FINNISH FOREST RESEARCH INSTITUTE

METLA

Ruotsinkylä Forestry Trail

Welcome to Finnish forest nature! The Forestry Trail will take you to 20 sites, at which forest management and silviculture are presented from many different angles. Boards along the trail provide brief information about each site. Maps of the Forestry Trail are shown on the information tables at the starting point and parking lot.

Anne Turunen

Forstry Trail points

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22. Professorin pytinki -museum cottage

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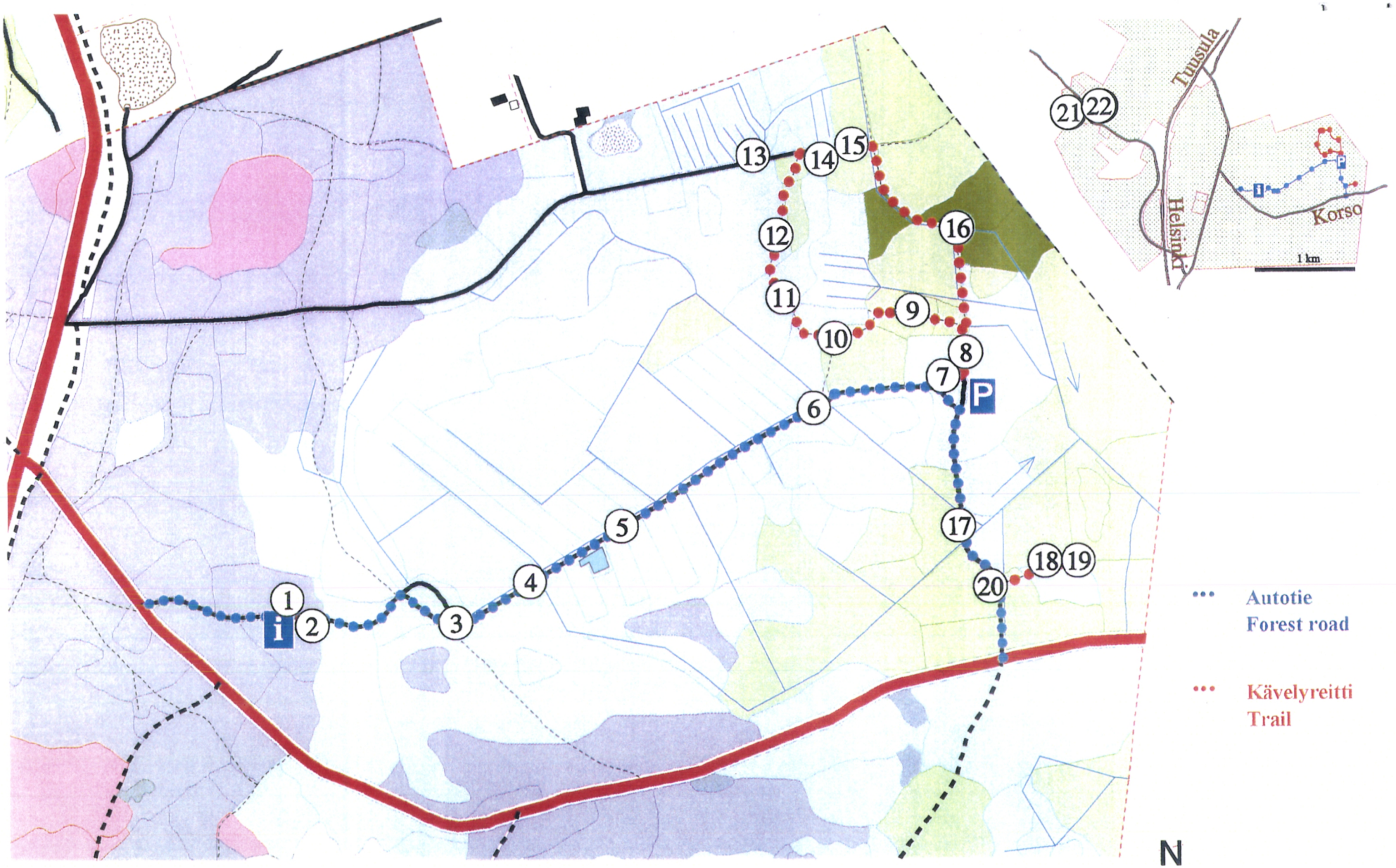


Kasvupaikkatyyppi
lehto ja vast. turvemaa
lehtomainen kangas ja vast. turvemaa
tuore kangas ja vast. turvemaa
kuivahko kangas ja vast. turvemaa
kuiva kangas ja vast. turvemaa
karukkokangas ja vast. turvemaa
kalliomaa, hietikko tai kivikko

Site type
very rich site
rich site
damp site
sub-dry site
dry site
barren site
rocky or sandy area

1. Starting point and information boards

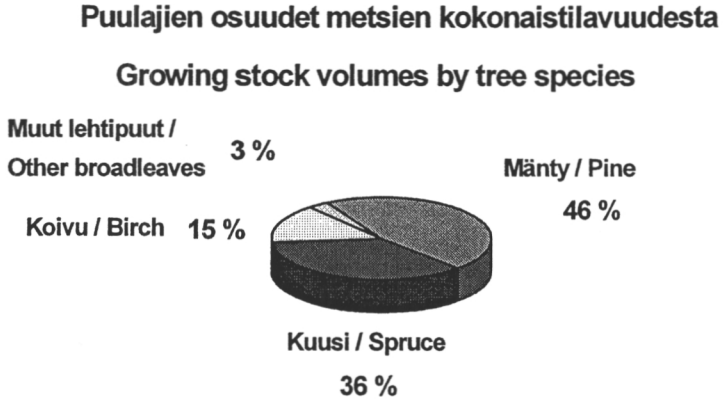
2. Genetic research on bog pine

One of the aims of peatland research has been to clarify the effect of genetic and habitat factors on the growth of trees. The total area of the experimental tree stand located on both sides of the road is 0.93 hectares. The tree stand has been planted in 1934, 1935 and 1938, and the origins of the trees stem from various types of pine bogs in Mäntyharju, Muhos, Padasjoki, Tuusula and Vilppula. After the cleaning of the sapling stand, the forest has been thinned in 1956, 1972 and 1983.

