kevo notes

8 1989

RISTO K. HEIKKINEN and RISTO J. KALLIOLA

Vegetation types and map of the Kevo nature reserve, northernmost Finland

1. Introduction

The usefulness of vegetation classification can be tested to some extent by vegetation mapping. Typical problems of mapping are that two types may fit the same stand, or vegetation may be different from any type described. These problems occured in the Kevo Nature Reserve. We mapped the vegetation of the area using previously described vegetation types (Kalliola 1939, Hämet-Ahti 1963, Eurola & Kaakinen 1978, Nordiska Ministerrådet 1984, Eurola et al. 1984) as far as possible. However, large areas could not be classified and needed new vegetation descriptions. Moreover, other vegetation types were often northern variants with floristic pecularities. This study was carried out to describe these special features, and also to increase our understanding of the subarctic vegetation processes. Particular attention was paid to tree line dynamics and the effects of forest damage caused by *Epirrita autumnata* (Lep., Geometridae).

The documentation of the present-day vegetation of the reserve may be important for the future analysis of gradual changes in the environment. The vegetation map (see inside pocket) shows the areal distribution of the vegetation types, while type descriptions enable comparison of the floristic or structural features of vegetation.

Although alpine heaths, forests and mires were distinguished in the 1:20 000 topographic maps (published 1975) and in the 1:100 000 outdoor map of the reserve (1983), detailed information of the vegetation was still lacking. In addition, earlier botanical studies are limited either to floristic observations or to information on small-scale vegetation patterns. We hope that this work will give useful basic information for future biological studies - which have been hampered in the past by a lack of basic data - as well as examplifying typical Finnish subarctic vegetation.

2. Study area

The Kevo Nature Reserve, founded in 1956, is located in Utsjoki, in the NW part of Inari Lapland, northernmost Finland (Fig. 1). The area includes most of the catchment area of the River Kevojoki that runs through the reserve from SW to NE in a steep-sided valley. The total area of the original Kevo Reserve was 350 sq. km, but it was enlarged to 710 sq. km in 1982. This study deals only with the original area of the reserve. Localities are given either by name or using the Finnish uniform grid system (grid 27° E on a scale of 1 x 1 km (see Heikinheimo & Raatikainen 1981).

The study area belongs to Fell Lapland, characterized by large subalpine mountain birch forests and gently sloping low fells (Kalela 1958). It lies in the subarctic zone north of the (nowadays) northern limit of the continuous pine forests (Hustich 1960, 1966, Kallio et al. 1969), or in the orohemiartic zone according to Ahti et al. (1964, 1968). The forests belong to the continental subzone of the subalpine mountain birch forest zone (Hämet-Ahti 1963), which coincides quite well with the palsa mire zone (Ruuhijärvi 1960, 1983). Thin-peated mires - especially on the fells - partly belong to the alpine mire complex (Eurola & Kaakinen 1978, 1979, Eurola et al. 1984), while the lakes are mainly oligotrophic *Carex* type lakes with a low number of species (Maristo

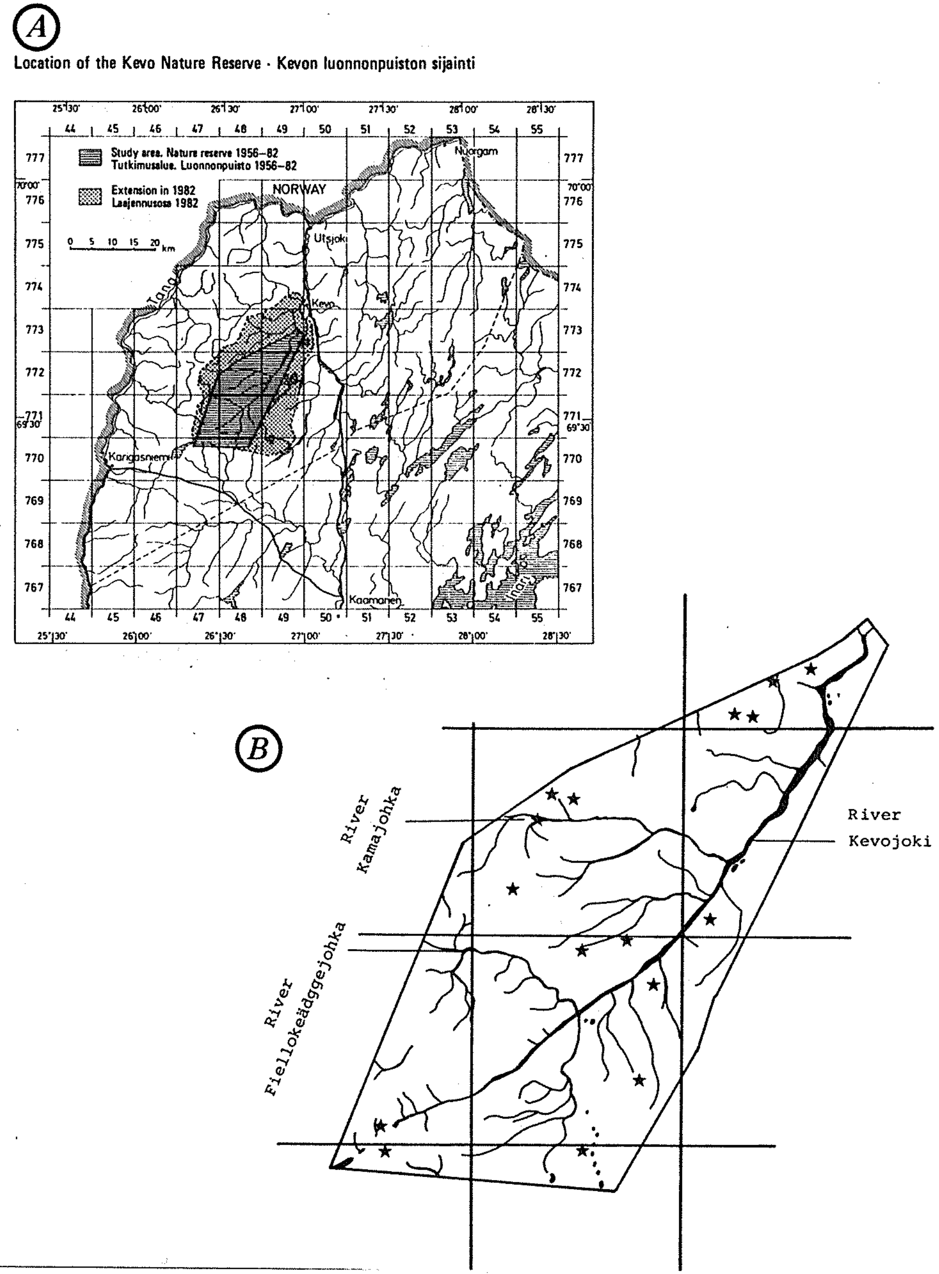

Fig. 1. (A) Location of the Kevo Nature Reserve. (B) Main rivers, brooks and springs (*) in the Kevo Reserve.

1941, Rintanen 1982).

Earlier floristic observations in the area were recorded in Kallio (1954), Laine et al. (1955), Kallio & Mäkinen (1957, 1975), Kallio et al. (1971) and Mäkinen et al. (1982), and especially in Kallio et al. (1969) and Laine (1956, 1970). Some other botanical studies (Kalliola 1939, Ruuhijärvi 1960, Hämet-Ahti 1963, Kärenlampi & Kauhanen 1972, Rintanen 1982) also include useful information.

2.1. Abiotic vegetational factors

The elevation of the area varies between 90 m and 552.9 m a.s.l., but is mainly between 200-400 m (Fig. 2). The greater the height, the lower the mean temperature and thermal sum and the shorter the growing season. The height factor also correlates with increasing windiness, greater unevenness of snow cover and changes in light and moisture conditions (Barry & Van Wie 1974, Mäkinen 1981).

Marginal and sub-marginal channels and subglacial ice- directed meltwater channels are common glaciofluvial formations (Syrilä 1964, Kaitanen 1969, see also Sudgen & John 1982) with special growth conditions (especially snow cover) and vegetation cover. Tertiary faults and depressions also have a marked effect on vegetation. At the bottom of the River Kevojoki valley and the gorges of some other rivers vegetation is usually more luxuriant, although stony and boulder-rich slopes may be almost plantless. The spot-like, floristically interesting cliff habitats that have been studied thoroughly by Laine (1956, 1970) are not included in this study.

The study area mainly belongs to the Inari Lapland granulite area although the NE corner is characterized by various types of gneisses (Fig. 2). More basic amphibolites and ultrabasic rocks occur as narrow intrusions near the River Kamajohka and gabbros and diorites in the SW corner of the reserve. Soils mainly include podsolized glacial tills covered by younger biogenic deposits (see Aaltonen 1952, Hinneri 1974), although in more moist habitats the horizons are weakly developed. River valleys are characterized by glaciofluvial deposits (often sand-rich gravel with large rounded stones). Weathering has created wide boulder screes and extensive talus cones (Kallio et al. 1969: 8-10).

Wind erosion has some importance in upper fell areas and on the sandy slopes of esker ridges. River erosion has marked effects on vegetation only along the River Kamajohka (Kalliola & Puhakka 1988). Frost heaving strongly affects vegetation in some moist sites at high elevations.

The climate is continental (Conrads continentality index 30-32, Tuhkanen 1980: 78), which is indicated by the abundance of dwarf shrubs and lichens in the forests. The occurrence of palsas and mires in large plate depressions and the absence of blanket bogs also indicate a continental climate (Eurola 1968, 1978).

The annual precipitation at the Kevo meteorological station (69° 45'N/27° 00'E) is 393.9±34 mm, 40 % of which falls during summer (Hämet-Ahti 1963: 21, Kallio et al.

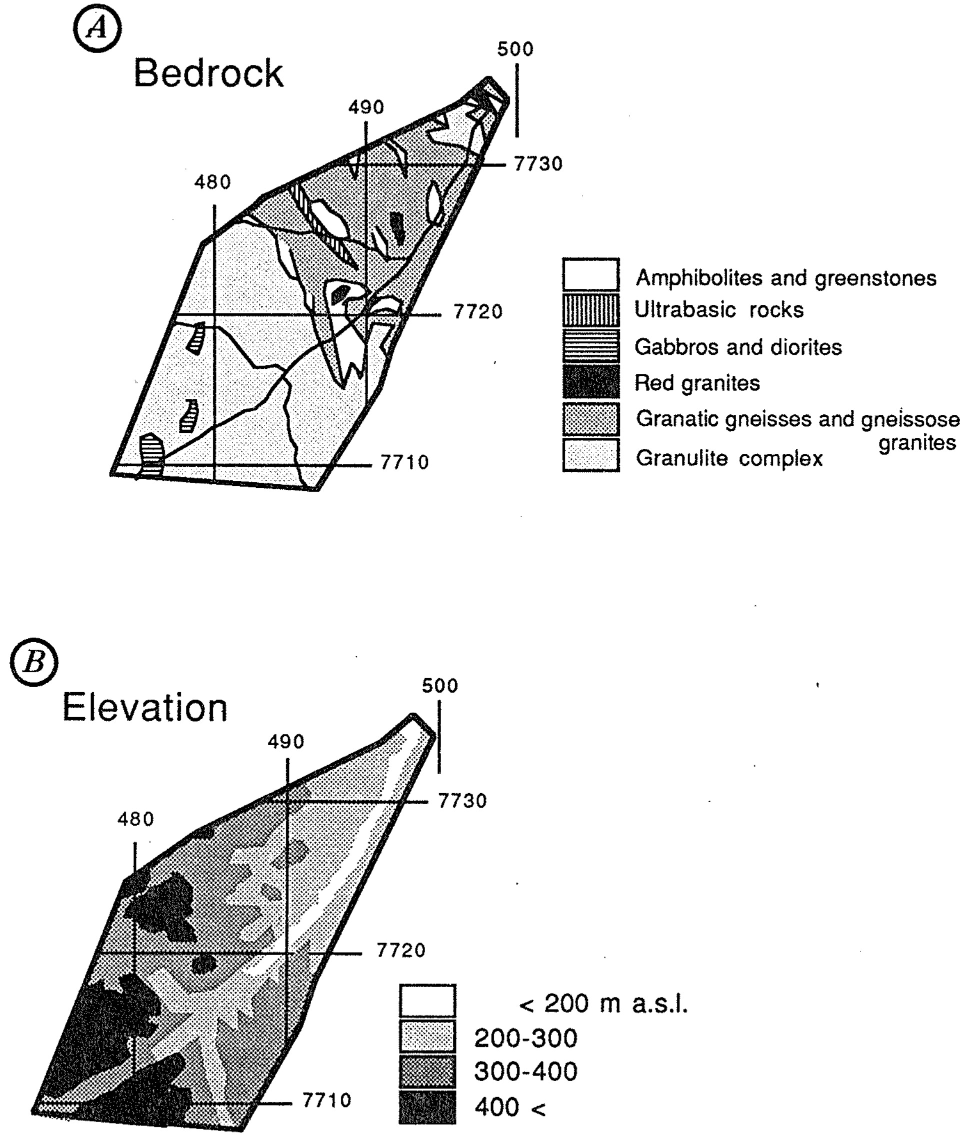

Fig. 2. Geological map (A) and the hypsometric layers (B).

1969: 15, Tuhkanen 1980: 79). The mean temperature sum (+5 °C) is 597±67 (Laaksonen 1979) and the average temperature during the warmest month (July, 1962-81) +12.7 °C (Kallio & Hurme 1983). The length of the growing season is 110-120 days (Tuhkanen 1980: 75). For more meteorological data see Kärenlampi 1972, Seppälä 1976, Niemelä 1979, Seppälä & Rastas 1980, Clark et al. 1985. Due to the complex geomorphology (valleys, exposed peaks, cliffs) the local microclimate may differ very much from the regional climate and offer suitable habitats for many southern plants (Kallio et al. 1969, Sonesson et al. 1975).

Snow cover varies according to topography, exposition, vegetation cover and windiness. It is over 150 cm in sheltered sites and less than 20 cm on fell tops (Kallio et al. 1969, Likitalo 1984). The uneven distribution of snow cover has the most significant effect on the vegetation in the alpine belt (see Kalliola 1939, Gjaerevoll 1956).

2.2. Biotic vegetational factors

The larvae of the moth *Epirrita autumnata* Bkh. (syn. *Oporinia autumnata*, Geometridae) caused birch forest damage in 1964-65 (referred to as *Epirrita* damage from now on) which changed the vegetation over large areas. Most of the defoliated trees died causing notable changes in the environment (Kallio & Lehtonen 1973, 1975, Lehtonen & Yli-Rekola 1979, Seppälä & Rastas 1980).

The other major factor affecting vegetation is reindeer husbandry. The reserve belongs to the herding area of the Paistunturit Reindeer Owners Association, where the maximum number of reindeer allowed is 7500. The number of reindeer in the reserve changes during the year. The area seems to be overgrazed because (1) "reindeer lichens" (*Cladina* spp.) are small, trampled and partly replaced by horn lichens or *Stereocaulon-species* (often in the protallium phase, see Ahti 1978), and (2) lichen patches are partly replaced by bare mineral soil or humus. Overgrazing promotes the dispersal of alpine species in the forest belt by providing habitats free from competition. Other human activities have nowadays practically no direct influence in this protected area.

3. Methods

The field work was done during the summers of 1983 and 84 by drawing the patterns of the vegetation types on 1:20 000 topographic maps. For large mire areas, aerial photographs were also used. The classification of the vegetation mainly followed previously described types, and references are given in the descriptions. In addition, five new vegetation types are defined according our personal judgements. These are represented by small but floristically interesting sites (e.g. brooksides), or large areas with a distinct physiognomy and vegetation (e.g. frost ground sites).

Vegetation was recorded from 1-5 sample plots (size 4 x 4 m), additional species lists and using extensive field notes. The original results from the coverage analyses are included in Heikkinen (1986), and a summary table (Table 1) which gives average abundances on the Domin-Krajina scale (Mueller-Dombois & Ellenberg 1974: 62) is presented here. Tree densities were analysed using the point-centered quarter method (see Shimwell 1971: 21-22). The nomenclature of vascular plants follows Mäkinen & Kallio (1979), of lichens Cannon et al. (1985) and of mosses Koponen et al. (1977).

