Guide to

The Montell Trail

in the Punkaharju Experimental Area

The Finnish Forest Research Institute

Contents

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Welcome to Punkaharju

The Finnish Forest Research Institute wishes visitors welcome to the Punkaharju Experimental Area. At Punkaharju you can see landscapes of great natural beauty, forest nature in all its diversity, as well as forestry research.

This guide will help you discover, within a short time, the forests of Punkaharju and provide you with information about the forestry research being carried out in the area. Points of interest along a path running for about 3.5 km are described in the guide: it will take about 1–1.5 hours to complete the Montell trail.

The path passes through the Punkaharju arboretum. All the tree species (about 50) growing in stands at Punkaharju are assembled in small groups in the arboretum. It also includes trees not growing elsewhere in Punkaharju. More detailed information about the arboretum can be found in a separate booklet.

The history and natural conditions of the Punkaharju area, as well as the Punkaharju Experimental Area and the activities of the Finnish Forest Research Institute, are described in more detail in a separate booklet. The booklets and more detailed information about the forests and research points in the experimental area are available from the Punkaharju Research Station or from the Finnish Forest Research Institute.

We hope that you will enjoy your visit to Punkaharju.

The Finnish Forest Research Institute

The Finnish Forest Research Institute (FFRI)

The FFRI is a national, independent research institute, whose task is to promote, by producing research data, the sustainable, diverse use and protection of Finland's forests.

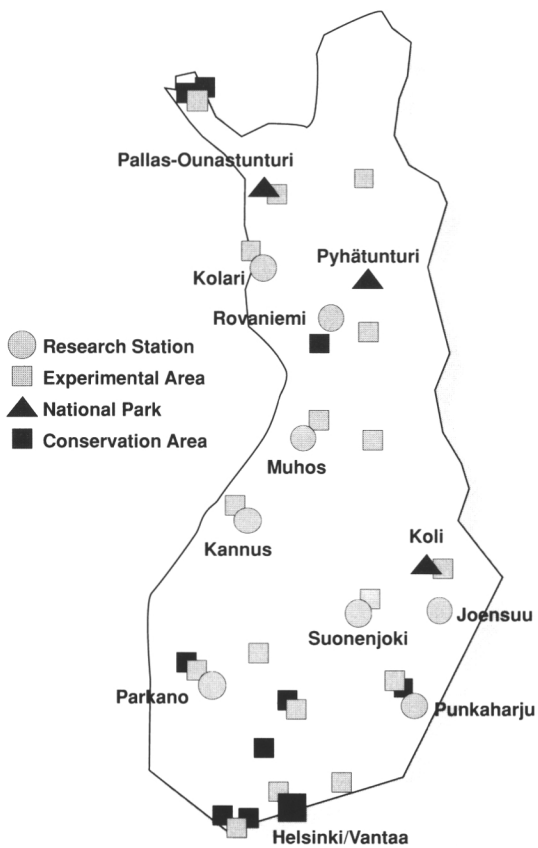
The FFRI was established in 1917. It has developed into a major organization with the head office in Helsinki and Vantaa, and eight research stations situated in different parts of Finland. The expertise of the more than 200 researchers at the institute ranges from traditional forestry science to the natural, social and economic sciences. The total input of the staff is about 1 000 person years.

The institute has about 140 000 ha of experimental forest and nature conservation areas available for long-term research and studies. There are over 20 000 sample plots in these forests, the oldest of which were established already during the 19th century.

The FFRI is the organization with the longest tradition of managing nature conservation areas in Finland. It manages the Pallas-Ounastunturi, Pyhätunturi and Koli national parks, as well as a large number of nature parks and other conservation areas. In addition to research work, the institute is responsible for guiding and advisory services in the areas.

The major research projects carried out by the institute have included long-term artificial regeneration and forest growing experiments on both mineral and peat soils. This work has provided a scientific basis for the silvicultural and forest improvement methods used in Finland. The national forest inventory has followed the development of Finland's forest resources since the 1920's. Important new research topics are forest health and multiple use.

In addition to research work, the institute is also responsible for the national forest statistics, calculating the norms for forest taxation, the forest genetic registers, monitoring the state of health of the forests, and the inspection of control chemicals.