It may be concluded from the appearance of the trees that the growth of pine is primarily affected by soil factors, because the bog pines have grown into straight saw logs on a dry site. Hereditary variation is relatively slight in pine, due to which the site plays an important role in the appearance of the trees.

3. Finnish tree species

Finland belongs to the northern coniferous zone. Forests predominated by conifers cover 89% of the total forest area in Finland. The most important tree species in Finnish forestry are Scots pine, Norway spruce and birch. Aspen, alder and other broad-leaved tree species only account for a few per cent of the total stand volume. Norway spruce has been the most popular tree species in recent years and the forest industry has utilised it more than pine in the course of the 1990s.



Trees grow slowly in Finland. In southern Finland, the average increment of tree stands has been 3.8 m^3/ha/year, while the corresponding figure in northern Finland has been ca. 1.9 m^3/ha/year. The rotation of coniferous stands is nearly 100 years in southern Finland, while that of broad-leaved stands is shorter, about 60-80 years. In terms of timber production, the objective of forest growing is to produce as large amounts of high-quality saw-timber trees of high economic worth as possible to meet the demand of the mechanical forest industry. The size and quality of the pulpwood that the pulp industry utilises as raw material in paper, cardboard and pulp production are not suitable for the production of sawn timber and plywood. In addition pulpwood harvesting, also small-diameter energy wood and small amounts of logging residue are harvested and chipped for energy production.

Properties of wood

Wood is a renewable natural resource with a wide range of properties. Compared to its weight, wood is a very sustainable building material and easy to process. The mechanical forest industry processes wood by sawing, planing, turning and gluing. In addition to sawn timber and plywood production, the mechanical forest industry´s product mix covers pillars, beams, blocks and fibre boards as well as various products made of glued laminated timber and Finnforest Kerto-LVL (laminated veneer lumber). The wood chips, sawdust and bark accruing from mechanical wood working can be used in pulp and paper manufacturing as well as in energy production.

Wood is composed of cellulose, hemicellulose and lignin. The paper industry utilises the long cellulose fibres of wood in its manufacturing process. Wood fibres are separated from each other either with the help of chemicals at the pulp mill or mechanically by grinding and refining, in which case the roundwood used must be fresh and healthy. In principle, any wood can be used as raw material in cellulose cooking.

Properties of Finnish tree species

	Basic density	Shrinkage-% of green measures (Volume)	Length of fibres
Pine	380...440 kg/m3	12,0	2 - 4 mm
Spruce	370...405 kg/m3	11,3	3 - 4 mm
Birch	460...515 kg/m3	17,0	n. 1 mm

Coniferous tree species

With conifers Finns usually mean Scots pine and Norway spruce, because common juniper and the common yew growing on the Åland Islands are insignificant from the point of view of forest economics. Conifers retain their needles also in winter and their cones protect their ripening seeds. The wood of conifers consists of long fibres or tracheids that improve the strength properties of paper. The cell structure of conifers is simple and regular. Annual rings are clearly distinguishable in the structure of the wood and consist of light spring wood and dark summer wood. The age of the tree can be determined by counting the number of its annual rings.

Scots pine *Pinus sylvestris*

Scots pine requires light and grows on dry mineral soil sites and nutrient-poor pine bogs. Pine also grows on fresh heathland, where its quality is lower. Pine grows a strong root system and a thick layer of bark around its stem. The sawmill and cellulose industries utilise pine as raw material. The two by-products of chemical pine pulp are pine oil and turpentine, which are used as raw materials in soap, paint, varnish and glue production.

The surface and heartwood of pine are very different. The darker heartwood that can be distinguished on a cross-sectional sawing surface is dead wood tissue that contains plenty of resin substances. The lighter surface wood is also called sapwood. Valuable knot-free sawn timber is obtained from pine butt logs of good quality. The rest of the log is divided into a top section with sound branches and a middle section with dry branches. The raw material of fine, special and packing papers is pine- and birch-based cellulose. The various uses of paper include office papers, brochures and posters, packing cardboard and non-adhesive and label papers.

Norway spruce *Picea abies*

Norway spruce grows usually in fresh heath forests and on spruce swamps. The initial development of a spruce seedling stand may be slow, but as the seedling stands grows older, it will grow well for a long time, if the tree stand is healthy. More than 100-year old spruce stands in southern Finland have often been damaged by a root rot and other harmful factors, however. Gales cause forest damages most often in spruce stands that are located near openings, because the root system of spruce has spread only into the topsoil. Spruce is a shade-tolerant tree species and produces often an understorey beneath birch and pine forests on fertile sites.

Spruce logs are used to produce sawn timber as well as rotary-cut timber for plywood and Finnforest Kerto-LVL production. Mechanical pulp produced by grinding for the production of newsprint or magazine paper is made of fresh and healthy spruce fibres. Other types of spruce fibres that do not meet the requirements set for the quality of mechanical pulp are utilised in chemical pulp production.

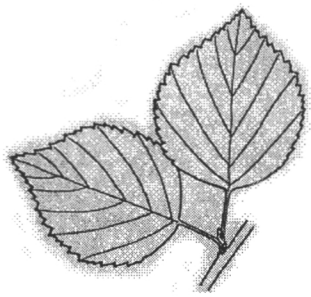
Broad-leaved tree species

The proportion of broad-leaved tree species of Finland´s total forest volume is 18 %. Broadleaves often grow as mixtures in forests dominated by conifers. The forest industry utilises mainly birch and aspen as raw material. In autumn, broadleaves prepare themselves for winter by dropping their leaves on the ground. The trees that in Finland are called noble broadleaves are oak, lime, maple, elm and ash. They grow only in the most southern part of Finland, i.e. by the northern borderline of their distribution area. Broadleaves have a developed structure formed by vascular tissue cells, supporting tissue cells and storage parenchyma cells. Counting the number of the annual rings of a broad-leaved tree species from a cross section usually requires a microscope.

