, delimitation, occurrence and distribution of var. *montana*.

Dependence on culture. On mesohemerober habitats the juniper has gained through the manuring by cattle, and through extermination of other species by sheep. (PULLIAINEN et al. (1968) have shown that in Lapland the juniper forms a very wanted winter food for the elk!) The old junipers in fjeld areas (e.g. in the Raututunturit and Saariselkä fjelds which during recent years have become popular tourist areas) are being used for firewood by tourists (we mainly use dry willow, which is better), and are locally in a danger of extinction. In Kuusamo, AHTI & HÄMET-AHTI (1970) found that the juniper occurred on only 6.7 % of the investigated hemerobe localities. *Hemerodiaphora*.

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