The Punkaharju Research Station and Experimental Area

The **Punkaharju Research Station**, FFRI, is located right next to the old Punkaharju railway station. The research station has been gradually expanded from a tree breeding station (1964) to a research station (1987), where 6 research officers and about 40 auxiliary staff are employed. The research station building was completed in 1982.

The Research Station has specialised in forest tree breeding research. Traditional breeding research includes crossing breeding and progeny trials. During the past few years the research topics have been expanded to include seed orchard research, resistance breeding and biotechnological research, i.e. vegetative propagation and gene technology. Biotechnological methods are used in the laboratory to produce, from small pieces of plant tissue, large numbers of seedlings with identically the same genetic properties as the mother tree; all the properties of high-quality tree individuals are thus transferred to the cloned individuals. Ways of transferring the genes of certain desirable traits to tree individuals for further breeding are also studied. In resistance breeding, individuals are being developed that are unpalatable to hares, voles and elks.

Nowadays Punkaharju has Finland's largest clone collection – a collection consisting of grafts from trees with superior properties – in which thousands of crossings are made annually. Progeny trials are used to find the best crossed progeny for practical artificial forest regeneration and research.

The **Punkaharju Experimental Area** was established in 1924. Today it comprises 1 790 ha of land and about 800 ha of lakes in six rural municipalities in Eastern Savo (Punkaharju, Kerimäki, Kesälahti, Kitee, Rautjärvi and Värtsilä). Almost 200 ha of land have been protected, e.g. the Punkaharju Nature Conservation Area was established in 1991, and includes the Punkaharju esker area proper.

The forests in the experimental area are primarily managed for research purposes. About 650 ha of land with a total of about 200 experiments are currently being used for research.

More detailed information about the Punkaharju Experimental Area and the history of Punkaharju can be found in another booklet.

The Growing of Exotic Tree Species at Punkaharju

Punkaharju is famous for its plantations of exotic tree species. The first plantation, a Siberian larch (*Larix sibirica*) stand of Raivola origin, was established by Forest Officer R. Montell in 1877 (Point M14 on the Montell trail). In addition to Siberian larch, European larch (*Larix decidua*) (Point M11), Siberian fir (*Abies sibirica*) and Swiss stone pine (*Pinus cembra)* (Point M6) were planted in the area at the end of the 19th century.

After Punkaharju was transferred to the FFRI in 1924, a start was made on continuing the growing of exotic tree species, initiated half a century earlier. A total of 150 ha of tree species trials, comprising over 50 exotic species, were established during the 1920's and 1930's at Laukansaari, Punkaharju. The aim of the trials is to determine how well trees from areas in Europe, Asia and North America with a similar climate thrive in Finland. Nowadays the trials also represent an irreplaceable source of information when investigating the effects of climate change on Finland's forests and native tree species.

In these trials, which have been continuing for decades, only a few tree species – e.g. larch and Douglas fir (*Pseudotsuga menziesii*) – have proved to be competitive as regards timber production with native tree species. The growth and development of a number of exotic species has been prevented by fungal or insect damage (e.g. Douglas fir, Point M26). In turn, the Finnish winter has proved to be fateful for many species; exceptionally cold winters especially have damaged the trees. However, a large number of exotic tree species are grown as ornamental trees.

The path starts from the old primary school, continues through the arboretum and up to crossing post 9, circles around through the Montell larch stand and the so-called congress slash-and-burn site to the Siira pine stand, and then back to the school. The path is about 3.5 km long, and it takes about 1–1.5 hours to walk. There is a board at many of the points indicating what tree species is growing there and the year of establishment. There is also an information board in some of the stands with information about the site.

M1. Information board and the old primary school

Before the new buildings were completed in 1982, the primary school served as the experimental station and field laboratory. Nowadays the school is used as a conservation office for the forest museum to be built at Punkaharju. The forest museum will be finished in 1994 next to the old railway station building of Punkaharju.

There is an information shelter at the edge of the parking area on the northern side of the school where notice boards with maps and trail markings provide information about the experimental area.