Plant species are classified according to their characteristics in relation to the most important environmental factors (see Table 1). For reasons of simplicity these classes are referred to only as flora elements (cf. Eurola et al. 1984) and they indicate certain characteristics or influences (such as spring water influence) of the growth sites. The categories are thus close to the concept 'ecological species groups' (see Whittaker 1967: 218-220). The classification used is based both on literature (Mårtenson 1956, Eurola & Kaakinen 1978, Mäkinen & Kallio 1979, Eurola et al. 1984) and on our own experience, and includes the following categories:

(1) Alpine element
(2) Silvine element
(species preferring types sELiT, sELiPlT, sEMT)
(3) Meadow forest element
(4) Tree mire (Spruce mire, in Finnish 'korpisuus') element
(5) Bog ('rämeisyys') element
(6) Poor fen ('nevaisuus') element
(7) Rich fen ('lettoisuus') element
(8) Swamp (surface-water, 'luhtaisuus') element
(9) Spring (ground-water, 'lähteisyys') element
(10) Snowbed element

The classification presented is used later in the characterizing and comparing of the floristic features of the vegetation types. Calculations of the total coverages of different growth forms (Table 3) were based on the values of the sample plots (see also Söyrinki et al. 1977).

4. Vegetation types

4.1. Forests

The total area of different forest types is 190 sq. km (52.3 % of the reserve). Subalpine birch forests prevail, pine forests and more luxuriant meadow forests only occur as small stands (Figs. 3 and 4, Table 4). About 84 % of the birch forests were destroyed by *Epirrita* in 1964-65 (see Fig. 3 and vegetation map). The abrupt changes in environmental conditions are reflected in the undergrowth which causes classification problems (Lehtonen & Yli-Rekola 1979). The transition to different forest types is often gradual, without clear boundaries except on steep valley slopes.

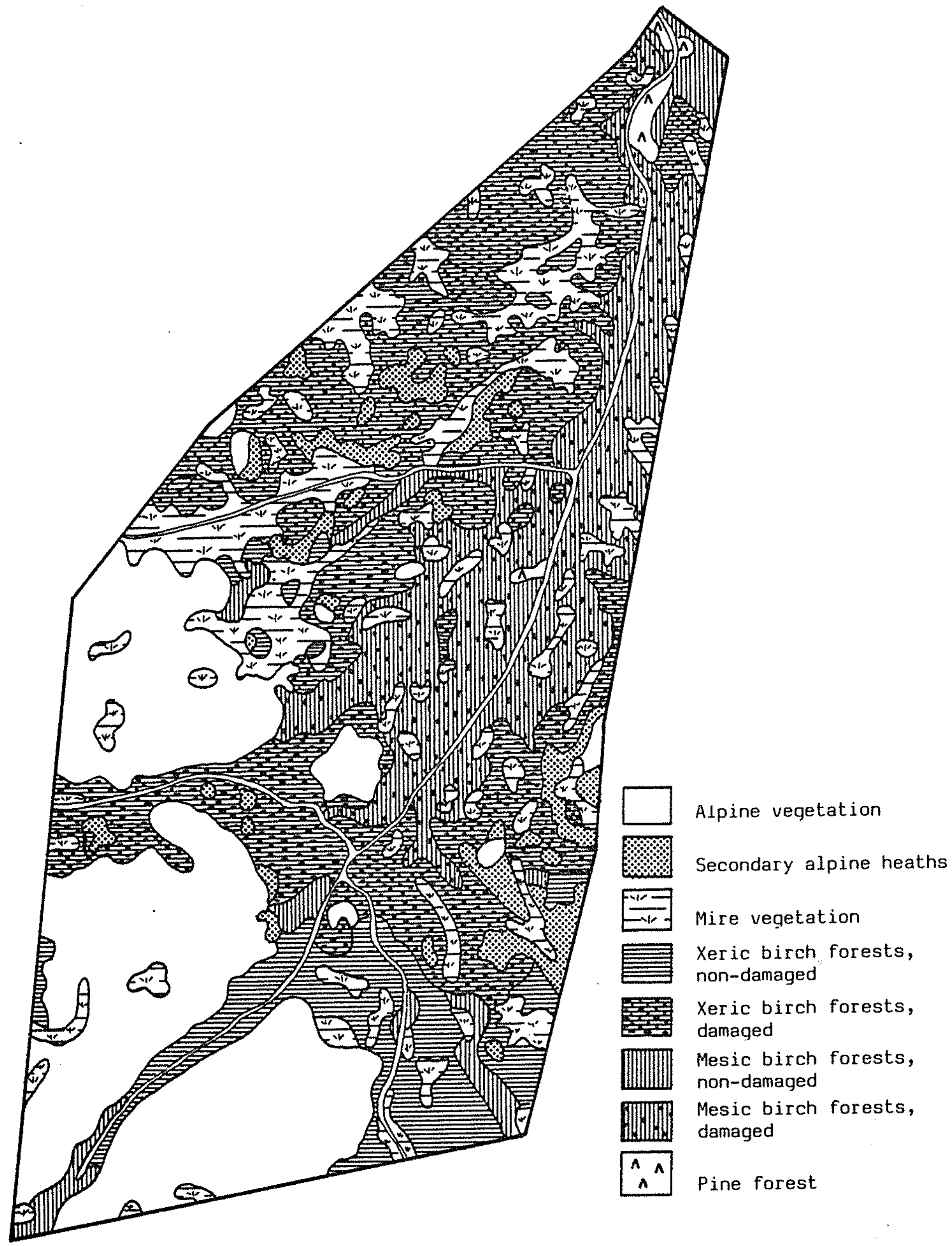

Fig. 3. Simplified vegetation map showing the main features of the study area vegetation. Xeric birch forests include stands of sELiT, mesic birch forests contain other birch forest types.

(1) Pine forest

Small stands above flood level in the River Kevojoki valley usually occur on glaciofluvial terraces where the mineral soil consists mainly of coarse sand (see Figs. 6 and 20 in Kallio 1964). The habitats are characterized by dryness, fairly high soil and air temperatures during the summer, rapid evaporation and relatively low wind speed (Kärenlampi 1972: 64-65).

The canopy layer (at 12-14 m) is normally rather open. Shorter, 0.5-6 m high pines are common, occasionally forming thickets (especially in glaciofluvial terraces). Polycormic mountain birches occur sparsely on glaciofluvial terraces, where the bush layer is mostly lacking and the undergrowth is formed by a mosaic of *Empetrum hermaphroditum* and lichen (especially *Cladonia* ssp.) patches (see Table 3). On the valley slopes the dominant tree gradually changes from pine to mountain birch. Two of the three pine forest types described by Hämet-Ahti (1963) occur in our area: (1) Lichen woodlands poor in mosses (mainly on the glaciofluvial terraces) and (2) Lichen woodlands rich in mosses (humid valley slopes). Both types have a low number of species (Table 1), which are acidocoles or amphiclines (Fig. 7).

Literature. Hämet-Ahti 1963: 104-109, Kärenlampi 1972, Nihlgård 1984: 175.

Birch forest types

(2) Subalpine *Empetrum-Lichenes* type (sELiT)

This is the most common forest type, typically occurring at greater elevations than the other forest types and forms almost all vertical forest lines. The sites are usually relatively dry, open, and windy, and have a fairly thin snow cover and sandy or gravelly morain soil. The daily summer temperature variation may be high. This type has been extensively (86 %) damaged by *Epirrita*.

The general description given by Hämet-Ahti (1963: 37-49) fits well in this area. The stands are very sparse (400-500 trees/ha), the birches low (2-4 m), polycormic or ± monocormic. The canopy coverage may occasionally be less than 10 % (normally 20-30 %). The bush layer is extremely sparse, the field layer dominated by dwarf shrubs. The undergrowth is formed by a mosaic of dwarf shrubs and lichens, as in pine forests. The lichen patches are often disturbed by reindeer trampling and grazing, which also promotes the existence of alpine plants (e.g. *Juncus trifidus, Loiseleuria procumbens, Luzula spicata* and even *Dryas octopetala*).

sELiT damaged by *Epirrita*. Dead birch trunks characterize the landscape. Some of the defoliated trees have produced basal shoots, but tree recovery is generally poor. The major part of the damaged areas is developing into secondary alpine heaths. However, their bush, field and ground layers still mostly resemble those in undamaged sELiT forests, although some alpine plants such as *Juncus trifidus, Luzula spicata, Loiseleuria procumbens, Cetraria nivalis* and *Ochrolecia frigida* seem to be favoured by the changed growing conditions.

Literature. Hämet-Ahti 1963: 37-49, Kallio & Lehtonen 1973, 1975, Lehtonen & Yli-Rekola 1979, Nihlgård 1984: 175.

(3) Subalpine *Empetrum-Lichenes-Pleurozium* type (sELiPlT)

This occurs at lower elevations than sELiT, usually on slopes with a humid microclimate and less extreme variation of temperature. 91.7 % of the stands have been damaged by *Epirrita*. The tree layer is mainly formed by polycormic, 4-6 m high (occasionally almost 10 m) mountain birches with a coverage of 30-60 % (c.f. Hämet-Ahti 1963: 51). The most important bushes are scattered 70-130 cm high junipers. The field layer is more uniform than in sELiT, although still patchy. Mosses mostly occur under trees and dwarf shrubs. The species composition is almost the same as in sELiT, although there are some species indicating the tree mire element. *Stereocaulon-species* are abundant in heavily grazed, relatively dry places.

sELiPlT damaged by *Epirrita*. Forest recovery is weak. Because of the changed microclimatical conditions - increased windiness and illumination, decreased soil moisture etc. - species requiring humid habitats have declined (see Lehtonen & Yli-Rekola 1979: 31). The changes in the field layer are more notable than in sELiT and it could be generalized that the destroyed variants of sELiT and sELiPlT therefore resemble one another more than the undamaged forests. However, species indicating the alpine element have not benefitted as clearly as in damaged sELiT. Damaged sELiPlT forests will mostly develop towards secondary alpine heaths, except in some humid depressions with successful sexual birch reproduction. The deepest depressions may also become embogged (cf. damaged sEMT).

Literature. Hämet-Ahti 1963: 49-52, Kallio & Lehtonen 1973, 1975, Lehtonen & Yli-Rekola 1979, Lehtonen 1981, Nihlgård 1984: 175.

(4) Subalpine *Empetrum-Myrtillus* type (sEMT)

Only small stands were found, usually on steep slopes, valley bottoms and sheltered depressions. According to Hämet-Ahti (1963: 57) sEMT becomes more common further north, because of increasing maritime climate. 47 % of the sEMT forests have been damaged by *Epirrita*. 4-7 m high birches (occasionally over 10 m) form the canopy, with a coverage of 30-60 % (60-80 % in the areas near the Lake Ristinäsjavri). The bush layer is of the same kind as in the sELiPlT depressions, dominated by 1-1.5 m high junipers (in a 30 x 30 m study plot at 7723:483 8.5 individuals/ha). Both the dwarf shrub-dominated field layer and moss-dominated ground layer are well developed and relatively uniform, not forming a mosaic.

sEMT damaged by *Epirrita*. Forest recovery is extremely poor. Species preferring humid habitats have clearly decreased in most areas. *Cornus suecica, Vaccinium myrtillus* and *Pleurozium schreberi* are particularly reduced, except in sheltered depressions, where juniper stands protect the undergrowth from radical environmental changes. Alpine features in vegetation development are not as important here as on the sELiT and sELiPIT sites. On the contrary, in the deepest depressions, the thick snow cover may promote paludification.

Literature. Hämet-Ahti 1963: 52-58, Kallio & Lehtonen 1973, Nihlgård 1984: 177.

(5) Mountain birch forest of low herb type

This occurs only along rivers or large brooks. The mountain birch forest type described on the Skandes by Nihlgård (1980; 2:71, 1984: 181) fits our forests quite well, where swamp influence replaces the missing maritime climate. The soil is fairly wet, non-podsolized with a thick (10-30 cm) mixed peat/humus layer covering glaciofluvial gravel and sand (see Hinneri et al. 1975). The type has been partly damaged by *Epirrita* (the middle parts of the River Kamajohka) but these areas were not studied separately.

The structure is somewhat different along the Rivers Kamajohka and Fiellokeädggejohka. By the meandering River Kamajohka, 5-8 m high mountain birches usually grow in small groups, and the riparian forests are relatively large, park-like, and composed of a mixture of minor communities (see Kalliola & Puhakka 1988). Along the River Fiellokeädggejohka the distribution of birches is more uniform. The dense, fairly species-rich field layer is dominated by grasses and herbs, while the ground layer is poorly developed (see Table 3). The total number of vascular plants is about 50 (Table 1). The species composition resembles that of herb and grass birch mires although the physiognomy is different. Vascular flora mainly comprises amphiclines, but there are also some basoclines (e.g. *Luzula* parviflora).

Literature. Nihlgård 1984: 181.

(6) Meadow forests

Only small stands occur along brooks and rivers (especially the River Kevojoki) in fairly deep valleys and gorges (see Fig. 7 in Kallio 1964), where they often gradually turn into herb and grass birch mires. There are minor occurrences at some brook gorges, where meadow forest vegetation lines the water course with a narrow belt. Swamp influence is marked, the soil moist and nonpodsolized.

The tree layer is composed of 5-7 m high birches, occasionally of *Populus tremula, Prunus padus*, or 4-6 m high *Salix borealis* (sites liable to flooding). The bush layer is dense and characterized by willows or junipers. The field layer is well developed, with tussocks of many grasses and sedges, or abundant herbs and ferns. Sparse mosses may occur in the hollows. As a whole, the physiognomy is not uniform because of the small-scale changes in environmental conditions between tussocks and hollows, ands because the variation in bedrock, elevation and swamp influence reflects the structure and species distribution.

This is the most species-rich vegetation type in the study area. Apart from the species listed in Table 1 Laine (1970: 103-104) mentions *Cerastium fontanum, Cirsium heterophyllum, Gymnocarpium dryopteris, Paris quadrifolia, Rubus saxatilis, Trollius europaeus* and the mosses *Brachythecium salebrosum, Calliergon cordifolium* and *Rhytidiadelphus triquetrus* as typical species (cf. Hämet-Ahti 1963: 62). The floristic structure is quite heterogeneous because alongside the meadow forest element, spring, swamp and tree mire elements are obsevable (Tables 1, 2). Some vasculars are basoclines (e.g. *Matteuccia struthiopteris, Myosotis procumbens* and *Viola biflora*), somewhat exacting (meso-eutrophic) mosses are *Bryum pseudotriquetrum, Campylium stellatum* and *Rhodobryum roseum*. However, the richness of the flora seems more likely to be based on good microclimatical conditions (warm habitat, long growing season, high air humidity and soil moisture) than on edaphical features of the soil.

Literature. Hämet-Ahti 1963: 61-62, Laine 1970, Nihlgård 1984: 184.

4.2. Mire vegetation

The total area of mires is 43.7 sq. km (11.96 % of the reserve, the average in Inari Lapland is 11-20 %; Ruuhijärvi 1978). Mires mostly occur between 200-350 m a.s.l. (Fig. 5, Table 4). The study area lies in the region of palsa mires, which are

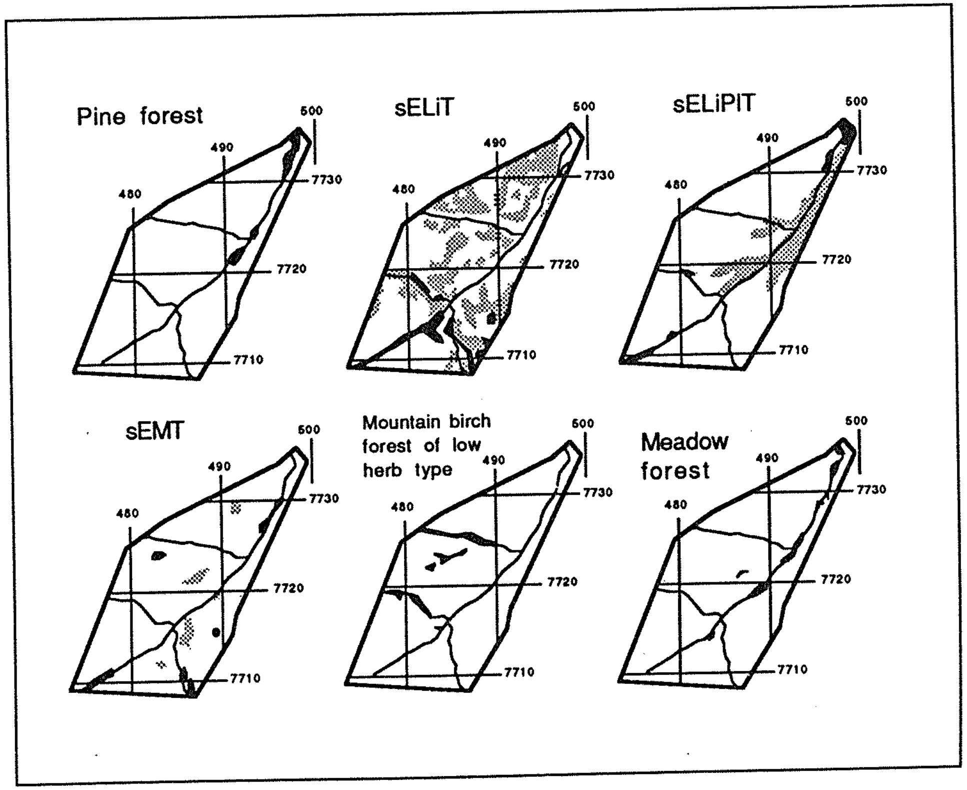

Fig. 4. The distribution of different forest types. Areas damaged by *Epirrita autumnata* are shaded grey.

characterized by *Sphagnum fuscum* hummocks, numerous willow swamps and flark vegetation (Ruuhijärvi 1978: 60-62). Palsa mires differ from aapa mires (typical to southern Lapland) in that they do not show any regular string-flark alternation but rather possess a grid-like structure. In some areas the upper margins of alpine mires are characterized by a belt of 0.5 m high hummocks on bare soil.