Birch *Betula pendula / Betula pubescens*

The three species of birch growing in Finland are silver birch, downy birch and dwarf birch. Silver birch produces high-quality saw timber and grows fast. The stem of downy birch is more modest than that of silver birch. Downy birch favours peatland sites and tight and moist soils more often than other tree species. Dwarf birch, which is a dwarf shrub growing in northern fjeld and mire areas, is insignificant from the point of view of forestry. Silver birch and downy birch differ in appearance and leaves. The two birches do not differ in the lightness of wood, but downy birch does not always meet the industrial requirements for measurements and quality. Birches require a light site and their seed production is very abundant.

Silver birch *Betula pendula*



Downy birch *Betula pubescens*

Birch logs are mainly rotary cut into veneers for plywood production. In addition to interiors, the best knot-free veneers are used in surface material production by the furniture industry. Because the domestic birch resources do not satisfy the forest industry´s demand, birch currently accounts for more than half of the roundwood imported to Finland. Birch growing has increased in Finland as recently as the last few decades, after Finns started to appreciate birch as timber of high worth, and not only as firewood. Birch has been particularly used in the afforestation of fields.

4. Forest regeneration

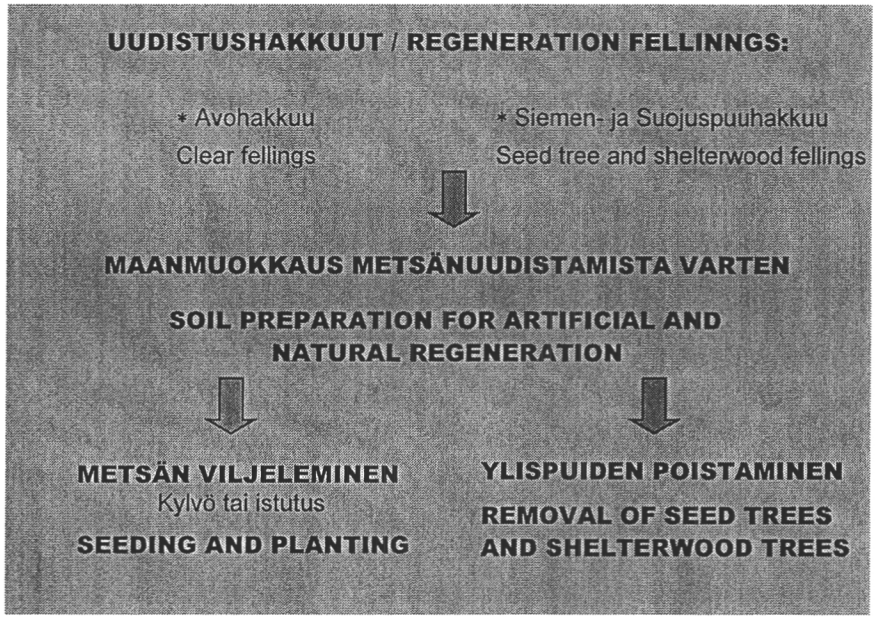
Regeneration emulates the natural development of forests

Forest management endeavours to emulate the natural development of forests. Before effective methods were introduced in forest fire prevention, forests have regenerated very slowly due to fires and gale damage. Today, forest fires are rare in Finland. The burnt-down areas have only amounted to a few hundred hectares a year. In Finland, forests have been burnt down on average once in 150 years.

When a forest stand grows older, the growth of trees starts to slow down. Due to the declined vitality of trees, the number of damages caused by the forces of nature increases in the forest. In commercial forests, forest management speeds up the cycle of nature, which means that the forest is

regenerated before the tree stand deteriorates. Either natural regeneration or seeding and planting can be used to establish a new stand. According to the Forest Act, however, a forest stand can be regenerated only after it has reached a sufficient size or age. A total of ca. 150,000 hectares of forests corresponding to ca. 0.1 per cent of the entire forest land area are regenerated in Finland annually. Final felling accounts for most of the timber sales income accruing to the forest owner during the rotation of the tree stand. Part of the timber sales income is used to establish a new forest, however, because the forest owner is obliged to establish a seedling stand after final felling. The measures to be taken after regeneration felling include cleaning of the cutting area, soil preparation and seeding or planting.

Stages of regeneration



It pays to regenerate the forest immediately after final felling, because the ground vegetation that hampers regeneration is only starting to develop then. The seedling stand to be aspired to must have a sufficient number of evenly-distributed seedlings of an economically feasible tree species that grows well on the site. The density of the seedling stand varies according to the tree species and growing objectives. The trees to be left standing in the cutting area and the sites important from the point of view of the diversity of the landscape must be taken into account as early as the planning stage of regeneration. Local Forestry Centres and Forest Management Associations assist individual forest owners in decisions concerning forest management. The Forestry Centres and Forest Management Associations provide guidance and services in matters related to forest planning, silvicultural measures and timber trade.

Planting densities (pcs/ha) specified in silvicultural recommendations:

Scots pine	Norway spruce	Silver birch	Downy birch	Larch	Aspen	Hybridaspen
min. 2000	min.1800	1600	2000	1300	2000	1000-2000

Natural regeneration

One can regenerate a forest naturally by leaving seed-bearers in the cutting area or by making use of stands bordering on narrow cutting strips. The conditions for natural regeneration must be sufficient as regards the soil and seed-bearers, because the growth of a new and productive tree generation must take place within a reasonable period of time. The best moment for felling is before a good seed year, and careful topsoil preparation improves the outcome of natural regeneration measures. After a new seedling stand has been created, the seed-bearers and nurse crop are removed from above it by cutting the standards in a careful manner. The seedling stand must have a sufficient

number of seedlings of satisfactory growth potential evenly spread out in the whole regeneration area before the standards are cut.

Pine can regenerate naturally on dry and barren mineral soil sites. It is recommended that spruce should be regenerated by planting, because the outcome of its natural regeneration is often uncertain. For natural regeneration to be sensible, the spruce stand must have plenty of seedlings of satisfactory growth potential before regeneration felling. Although birch produces a large amount of seeds, its seeds have a low germination percentage. The natural regeneration of silver birch succeeds best in a spruce-dominated forest on a nutrient-rich mineral soil site, where silver birches of good quality have grown as a mixture.