M2. Birch stands

■ There is a beautiful young silver birch (*Betula pendula*) stand growing on both sides of the road next to the information shelter. The trees on the right side of the road were planted in 1964 and consist of progeny from plustrees E182 and E189, as well as open-pollenated progenies of "Olli" Masur birch (*Betula pendula* var. *carelica*) ("Olli" Masur birch, point M32). Progeny of the same plustree have been planted next to the school.

Plustrees form the basic material used for forest tree breeding, and are the best individuals selected from Finland's natural forests (see also Point M12, Kanerva pine). The are the basis for both the production of high-quality reforestation material and the development of forest tree breeding. The crossing of plustrees is an important tree breeding method when developing seedlings of better quality and growth. Crossings are usually performed in so-called clone collections, in which the plustrees have been propagated by grafting. The largest clone collections in Finland are

located in Punkaharju (Point M30). A clone is a group of genetically identical individuals.

The differences between the development of healthy birch seedlings and those suffering from birch rust (*Melampsoridium betulinum*) have been studied, for instance, in the birch stands at this point. The stand has been thinned three times already – in 1972, 1978 and 1988.

M3. The arboretum

■ The path continues through the arboretum. The Punkaharju arboretum was established in 1927. Originally a total of 72 tree species (54 conifers) were planted there. Part of the park was lost when the new Punkaharju by-pass (trunk road 14) was built, and some of the tree species have died. The regeneration and repairing of the arboretum was started in 1990. At present, there are 40 coniferous species and about 20 hardwood species growing in the arboretum.

Here you can see, within a rather restricted area, almost all the tree species being grown in the Punkaharju Research Area. The arboretum also includes tree species not found elsewhere in the research area. Although the plantations in the arboretum are so small that they are not suitable for research purposes, they do provide some information about the adaptability of the species to Finnish conditions. The main function of the arboretum is to demonstrate which exotic tree species can be grown in Finland, and hence it serves the needs of research, teaching and recreation.

M4. The Finnish Forest Research Institute's 70th anniversary birch stand

■ At the last point in the arboretum, on the left of the path, there is a Masur birch stand (Masur birch, Point M8) which was planted in June 1988 to mark the 70th anniversary of the Finnish Forest Research Institute. At the time of planting the seedlings were one year old and about 1 m tall. They were produced at Punkaharju by vegetative propagation from the same tree in test tubes to give seedlings with identically the same genetic composition.

The advantage of cloning is e.g. the transfer of the good properties of the mother tree to all the progeny. Clones can also be produced e.g. by means of branch cuttings or by grafting. Using modern biotechnology the tree breeders have also recently succeeded in producing new seedlings from the tissue of the

mother tree by means of tissue culture. Such birch seedlings will soon be an everyday occurrence in practical reforestation, but so far they have mainly been used in research work.

M5. Old, artificially regenerated pine stand

■ The Masur birch stand is bordered by one of the oldest artificially regenerated stands in Punkaharju; the Scots pine (*Pinus sylvestris*) stand regenerated in 1892 by seeding on land used for slash-and-burn agriculture. Birch is growing as an admixture in the stand, the trunks of which subsequently become covered in lichens and moss and can no longer be distinguished by their white trunks. Artificially regenerated stands gradually start to resemble naturally regenerated ones as they get older. Could you have imagined that this stand had been artificially regenerated?

At the end of the 19th century **slash-and-burn agriculture** was still rather common in the Punkaharju area. The hardwood forest where this stand now stands was cut down, the brush burnt, and one crop of rye planted. Rye was followed by one crop of oats, which was simultaneously sown with pine seed and, in a small area, also with spruce.

The **first forest cultivation experiment** at Punkaharju was established in the stand in the same year the Research Area was founded in 1924. The effects of different thinning intensities on the growth and development of the tree stand is being followed on the plots: one of the three plots has been thinned very lightly, the others more intensively. The mean height of the stand in 1987, i.e. when the stand was 95 years old, was about 30 m.

This is an ideal opportunity to tell about **Scots pine,** a species so important to Finland. It is the world's most widespread pine species: its natural range includes most of Siberia and Europe, apart from the westernmost and southernmost regions. The main distribution area of Scots pine is in the continental east. Scots pine has formed a number of geographical races, which differ from each other as regards their metabolism and also to some extent their external appearance.