(7) Heathy hummock bog

This forms 100-200 m broad belts in the margins of large mires, and also occurs in small patches inside birch forests. The peat layer is fairly thin, often overlying stony gravel and boulders. The bogs are treeless and bushless except for the sometimes abundant *Betula* nanas. The field layer consists of dwarf shrubs 20-30 cm high, grasses and sedges (see Table 3). Hummocks 40-50 cm high are common. In the flora hummock bog, tree mire and silvine elements are most abundant (Tables 1, 2).

Literature. Eurola & Kaakinen 1978: 45, Eurola et al. 1984: 71.

(8) *Salix-Betula nana* bogs

These typically occur on the borders of large mires. The peat layer is thicker (up to 1 m on hummocks) than in heathy hummock bogs. The physiognomy is characterized by hummocks 40-100 cm high and bush thickets formed by grey willows (*Salix glauca* and *S. lapponum*) and *Betula nana*. Trees are normally absent although they are common in the upper region of the River Kamajohka. On the hummocks the field layer is composed of dwarf shrubs, grasses and sparse sedges; the ground layer is poorly developed. The vegetation in the moist hollows between the hummocks is usually relatively open. This type is both physiognomically and floristically rather uneven, quite often characterized by strong spring or swamp influences (distinction from grey willow swamps may be difficult).

Literature. Jensen 1980: 3A:27.

(9) Dwarf shrub bog (including palsas)

In the central parts of large palsa and other mire areas, a mosaic with flark fens usually develops. The largest palsas are 3-6 m high. Trees are normally absent and the vegetation is characterized by a fairly dense field layer formed by dwarf shrubs. The ground layer consists predominantly of mosses (coverage 50-70 %), although the palsas, which are often eroded, show bare peat.

It should be noted that this type includes both the *Betula nana* bog and *Sphagnum fuscum* palsa bog of Eurola & Kaakinen (1978: 47-49), Eurola et al. (1984: 73-77). Due to the marginal location of the Kevo Reserve we did not find this division reasonable in our area. Some stands with very small coverage could even have been classifield as *Sphagnum fuscum* bogs, but these occurrences were also included in this quite broad bog type.

Literature. Ruuhijärvi 1960: 128-133, Söyrinki et al. 1977: 80-81, Eurola & Kaakinen 1978: 47-49, Eurola et al. 1984: 76-77, Borg 1984: 241-243, 248.

(10) *Eriophorum vaginatum* bog

There were only three major occurrences (7729/30:495, 7708:487, 7721:493), although fragmentary occurrences in the moist parts of other bog types were also found. Trees and bushes are normally absent; the field layer is dominated by grasses (especially *Eriophorum vaginatum*) and a few dwarf shrubs (Table 1). A uniform *Sphagnum* moss carpet forms the ground layer. Hummocks are rare, the intermediate level is moist and may have flarks. The floristic composition indicates bog and poor fen elements (Table 2). Most vasculars are either amphiclines or acidoclines, only *Vaccinium microcarpum* acidocole (Fig. 7).

Literature. Ruuhijärvi 1960: 141-144, Söyrinki et al. 1977: 84-83, Eurola & Kaakinen 1978: 45, Eurola et al. 1984: 45, Borg 1984: 240.

(11) Minerotrophic short sedge fen

This usually occurs as small patches around large mire areas, on sites with a marked swamp influence. The type is minerotrophic with a shallow peat layer. Trees and bushes are absent except for some *Betula nanas* 15-30 cm high. The field layer is dominated by *Trichophorum cespitosum*, and the ground layer is poorly developed. Most vasculars are amphicoles, only *Salix myrsinites* and *Thalictrum alpinum* are basidofiles.

Literature. Kalliola 1939: 95-101, Eurola & Kaakinen 1978: 54, Eurola et al. 1984: 82, Borg 1984: 286.

(12) *Sphagnum* flark fen

This occurs mainly in larger mire areas. The field layer is dominated by sedges (coverage 50-80 %) and the ground layer by *Sphagnum* mosses alternating with open water. This type usually forms a mosaic with dwarf shrub bogs. A poor fen element in the flora (Tables 1, 2) is most notable and most vasculars are acidocoles or amphicoles.

Literature. Ruuhijärvi 1960: 75-80, Söyrinki et al. 1977: 60- 61, Eurola & Kaakinen 1978: 56, Eurola et al. 1984: 83-84, Borg 1984: 295.

(13) *Drepanocladus* flark fen

This is the most common flark fen type, and it usually forms a mosaic with dwarf shrub bogs or with *Sphagnum* flark fens. These two flark fen types may sometimes be difficult to distinguish. As a general rule spring and swamp water influences are stronger in *Drepanocladus* flark fens (extreme cases resemble springy fell fens). *Drepanocladus revolvens* and *Scorpidium scorpidioides* are typical mosses in the sites characterized by spring influence. Tree and bush layers and dwarf shrubs are usually lacking although scattered grey willows 40-50 cm high may occur. The ground layer is formed by a relatively closed moss cover alternating with open water.

Literature. Ruuhijärvi 1960: 80-84, Eurola & Kaakinen 1978: 56-57, Eurola et al. 1984: 84, Borg 1984: 289, 300, 304.

(14) Poor mud bottom flark fen

There are small treeless and bushless occurrences in the central parts of palsa mires, near brooks. The vegetation typically forms a mosaic of mud bottom and *Sphagnum* flarks. The field layer is dominated by sedges but the vegetation cover is only 5-20 %. The middle parts of flarks are sometimes heaved, probably indicating the first stages of the palsa development processes (see Ruuhijärvi 1960: 218-220). The flora is almost the same as in other flark fens (Table 1), although *Ranunculus hyperboreus* clearly prefers mud bottoms.

Literature. Ruuhijärvi 1960: 84-90, Söyrinki et al. 1977: 61- 62, Eurola & Kaakinen 1978: 57, Eurola et al. 1984: 84, Borg 1984: 310.

(15) Springy fell fen (Ground-water influenced mountain fen)

This typically occurs on the upper margins of large fens with strong spring influence. The type often changes gradually to other fen types such as *Drepanocladus* flark fens. Trees are usually absent but the bush layer (30-50 cm high grey willows, coverage 20-30 %) may be well developed in the areas characterized by stronger swamp influence (see Eurola et al. 1984: 18-19). The field layer is 30-40 cm high, sedge-dominated. The ground layer is well developed, the peat layer rather thin. In some areas there are regular occurences of hummocks 10-80 cm high with bushes or even trees.

The flora indicates swamp, spring and poor fen elements. The moss flora also indicates meso-eutrophy (e.g. *Calliergon sarmentosum, Drepanocladus badius, D. exannulatus, Paludella squarrosa* and *Sphagnum teres*). Most of the vasculars are amphiclines, but there are also a few basoclines (*Carex livida, Eriophorum scheuchzeri, Salix myrsinites*) with small coverage. In some areas spring influence is so weak that the mire resembles the oligotrophic alpine mire type *Carex rotundata* fen (Persson 1965: 254, Eurola et al. 1984: 102). However, these very small stands were included in the springy fell fens.

Literature. Eurola & Kaakinen 1978: 76, Eurola et al. 1984: 103, Borg 1984: 290.

(16) Swampy sedge fen (Flood fen)

This usually occurs near rivers and brooks in large mire areas, often together with grey willow swamps or springy fell fens. Surface-water cover is about 0-10 cm during the summer, and the thickness of the peat layer also varies. Some willows 20-40 cm high may occur. The field layer (height 30-50 cm) is formed by sedges and grasses. The

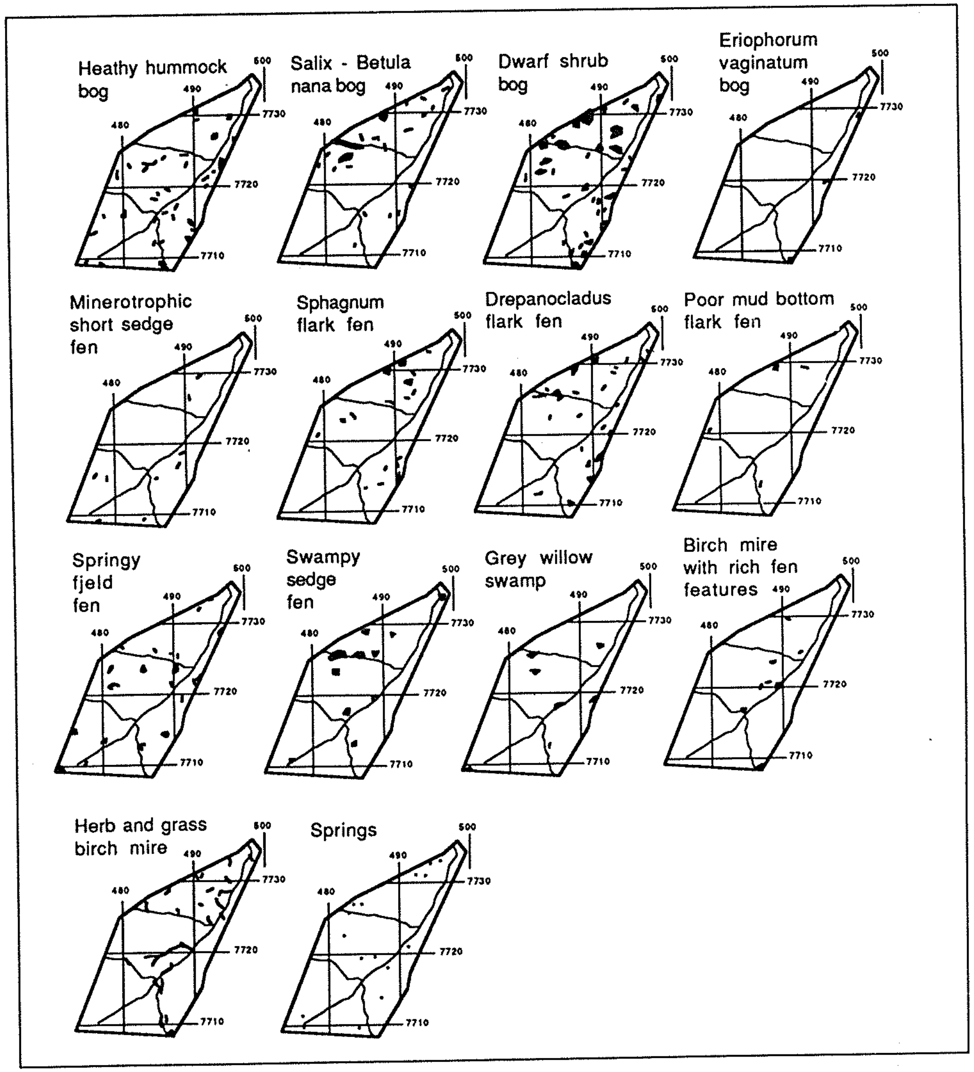

Fig. 5. The distribution of different mire types.

ground layer is rather poorly developed, dominated by *Drepanocladus* and *Sphagnum* mosses. The type may have hummocks. In addition to the swamp element, spring and poor fen elements are well represented in the flora.

Literature. Kalliola 1939: 76-77, Söyrinki et al. 1977: 55, Eurola & Kaakinen 1978: 50-51, Eurola et al. 1984: 78, Borg 1984: 323.

(17) Grey willow swamp

This typically forms a 15-20 m wide belt on river- and brooksides subject to frequent flooding. The type changes gradually to swampy sedge fens and distinction between these types is sometimes difficult, especially when they form a mosaic (e.g. in the mire area of the River Kamajohka). Stands are usually treeless (sometimes a few *Betula pubescens* or *Salix borealis*). The grey willow-dominated bush layer is thick, 1-1.5 m high (coverage 40-100 %). The field layer is dominated by grasses and sedges, and dwarf shrubs may be abundant. The ground layer is usually dominated by mosses which may form hummocks.

Literature. Eurola & Kaakinen 1978: 71, Eurola et al. 1984: 99, Borg 1984: 271.

(18) Birch(-spruce) mire with rich fen features

Only a few occurrences were found in the study area (7719:487, 7721:488, 7709:486, 7717/18:486), near springs, usually along spring- water brooks in the birch forest belt. The thin peat layer may occasionally be lacking. The tree layer is formed by birches 6-8 m high, also *Salix borealis* and *S. caprea* (canopy coverage 30-40 %). The coverage of bush layers (grey willows) is quite variable. The field layer is characterized by tussocks of *Carex cespitosa* and *C. juncella*. The ground layer is open, often cut by a braided brook system. The rich flora mainly indicates spring swamp and tree mire elements (Tables 1, 2). Vasculars are mostly amphiclines, *Thalictrum alpinum* is the only basocline. However, many of the mosses indicate meso-eutrophy: e.g. *Campylium stellatum, Drepanocladus tundrae, Paludella squarrosa, Sphagnum warnstrofii* and *Tomentypnum nitens*.

Literature. Söyrinki al. 1977: 114-117, Eurola & Kaakinen 1978: 64-65, 76-77, Eurola et al. 1984: 91-92.

(19) Herb and grass birch(-spruce) mire

This occurs along brooks and rivers, often forming a narrow belt. On level ground it changes gradually to other mire types. The tree layer is usually formed by birches 6-10 m high which are often defoliated by *Epirrita* (coverage has decreased from about 50 % to 0-10 %). *Salix borealis* (3-6 m) is sometimes common. Bush coverage (*Salix glauca* and *S. lapponum*, height 80-150 cm) varies from 15 to 25 %. The composition of the field layer is variable, most typically it comprises grasses and sedges. The ground layer is open, mosses are common only on tussocks. Most vasculars are amphiclines, but there are also a few basoclines: *Carex capillaris, Luzula parviflora, Salix myrsinites, Thalictrum alpinum* and *Viola biflora*.

Literature. Ruuhijärvi 1960: 179-187, Söyrinki et al. 1977: 105-111, Eurola & Kaakinen 1978: 43, Eurola et al. 1984: 69-70, Borg 1984: 188-189.

(20) Springs

20a Meso-eutrophic springs

There were over 30 occurrences, usually in the birch forest belt, and typically in areas just above springy fell fens and in birch mires with rich fen features. The nature of the springs varies greatly according to their position in relation to other vegetation types and topography. The springs within birch mires with rich fen features are characterized by a well-developed tree layer (usually *Salix borealis* 4-5 m high). The field layer is open, dominated by herbs, and the ground layer formed by a mosaic of mosses (coverage 60-80 %), bare mineral soil and open water.

In addition to the spring element (e.g. *Chrysosplenium tetrandrum, Epilobium alsinifolium, E. hornemannii, Bryum pseudotriquetrum, B. weigelii, Philonotis* sp.) the tree mire element (e.g. *Calamagrostis phragmitoides*) is also notable. Some of the vasculars are basoclines: *Angelica archangelica, Chrysosplenium tetrandrum, Cystopteris montana, Epilobium alsinifolium* and *E. hornemannii*.

Literature. Eurola & Kaakinen 1979: 72, Eurola et al. 1984: 100, Borg 1984: 324.