Seeding and planting of forests

Regeneration of forests by seeding or planting is necessary when the outcome of natural regeneration is uncertain or when the forest owner wants to change the tree species to be grown. It is possible to establish a seedling stand either by seeding or by planting seedlings grown at a forest nursery. To establish a seedling stand by seeding or planting is often the surest method of regeneration, which enables the forest owner to benefit from forest tree breeding through the use of planting material of good genetic quality and origin. Such planting material can be purchased from forest tree orchards. Planting density recommendations vary according to tree species.

Soil preparation

The objective of soil preparation in regeneration areas is to change the thermal, water and nutrient economy of the soil to be favourable for the growth of a forest, and to decrease the shading caused by ground vegetation as well as root system competition. Without soil preparation, regeneration succeeds only on the most barren and fertile soils

In soil preparation, the raw humus of the soil surface is broken using means appropriate to the site. With time, the marks of soil preparation even out so that no more signs of it are visible in the terrain. The most common soil preparation methods are scalping and harrowing. Mounding and leading excess surface water to ditches are used on waterlogged mineral soil sites and drained peatland. In northern Finland, ploughing is used on tight soils with a thick raw humus formation. Prescribed burnings can also be used in regeneration areas, due to which additional nutrients are released into the soil for uptake by a new seedling stand and the level of harmful soil acidity is lowered.

Root rot and regeneration

In southern Finland, root rot is the main cause of economic losses in forests. Root rot is a decay fungus causing butt rot in spruce and annosus root rot (P-type) in pine. The fungus can live on stumps for a long time and eventually spread to new trees. It is therefore recommended that the tree species of the forests troubled by root rot should be changed in connection with regeneration. The tree species most resistant to root rot are aspen and birch, but also pine can be considered.

From an old spruce stand to a mature seedling stand

According to forest management recommendations, the spruce stands that have grown on a fresh mineral soil sites (*myrtillus* site type) in southern Finland should be regenerated when they have achieved a mean diameter of 26-28 cm or the age of 90-100 years. In summer 2001, the mean diameter of this spruce stand, now ripe for regeneration, was **34 cm** and it was **about 90 years** old. The diameter of the smallest tree was 22 cm and that of the tallest tree was more than 50 cm.

The trees in the regeneration area on the other side of the ditch were cut in winter 1999. A few years after final felling, there were scattered seedlings of spruce, birch and mountain ash in the felling area, which had emerged naturally. With the aim of establishing a dense seedling stand of satisfactory growth potential in the area, the soil was prepared and seedlings were planted. An adjacent but somewhat more distant spruce seedling stand has been established in spring 1991.

After clear felling, the soil surface has been prepared by harrowing before the beginning of the seeding and planting work. The birches that have emerged naturally among the seedling stand have been left there to shelter the seedlings from frost.

5. From mire to heathy peatland

A site is classified as mire when the thickness of peat formation is minimum 30 cm and more than 70% of the ground is covered by peatland vegetation. In most natural state mires, the growth of trees is restricted by the moist and nutrient-poor substrate. Approx. one third of the forest land in Finland has originally been covered by mires, and nearly half of them have been drained with the help of forest-improvement subsidies. Mires have been drained with the aim of improving the preconditions for the seeding and planting of forests as well as for increasing the growth of tree stands. Today, the draining of natural state mires is no longer carried out as forest improvement projects funded by the state. Instead, the private forest owners interested in meeting the growing improvement need of old drainage areas are entitled to financial aid in compliance with the Act on the Financing of Sustainable Forestry.

The Forest Improvement Act passed in 1928 started the draining of mires in Finland in an unparalleled manner. The outbreak of war interrupted the hard work of spadesmen that had been going on for more than a decade, for nearly as long a period. In fact, as many as 700,000 hectares of mires were drained using muscular strength. A considerable share of the forests located in old drainage areas is by now ripe for regeneration.

After the wars, the mechanisation of forest drainage was first started with the help of crawler tractor-drawn draining ploughs and later continued with tractor diggers. At the turn of the 1960s and 1970s, first-time drainage was at its height in Finland. Nearly 300,000 hectares of mires were then drained every year, due to which there are now 30 and 40-year old tree stands in huge drainage areas waiting to be thinned. Mainly due to these fast-growing tree stands in need of first thinning, mires account for as much as one fourth of the total increment of the forests in Finland.

The Pirunkorpi area was drained for the first time in 1929, after which the ditches have been cleaned a few times. Peatland vegetation has receded and there is only a thin layer of peat on fine sandy soil. The original site has turned from mire into forested heathy peatland. It is typical of heathy peatland areas that the soil surface is sinking as a result of drainage. This can be detected by examining the clearly visible root collars of old stumps. Most forests in the Pirunkorpi drainage area were regenerated in the 1990s, at which time the spruce stand had reached regeneration maturity.

6. Tending of a seedling stand

The objective of tending a seedling stand is to ensure the growth of the tree stand as well as to increase the income from felling. The forms of work included in the tending of a seedling stand include clearing the brush that prevents the growth of seedlings and thinning the seedling stand to a suitable growth density. The seedlings of a tended seedling stand have enough growing space and they are vigorous. The money invested in the tending of the seedling stand will start to return to the forest owner in the form of stumpage income as soon as the first thinning of the forest has been carried out. The amount of timber harvested from a forest that has been tended since the establishment of a seedling stand is 20-30 per cent larger than the amount obtained from the final felling of an untended forest.

The first thinning of untended forests must be advanced due the excessive density of tree stands. As a result of advanced felling, the accrual of commercial wood remains small and harvesting costs rise considerably. Even if the tending of the seedling stand has been neglected when due, it still pays to

improve the condition of the forest before the actual first thinning. The Act on the Financing of Sustainable Forestry has enabled private forest owners to receive government support for the improvement of seedling stands and young forests. The aim of the support is to maintain the vitality and productivity of forests.