On the average, Scots pine flowers in southern Finland during the second week of June. The seeds are ripe by the second autumn after flowering, and are shed in early spring the following year. Scots pine grows at a fast rate when young, but its growth slows down later on much more rapidly than for instance Norway spruce. Scots pine does not grow quite as tall as Norway spruce.

Scots pine on relatively fertile soil in southern Finland can reach an age of 200–250 years; trees as old as 500–600 years have been found. The rotation period in commercial forests is about 80–120 years.

Scots pine only grows well if it has sufficient light. In natural forest succession, Scots pine follows hardwoods, and Norway spruce, which can better withstand shading, appears later on under pine. Although pine can be found on infertile sites, it grows best on moderately fertile sites (dry and dryish mineral soils). In Finnish Lapland pine forms the timber line.

Scots pine is the most important tree species in Finnish forestry: about 45% of the growing stock is pine. Pine is used as sawtimber, poles, railway sleepers and in the manufacture of pulp and paper. High-quality pine sawtimber is especially in demand as a building material and in interior work.

M6. Stone pine

■ **Stone pine** (*Pinus cembra*) grows naturally in two geographically isolated areas lying about 2 000 km apart: in the Alps, and in NW Russia, western and central Siberia. Alpine stone pine and Siberian stone pine are usually differentiated from each other, although they are very similar in appearance.

The closest area to Finland where Siberian stone pine (here in this stand) grows naturally is along the River Viena. It grows well in Finland and is one of the oldest exotic tree species to be cultivated in Finland. Owing to its dense crown it has been a popular ornamental tree. It has also been used to form shelter and isolation hedges in seedling nurseries; there are fine hedges of this sort in Punkaharju, too. In addition to lodgepole pine (*Pinus contorta*) and Macedonian pine (*Pinus peuce*), stone pine is almost the only exotic species of pine that develops into a beautiful tree in Finland. However, in order to thrive it requires exceptionally fertile soil.

The large cones of stone pine fall whole to the ground during the second late autumn after flowering, and the seeds are released as the cone decomposes. The seeds are large and nutritious, according to Russian sources unshelled seeds contain as much as 60% fat. It is thus not surprising that the seeds of stone pine are used as food by many animals and also by man. Even at the end of the 19th century the seeds of stone pine were considered to be so nutritious that the Russian government started a campaign to

spread stone pine to Finland – as an alternative source of food in times of famine.

The strongly-scented wood of stone pine is soft and light, but does not rot easily. Owing to its beautiful knotted grain stone pine wood is popular in Switzerland and Austria as a panelling for rooms. In Siberia clothes cupboards and chests are made from stone pine because the smell of the wood is believed to repel moths.

The cones of stone pine have attracted rather exotic inhabitants to Punkaharju: the seeds are eaten by nutcrackers, a strong-beaked bird the size of a jay. They can be seen especially at the end of summer crowding around the large juicy cones, pecking out the seeds and hiding them in the ground as a winter food store.

M7. Macedonian pine

■ A little further on, on the left of the path, there is a stand of **Macedonian pine** (*Pinus peuce*). This pine closely resembles stone pine.

Macedonian pine grows naturally in a number of different areas in the Balkans: in Albania, along the border between Greece and Jugoslavia, and in the mountains of Bulgaria. It is a mountain tree and forms pure stands at altitudes as high as 1 600–2 000 m. Above this altitude it grows in mixed stands with mountain pine (*Pinus mugo*) (Point M9); on the lower slopes of the mountains it forms mixed stands with Scots pine.

Macedonian pine grows slowly and is therefore not worth growing for its timber. In contrast, it is an ideal ornamental and park tree because it is surprisingly resistant, and is adaptable to very different climatic conditions.

Stone pine and Macedonian pine belong to the group of so-called five-needle pines: their needles are born in small tufts containing five needles. However, these two species can be easily distinguished by their cones. The cones of stone pine are large, upright, ball-shaped and resiny; Macedonian pine cones are large, somewhat elongated (8–15 cm) and hang down from the branches. The young shoots are another good distinguishing mark: on stone pine they are covered with a thin layer of down, but bare on Macedonian pine.