20b Fell springs

These occur mostly in the alpine belt, bordered by snowbed vegetation, and seldom in larger mire areas. All vegetation layers are rather poorly developed. The ground layer mainly comprises mosses, but non-vegetated patches are also common. The flora indicates the snowbed element in addition to the spring element. The ground layer largely resembles that of meso-eutrophic springs except that *Anthelia juratzkana* is common. Most vasculars are amphiclines, but *Cerastium cerastoides, Epilobium alsinifolium, E. hornemannii, Eriophorum scheuchzeri, Phleum alpinum* and *Ranunculus nivalis* are basoclines.

Literature. Persson 1961: 142-146, 1965: 255, Eurola & Kaakinen 1978: 77-78, Eurola et al. 1984: 104, Borg 1984: 325.

4.3. Alpine vegetation

Alpine vegetation occurs at elevations above 350-400 m and covers 99.8 sq. km (27.5 % of the reserve, see Fig. 6, Table 4). The wide transition zone between forested land and alpine heaths is characterized by a combination of alpine (*Diphasium alpinum, Loiseleuria procumbens, Luzula spicata, Cetraria nivalis* etc.) and silvine (*Cornus suecica, Diphasium complanatum, Pleurozium schreberi* etc.) flora elements. Solitary mountain

Table 1. The summary table of vegetation types.

Key to the vegetation types:
Forests. (1) Pine forest (Number of study plots=2), (2a) sELiT (n=4), (2b) damaged sELiT (n=5), (3a) sELiPfT (n=2), (3b) damaged sELiPfT (n=2), (4) sEMT (n=2), (5) Mountain birch forest of low herb type (n=2), (6) Meadow forest (n=2).
Mires. (7) Heathy hummock bog (n=2), (8) *Salix-Betula nana* bog (n=2), (9) Dwarf shrub bog (n=4), (10) *Eriophorum vaginatum* bog (n=2), (11) Minerotrophic short sedge fen (n=2), (12) *Sphagnum* flark fen (n=2), (13) *Drepanocladus* flark fen (n=3), (14) Poor mud bottom flark fen (n=2), (15) Springy fell fen (n=2), (16) Swampy sedge fen (n=4), (17) Grey willow swamp (n=2), (18) Birch mire with rich fen features (n=2), (19) Herb and grass birch mire (n=5), (20a) Meso-eutrophic spring (n=1), (20b) Alpine spring (n=2).
Other types. (21) *Empetrum* heath (n=2), (22) *Betula nana* heath (n=2), (23a) *Salix herbacea* snowbed (n=2), (23b) *Nardus stricta* snowbed (n=2), (24) Brookside meadow (n=3), (25) Bolder-rich brookside (n=2), (26) Gravelly brookside (n=2), (27) Frost ground sites (n=6), (28a) Secondary alpine heath, dry subtype (n=4), (28b) Secondary alpine heath, moist subtype (n=2).

Coverages are presented on the Domin-Krajina scale: 10=about 100 %, 9=>75 %, 8=50-75 %, 7=33-50 %, 6=25-33 %, 5=10- 25 %, 4=5-10 %, 3=1-5 %, 2=<1 %, small cover, 1=seldom, with insignificant cover, +=solitary, with insignificant cover, a=additional species met outside study plots. Coverage values are averages based on study plots (original tables with study plots habitat information are in Heikkinen 1986). The estimated coverage of birches before *Epirrita* damage in type (18) was 4, and in type (19) 7.

Species are arranged according to flora element groups (see Chapter 3.), which are completely indicated by the letters in brackets (large letter = value 1, small = 0.5): SI=silvine element, M=meadow forest element, A=alpine element, SN=snowbed element, SW=swamp element, SP=spring element, RF=rich fen element, PF=poor fen element, B=bog element and T=tree mire element. Table 2 was calculated on the basis of these values and species appearances.

	Forests								Mires															Alpine and sec. alp. heaths, frost ground sites and brooksides									
Species with wide ecological amplitude (no flora element values)																																	
	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Betula nana	-	-	2	3	a	3	2	-	4	5	5	3	3	+	-	-	3	3	3	-	2	-	+	4	8	2	+	3	a	+	4	5	4
B. pubescens	3	5	2	7	3	7	4	+	-	-	-	-	+	-	-	-	-	a	+	-	3	+	+	a	-	-	-	-	1	+	1	+	-
Vaccinium myrtillus	-	1	1	5	4	7	4	a	4	3	-	2	-	-	-	-	+	-	-	-	-	3	-	a	2	2	4	-	-	-	+	4	4
Empetrum hermaphroditum	7	7	6	7	8	5	2	-	5	6	7	5	+	-	-	-	+	-	+	-	-	3	-	7	5	3	4	+	-	+	5	5	4
Carex bigelowii	-	a	+	+	a	-	a	-	3	2	1	-	2	-	-	-	-	-	-	-	-	-	-	3	3	4	+	a	-	2	3	3	+
Hepaticae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	3	-	-	-	+	-	
Cladonia stellaris	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. sylvatica coll.	5	4	3	-	+	-	-	-	+	3	3	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	-	-	-	3	3	3
Ochrolechia frigida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	-	-	-	-	-	-	-
Ochrolechia sp.	-	3	4	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	4	3	-

Species indicating mainly silvine element	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Diphasium complanatum (SI)	-	a	2	a	a	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium annotinum var. dubium (SI,a)	-	a	-	a	1	a	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	a	a	-	-	-	-	-	a	+	-
L. clavatum (SI,a)	-	-	-	-	+	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	-	-	-	-	-	-	a	-
Pinus sylvestris (SI)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juniperus communis (SI,T)	a	-	+	3	3	5	a	3	a	-	-	-	a	-	-	-	-	-	-	+	3	1	-	a	a	-	-	+	+	-	-	4	-
Phyllodoce caerulea (SI)	-	3	3	a	a	a	-	-	3	+	a	-	-	-	-	-	-	-	-	-	-	-	-	4	4	3	2	-	-	a	3	-	-
Vaccinium vitis-idaea (SI,B)	5	3	3	3	3	3	2	a	3	3	3	-	-	-	-	-	-	-	-	-	2	-	-	2	5	-	3	-	-	-	-	4	6
Pedicularis lapponica (SI,T)	-	+	a	a	a	1	a	+	-	a	-	-	-	-	-	-	-	-	-	+	a	-	-	a	+	-	-	-	-	-	+	+	+
Linnaea borealis (SI,T)	-	-	1	+	1	1	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	-	-	-	-	-	-	+	-
Campanula rotundifolia (SI)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	a	a	-	a	-	-
Antennaria dioica (SI,a)	-	a	a	-	-	-	+	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	+	1	-
Solidago virgaurea (SI,T)	-	+	+	-	1	+	a	a	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	a	a	-	-	+	+	-
Calamagrostis lapponica (SI)	a	-	-	+	-	a	a	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	+	a	a	-	-	a	-	-	-	-	2
Deschampsia flexuosa (SI,T)	a	3	1	3	4	3	5	-	2	2	-	-	-	-	-	-	-	-	-	-	-	1	-	a	3	3	3	5	-	3	1	3	4
Festuca ovina (SI,A)	a	a	-	a	a	a	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	a	+	-	-	4	7	-	3	+	3
Barbilophozia sp. (SI)	-	-	-	-	-	3	-	3	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Ptilidium ciliare (SI)	3	-	1	-	-	3	-	-	2	-	a	-	-	-	-	-	-	-	3	-	-	-	-	-	+	-	-	-	-	-	-	3	-
Drepanocladus uncinatus (SI,sw)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	+	-	-	-	-	2	3	-	+	-	-
Pleurozium schreberi (SI,B)	-	1	3	9	7	5	4	-	3	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	3	3
Polytrichum juniperinum (SI)	-	3	3	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3	3	3	2	3	-	-	+	3	-
Cetraria islandica (SI,a)	1	2	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	3	-	-	-	1	+	-
Cladonia amaurocraea (SI)	-	+	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	1	-
C. coccifera (SI)	4	5	+	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	3	4	+	3	-	-	-	+	4	1
C. cornuta (SI,B)	-	-	+	+	+	-	-	-	1	+	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. deformis (SI)	-	3	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	+	-	-
C. gracilis (SI)	2	3	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	+	-
C. rangiferina (SI,B)	-	3	+	2	-	3	-	-	2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	+	-
C. squamosa (SI,B)	-	3	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-
C. uncialis (SI)	-	2	1	-	-	+	-	-	-	a	1	-	-	-	-	-	-	-	-	-	-	-	-	+	a	-	+	-	-	-	+	3	+
Cladonia sp. (proth.)	3	-	5	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3	-
Nephroma arcticum (SI)	-	-	-	4	3	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Stereocaulon paschale (SI,A)	-	-	4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stereocaulon sp. (SI,A)	3	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	5	-	2	-	-	-	-	5	+

Species indicating mainly meadow forest element	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Alchemilla glomerulans (M,SP)	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa nemoralis (M)	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species indicating mainly alpine element	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Huperzia selago (A,s,T)	-	a	-	-	a	-	-	-	-	a	-	-	+	-	-	-	-	-	-	-	+	-	+	a	a	1	-	-	-	a	+	-	-
Arctostaphylos alpinus (A)	-	+	a	a	-	a	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	-	-	-	-	-	+	1	-
Loiseleuria procumbens (A)	3	a	a	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	a	+	2	a	-	-	2	a	-
Hieracium alpinum (A)	-	a	a	a	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	+	+	-	-	+	+	+	-
Juncus trifidus (A)	3	+	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	2	2	-	-	a	1	+	-
Luzula spicata (A)	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	-	-	-	-	+	+	+	-
Polytrichum piliferum (A)	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	a	-	-	-	-	+	3	-
Cetraria cucullata (A)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	+	+	-
C. ericetorum (A)	-	2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	1	+	-
C. nivalis (A)	-	a	3	-	-	-	-	-	-	+	2	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	3	3	-

Species indicating mainly snowbed element	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Diphasium alpinum (A,SN)	-	1	+	-	+	a	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	3	2	a	-	-	+	3	-
Salix herbacea (SN)	-	1	-	a	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	3	a	+	5	4	-	-	+	3	3	-
Polygonum viviparum (SN,SP)	-	-	-	-	-	-	3	+	-	-	-	-	a	-	-	-	-	-	-	a	2	a	+	-	-	-	+	+	1	a	+	-	-
Sibbaldia procumbens (SN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	+	-	-	-	3	-	-	-
Cassiope hypnoides (SN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	+	-	-	-	2	-	-
Gnaphalium supinum (SN,sw)	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	+	-	-	1	-	-	-
Taraxacum croceum (SN,SP,T)	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	+	-	2	-	-	a	-	+	-	+	-	-	-
Nardus stricta (SN,SP)	-	-	-	-	-	-	6	-	a	a	-	-	-	-	-	-	-	-	-	-	-	-	3	a	a	4	8	5	-	4	a	-	-
Carex lachenalii (SN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	+	+	a	-	+	a	-	-
Anthelia juratzkana (SN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	a	-	-	-	-	-	-	-
Kiearia starkei (SN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-

Species indicating mainly swamp element	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Equisetum fluviatile (SW,PF)	-	-	-	-	-	-	-	a	-	a	-	-	-	-	-	-	2	a	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E. palustre (SW,SP)	-	-	-	-	-	-	+	-	-	-	-	-	-	-	3	-	-	2	-	3	3	3	-	-	-	-	-	a	-	+	+	-	-
Salix glauca (SW,SP)	-	-	-	-	-	-	3	a	-	5	3	-	+	-	2	-	2	3	5	-	5	-	-	a	a	-	-	1	3	-	+	-	-
S. hastata (SW,SP)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	a	4	-	-	-	-	-	-	-	-	5	-	-	-	-
S. lapponum (SW)	-	-	-	-	-	-	-	a	a	2	a	-	+	-	a	-	3	1	7	-	3	-	-	-	-	-	-	-	-	-	+	-	-
S. phylicifolia (SW,T)	-	-	-	-	-	-	1	3	-	a	-	-	-	-	-	-	-	1	3	a	2	5	-	-	-	-	-	3	+	-	a	-	-
Trollius europaeus (SW,SP)	-	-	-	-	-	-	+	3	-	-	-	-	-	-	-	-	-	a	+	-	3	-	-	-	-	-	-	3	-	-	a	-	-
Parnassia palustris (SW,sp)	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	+	+	-	-	-	-
Filipendula ulmaria (SW,SP)	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	+	4	-	-	-	-	-	-	4	-	-	-	-	-
Potentilla palustris (SW)	-	-	-	-	-	-	-	5	-	-	-	-	a	-	3	-	5	1	5	4	3	-	-	-	-	-	-	2	3	-	-	-	-
Viola biflora (SW,SP)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	2	a	a	-	-	-	-	a	-	-	-	-	-
V. epipsila (SW)	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	3	+	2	3	3	-	-	-	-	-	-	3	1	-	-	-	-
Epilobium palustre (SW,SP)	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	3	a	2	2	2	1	-	-	-	-	-	+	-	a	-	-	-
Galium uliginosum (SW)	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	2	1	-	-	-	-
Cirsium helenioides (SW,SP)	-	-	-	-	-	-	3	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus filiformis (SW)	-	-	-	-	-	-	-	a	-	a	-	-	-	-	-	-	a	3	a	-	-	-	-	-	-	-	-	a	-	-	-	-	-
Luzula sudetica (SW,T)	-	-	-	-	-	-	3	+	-	-	-	-	-	-	-	-	-	-	2	a	+	-	-	-	-	-	-	3	-	-	-	-	-
Agrostis mertensii (SW,SP)	-	-	-	-	-	-	-	2	a	a	-	-	-	-	-	-	-	+	a	-	1	3	2	-	-	a	-	4	3	3	+	-	-
Anthoxanthum odoratum (SW,SP)	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	+	-	a	-	-	-	-	a	-	-	-	-	-
Calamagrostis stricta (SW)	-	-	-	-	-	-	+	4	-	-	-	-	-	-	-	-	1	2	+	3	-	-	-	-	-	-	-	4	a	-	-	-	-
Deschampsia cespitosa (SW)	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vahlodea atropurpurea (SW,T)	-	-	-	-	-	-	3	-	-	a	-	-	-	-	-	-	-	a	-	-	-	-	+	-	-	-	-	a	-	2	-	-	-
Carex aquatilis (SW,PF)	-	-	-	-	-	-	a	-	-	a	-	-	-	-	4	3	-	6	6	-	3	-	-	-	-	-	-	-	-	-	-	-	-
C. buxbaumii ssp. alpina (SW,SP)	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
C. canescens (SW)	-	-	-	-	-	-	a	+	-	+	-	-	-	a	-	a	3	3	3	2	3	a	-	-	-	-	-	1	-	-	-	-	-
C. cespitosa (SW,SP)	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	a	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
C. juncella (SW)	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	2	-	3	5	-	-	-	-	-	-	1	a	-	-	-	-
Eriophorum scheuzeri (SW)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	+	-	-	-	-	a	-	-	-	-	-
Marcanthia polymorpha (SW,SP)	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Sphagnum squarrosum (SW)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	a	a	-	a	-	-	-	-	-	-	-	-	-	-	-	-
Bryum pseudotriquetrum (SW,SP,PF)	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	+	-	3	-	a	+	-	-	-	-	+	1	-	-	-	-
Calliergon cordifolium (SW)	-	-	-	-	-	-	-	-	-	-	-	-	-	a	+	-	a	3	3	3	+	4	-	-	-	-	-	-	-	-	-	-	-
C. stramineum (SW,SP,PF)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	a	-	5	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-
Cinclidium subrotundum (SW,RF)	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Racomitrium microcarpum (sw)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	+	-	-

Species indicating mainly spring element	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Selaginella selaginoides (SP,RF)	-	-	-	-	-	-	+	a	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	1	+	a	-	-	-
Stellaria calycantha (sw,SP)	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	2	2	1	+	-	-	-	-	+	-	-	-	-	-
Ranunculus hyperboreus (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Thalictrum alpinum (sw,SP)	-	-	-	-	-	-	-	a	-	-	-	-	a	-	-	-	-	-	-	a	2	-	-	-	-	-	-	+	+	-	-	-	-
Angelica archangelica (SP,t)	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Bartsia alpina (sw,SP)	-	-	-	-	-	-	1	a	a	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Pinguicula vulgaris (SP,RF)	-	-	-	-	-	-	-	-	a	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	a	-	-	-	+	-	-