The seedling stands on the site were established in spring 1991. The seedling stand on the side of the road has been planted using 2-year old and the stand on the other side of the ditch using 4-year old spruce seedlings. Birches and other broad-leaved tree species have emerged naturally among the spruce stand. It is recommended that the spruce seedling stand should be thinned to the density recommended in planting instructions, when the stand top height is at 4-5 metres, and the other tree species when the stand top height is at 5-8 metres. From the point of view of the diversity of nature, it is important to leave also broadleaves of high quality in stands of conifers. It is necessary to use broadleaves as shelter against frost in low-lying spruce seedling stands. The shelterwood is removed at a later stage when the seedling stand has grown sufficiently. The best birches in the spruce stand can be allowed to grow into saw logs.

7. Parking lot and information boards

8. Stands of exotic tree species

Exotic tree species can be grown in Finland only in special cases and in small areas. It is necessary that naturally growing domestic tree species are favoured in forest regeneration, although exotic tree species are not a threat to the original nature of Finland yet. Exotic coniferous tree stands account only for ca. 0.1 per cent of the forest land. After larch, the most frequently grown exotic forest tree species is lodgepole pine. On the right side of the Forestry Trail, there is an experimental plantation of **Lodgepole pines** (*Pinus kontorta* var. *latifolia*), established in 1982 using 2-year old seedlings of Canadian origin. The young tree stand on the other side of the road is a pine (*Pinus sylvestris*) stand of Finnish origin that was planted at the same time.

Lodgepole pine grows typically in burned areas and regenerates with the help of serotinous cones that open only when warmed. Lodgepole pines benefit from rapid growth during the seedling and pole stages especially in grassy regeneration areas. The stem of lodgepole pine is usually straight and slowly narrowing. Due to branchiness, the quality of timber and the accruing amount of saw logs do reach the level of domestic pine, however. Hence, there is no need to use it in large quantities in Finland. Because the rotation of lodgepole pine is short (50-70 years) and its initial development is rapid, it would pay to grow it more and use it mainly as raw material in the Finnish paper industry.

In Finland, the growing of lodgepole pine has also been hampered by various harmful factors, while one of its advantages is resistance to pine twisting rust. Snow, gales, moles and elks as well as the insect European pine saw fly and the fungal disease *Gremmeniella abietina* have caused great damage to lodgepole pine. For this reason, the growing of lodgepole pine has decreased also in Sweden, in comparison with the large numbers of lodgepole pines planted in the 1980s.

By studying stands of exotic tree species and different origins, it is possible to look for new and alternative tree species which could be used side by side with the domestic ones and which would better correspond to the various objectives of timber production. Growing of tree stands of foreign origin in commercial forests always requires careful consideration so that the suitability of the exotic tree species for local conditions is ensured. As an alternative, exotic tree species are very suitable for the construction of park and garden areas and cultural landscapes, as well as for the growing of Christmas trees and decorative coniferous twigs.

Visitors can acquaint themselves with stands of exotic tree species on the guided Paratiisinmäki Trail. The Trail begins in the yard of the field station.

9. Forest surveying

The forest management plan of an individual forestry estate is based on a regional forestry plan, and it covers the management and use of forests by the individual estate. 70 per cent of the forest owners in Finland have an estate-specific forest management plan. An estimate of the timber resources and felling potential of the forestry estate, as well as the necessary silvicultural measures to be taken, are in included in the forest management plan. The forest management plan and advice to the forest owners are the two most important tools for maintaining biological diversity and sustainable forestry on private holding level.

Forest planning is implemented as surveys of stands, which means that the area under planning is divided into standardised stand compartments with regard to tree stands and sites. Data is gathered on the tree stands and sites within each stand compartment, based on which proposals are made for the measures that need to be taken during the following 10-year period.

The volume of the tree stand (**m^3/ha**) can be determinated from a table with the aid of the basal area (**ppa**) and mean height (**h**) of the tree stand. An angle gauge is used for determining the basal area of the forest. The accuracy of evaluation improves, when several angle-gauge sample plots on different sides of the stand compartment are evaluated first.

Basal area measurement by an angle gauge:
On the selected measuring site, one turns around 360 degrees and counts all the trees, the stems of which at breast height fill the aiming notch of the angle gauge. Of the so-called marginal trees, which are as wide as the notch, only every other one is counted.

Pohjapinta-ala,		Keskipituus, m			Mean height, m	
Basal area	18	20	22	24	26	28
m^2/ha	Runkotilavuus kuorineen m^3/ha			Growing stock volumes including bark m^3/ha		
20	176	194	211	229	246	264
22	193	213	232	252	271	291
24	211	232	253	275	296	317
26	229	252	275	297	320	344
28	246	271	296	320	345	370
30	264	290	317	343	370	397
32	281	310	338	366	394	423
34	298	329	359	389	419	449
36	316	348	380	412	444	476
38	334	368	401	435	468	502
40	352	387	422	458	493	529

Determination of mean height:
On the angle-gauge sample plot, a **median tree** corresponding to the mean height of the tree stand can be determined by visual estimation, or diameters at breast height (**$d_{1,3}$**) can be measured. The height of the median tree is estimated or measured by a height meter (hypsometer).

You can compare the figures below with your own angle gauge values.

- Number of trees counted using an angle gauge **37 pcs** ⇒ PPA = **37 m^2/ha**
- Height of the median tree **28 m** ⇒ Median height = **28 m**
- Volume of the tree stand according to the table ⇒ **489 m^3/ha**
- Total volume of timber in the stand compartment ⇒ 0.47 ha*489 m^3/ha = 230 **m^3**
- Mean diameter $d_{1.3}$ **31 cm** ⇒ Ripe for regeneration

10. Downy birch stand and Norway spruce understorey

After the forest stand had been cut in 1916, it was a sparsely stocked, young birch forest, among which there were a few spruces. The spruces and pines were removed from the birch stand in the 1950s. A tall understorey consisting of spruce seedlings has since then emerged beneath the downy birch stand (*Betula pubescens*). In general, an understorey emerges naturally before regeneration felling, and it is clearly younger than the dominating tree stand. Due to being shade-tolerant, spruce makes the best understorey. On fresh forest soils, the typical understorey beneath birch and pine stands consists of spruce seedlings, while spruce stands seldom have an understorey. It has been observed that draining of peatland promotes stocking with seedlings, due to which a dense understorey often emerges on mires that are more fertile than average.