M8. Masur birch

■ **Masur birch** or **curly-grained birch** (*Betula pendula* var. *carelica*) is a special form of silver birch (*Betula pendula*). Curly graining occurs much less frequently in downy birch (*Betula pubescens*) and other tree species. Curly graining is considered to be an inherited disease where the development of the annual rings of the tree is disturbed and the wood which is formed is harder than normal, often brown and has a decorative grain. Masur birch also differs in its external appearance from "healthy" birches: the trunk usually has bumps, furrows and ring-shaped protuberances. Masur birch grows slowly and is usually rather forked and bushy. It is ideally suited as a park or garden tree.

Masur birch grows naturally within a rather small region; in addition to southern Finland, it occurs to a significant extent only in southern Sweden, southeastern Norway, Soviet Karelia, the St. Petersburg area, the Baltic countries and in Byelorussia. In southern Finland Masur birch mainly grows naturally on old slash-and-burn agricultural areas.

Despite its slow growth and unusual form, Masur birch produces a valuable raw material for the carpentry industry. The price of green, barked Masur birch timber can be as much as FIM 10 000/m^3. It is the only type of timber to be sold in Finland on a weight basis. Masur birch is used e.g. in art and ornamental articles and as a veneer in furniture.

This stand was planted already in 1934, i.e. it is now about 60 years old. A Masur birch stand managed to produce curly-grained wood reaches final cutting already at an age of about 50 years. It can be grown for a longer period, e.g. as a park or landscape tree or, as here, for research purposes.

M9. Woody mountain pine

■ Across the road from the Masur birch stand you will find a stand of **mountain pine** (*Pinus mugo*) growing on the right of the path. There are many subspecies of mountain pine, most of which are bushy forms, but some like this one grow into small trees. There are bushy mountain pines growing in the Punkaharju area, e.g. in the arboretum.

Mountain pine comes from the mountainous regions of central and southern Europe, especially the Alps. It grows there as dense bushy stands along the timberline. The value of mountain pine primarily lies in its function as a shelter forest. Owing to its adaptability, it has also been grown as shelter stands, for binding

moving sand dunes or as a pioneer tree on infertile sandy soils before planting other tree species. Outside its natural range mountain pine has also been grown much as an ornamental tree, although as it ages it often becomes sparse and straggly.

The wood of mountain pine is very resinous, strong and rot-resistant. However, mountain pine is not grown at all for its timber; the wood is used to some extent for firewood, charcoal and railway sleepers. Torches are also made of the wood owing to its high resin content.

M10. Young plantation

■ The path runs through a young plantation, planted in 1980. The development of the naturally regenerated young Scots pine stand is being compared to that of planted lodgepole pine (*Pinus contorta*), Siberian larch (*Larix sibirica*) and Norway spruce (*Picea abies*) stands, and later on also the timber production capacity.

M11. Old European larch stands

■ Immediately after the plantation we come to a crossroads (crossing post 9), from where the path continues to the right. One of the oldest artificially regenerated stands at Punkaharju, a **European larch** (*Larix decidua*) stand established in 1880, is growing at the crossroads.

European larch grows naturally over an extensive area in central Europe, mainly in the mountains: the Alps, Tatra Mountains, the Carpathians and southern Poland. In the mountains it can grow up to an altitude of 2 000 m, where it forms the timberline together with mountain pine (Point M9) and stone pine (Point M6). European larch is well adapted to different growing conditions, and it is cultivated in many countries. It is not especially susceptible to e.g. snow, storm or harvesting damage, but it is very susceptible to a fungus disease called larch cancer (*Lachnellula willkommii*).

Under favourable conditions European larch attains a height of over 40 m and a diameter of 120 cm. It can live to a great age, trees over 1 000 years old even have been found. As the trees age the trunks become covered in a very thick layer of bark: as much as one quarter of the volume of large trunks can be bark. The stems of European larches growing in dense stands are usually rather straight and branch-free, but in open areas the tree readily

develops into a twisted and branchy form.