Saussurea alpina (m,sw,SP)	-	-	-	-	-	-	a	4	-	-	-	-	a	-	-	-	-	-	-	+	3	a	-	-	-	-	-	3	-	-	-	-	-
Phleum alpinum (SP)	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	4	-	2	-	-	-
Poa rigens (SP,T)	-	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2	+	3	+	-	-	-	-	3	-	+	-	-	-
Scapania sp. (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	+	-	-	-	-	-
Sphagnum teres (SW,SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	7	3	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Anisothecium palustre (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	a	3	-	-	-	-	-	-	-	-	-	-
Bryum weigelii (SP)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	a	-	4	3	-	-	-	-	-	-	-	-	-	-
Calliergon sarmentosum (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	a	a	-	-	-	-	-	-	-	-	-	-
Drepanocladus tundrae (SW,SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	4	-	-	-	-	-	-	-	-	-	-
Paludella squarrosa (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	7	-	a	4	-	-	3	-	-	-	-	-	-	-	-	-	-
Philonotis fontana (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	-	-	-	-	-	-	-	-	-	-
P. tomentella (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	4	-	-	-	-	+	-	-	-	-	-
P. seriata (SP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-
Rhizomnium pseudopunctatum (SP)	-	-	-	-	-	-	-	5	-	-	-	-	-	-	+	-	-	-	2	5	-	a	-	-	-	-	-	-	-	-	-	-	-

Species indicating mainly rich fen element

	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Salix myrsinites (SP,RF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	a	-	-	-	-	-	-	3	6	-	1	-	-
Tofieldia pusilla (sw,RF,PF)	-	-	-	-	-	-	-	-	a	-	-	-	+	-	-	-	-	-	-	-	-	-	-	a	-	+	-	-	-	-	+	-	-
Carex livida (RF,PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphagnum warnstorfii (SP,RF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Drepanocladus revolvens (RF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scorpidium scorpidioides (SW,RF)	-	-	-	-	-	-	-	-	-	-	-	-	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species indicating mainly poor fen element

	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Andromeda polifolia (PF)	-	-	-	-	-	-	-	-	+	+	+	3	+	-	1	+	+	a	1	-	-	-	-	-	-	+	-	2	+	-	3	-	-
Menyanthes trifoliata (PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex chordorrhiza (PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. lasiocarpa (PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	a	3	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. magellanica (SW,PF)	-	-	-	-	-	-	-	-	-	+	-	a	-	a	4	a	2	3	3	-	-	-	-	-	-	-	-	+	-	-	-	-	-
C. rariflora (PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	5	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. rostrata (sw,PF)	-	-	-	-	-	-	-	-	-	2	-	a	a	a	+	2	8	4	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. rotundata (PF)	-	-	-	-	-	-	-	-	-	+	-	5	3	7	7	5	3	5	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Eriophorum angustifolium (sw,PF)	-	-	-	-	-	-	-	-	-	2	-	-	3	4	5	3	3	4	-	-	-	-	-	-	-	-	-	a	-	-	2	-	-
E. russeolum (PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichophorum cespitosum (rf,PF)	-	-	-	-	-	-	-	-	-	a	-	-	9	-	3	a	+	-	-	-	-	-	-	-	-	4	a	4	a	-	4	-	-
Sphagnum compactum (PF)	-	-	-	-	-	-	-	-	-	-	+	-	-	a	-	-	-	-	-	-	-	-	-	-	-	2	a	1	-	-	1	-	+
S. lindbergii (PF)	-	-	-	-	-	-	-	-	-	-	-	6	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. papillosum (PF)	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drepanocladus procerus (SW,PF)	-	-	-	-	-	-	-	-	-	-	-	-	2	3	7	7	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species indicating mainly bog element

	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Rubus chamaemorus (B)	-	-	-	-	-	-	-	-	1	3	7	5	-	+	-	-	-	-	2	-	5	1	-	-	-	-	-	-	-	-	-	-	+
Calluna vulgaris (B)	-	3	a	-	-	-	-	-	a	+	-	-	-	-	-	-	-	-	-	-	-	-	-	a	-	+	a	-	-	-	4	-	-
Ledum palustre (B)	-	-	-	-	-	-	-	-	4	5	7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Vaccinium microcarpum (B)	-	-	-	-	-	-	-	-	-	1	-	1	-	-	+	-	-	a	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V. uliginosum (B,T)	2	2	1	+	a	5	4	a	5	3	5	4	1	-	-	-	2	a	4	+	3	1	-	a	a	+	3	3	4	a	3	3	4
Eriophorum vaginatum (PF,B)	-	-	-	-	-	-	-	-	a	a	a	8	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphagnum fuscum (B)	-	-	-	-	-	-	-	-	-	-	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. nemoreum (B)	-	-	-	-	-	-	-	-	3	5	3	-	-	-	-	-	-	-	2	-	-	-	-	-	-	a	-	2	-	-	-	-	5
Aulacomnium palustre (B)	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	a	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-
Dicranum undulatum (B)	-	-	-	-	-	-	-	-	-	5	5	-	-	-	-	-	2	-	-	-	-	5	-	-	3	-	-	-	-	-	-	-	5
Polytrichum strictum (B)	-	-	-	-	-	-	-	-	-	2	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Icmadophila ericetorum (B)	-	-	1	-	-	-	-	-	+	2	2	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-

Species indicating mainly tree mire element

	1	2a	2b	3a	3b	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20a	20b	21	22	23a	23b	24	25	26	27	28a	28b
Equisetum pratense (T)	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	-	-
E. sylvaticum (T)	-	-	-	-	-	-	-	a	a	5	a	-	-	-	-	-	-	-	-	3	+	1	+	a	-	-	-	a	-	-	+	-	-
Salix borealis (SP,T)	-	-	-	-	-	-	a	8	-	-	-	-	-	-	-	-	-	-	-	5	-	a	-	-	-	-	-	-	-	-	-	-	-
Rubus arcticus (T)	-	-	-	-	-	-	a	3	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-	-	3	a	-	-	-	-
Geranium sylvaticum (T)	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	+	-	-	-	-	-
Cornus suecica (M,T)	-	-	-	-	-	5	+	a	-	2	-	-	-	-	-	-	-	-	-	-	+	3	-	-	a	-	-	-	-	-	-	-	-
Pyrola minor (T)	-	-	-	-	3	a	+	+	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	+	+	-	-	-	+	-
Trientalis europaea (T)	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-	2	+	-	-	-	-	a	+	a	-	-	-	-
Melampyrum pratense (t)	-	-	-	a	-	+	a	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis phragmitoides (SW,T)	-	-	-	-	-	-	2	5	-	+	-	-	-	-	-	-	-	-	a	3	6	5	-	-	-	-	-	4	-	-	-	-	-
Carex brunnescens (T)	-	-	+	-	a	+	a	-	3	a	-	-	-	-	-	-	-	-	+	-	+	3	-	-	-	-	-	a	-	-	-	-	-
C. vaginata (B,T)	-	-	-	-	-	-	3	a	a	-	a	-	-	-	-	-	-	3	-	-	1	-	-	a	-	-	+	3	-	-	-	-	5
Sphagnum girgensohnii (T)	-	-	-	-	-	-	5	3	-	-	-	4	-	-	-	-	-	a	8	-	3	-	3	-	-	-	-	-	-	-	-	-	-
Dicranum fuscescens (T)	-	5	3	3	1	7	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	3	-	3	-	-	-	1	3	-
Polytrichum commune (T)	-	-	-	+	-	4	3	-	6	-	-	-	-	+	-	-	-	a	5	+	5	4	-	-	-	-	-	5	-	-	-	-	-

Additional species to the summary table:

(1) Pine forest: Cladonia stellaris (SI,B) 3
(2A) sELiT: Salix xerophila (SI) a; Cladonia bellidiflora (SI,A) a; C. crispata (SI,A) 1
(2B) damaged sELiT: Dicranum scoparium (B,T) +; Alectoria ochroleuca (A) +; Cladonia bellidiflora (SI,A) +
(3A) sELiPIT: Peltigera aphthosa (SI,T) 1
(4B) sEMT: Epilobium angustifolium (SI,T) a; Hieracium sp. (T) a; Luzula pilosa (SI,M) a; Cladonia crispata (SI,A) 1; Peltigera malacea (SI) +
(5) Mountain birch forest ...: Populus tremula (SI) +; Alchemilla murbeckiana (M,SP) +; Potentilla crantzii (SI) a; Euphrasia frigida (sw,SP) +; Hieracium sp. (T) a; Luzula parviflora (m,T) a
(6) Meadow forest: Equisetum arvense (T) 2; Thelypteris phegopteris (T) a; Matteuchia struthiopteris (M) a, Dryopteris assimilis (T) a; Gymnocarpium dryopteris (m,T) a; Salix myrsinifolia (SW,SP) a; Caltha palustris (sw,SP) a; Arabis alpina (SP) +, Chrysosplenium tetrandrum (sw,SP) a; Ribes spicatum (M) a; Alchemilla murbeckiana (M,SP) a; Prunus padus (M) a; Rubus saxatilis (M,T) a; Sorbus aucuparia (T) a; Epilobium angustifolium (M,T) +; E. hornemannii (SP) +; Myosotis decumbens (M) a; Euphrasia frigida (sw,SP) a; Gnaphalium norvegicum (M, sw) a; Luzula parviflora (m,T) a; Melica nutans (M) a; Milium effusum (M,T) 3; Carex loliacea (SP) a; C. norvegica ssp. inferalpina (SW,SP) a; Campylium stellatum (RF) +; Hypnum lindbergii (SW) a; Plagiomnium ellipticum (SW,SP) 2
(7) Heathy hummock bog: Carex pauciflora (PF,B) a; Sphagnum angustifolium (PF,B) a; Peltigera malacea (SI) +
(8) Salix-Betula nana bog: Juncus biglumis (SP) a
(9) Dwarf shrub bog: Dicranum elongatum (T) 3; Sphaerophorus globosus (A) +
(12) Sphagnum flark fen: Carex limosa (PF) a; Sphagnum annulatum (PF) a; S. majus (PF) a; S. subfulvum (RF,PF) a
(13) Drepanocladus flark fen: Epilobium hornemannii (SP) a; Carex stenolepis (SW,PF) +; Drepanocladus exannulatus (SP) a
(14) Poor mud bottom flark fen: Eriophorum medium (PF) +; Sphagnum majus (PF) a
(15) Springy feld fen: Drepanocladus badius (SP,RF,PF) a
(16) Swampy sedge fen: Caltha palustris (sw,SP) a
(17) Grey willow swamp: Salix lanata (sw,SP) a; Petasites frigidus (SP) +
(18) Birch mire with rich fen features: Campylium stellatum (RF) a; Helodium blandowii (RF) 1; Oncophorus wahlenbergii (SW,SP) 2; Plagiomnium ellipticum (SW,SP) +; Tomentypnum nitens (RF) 2
(19) Herb and grass birch mire: Lycopodium annotinum (M) a; Salix caprea (T) 2; Caltha palustris (sw,SP) a; Luzula multiflora ssp. frigida (T) 2; L. parviflora (m,T) 1, Carex capillaris (SP,rf) +; Coeloglossum viride (T) a; Sphagnum riparium (SW,SP) a; S. subfulvum (RF,PF) +Hylocomium splendens (SI) a; Plagiomnium ellipticum (SW,SP) a; Rhodobryum roseum (T) 2
(20A) Meso-eutrophic spring: Cystopteris montana (SP) a; Cardamine pratensis (SW,SP) a; Chrysosplenium tetrandrum (sw,SP) 1; Epilobium alsinifolium (SP) 3; E. hornemannii (SP) 1; Cratoneuron decipiens (SP) a; C. filicinum (SP) a
(20B) Alpine spring: Cerastium cerastoides (SN,SP) 1; Ranunculus nivalis (SN,SP) a; Epilobium anagallidifolium (SP) 1; Juncus biglumis (SP) 1; Drepanocladus exannulatus (SP) a; Mniobryum wahlenbergii (SP) 3; Oncophorus wahlenbergii (SW,SP) a
(21) Empetrum heath: Silene acaulis (A) a; Dryas octopetala (A) a; Diapensia lapponica (A) a; Luzula arcuata (A) a; Carex glacialis (A) a; Alectoria nigricans (A) 1; A. ochroleuca (A) a; Sphaerophorus fragilis (A) a; S. globosus (A) 2; Thamnolia vermicularis (A) a
(23A) Salix herbacea snowbed: Dicranum sp. 3
(23B) Nardus stricta snowbed: Chandonanthus setiformis (SN) 3
(24) Brookside meadow: Equisetum arvense (T) +; Rumex acetosa (SW,sp) a; Ranunculus acris (SW,SP) a; Potentilla crantzii (SI) a; Epilobium angustifolium (SI,T) +; Orthilia secunda (T) +; Luzula multiflora ssp. frigida (T) a; Festuca rubra (m) a; Carex norvegica ssp. inferalpina (SW,SP) +; Coeloglossum viride (T) a; Racomitrium aciculare (SW) +
(26) Gravelly brookside: Oxyria digyna (sw) a; Cerastium alpinum (SI,m) a; C. cerastoides (SN,SP) +; Cardamine bellidifolia (SN) +; Epilobium anagallidifolium (SP) +; Veronica alpina (SW) a; Luzula wahlenbergii (A,SW) a
(27) Frost ground site: Diapensia lapponica (A) +; Carex dioica (PF) +; C. loliacea (SP) a; Cladonia alpicola (SI,A) +
(28A) Secondary alpine heath, dry subtype: Dicranum robustum (SI) 3; Cetraria delisei (SI,S) +; Cladonia crispata (SI,A) +

birches grow more and more spasmodically and they are often bushes less than 0.5 m high.

For practical (mainly cartographic) reasons we included only two alpine heath types in this study, although more communities could have been differentiated (cf. Kalliola 1939).

(21) *Empetrum* heath

Empetrum heaths (see Fig. 6 in Syrilä 1964) are characterized by a thin snow cover, rather extreme temperature variations, hard wind and a dryish growing season. The soil is usually podsolized. At lower elevations *Empetrum* heaths gradually turn into sELiT or secondary alpine heaths. The field layer (height 10-30 cm) is dominated by *Empetrum hermaphroditum*. The ground layer is lichen-dominated, often forming a mosaic with *Empetrum* (cf. *Empetrum-Cetraria nivalis* sociation of Kalliola 1939: 185-193). There may be extensive occurrences of bare mineral soil in exposed windy pathces or polygones with lichen covered stones on fell tops. Some of these areas could be classified as *Diapensia-Loiseleuria-Empetrum* sociation of Kalliola 1939: 175-184).

Because of our wide definition of the type, flora is quite rich (cf. Kalliola 1939). Wind deflation areas are favoured by species such as *Diapensia lapponica, Loiseleuria procumbens, Polytrichum piliferum, Cornicularia divergens* and *Thamnolia vermicularis*. Calcareous places indicated by *Dryas octopetala* also include *Pinquicula vulgaris, Solidago virgaurea, Tofieldia pusilla* and occassionally *Silene acaulis*.

Literature. Kalliola 1932: 29-35, 1939: 175-193, Ryvarden 1969: 23, Jensen 1984: 61.

(22) *Betula nana* heath

This mostly occurs in sites with a thicker and longer snow-lie than those of *Empetrum* heaths. *Betula nana* bushes 40-60 cm high (coverage 60-70 %) surrounded by dwarf shrubs alternate with lichen-dominated patches. The undergrowth often forms a mosaic (see Fig. 36 in Kallio et al. 1969). In contrast to *Empetrum* heaths, it has many species that are chionofiles (Kalliola 1939: 26-27): *Pleurozium schreberi, Cetraria islandica, Cladonia alpestris, C. sylvatica* coll. and *C. rangiferina*. Chionofobes (e.g. *Loiseleuria procumbens, Arctostaphylos alpinus* and *Cetraria nivalis*) are rare.

Literature. Kalliola 1932: 27-29, 1939: 193-200, Ryvarden 1969: 22, Jensen 1984: 60.

4.4. Vegetation on brook- and riversides

The total length of brooks and rivers in the Kevo Reserve is over 300 km. There is usually at least a narrow belt of luxuriant vegetation along them in contrast to the surroundings. These vegetation patches are ecologically interesting and should not be neglected in vegetation classification or mapping. We divided the vegetation on brook-

and riversides into four rather broadly defined physiognomical categories. Their tota area is about 65 ha (about 0.1 % of the reserve, see Table 4).

(23) Snowbed brookside

In the study area this was usually located in channels created by meltwater durin glaciation (Syrilä 1964: 339-343, Sudgen & John 1982: 301-316), especially in thei upper parts, which are 10-30 m wide and 2-10 m deep. The field layer is low (5-15 cm and the ground layer is dominated by mosses alternating with bare peat, stones o open water. This type includes three snowbed vegetation types:

(1) Mossy snowbeds, which occur particularly in the upper course of snowbed brook The extremely short growing season prevents the occurence of vascular plants. Th liverwort *Anthelia juratzkana* is dominant among bare rocks and bolders.