Due to competition from the overstorey, the height growth of the understorey is retarded early on, and the understorey often grows more slowly than seedlings that have been able to grow freely. In most cases, the seedlings of an understorey are even-aged, although their heights may vary greatly. The growth of a spruce understorey located beneath an old and slow-growing downy birch stand may be nearly normal.

The understorey can be utilised in regeneration either partly or totally. For the understorey to have growth potential, it must be appropriate to the site in terms of its tree species. It must also be sufficiently dense and even, and capable of recuperating, for the growing to be sensible. Removal of the overstorey causes great changes in the temperatures of the air and soil, as well as in moisture levels and the amounts of light and nutrients available to the understorey. Due to the great changes, it takes several (5-10) years from the freed understorey to reach the development level of a seedling stand that has grown freely.

It can be more cost-effective to utilise an understorey in regeneration than to establish a new seedling stand either by natural regeneration or by seeding and planting. The diversity of nature is also enhanced, when small groups of understorey are left in the regeneration area. The benefits of utilising the understorey include a shorter rotation of the tree stand and immediate cost-savings in regeneration. Harvesting requires that the marking of the tree stand is carried out in a careful manner and that harvesting is implemented with care so that the possible damages that may be caused to the growing seedling stand will remain as slight as possible. Saving the seedling stand increases the costs caused by the felling of the overstorey and by local transports. Due to this, the growing of a two-storey forest is often laborious and requires careful and independent action from the forest owner.

11. Importance of successful forest regeneration

The highest forest income accrues from timber sales in connection with final felling and the highest forest expenses are caused by regeneration. When regeneration is planned, it is important to assess the total costs of forest growing. The main precondition for a productive forest is a dense seedling stand of satisfactory growth potential. Successful regeneration plays a decisive role in the management and felling of the forest stand and in the economic gain it will yield in future.

Certainty is to be emphasised in the selection of a regeneration method. If the preconditions for natural regeneration are poor, then seeding and planting are the most profitable regeneration methods. Even though the spruce stand grows reasonably well by now, its natural regeneration has been slow with some gaps appearing in the seedling stand. The fact that the height of the tree stand varies makes the planning of thinning more difficult and increases harvesting costs.

It is necessary to monitor the development of the seedling stand also after the regeneration work is complete, because a seedling stand with gaps can be repaired afterwards. Repair planting must be carried out as soon as possible so that the repair seedlings can adjust themselves to the existing seedling stand. It is recommended that the naturally developing tree stand should primarily be used

to fill the gaps in the seedling stand, because the labour costs of repair planting are high and only part of the repair seedlings will survive in growth competition. The costs caused by regeneration can be considerably reduced, if e.g. mechanical soil preparation is combined with simultaneous hay control and sowing.

Average regeneration costs in 1999 :

Clearing of regeneration areas	**387 mk/ha**
Harrowing and scarification	**736 mk/ha**
Ploughing and mounding	**1074 mk/ha**
Prescribed burning	**1448 mk/ha**
Seeding	**920 mk/ha**
Planting	**3439 mk/ha**

12. Forest growing and thinning

The site to be thinned is a pine stand established in 1975. The stand grows well, but because the trees are crooked and their thick branches are only slowly naturally pruned, the quality of the forest stand is lowered. The forest stand should be thinned urgently, before a reduction in its living crown has a negative effect on its growth. A section of the stand compartment will be totally left without thinning and used as a reference stand. The living crown of pine should amount to minimum 40 per cent, that of birch to 50 per cent and that of spruce to 60 per cent of the total height of the tree.

The poor quality of the tree stand has resulted from the site (*myrtillus* site type), which is too fertile for pine, as well as from some mistakes made in connection with planting. When the stand is thinned, special attention should be paid to the quality of the trees to be removed. The aim is leave only the trees of superior quality to grow, because crooked trees with thick branches cannot be used as timber trees. In Finland, the price paid to the forest owner for a timber tree has been three times the price of pulpwood.

Objectives of forestry

The objective of silvicultural work is to maintain the vitality and productivity of forests. Silvicultural and felling measures can be used to promote the development of the forest and the economic gain it will yield in future. Such measures increase the amount of commercial timber that can be harvested from well-managed forests and ensure the accrual of timber sales income during the whole rotation. Thinning is used to direct increment to trees of good growth potential and quality. The crowns of the trees with increased growing space remain vigorous, and the soil is sufficiently fertile due to increased amounts of heat and light.

A cost-effective first thinning presupposes a well-managed seedling stand. The aim is to carry out the first thinning that results in commercial timber when the stand top height is at 13-15 metres. In neglected and dense forest stands, first thinning must be advanced, due to which the accrual of commercial timber remains considerably below the normal level. A dense tree stand also slows down harvesting during first thinning and increases the risk of harvesting damage in the residual tree stand.

Thinning models

The forest-management models for sustainable forestry include thinning models that are based on the basal area and top height of the forest. The thinning models indicate the thinning need of the forest stand and the volume of the residual stand. When such models are applied to thinning, the amount of wood accruing from thinning is sufficient from the point of view of harvesting and the total forest yield is the best possible. However, application of thinning models must always be

based on the initial situation. If the forest stand to be thinned is dense, a lowered thinning intensity is recommended. The recommended thinning intensity is no more than 1/3 of the total stand volume.

Harvesting damage
When a forest stand is thinned, mechanical tree harvesting may bruise or damage the residual tree stand. In addition to bruised stems, the most common harvesting damages caused by heavy forestry equipment are damages in the terrain and root systems, resulting from clearing road pressure.

Damaged spots may expose the tree stand to various fungal and insect damages. The most common fungal disease in the coastal areas and southern Finland is root rot. It causes butt rot in spruce stands and annosus root rot (P-type) (*Heterobasidion annosum*) in pine stands. Root rot is prevented with a biological preparation called Rotstop that is spread on new stumps in connection with felling in summer. Rotstop prevents the spores of the decay fungus from spreading, while not being hazardous to forest health.