The properties of the wood of European larch vary. However, it is usually extremely rot resistant. In underwater structures the wood becomes stone hard and almost completely resistant to rot. It is used in a wide range of structures that are in contact with water. For instance, the pile structures of medieval buildings in Venice are of larch.

The timber production of larch and the effects of various treatments on the productivity are being studied in this larch stand. When the stand was measured in 1988 the volume of the stand was over 600 m^3/ha, and the total production on all the plots (remaining tree volume + wood removed in thinnings) was over 1 000 m^3/ha, i.e. clearly larger than that of domestic tree species. The mean height (mean height of the 100 thickest trees/ha) in the stand next to the road was 37 m, and further away on the plot in an untouched state 38.5 m. The volume of the largest trees was as high as 6 m^3.

M12. Kanerva pine

■ If you like you can take a short detour from the route at this point and continue straight on from crossing post 9 to see the **Kanerva pine**, which is located about 200 m away on the left of the path.

The Kanerva pine is a **plustree**, a tree of excellent quality and wood production selected for breeding purposes. A plustree must have the following properties: better than average wood production, a stem of good form, a long and dense crown, thin branches, straight branch angle and thin bark. Many of these properties are highly inheritable and so, using plustrees, the tree breeders have been able to produce seedlings with superior genetic properties for forest regeneration purposes.

The Kanerva pine (plustree E 1101) has been named after its finder, District Forest Officer Yrjö Kanerva, who worked for a long time in the Punkaharju Research Area. One of the progeny growing near to the Kanerva pine has also been selected as a plustree. A total of over 25 000 plustrees of different tree species have been selected in Finland, the first of them here in Punkaharju in 1947.

M13. Artificially regenerated Norway spruce stand

■ The path continues to the right from the crossing post and goes past a Norway spruce stand growing on the right.

Norway spruce (*Picea abies)* grows naturally throughout the whole of the northern European coniferous forest zone, in extensive areas of western and northwestern Russia, in the mountains of central Europe, the Alps, throughout most of the Balkan mountain ranges and in the east throughout almost the whole of the Siberian coniferous forest belt.

Norway spruce usually grows in mixed stands together with pine, larch, birch and aspen. Especially after major disasters (forest fires, storms) these tree species appear first on the site as pioneer species in the forest succession. Spruce germinates under the shelterwood formed by these tree species and gradually comes to dominate the site. A pure spruce stand is often formed in the final stage of succession.

Norway spruce flowers, on the average, at the end of May and beginning of June in southern Finland. The seeds ripen the same year and fall to the ground either in the autumn or in the following early spring. Spruce produces a good seed crop on the average about every ten years.

Spruce is a rather long-living tree species – up to 250 300 years. It withstands shading better than Scots pine but is not a real shade tree species. To grow well it requires moist and fertile soil. Of the European tree species, Norway spruce grows the tallest, on the best sites over 50 m. The tallest Norway spruce found in Finland is 42 m. Norway spruce is especially susceptible to rot fungi as it gets older. The fungus can enter the stem via root or stem damage, for instance.