(2) *Salix herbacea* snowbeds. The field layer is dominated by *Salix herbacea*, and othe vasculars are rare. The ground layer consists of moss and lichen patches. Snow usuall melts in June-July. This type often surrounds the previous one.

(3) *Nardus stricta* snowbeds. These occur in shallow channels and depressions and als at the margins of deeper channels; These sometimes form a mosaic with *Salix herbace* dominated vegetation. The snowbed character is weaker than in the previous types. Th undergrowth is dominated by grasses, mosses and lichens, which only occur sparsel

The flora is poor in species, which comprise snowbed specialists and those indicatin spring, swamp and alpine elements (Tables 1, 2).

Literature. Mossy snowbeds: Kalliola 1932: 91, 1939: 164-165, Jensen 1984: 107.
Salix herbacea snowbeds: Kalliola 1932: 87-88, 1939: 161-162, Gjaerevoll 1956: 106-127, 1965: 263, Jense 1984: 104.
Nardus stricta snowbeds: Kalliola 1932: 59, 1939: 154-157, Gjaerevoll 1956: 83-84, 1965: 263, Jensen 198 77.

(24) Brookside meadow

This heterogeneous group of grass-dominated communities is distinguished by i physiognomical-topographical features rather than by its floristic composition (c. Kalela 1939: 49). It occurs on many brooksides in both the alpine and birch forest bel The width of the occurrences varies between 1-40 m. There is normally no tree laye although the bush layer may be dense. The mossy ground layer covers 20-40 % Common grasses in the alpine belt are *Agrostis mertensii, Anthoxanthum odoratum Nardus stricta* and *Phleum alpinum*, and particularly at lower altitudes the abundan of *Nardus stricta* decreases. Sites with frequent floods are favoured e.g. b *Calamagrostis phragmitoides* and *C. stricta*. In some cases the vegetation is charact rized by *Trichophorum cespitosum* and *Betula nana*. Here, the soil is often stony ar affected by frost activity.

Literature. Kalela 1939: 135-140, 250-252.

(25) Bolder-rich brookside

There were a few occurrences in depressions in the middle of patterned ground or in wide gorges with bolder scree. There is no tree layer, but bushes occur occasionally. When present, the field layer is dominated by grasses. The ground layer is very weakly developed. Scattered plants are distributed between the boulders. The flora indicates spring and swamp elements and vasculars are mostly amphiclines; Only *Salix myrsinites* and *Selaginella selagonoides* are basoclines.

(26) Gravelly brookside

There were usually small occurrences together with brookside meadows, in the upper courses of fell brooks. In the birch forest belt they occur occasionally along the Rivers Kama- and Fiellokeädggejohka, and on some lake shores. There are no trees or bushes, and only poorly developed undergrowth. The plants form solitary tussocks among bare gravel and rounded stones. The floristic composition is heterogeneous (Tables 1, 2). Brooks flowing down from snowbeds and alpine springs carry diaspores from these habitats. The vascular flora mainly includes amphiclines but there are also some basoclines (*Cerastium alpinum, C. cerastoides, Saxifraga stellaris*.

4.6. Other types

Under this heading are described two rather heterogeneous vegetation types that are typical of the study area. The total area covered by these is 22.7 sq. km (6.25 % of the reserve, see Fig. 6, Table 4).

(27) Frost ground sites

Frost heaving and regelation affect the structure and the species composition of vegetation (Tedrow 1968: 198, Rintanen 1970: 13-15). Factors promoting strong frost heaving are high soil moisture, thin snow cover and low winter temperatures (Rintanen 1970: 1-2, Washburn 1979: 121-122). Depending on the strength of heaving vegetation may be almost the same (*Empetrum* heath -polygons) or absolutely different from the surroundings.

In this work, frost ground sites are treated as a floristically uneven but structurally characteristic group. It is a somewhat wider definition than the patterned grounds of Washburn (1956, 1979, see Rintanen 1970: 2). The largest occurrences are found in gentle depressions in the fells. The sites are usually moist, the soil being unleached with pH near to 7, a higher Ca content than in the surroundings and a poorly developed peat/humus layer.

The sites are treeless areas with a sparse bush layer and usually poorly developed field and ground layers; They usually have a mosaic-like appearance. Bare sand, bou ders, black peat or open water may cover large parts of the area. Boulders and stone often form sorted circles. The frost ground sites of the Kevo Reserve include th following groups:

(1) Polygons at the tops of fells (see 4.4.; Washburn 1979: 133-146)

(2) Hollow grounds occurring at the edges of mires. Vegetation usually resemble heathy hummock bogs where plant cover is occasionally broken by frost heaved stone and plantless hollows (type "Hollows and belts at the edges of bogs" in Rintanen 197(4-5).

(3) Stony sites with flowing spring water (Rintanen 1970: 5). The type occurs in th upper course of fell brooks or at mire edges in the birch forest belt. Typical feature are stoniness and braided brooks with sparse plant cover. *Betula nana* and *Sali myrsinites* are occasional bushes.

(4) Sandy sites with flowing spring water. Bare sand dominates and vegetation sparse. *Trichophorum cespitosum* is usually abundant, and there may also b thin-peated areas with a few other vascular plants (e.g. *Pinquicula vulgaris*).

(5) Sandy sorted polygons and steps (Washburn 1979: 141-146, 147-151). A heterogen type characterized by bare plantless sand. Some occurrences could be classifield non- sorted polygons (see type D in Rintanen 1970: 5-6).

Frost heaving demands good endurance by species growing on unstable soil (Dal 1956). On the other hand, due to the fairly open nature of these habitats they ar almost free of competition, and their vegetation is very varied (see Table 1). Fc example, alpine plants such as *Diapensia lapponica* (normally in wind deflation area and *Salix herbacea* (snowbeds) may occur side by side with *Salix myrsinites*, whic usually occurs on rich fens or along brooks.

Vascular flora includes many basoclines and one basocole (*Dryas octopetala*). W agree with Rintanen (1970: 2,11) when he states that the success of exacting species mostly based on the lack of competition, although sufficient soil moisture, preventio of humus formation and flowing seepage water also help. It should be noted th small-scale topographical and microclimatical changes can cause differences in growt conditions between centres and more moist bolder or stone circles, and therefor alpine species occur in the middle, on bare soil patches, while mire species occur in th margins.

Literature. Rintanen 1970.

(28) Secondary alpine heaths

These are areas that lack trees for some unknown reason. The explanation is probab old birch damage caused by *Epirrita autumnata* (see Tenow 1972: 30-31). In some area it is possible to find remnants of dead birches, or even partly living root crowns (Kalli

& Lehtonen 1973: 62, 65). Occurrences are mostly in upper fell areas, not in deeper depressions or valleys (see Tenow 1975, Niemelä 1979, 1980) or near ant nests (see Laine & Niemelä 1980). The largest areas are even over 1 sq. km. The type is divided into two subtypes:

(1) Dry subtype (91 %). The vegetation resembles alpine *Empetrum* or *Betula nana* heaths. It usually occurs in areas surrounded by sELiT forests near the forest line, and sometimes at lower heights. The vegetation is dominated by dwarf shrubs and the ground layer often consists of heavily grazed lichen stands. The undergrowth usually forms a mosaic as with sELiT. Occasionally wide juniper stands may give a somewhat peculiar physiognomy to the vegetation.

(2) Moist subtype (9 %). An intermediate type between alpine heaths and heathy hummock bog. The field layer is dominated by dwarf shrubs. The ground layer consists of moss patches (especially *Polytrichum commune*) and lichens. The boundaries between dry subtype and heathy hummock bogs are vague. This type occurs mainly in damaged sELiPIT forests, usually in small depressions.

Silvine and alpine elements prevail in the dry subtype, while in the moist subtype the alpine element is less important, ad is replaced by the tree mire element (cf. damaged sELiPIT) and sEMT). As explained earlier (see also Kallio & Lehtonen 1973, Kallio et al. 1983: 107), secondary alpine heaths have probably developed from earlier outbreaks of *Epirrita autumnata*. The surrounding forests have apparently also been defoliated, although the trees have mainly recovered while the ancient trees of the present-day treeless areas have not (however, we cannot judge the reasons for these relatively large regional differences). It is likely that the same kind of alpine heaths will develop in areas infested by *Epirrita* in 1964-65 (see Lehtonen 1981: 126).

Another reason for these treeless areas could be human activities such as firewood logging. However, this probably does not account for most of these large areas, although there are some old treeless reindeer separation places. These sites are easily distinguishable by the presence of hemerophilous plant species.

Literature. Kallio & Lehtonen 1973: 62-65.

5. Discussion

5.1. General features

The most typical flora elements in the vegetation types of the area are silvine, alpine and tree mire elements (Table 2). Only meadow forests and different fen types do not feature alpine plants. Mire vegetation typically indicates strong spring influence, which is a typical "northern characteristic" (Eurola et al. 1984: 22). The swamp element is notable in most of the mire types, but the rich fen element is rather poorly represented. The same elements are also pronounced in other vegetation types occurring in brook and river margins (e.g. meadow forests, mountain birch forests of low herb type and brookside meadows).

The most extensive vegetation types include three subalpine birch forest types, two alpine heaths and a secondary alpine heath, which cover altogether 84.9 % of the reserve (Table 4). However, these types only include 33 % of the total flora in the area (cliff site plants excluded). On the other hand, a few minor types such as meadow forests, mountain birch forest of low herb type, springs and frost ground sites contain 68 % of the flora, but they only cover about 4.5 sq. km (1.2 % of the reserve). These types mainly occur along rivers and brooks, and consequently, a map showing areas rich in species would resemble the map showing the main rivers (Fig. 1).

The vascular flora of the vegetation types are compared using the acidity requirement classification of Mäkinen & Kallio 1979 (Fig. 7). Amphiclines - species not depending on the acidity of the habitat - clearly prevail in all vegetation types, while species preferring or requiring basic substrate (basocoles, basoclines) are in the minority in all types. This may be understood in terms of the poor bedrock (see Fig. 2). Most of the exacting species occur mainly on sites with strong spring or swamp influences.

5.2. Forest line dynamics

In many sites featuring a gradual change from forested land to alpine heaths, the vertical forest line is often difficult to determine. Many fells have a 0.5-1.5 km wide transition zone of scattered birches or partly trunkless but still living root hummocks.

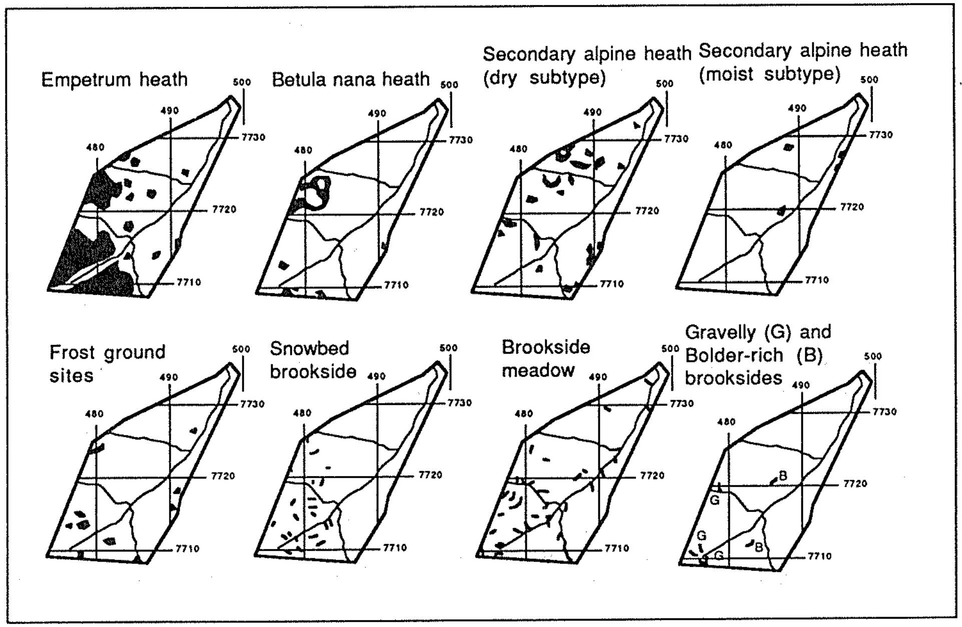

Fig. 6. The distribution of alpine heaths, frost ground sites, secondary alpine heaths and vegetation types on brooksides.

Table 2. The distribution of flora element values in vegetation types. This table is based on the floristic information given in Table 1. The values are total amounts of species belonging to a certain flora element (e.g. 10 in column SN means in that type 10 snowbed indicator species - with a value of 1 - have been met). Additional species are also taken into account.

		SI	M	A	SN	SW	SP	RF	PF	B	T
1	Pine forest	12.0	-	4.5	-	-	-	-	-	3.0	2.0
2	sELiT	22.0	-	13.5	1.5	-	-	-	-	6.0	6.0
	dsELiT	21.0	-	12.0	1.5	-	-	-	-	9.0	9.0
3	sELiPIT	15.0	-	5.5	-	-	-	-	-	5.0	9.5
	dsELiPIT	17.0	-	6.5	1.5	-	-	-	-	4.0	10.0
4	sEMT	24.0	2.0	5.5	1.0	-	-	-	-	3.0	12.5
5	Mountain birch forest of low herb type	12.0	3.5	1.0	2.0	14.5	14.0	1.0	1.0	5.0	24.5
6	Meadow forest	6.0	13.0	-	2.0	33.0	35.5	3.0	2.0	3.0	26.5
7	Heathy hummoch bog	13.0	-	4.4	4.0	5.5	5.0	1.0	6.0	14.0	9.0
8	*Salix-Betula nana* bog	11.0	1.0	3.0	1.5	12.0	4.0	0.5	9.0	14.0	10.0
9	Dwarf shrub bog	11.0	-	2.5	-	2.0	1.0	-	3.0	14.0	4.0
10	*Eriophorum vaginatum* bog	-	-	-	-	1.5	-	-	6.0	8.0	2.0
11	Minerotrophic short sedge fen	1.0	0.5	1.0	1.5	10.0	7.0	3.5	8.0	1.0	3.0
12	*Sphagnum* flark fen	-	-	-	-	5.0	-	2.0	17.0	1.0	1.0
13	*Drepanocladus* flark fen	-	-	-	-	13.0	9.0	3.5	14.0	2.0	-
14	Poor mud bottom flark fen	-	-	-	-	6.0	1.0	1.5	15.0	-	-
15	Springy fell fen	1.0	-	-	-	13.0	8.0	3.5	8.0	1.0	3.0
16	Grey willow swamp	1.0	-	-	-	20.5	10.0	-	5.0	4.0	8.0
17	Swampy sedge fen	-	-	-	-	25.5	10.0	-	5.0	4.0	8.0
18	Birch mire with rich fen features	3.0	1.5	-	1.0	23.0	24.5	3.0	2.0	2.0	12.0
19	Herb and grass birch mire	5.0	3.0	2.0	2.5	25.0	20.5	4.5	2.0	5.0	23.5
20a	Meso-eutrophic spring	2.0	1.5	-	2.0	14.5	26.0	1.0	2.0	4.0	12.5
20b	Alpine spring	2.0	-	1.0	12.5	9.0	26.0	-	1.0	-	7.0
21	*Empetrum* heath	19.0	-	24.0	3.5	1.5	2.0	1.0	1.0	4.0	10.0
22	*Betula nana* heath	20.0	1.0	12.5	3.5	1.0	2.0	-	-	6.0	9.0
23	Snowbed brook side	10.0	-	10.5	11.0	2.5	4.5	2.5	4.0	6.0	8.0
24	Brook side meadows	11.0	1.0	3.5	4.0	29.5	24.0	2.5	5.0	3.0	24.0
25	Gravelly brook sides	3.0	0.5	5.0	9.5	6.0	13.0	2.0	-	1.0	7.0
26	Bolder-rich brook sides	4.0	-	1.0	1.0	12.0	8.5	2.5	3.0	1.0	5.0
27	Frost ground sites	15.0	-	14.5	7.0	9.5	11.0	3.5	7.0	4.0	8.0
28a	Secondary alpine heath dry subtype	24.0	-	15.0	2.0	-	-	-	-	6.0	8.0
28b	Secondary alpine heath moist subtype	10.0	-	2.0	-	-	-	-	1.0	8.0	4.0

SI=silvine element, M=meadow forest element, A=alpine element, SN=snowbed element, SW=swamp element, SP=spring element, RF=rich fen element, PF=poor fen element, B=bog element, T=tree mire element