It has been possible to reduce the damages caused by mechanical harvesting by intensifying the planning and development of forestry equipment. The control and movement of the present forestry equipment is so smooth that hardly any tracks are left in the terrain. Skilled labour and careful planning of tree harvesting play a key role in prevention of damage, however. In the event that the ground is moist and soft, tree harvesting is carried out only in winter, while the ground is frozen. Both the quality of work and productivity of felling improve a great deal, if slash is cleared before thinning.

13. Curly birch *Betula pendula* var.*carelica*

The stand has been planted in 1984 using different types of 2-year old cross-breed seedlings of curly birch. The reference stands are silver and downy birch stands of Punkaharju origin.

Curly-grained wood is a result of mutation, a variety inherited through the seed, which retards the growth of the tree and prevents the normal development of annual growth rings. Curly-grained wood is most common in silver birch, but it has been found also in mountain ash and alder, as well as in downy birch. Curly graininess results in broader primary rays in the wood as well as in tissue growth in exceptional directions.

Curly birch is best distinguished by its bush-like mode of growth. It also grows more slowly than silver birch, and its stem is knotty and slightly twisted. The abnormal bud growth in curly-grained wood results in a forked stem, due to which the growing of high-quality curly birches for rotary cutting requires special pruning at an early age. Among the many types of curly-grained wood are the strongly patterned protuberance and neck types and the less common stripe, ring and curly-grained ice-wood types. Sometimes curly graininess is detected only when the tree is cut and the wavy growth rings become visible. In addition to the chancy curly birch seedlings regenerated by seeding, it is nowadays also possible to purchase micro-propagated planting material that has been cloned and develops completely curly-grained wood.

Curly-grained wood of good quality is highly valued. Thin face veneer made of curly-grained wood is used in details of furniture and interior decoration as well as in various objects of the carpentry industry.

14. Aspen *Populus tremula*

Aspen is a fast-growing tree species that is important from the point of view of the diversity of nature. Aspens act as habitats for several endangered species of organisms living only on aspen, such as *Cucujus cinnaberinus* and *Polyporus pseudobetulinus*. Large poplar longhorn that damages the wood of aspen and red popular leaf beetle (*Chrysmela populi*) that gnaws at its leaves are the most common harmful insects. Many game animals, such as elk and hare, like to feed on aspen. Because the wood of aspen is soft, it is a suitable nesting tree for many cavity nesters. As a pioneer tree species, aspen is the first to conquer open sites with the help of its stump and root shoots.

Aspen has previously been used as a raw material for matches and as firewood. After the match industry declined in the 1970s, aspen has mainly been out of industrial use in Finland until the 1990s, at which time the paper industry started to make use of the fibrous properties of aspen. Acquisition of sufficient quantities of aspen raw material of domestic origin has been problematic, because aspen is susceptible to decay and a wide range of fungal and insect damage. Fast-growing hybrid aspen is a crossbreed that has only in recent years been grown for the needs of the forest industry. The aim of hybrid aspen growing is to produce raw material for the paper industry by exploiting the short rotation and vegetative reproduction of aspen. Visitors can acquaint themselves with a hybrid aspen plantation on site 19.

The homogeneous wood of aspen is straight-grained and light. Its fibrous properties are well suited for the manufacture of fine papers of superior quality. Compared to other tree species, the paper made of aspen is lighter, and its opacity is superior to that of other papers. Because the wood of aspen is light, only small quantities of expensive chemicals are needed in the bleaching of paper. Because the heat conductivity of aspen is low, it makes a good material for sauna benches.

15. Black alder *Alnus glutinosa*

The black alder stand has been planted in October 1952 using 3-year old seedlings. The tree stand has been cleared twice and thinned in 1974 and 1982. Black alder thrives on wetland in nutritious herb-rich forest sites (groves) and on grove-like spruce swamps as well as in flood areas. Black alders growing in natural spruce swamps enhance the diversity of forest nature and provide invaluable habitats for many species of flora and fauna.

The litter of black alder has a curative effect on the site, and when black alder grows nurse crop, it affects the growth of spruce least of all domestic broad-leaved tree species. Due to bacterial activity in its roots, black alder is capable of binding nitrogen directly from the air. The best new tree generation rises from stump shoots, because the outcome of black-alder regeneration by seeding is often poor.

In favourable conditions, planted black alder grows a straight stem suitable for a saw log and it can be regenerated when 60 years old, even though its life cycle can be as long as 120 years. Demand by the carpentry industry and the afforestation of fields have increased the planting of black alder in recent years. The growing of black alder adds to the selection of such domestic tree species that the carpentry and sawmill industries can utilise as raw material. The wood of black alder works easily and is light and resistant to rot. The colour of black alder is usually reddish and quite beautiful. The intensity of colour depends on the date of felling, site and drying. Black alder is most frequently used in panels, timber panelling of the sauna and solid glue timber panels.

16. Important habitats in forest nature

In terms of forest diversity, herb-rich forest sites (groves) are among our most important habitats. While herb-rich forests only account for about one per cent of the forest area in Finland, their fertile and nutritious soils provide habitats for more than half of the endangered species in the country. Herb-rich forest sites are often located on calcareous soil, alongside streams. Abundant herb-rich vegetation is composed of moss typical of herb-rich forests, herbs and grass, ferns as well as undergrowth vegetation.
The area has been a herb-rich spruce swamp with a mixed tree stand and its tending has favoured black alder. The oldest naturally reproduced black alders are already more than 120 years old. In May, the white flowers of wood anemone cover almost all of the ground, but gradually ferns and stinging nettles conquer the site. Through plant species which start their growth and flowering at different times, the herb-rich vegetation changes its form throughout the whole growing season. On ditch margins, the bright yellow flowers of marigold stand out among the rest of the green vegetation. The luxuriant environment and old broad-leaved tree species make suitable habitats for many forest birds, the singing of which can best be heard on a summer morning.