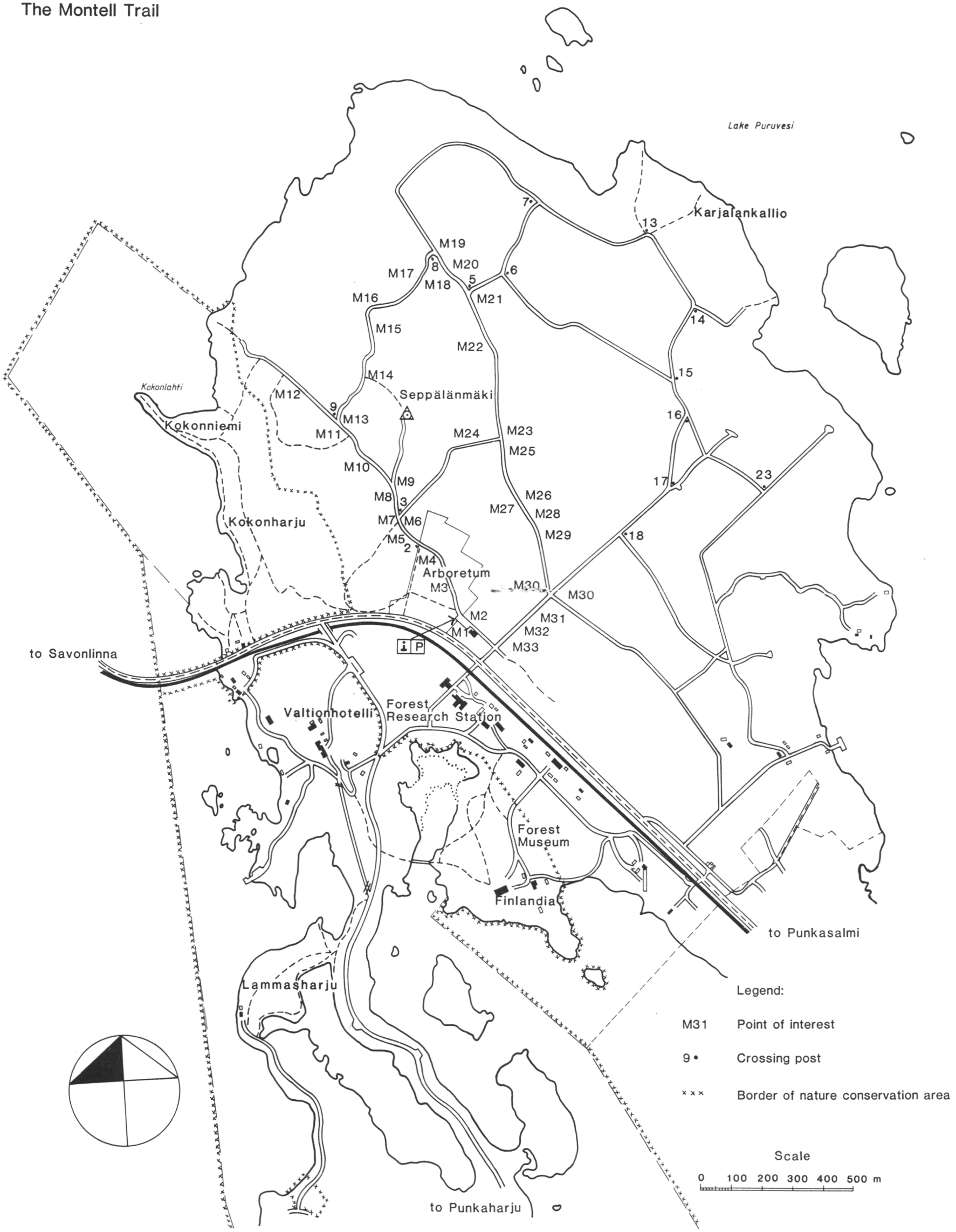
About 37% of the growing stock in Finnish forests is Norway spruce. It is used as both sawtimber and as a raw material for the pulp and paper industries.

This spruce stand is an example of a normal commercial forest which has been managed and thinned. It is about 50 years old; on this rather fertile site the tree stand has grown rather well. The storm damage in autumn 1985 caused some damage in the stand.

M14. The Montell larch stand

■ After the spruce stand you will again see a tremendous larch stand, but this time it is **Siberian larch** (*Larix sibirica*). The stand is not only old and massive, but also historic: it is the first

The Montell Trail



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plantation established at Punkaharju. It was planted in 1877 with four-year-old seedlings, and it bears the name of the Montell larch stand after its founder.

Siberian larch grows naturally in northeastern Russia, especially in the western and southwestern parts of Siberia and in the Ural Mountains. Its distribution in the west extends to the eastern side of Lake Onega.

Siberian larch has mainly been cultivated outside its natural distribution in the Soviet Union and Finland. The most famous Siberian larch plantation appears to be the Raivola larch stand, growing on the Karelian Isthmus, which was established in 1738 to ensure a supply of masts for the Russian fleet. Peter the Great himself is believed to be the instigator. Siberian larch grows excellently in Finland, which is relatively close to its natural range.