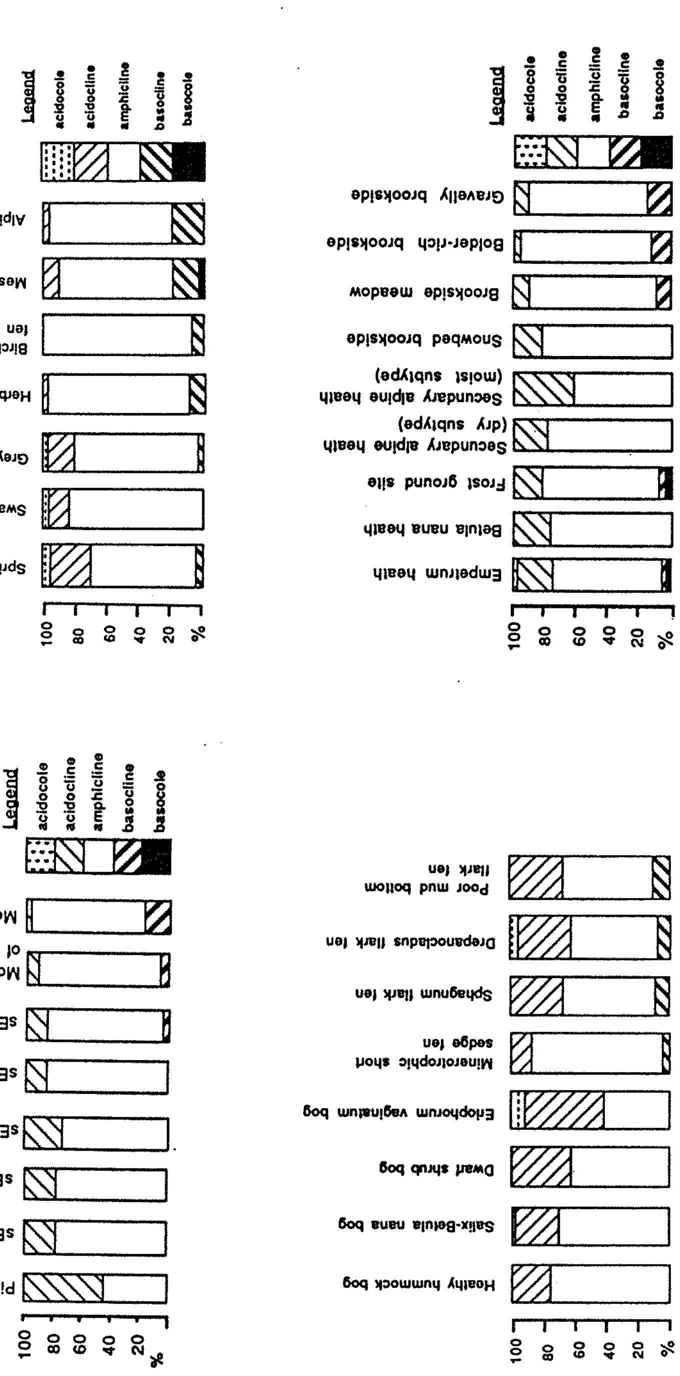

Fig. 7. The acidity requirements of the vascular plants in different vegetation types. The diagrams are based on the information given in Table 1 (additional species also included), and on the acidity requirement information in Mäkinen & Kallio 1979. ACOLE = acidocole; requiring acid substrate, ACLIN = acidocline; preferring acid substrate, AMPHI = amphicline; not depending on the acidity of the habitat, CLIN = basocline; preferring basic or neutral substrate, BCOLE = basocole; requiring basic substrate. The diagrams show percentage portions of these groups in the flora of each vegetation type.

Table 3. The total coverages of different growth forms (A=Trees, B=bushes, C=dwarf shrubs, D=herbs, E=mosses, F=lichens, G=plantless areas) in vegetation types. Values are based on the sample plots.

		A	B	C	D	E	F	G
1	Pine forest	49.0	-	51.5	1.5	1.5	35.5	-
2	sELiT	20.0	-	68.0	1.8	13.8	36.0	-
	dsELiT	0.8	-	45.8	1.6	7.4	35.0	10.0
3	sELiPIT	40.0	1.0	64.0	1.5	83.5	8.0	-
	dsELiPIT	4.0	3.0	61.5	8.0	37.5	11.5	-
4	sEMT	35.0	20.0	71.5	12.5	83.0	4.5	-
5	Mountain birch forest of low herb type	7.5	1.0	19.0	66.0	27.0	-	-
6	Meadow forest	50.0	6.0	-	92.0	49.5	-	-
7	Heathy hummoch bog	-	-	64.5	4.0	36.0	1.5	-
8	*Salix-Betula nana* bog	-	13.0	59.5	15.0	36.0	3.5	-
9	Dwarf shrub bog	-	1.7	110.1	37.0	63.0	6.7	-
10	*Eriophorum vaginatum* bog	-	-	36.0	90.0	77.5	-	-
11	Minerotrophic short sedge fen	-	-	2.0	87.0	0.5	-	10.0
12	*Sphagnum* flark fen	-	-	-	71.0	96.5	-	-
13	*Drepanocladus* flark fen	-	0.7	-	90.9	94.3	-	3.3
14	Poor mud bottom flark fen	-	-	-	40.0	37.5	-	50.0
15	Springy fell fen	-	4.5	2.0	81.0	91.0	-	-
16	Grey willow swamp	-	59.0	7.5	47.0	84.0	-	-
17	Swampy sedge fen	-	1.0	1.5	88.6	11.6	-	20.0
18	Birch mire with rich fen features	22.5	6.0	-	64.0	42.0	-	4.5
19	Herb and grass birch mire	3.8	12.5	4.2	90.0	36.2	-	-
20a	Meso-eutrophic spring	-	22.0	4.0	27.0	51.0	1.0	10.0
20b	Alpine spring	-	-	1.5	2.5	52.0	-	48.0
21	*Empetrum* heath	-	-	63.0	2.0	1.5	36.0	3.0
22	*Betula nana* heath	-	-	115.5	6.5	41.0	35.0	-
23	Snowbed brook side	-	-	30.5	45.5	6.5	8.0	-
24	Brook side meadows	-	3.0	5.7	87.9	19.1	-	-
25	Gravelly brook sides	-	-	-	12.0	-	-	88.0
26	Bolder-rich brook sides	-	41.0	5.0	35.0	6.5	-	42.0
27	Frost ground sites	-	-	29.2	16.0	-	12.2	38.2
28a	Secondary alpine heath dry subtype	-	6.0	62.0	4.6	14.3	25.3	-
28b	Secondary alpine heath moist subtype	-	1.5	56.5	23.5	58.0	4.0	-

Table 4. The coverages and vertical distribution (m a.s.l.) of vegetation types (springs not included).

	1	*2*	*3*	*4*	*5*	*6*	
Total area (sq. km)	0.97	119.5	57.0	9.8	1.44	1.26	
% of the Reserve	0.26	32.9	15.7	2.7	0.4	0.3	
% of the forests	0.5	62.9	30.0	5.1	0.8	0.65	
< 200 m (%)	70.1	0.5	13.7	1.5	-	36.8	
200-300 m (%)	29.9	16.0	52.9	28.4	5.6	58.1	
300-400 m (%)	-	80.0	29.7	68.5	92.4	3.6	
> 400 m (%)	-	3.5	3.7	1.6	2.0	1.5	
	7	*8*	*9*	*10*	*11*	*12*	*13*
Total area (sq. km)	13.55	8.8	9.2	0.3	0.2	2.1	3.9
% of the Reserve	3.7	2.4	2.5	0.07	0.05	0.6	1.1
% of the mires	30.9	20.3	21.1	0.6	0.4	4.9	8.9
< 200 m	1.2	0.5	-	20.7	-	-	1.3
200-300 m	36.1	26.9	30.8	65.5	18.6	36.8	33.4
300-400 m	54.8	71.9	69.0	13.8	61.9	63.2	65.3
> 400 m	7.9	0.7	0.2	-	19.5	-	-
	14	*15*	*16*	*17*	*18*	*19*	
Total area (sq. km)	0.5	1.7	1.0	0.8	0.2	1.5	
% of the Reserve	0.12	0.5	0.3	0.2	0.05	0.4	
% of the mires	1.0	3.8	2.3	1.8	0.4	3.3	
< 200 m	-	2.3	5.5	3.6	-	1.3	
200-300 m	15.6	45.7	10.5	30.3	66.3	45.2	
300-400 m	84.4	46.9	82.3	54.1	33.7	53.5	
> 400 m	-	5.1	1.7	12.0	-	-	
	21	*22*	*23*	*24*	*25*	*26*	
Total area (sq. km)	89.2	10.6	0.14	0.4	0.07	0.02	
% of the Reserve	24.6	2.9	<0.05	0.1	<0.05	<0.01	
% of the alpine heaths	89.4	10.6	-	-	-	-	
< 200 m	-	-	-	1.0	-	-	
200-300 m	<0.05	-	1.4	20.0	22.5	25.0	
300-400 m	31.6	56.7	37.0	70.9	77.5	75.0	
> 400 m	68.4	43.3	61.6	8.9	-	-	
	27	*28*	*dry*	*moist*			
Total area (sq. km)	1.74	30.0	0.91*30	0.09*30			
% of the Reserve	0.5	5.8	-	-			
< 200 m	-		-	-			
200-300 m	9.2		6.6	40.7			
300-400 m	52.8		91.4	59.3			
> 400 m	38.0		2.0	-			

1) Pine forest, 2) sELiT, 3) sELiPIT, 4) sEMT, 5) Mountain birch forest of low herb type, 6) Meadow forest

7) Heathy hummock bog, 8) *Salix-Betula nana* bog, 9) Dwarf shrub bog (including palsas), 10) *Eriophorum vaginatum* bog, 11) Minerotrophic short sedge fen, 12)*Sphagnum* flark fen, 13) *Drepanocladus* flark fen, 14) Poor mud bottom flark fen, 15) Springy fell fen, 16) Swampy sedge fen, 17) Grey willow swamp, 18) Birch mire with rich fen features, 19) Herb and grass birch mire

21) *Empetrum* heath, 22) *Betula nana* heath, 23) Snowbed brookside, 24) Brookside meadow, 25) Bolder-rich brookside, 26) Gravelly brookside 27) Frost ground sites, 28) Secondary alpine heaths

The forest line normally lies between 380-420 m a.s.l. It seems to have risen on the Fells Fiellokeäddgeskaidi and Moskuskaidi, where the actual forest line is 20-50 metres higher than the topographic maps show (based on aerial photographs from 1961). In both cases the rise in the forest line is due to the regeneration of old trunkless birch bushes that already existed in the area. These forests were probably damaged earlier for some reason (*Epirrita autumnata*?; see Tenow 1972). The production of 1-3 m high new trunks has caused forest regeneration.

The same kind of forest regeneration could also happen in some treeless areas (e.g. the Fells Podosroadja, Skierrefalis and Kompumtsohka), since many alpine heath areas have a sufficient number of trunkless but still living birch bushes (cf. Fig. 8 in Kallio & Lehtonen 1973: 61) to promote rapid forest recovery. Forest line dynamics are thus largely based on the trunk production-destruction dynamics of the same mountain birch individuals. Kullman (1981: 105) states that the tree limit has risen and the density of birch forests increased in Scandinavia recently. However, this is not the case in our area, where one can see both rising and falling (the latest *Epirrita* damage) forest lines.

5.3. The effects of the *Epirrita* damage

The lack of a birch canopy has radically changed environmental conditions over large areas. These changes include openess, windiness, drought in upland areas, increasing moisture in depressions and changes in snow cover. During the field work it became apparent that some alpine plants such as *Diphasium alpinum, Loiseleuria procumbens* and *Juncus trifidus* have taken advantage of the latest *Epirrita* damage.

Forest recovery after the *Epirrita* damage has been very poor (see vegetation map). The most badly damaged birch forest types are sEMT and sELiPlT, where trees were on average taller and older. Areas with poor regeneration (stages 0-2) are developing towards (secondary) alpine vegetation, while areas with better regeneration (stages 3-4) will at least partly recover.

The ripening and germination rate of mountain birch seeds is somewhat contradictory Vaarama & Valanne (1973: 79-80). We observed abundant seedling stands at a few sites (e.g. riversides, mesic forests), but the plants were usually many years old. This is indicated by their thick, bent structure (see Fig. 11 in Kallio & Lehtonen 1973) which is probably caused by mammal herbivores. In areas with stronger abiotic stress, e.g. in the upper fell areas and xeric forests, seedlings are rare (see Kallio et al. 1983: 105-107). In the areas damaged by *Epirrita* the low number of adult trees may also explain the lack of seedlings. Long distances between birches may even favour hybridization with *Betula nana* (see Vaarama & Valanne 1973: 81-82).

This all indicates that vegetative reproduction and strength (ability to form many corms and base cuttices even after complete loss of leaves) seem to be successful strategies for the persistence of mountain birches. Due to the slow rate of sexual reproduction, the evolution of this subspecies is slow. This may partly explain its morphological heterogenity (see Vaarama & Valanne 1973: 82, Kallio & Mäkinen 1978: 49-60).

Temporal changes in vegetation are also indicated by the distribution pattern c *Juniperus communis*. Well developed juniper stands typically occur in large depressior in the forest types sEMT and sELiPlT, and also in brook- and riverside habitats. I addition, groups of junipers also occur in some sEliT type forests and even on alpin heaths. It is likely that environmental conditions were quite different when these "dr vegetation" stands originated. This is supported by the view that *Juniperus communi* is a somewhat exacting species in the Utsjoki region with rare sexual reproductio (Kallio et al. 1969: 92-98). The xeric juniper stands may have originated in humi forests which were later damaged by *Epirrita*. Birch forest damage is not lethal to th junipers, and they have even benefitted from the latest damage in some areas (Kalli et al. 1971: 93). Strong juniper stands may survive over hundreds of years although th surrounding vegetation changes notably.

5.4. Vegetation analysis and classification

The vegetation classification presented is subjective and it is based both on floristi and physiognomical criteria. In order to obtain objectively defined vegetation types th area should be sampled randomly, and classification should be based on ordination o objective classification (see Gauch 1982). However, in an area as wide as the Kev Reserve this would be too onerous, and sampling representativeness would still be problem. In addition, classification based too strictly on mathematical multivariat analyses could lead to an impractical and complex system, at least for the use o vegetation mapping. We therefore argue that subjective classification should still b appreciated as a rapid and reasonable method for wider areas.

As Persson (1961: 19) states, the usefulness of the so-called Braun-Blanquet metho (see Westhof & Van Der Maarel 1973) normally decreases in areas with fewer specie In these areas the ecological amplitude of species increases. This is the case in th study area, where it would often be difficult to find character species. Therefore som of the communities could be defined by rare species, whose distribution is concent rated on this community. This causes problems in distinguishing the same type whe another region or another person is involved.

On the other hand, the use of dominant species as a basis for classification (so-calle dominance types, see Whittaker 1975: 128) could lead to coarse-featured classification where vegetation type characteristics and the structure of the undergrowth vary notabl (Whittaker 1962: 141-143). However, these communities could be superior when th classification is intended for vegetation mapping purposes using remote sensin methods (see Clark et al. 1985).

In the Finnish site-type system the classification of vegetation is based on th characteristics of the undergrowth (see Frey 1973), which is reasonable in areas poo in species - as the study area. For example the ground layer in mires indicates change in environmental conditions more precisely than the tree or bush layer, and the fiel layer usually consists of vasculars with wider ecological amplitudes. The same is als true of most forest types and alpine heaths.

Acknowledgements. We would like to thank the following for their valuable comments on the manuscript and for assistance in problems concerning the classification of vegetation: Prof. Seppo Eurola, Prof. Sakari Hinneri, Ms. Heli Hurme, M.Sc., Prof. Paavo Kallio, Mr. Unto Laine, Lic.Phil., Dr. Juhani Lehtonen, Dr. Yrjö Mäkinen, Dr. Seppo Neuvonen and Prof. Arne Rousi. Mr. Kai Aulio, Lic.Phil., Mr. Reino Fagersten, M.Sc., Ms. Merja-Liisa Jokinen, M.Sc. and Mr. Unto Laine helped us in identifying moss species. For technical assistance both at Turku and at Kevo we are indepted to the staff of the Kevo Subarctic Research Institute. Mrs. Anna Damström, M.A., kindly checked the English language of the vegetation map. The study was supported by the University of Turku Foundation, the University of Turku Society, Metsähallitus, the Emil Aaltonen foundation and the Academy of Finland.