If the habitats referred to in the present Forest Act are in a natural state, or resemble a habitat in natural state and are of special importance, such as fertile patches of herb-rich forest, they shall be preserved. The sites are usually clearly distinguishable and small in area. They must be managed and utilised so that the special features that are valuable from the point of view of the diversity of nature are preserved. In compliance with the Act on the Financing of Sustainable Forestry, private forest owners are entitled to environmental support which enables them to meet the financial losses caused by the preservation of the sites specified in the Forest Act.

The habitats of special importance specified in the Forest Act include:

- the immediate surroundings of springs, streams and small pools
- herb-rich and grassy hardwood-spruce swamps, ferny hardwood-spruce swamps and grove-like spruce swamps in southern Finland
- fertile patches of herb-rich forest
- heath forest islets in undrained wetlands
- gorges and ravines
- steep bluffs and the underlying forests
- the areas unimportant from the point of view of timber production, sandy soils, exposed bedrock, boulder fields, wetlands with sparse tree stand and flood meadows

17. and 18. Growth of forest

Sites 17 and 18 are experimental plots included in peatland research. The aim is to study the growth and recovery of the spruce understorey. The tree stands of the experimental plots have been measured at intervals of ca. 5-10 years since the year 1930. The tree stands have risen in an area cut by Russians in 1916, at which time their starting points have been fairly similar. Prior to drainage in 1929, the site type was herb-rich spruce swamp with a 10-20 cm peat formation on sandy soil. The tree stand at that time consisted of a young birch forest with a few spruces as undergrowth.

The Norway spruce stand

In 1951, the tree stand in question was described as a fairly fast-growing birch forest with small openings, among which there were a few aspens and patches of spruce undergrowth. Most of the birches were removed from above the spruce undergrowth in felling in 1978, after which the spruce stand has recovered well and continued to grow. The stand has been thinned at the previous time in

1997. In the measurements of the year 2001, the height of the spruce stand was **20 m**, mean diameter **27 cm,** number of trees **680 pcs/ha,** basal area **32,5 m^2/ha** and growing stock volume **290 m^3/ha**.

The downy birch stand

Birch has been favoured in the seeding and planting of the forest located on the experimental plot. The spruce undergrowth that had emerged underneath the birches was cleared in the 1950s. There were also a few aspens and spruces among the birches that were removed in connection with a later thinning. In summer 1965, the growth of the forest was boosted by means of a phosphorus-potassium fertiliser (phosphorus 16.5% and potassium 16.5%). A total of 600 kg of the fertiliser was spread per hectare. The downy birch stand is turning old and approaching the end of its rotation. The trees of this stand have grown into straight logs of fairly good quality. In the measurements of the year 2001, the height of the 85-year old downy birch stand was **27 m**, mean diameter **29,5 cm,** number of trees **325 pcs/ha,** basal area **22,5 m^2/ha** and growing stock volume **250 m^3/ha**.

19. Hybrid aspen

Hybrid aspen is a fast-growing cross breed between the domestic (European) aspen (*Populus tremula* L.) and trembling aspen (*P. tremuloides* Michx.) from North America. The first cross breeds of hybrid aspen were carried out by the Finnish Forest Research Institute in the 1950s. This hybrid aspen stand, the seedlings of which represent 24 different clone origins, has been planted in spring 1999. The site is a vigorous upland forest with grass-herb vegetation (Oxalis-myrtillus site type).

The growing of hybrid aspen is becoming popular, because the paper industry has started to use aspen in the 1990s. There has been a significant increase in the number of planted hybrid aspen stands in the last decade. Like the wood of domestic aspen, the wood of hybrid aspen is also especially suitable for the production of mechanical pulp and fine paper. Seedlings produced by means of cloning are used in the reproduction of hybrid aspen. The objective is to grow new hybrid aspen stands with as short a rotation as 20-25 years and to regenerate the stands naturally by making use of the strong capability of aspen to put out shoots.

At best, a hybrid aspen stand produces a yield of 300 m3 in 25 years, while the yield of domestic aspen is 200 m3/ha during the same period. Hybrid aspen grows more rapidly than any other domestic tree species. The area has been surrounded by a fence and the seedlings have been protected with tubes against mole, hare and elk damage. To avoid damage, the growing of aspen is not recommended in areas frequently visited by elks.

20. Natural state forests

Because no silvicultural measures have been taken for decades in the stand compartment, it has been able to develop naturally. Birches have mainly decayed and a vigorous spruce stand has risen beside the birch stand and conquered the broadleaf stand. There are plenty of windthrows in the forest, along with standing dead trees and decaying snags, which house a host of polypores and fungi as well as micro-organisms. Broadleaves and especially aspen are important habitats for many micro-organisms. The beetles and fungi living in and on decaying wood are often demanding with regard to their habitats. This is why the majority of our endangered forest species are those of old forests.

The biggest difference between natural state and commercial forests is the amount of decaying wood. It has been estimated that the amount of decaying wood in commercial forests is less than 5%

of the volume of the tree stand, while the amount in natural state forests can be as high as 40%. The diversity of habitats in commercial forests is enhanced, when groups of trees are left in felling areas and snags and standing dead trees are exempted from felling. The trees that are left standing are of little value to the forest owner, but they are invaluable as key biotopes.

To ensure the preservation of the diversity of forest nature, it is central to protect also such small sites in commercial forests that are important from the point view of the diversity of nature. In addition to these sites, the total area of different types of nature reserves amounts to 3.4 million hectares, which is more than 10% of the entire land area of Finland. The protected areas, most of which are located on state-owned land, ensure the preservation of even the most demanding and endangered species.

21. Ruotsinkylä Field Station

The Ruotsinkylä Research Area was established in 1923. Located in Tuusula, it is in the immediate vicinity of capital city area. There are over 500 hectares of diverse research forests in Ruotsinkylä. The Ruotsinkylä Research Area offers a range of forests. Sites vary from bare rock and infertile heaths to rich, stream-bank groves. The forests include stands at different stages of development and there are many cultivation trials with exotic (non-native) tree species.

22. Professorin Pytinki – museum cottage