6. References

Aaltonen, V.T. 1952: Soil formation and soil types. - Fennia 72: 65-73.

Ahti, T. 1978: Jäkäläinen Lappi. - Acta Lapponica Fenniae 10: 64-68. (Summary: The lichen country Lapland).

Ahti, T., Hämet-Ahti, L. & Jalas, J. 1964: Luoteis-Euroopan kasvillisuusvyöhykkeistä ja kasvillisuusalueista. - Luonnon Tutkija 68(1): 1-28.

Ahti, T., Hämet-Ahti, L. & Jalas, J. 1968: Vegetation zones and their sections in northwestern Europe. - Annales Botanici Fennici 5(3): 169-211.

Barry, R.G. & Van Wie, C.C. 1974: Topo- and microclimatology in alpine areas. - In Ives, J. & Barry, R.G. (ed.): Arctic and alpine environments: 73-83.

Borg, L. 1984: Myrvegetation. - In Nordiska ministerrådet (ed.): Vegetationstyper i Norden: 197-330.

Cannon, P.F., Hawksworth, D.L. & Sherwood-Pike, M.A. 1985: The British ascomycotina. An annotated checklist. - 302 s. Commonwealth Mycological Institute. The British Mycological Society. Huddersfield.

Clark, M.J., Gurnell, A.M., Milton, E.J., Seppälä, M. & Kyöstilä, M. 1985: Remotely-sensed vegetation classification as a snow depth indicator for hydrological analysis in sub-arctic Finland. - Fennia 163: 195-216.

Dahl, E. 1956: Rondane. Mountain vegetation in South Norway and its relation to the environment. - Videnskaps Akad. Skrifter I, Mat. Naturv. Kl. 1956 (3): 1-374.

Eurola, S. 1968: Luoteis-Euroopan suokasvillisuusvyöhykkeistä sekä niiden rinnastamisesta paljakka- ja metsäkasvillisuusvyöhykkeisiin. - Luonnon Tutkija 72(1-2): 1-22.

Eurola, S. 1978: Kasvillisuuden suurjako Lapissa. - Acta Lapponica Fenniae 10: 26-30. (Summary: The vegetation zones and belts in Lapland).

Eurola, S. & Kaakinen, E. 1978: Suotyyppiopas. - Porvoo. 88 s.

Eurola, S. & Kaakinen, E. 1979: Ecological criteria of peatland zonation and the Finnish mire type system. - In International Peat Society (ed.): Classification of Peat and Peatlands, Proceedings of the International Symposium Hyytiälä, Finland September 17-21.1979: 20-32.

Eurola, S, Hicks, S. & Kaakinen, E. 1984: Key to Finnish Mire Types. - In Moore, P.D. (ed.): European Mires: 11-117.

Frey, T.E.A. 1973: The Finnish school and forest site-types. - In Whittaker, R.H. (ed.): Ordination and classification of communities: 403-434.

Gauch, Hugh, G., Jr. 1982: Multivariate analysis in community ecology. - Cambridge University Press. Gambridge. 298 pp.

Gjaerevoll, O. 1956: The plant communities of the Scandinavian alpine snow-beds. - Kungl. Norske Vidensk. Selsk. Skr. 1956(1): 1-405.

Heikkinen, R.K. 1986: Kevon luonnonpuiston kasvillisuudesta. - M. Sc. Thesis. Department of Botany. University of Turku. 154 pp.

Heikinheimo, O. & Raatikainen, M. 1981: Ruutukoordinaattien ja paikannimien käyttö Suomessa. - Notulae Entomologicae 61: 133-154. (Summary: Grid references and names of localities in the recording of biological finds in Finland).

Hinneri, S. 1974: Podzolic prosesses and bioelement pools in subarctic forest soils at the Kevo Station, Finnish Lapland. - Reports from the Kevo Subarctic Research Station 11: 26- 34.

Hinneri, S., Sonesson, M. & Veum, A.K. 1975: Soils of Fennoscandian IBP Tundra Ecosystems. - In Wielkolaski, F.E. (ed.): Fennoscandian tundra ecosystems. Part 1. Berlin- Heidelberg-New York. Spinger Verlag, Ecological Studies 16: 31-40.

Hustich, I. 1960: Plant geographical regions. - In A. Sömme (ed.): A geography of Norden: 54-62. Oslo.

Hustich, I. 1966: On the forest-tundra and the northern tree- lines. - Reports from the Kevo Subarctic Research Station 3: 1-47.

Hämet-Ahti, L. 1963: Zonation of the mountain birch forests in northernmost Fennoscandia. - Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(4): 1-127.

Jensen, E.W. 1980: Subalpin-alpin myrvegetation. - In Nordiska Ministerrådet (ed.): Representative naturtyper i Norden. Vegetationstyper. Lund: 3A.

Jensen, E.W. 1984: Alpin vegetation. - In Nordiska Ministerrådet (ed.): Vegetationstyper i Norden: 7-118.

Kaitanen, V. 1969: A geographical study of the morphogenesis of northern Lapland. - Fennia 99(5): 1-85.

Kalela, A. 1939: Über Wiesen und wiesenartigen Pflanzengesellschaften auf der Fischerhalbinsel in Petsamo Lappland. - Acta Forestalia Fennica 48(2): 1-523.

Kalela, A. 1958: Über die Waldvegetationszonen Finnlands. - Botaniska Notiser 111: 353-368.

Kallio, P. 1954: Turun Eläin- ja Kasvitieteellisen Seuran Lapin retki v. 1954. - Luonnon Tutkija 58(5): 145-151.

Kallio, P. 1964: The Kevo Subarctic Research Station of the University of Turku. - Annales Universitatis Turkuensis A, II: 32, 9-40.

Kallio, P. & Lehtonen, J. 1973: Birch forest damage caused by Oporinia autumnata (Bkh.) in 1965-66 in Utsjoki, N Finland. - Reports from the Kevo Subarctic Research Station 10: 55-69.

Kallio, P. & Lehtonen, J. 1975: On the ecocatastrophe of birch forests caused by Oporinia autumnata (Bkh.) and the problem of reforestation. - In: Wielgolaski, F. E. (ed.), Fennoscandian tundra ecosystems. Part 2. Springer Verlag, Berlin - Heidelberg - New York. Ecological Studies 17: 174-180.

Kallio, P. & Mäkinen, Y. 1957: Untersuchungen Über die Flora von Utsjoki in Nordfinnland II. - Archivum Societatis Zoologicae Botanicae Fennicae Vanamo 12(1): 12-29.

Kallio, P. & Mäkinen, Y, 1975: Vascular flora of Inari Lapland. 3. Salicaceae. - Reports from the Kevo Subarctic Research Station 12: 66-105.

Kallio, P. & Mäkinen, Y. 1978: Vascular flora of Inari Lapland. 4. Betulaceae. - Reports from the Kevo Subarctic Research Station 14: 38-63.

Kallio, P. & Hurme, H. 1983: National and International Cooperation at Kevo Subarctic Research Station, Finnish Lapland. - Geojournal 7.4: 353-359.

Kallio, P., Laine, U. & Mäkinen, Y. 1969: Vascular flora of Inari Lapland. 1. Introduction and Lycopodiaceae - Polypodiaceae. - Reports from the Kevo Subarctic Research Station 5: 1-108.

Kallio, P., Laine, U. & Mäkinen, Y. 1971: Vascular flora of Inari Lapland. 2. Pinaceae and Cupressaceae. - Reports from the Kevo Subarctic Research Station 8: 73-100.

Kallio, P., Niemi, S., Sulkinoja, M. & Valanne, T. 1983: The Fennoscandian birch and its evolution in the marginal forest zone. - Collection Nordicana 47: 101-110.

Kalliola, R. 1932: Alpiinisesta kasvillisuudesta Kammikivialueella Petsamon Lapissa. Kasvillisuusmonografia. (Referat: Über die alpine Vegetation im Kammikivi-Gebiet von Petsamo-Lappland. Eine kleine Vegetationsmonographie. - Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo 2(2): 1-121.

Kalliola, R. 1939: Pflanzensoziologische Untersuchungen in der alpinen Stufe Finnisch-Lapplands. - Annales Botanici Societatis Zoologicae-Botanicae Fennicae Vanamo 13(2): 1- 328.

Kalliola, R.J. & Puhakka, M. 1988: The dynamic and vegetation mosaicism: A case study at river Kamajohka, northernmost Finland. - Journal of Biogeography 15(5/6): 703-719.

Koponen, T., Isoviita, P. & Lammes, T. 1977: The bryophytes of Finland. An annotated checklist. - Flora Fennica 6: 1-77.

Kärenlampi, L. 1972: Comparisons between the microclimates of the Kevo ecosystem study sites and the Kevo Meteorological Station. - Reports from the Kevo Subarctic Research Station 9: 50-65.

Kärenlampi, L. & Kauhanen, H. 1972: A direct gradient analysis of the vegetation of the surroundings of the Kevo Subarctic Station. - Reports from the Kevo Subarctic Research Station 9: 82-98.

Laaksonen, K. 1979: Areal distribution of montly mean air temperatures in Fennoscandia (1921-1950). - Fennia 157(1): 89-124.

Laine, K.J. & Niemelä, P. 1980: The influence of ants on the survival of mountain birches during an Oporinia autumnata (Lep.Geometridae) outbreak. - Oecologia (Berl.) 47: 39-42.

Laine, U. 1956: Kevojoen kanjonin floristiset ja geobotaaniset erikoispiirteet. - M. Sc. Thesis, Department of Botany, University of Turku, Finland, 159 pp. + maps.

Laine, U. 1970: Kevojoen kurulaakson kasviston rakenteesta ja siihen vaikuttavista tekijöistä I + II. - Phil. Lic. Thesis, Department of Botany, University of Turku, Finland. 201 pp. + 258 pp.

Laine, U., Lindgren, L. Mäkinen, Y. 1955: Havaintoja Utsjoen pitäjän länsiosan kasvistosta. - Archivum Societatis Zoologicae Botanicae Fennicae Vanamo 9(2): 120-135.

Lehtonen, J. 1981: Kasvillisuuden muutokset tunturimittarin aiheuttaman tuhon jälkeen. - Luonnon Tutkija 85: 123-126.
Lehtonen, J. & Yli-Rekola, M. 1979: Field and ground layer vegetation in birch forests after Oporinia damage. - Reports from the Kevo Subarctic Research Station 15: 27-32.
Likitalo, O. 1984: Talviset paikallisilmasto-olosuhteet Kevolla. - M. Sc. Thesis. Depart ment of Geography and Geology. University of Turku. Finland. 59 pp.
Maristo, L. 1941: Die Seetypen Finnlands auf floristischer und vegetationsphysiognomischer Grundlage. - Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo 15(5): 1-314 + Tabelle.
Mueller-Dombois, D. & Ellenberg, H. 1974: Aims and Methods of Vegetation Ecology. - 547 pp. New York.
Mårtensson, O. 1956: Bryophytes of the Torneträsk area, Northern Swedish Lappland. II. Musci. - Kungl. Svenska Vetenskapsakademiens Avhandlingar i Naturskyddsärenden 14: 1-321.
Mäkinen, Y. 1981: Inarin Lapin kasvistokartoitus. - Luonnon Tutkija 85: 84-90.
Mäkinen, Y. & Kallio, P. 1979: The vascular plants of Inari Lapland, Finland. - Kevo Notes 4: 1-45.
Mäkinen, Y., Kallio, P., Laine, U. & Nurmi, J. 1982: Vascular flora of Inari Lapland. 5. Urticaceae - Caryophyllaceae. - Reports from the Kevo Subarctic Research Station 18: 10-94.
Niemelä, P. 1979: Topographic delimitation of Oporinia-damages: Experimental evidence of the effect of winter temperature. - Reports from the Kevo Subarctic Research Station 15: 33-36.
Niemelä, P. 1980: Dependence of Oporinia autumnata (Lep.Geometridae) outbreaks on summer temperature. - Reports from the Kevo Subarctic Research Station 16: 27-30.
Nihlgård, B. 1984: Skogsvegetation. - In Nordiska Ministerrådet (ed.): Vegetationstyper i Norden: 119-198.
Nordiska Ministerrådet 1984: Vegetationstyper i Norden. - Berlings, Arlöv. 539 pp.
Persson, Å. 1961: Mire and spring vegetation in an area north of lake Torneträsk, Torne Lappmark, Sweden. I. Description of the vegetation. - Opera Botanica 6 (1): 1-187.
Persson, Å. 1965: Mountain mires. - Acta Phytogeographica Suecica 50: 249-256.
Rintanen, T. 1970a: On the vegetation and ecology of frost ground sites in eastern Finnish Lapland. - Annales Botanici Fennici 7(1): 1-24.
Rintanen, T. 1982: Botanical lake types in Finnish Lapland. - Annales Botanici Fennici 19(4): 247-274.
Ruuhijärvi, R. 1960: Über die regionale Einteilung der nordfinnischen Moore. - Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo 31(1): 1-360.
Ruuhijärvi, R. 1978: Lapin suot. - Acta Lapponica Fenniae 10: 36-43. (Summary: The mires of Lapland).
Ruuhijärvi, R. 1983: The finnish mire types and their regional distribution. - In Gore, A.J.P. (ed.): Swamp, bog, fen and Moor. B. Regional studies: 47-67.
Ryvarden, L. 1969: The vascular plants of the Rastigaissa area (Finnmark, Northern Norway). - Acta Borealia A, Scientia 26: 1-56.
Seppälä, M. 1976: Periglacial character of the climate of the Kevo region (Finnish Lapland) on the basis of the meteorological observations 1962-71. - Reports from the Kevo Subarctic Research Station 13: 1-11.
Seppälä, M. & Rastas, J. 1980: Vegetation map of northernmost Finland with special reference to subarctic forest limit and natural habitats. - Fennia 158(1): 41-61.
Shimwell, D.W. 1971: Description and Classification of Vegetation. - 322 pp. London.
Sonesson, M., Wielkolaski, F.E. & Kallio, P. 1975: Description of Fennoscandian tundra ecosystems. - In Wielkolaski, F.E. (ed.): Fennoscandian tundra ecosystems. Part 1. Berlin- Heidelberg-New York. Spinger Verlag, Ecological Studies 16: 3-28.
Sudgen, D.E. & John, B.S. 1982: Glaciers and Landscape. - 376 pp. London.
Syrilä, S. 1964: Retreat of the continental ice and fluvioglacial erosion features on the Tuolbanjaugoaivi fjeld in northernmost Finland. - Reports from the Kevo Subarctic Research Station 1: 338-345.
Söyrinki, N., Salmela, R. & Suvanto, J. 1977: Oulangan kansallispuiston metsä- ja suokasvillisuus. - Acta Forestalia Fennicae 154: 1-150.
Tedrow, T. 1968: Pedogenic gradients of the polar regions. - The Journal of Soil Science 19:197-204.
Tenow, O. 1972: The outbreaks of Oporinia autumnata Bkh. and Operophtera spp. (Lep., Geometridae) in the Scandinavian mountain chain and northern Finland 1862-1968. - Zoologiska Bidrag från Uppsala, suppl. 2, 1972: 1-107.
Tenow, O. 1975: Topographic dependence of an outbreak of Oporinia autumnata Bkh. (Lep.Geometridae) in a mountain birch forest in northern Sweden. - Zoon 3: 85-110.
Tuhkanen, S. 1980: Climatic Parameters and Indices in Plant Geography. - Acta Phytogeographica Suecica 67: 1-110.
Vaarama, A. & Valanne, T. 1973: On the taxonomy, biology and origin of Betula tortuosa Ledeb. - Reports from the Kevo Subarctic Research Station 10:70-84.
Washburn 1956: Classification of patterned ground and review of suggested origins. - Geological Society of America Bulletin 67: 823-865.

Washburn, A.L. 1979: Geocryology - a survey of periglacial processes and environments. - 406 pp. London.
Westhoff, V. & Van Der Maarel, E. 1973: The Braun-Blanquet Approach: - In Whittaker, R.H. (ed.): Ordination and classification of communities: 617-726.
Whittaker, R.H. 1962: Classification of natural communities. - Botanical Rewiews 28 (1): 1-239.
Whittaker, R.H. 1967: Gradient analysis of vegetation. Biological Reviews 42: 207-264
Whittaker, R.H. 1973: Approaches to classifying vegetation. - In Whittaker, R.H. (ed.): Ordination and classification of communities: 323-354.
Whittaker, R.H. 1975: Communities and ecosystems. - 385 pp. New York.