Siberian larch requires a lot of light and a rather fertile soil. It grows rapidly and can achieve a height of 45 m and a diameter of 90 cm even. In experiments carried out in Punkaharju, Siberian larch has been found to exceed the wood production of domestic pine by over 60% at an age of 30 years. The wood production and growth rate of Siberian larch are not, however, quite as great as those of European larch.

The wood of Siberian larch is very dense, when floating the logs in the USSR for instance it is bound together with the logs of other tree species to prevent it from sinking. Like European larch it is very resistant to rot and is ideally suited for marine structures. As is typical for larch the wood easily splits as it seasons and is worked; in order to prevent splitting holes should be bored for nails and screws.

This larch stand is an excellent example of the success of Siberian larch. The tallest tree in Punkaharju is growing in this stand: in 1989 its height was 42 m.

M15. Regeneration area

■ There is a regeneration area on the right of the path. It was clear cut in 1992, and then planted with Siberian larch seedlings. Before planting the understorey of Norway spruce that had developed under the preceding stand was removed. The surface of the soil surface was broken by harrowing; this makes the nutrient status and moisture conditions of the soil more favourable for the new seedlings. At the same time the young trees are provided

with more growing space amongst the lush ground vegetation. Because the site is very fertile (grovelike site type), it has become covered in grass. The hardwood undergrowth has to be removed almost every year. Without seedling stand treatment the seedlings would become smothered under the ground vegetation.

M16. Siberian larch stand

■ The path leads through a Siberian larch stand that was planted in 1895. The growth and wood production of larch has been studied in the stand. The large metal funnels on the site are used for studying the variation in the amount of litter in a larch stand. The needles, flower residues and seeds fall into the funnels and are later counted and weighed in the laboratory. As the surface area of the funnels is known, it is possible to calculate how much litter falls per hectare each year, and how litter affects the fertility of the soil.

M17. Hybrid larch stand

■ On the left of the path there is a larch stand that was naturally regenerated by seed-tree cutting in 1925. Most of the trees in the stand are naturally formed crossings, hybrids, between European and Siberian larch. The differences in the growth rhythm of Siberian and European larch are especially evident in the spring and autumn: the needles of trees with a different genetical composition are formed or turn yellow at different times. The stand in spring has trees with no needles and ones with an almost fully developed foliage.

The hybrid larch stand has proved to have good timber production. In 1988 the volume of the stand was 524 m^3/ha and the dominant height (100 thickest trees/ha) 35 m.

A Norway spruce stand planted in 1925 is growing on the other side of the path. Here it is easy to compare the differences in the undergrowth in different stands: under the shading spruce there are only a few plant species in addition to mosses, while in the well-illuminated larch stand there are many species of ground vegetation.

M18. Capercaillie mating ground

■ The path leads up to crossing post 8. On the right side, in the corner formed by the roads, there is a capercaillie (*Tetrao urogallus*) mating ground, where the capercaillie act out their mating

rites every spring. The numbers of this bird, Finland's largest forest game-bird, have decreased in recent years. In order to maintain the capercaillie stock an effort should be made to preserve forests suitable for the mating rites of the capercaillie; the bird is sensitive to changes caused by forest management, and new mating grounds are not necessarily easy to find.

The path turns sharply to the right at crossing post 8. If you want you can make a detour to the left of the path to admire the massive-trunked European larches – and feel something of the atmosphere in a central European larch stand.

M19. Larch comparison experiments

■ Siberian and European larch seedlings of different origin were planted in 1950 on the left of the path before the crossing point. The purpose of the experiment was to compare the growth and success of larch strains from different geographical areas. As is often the case in research, the larches that have grown the best are of unknown origin!

M20. Congress slash-and-burn

■ A fairly young birch stand is growing on the left of the path. A forest sowing experiment was originally established on the site in 1949 for the excursion of the 2nd World Forestry Congress; the area was burnt and cultivated using traditional methods, the tree seeds being sown amongst the cereal shoots. However, the pine stand died and a naturally regenerated birch stand developed on the site consisting of both silver birch (*Betula pendula*) and downy birch (*Betula pubescens*).

Treatment and productivity experiments have been established in the birch stand, the aim of which is to determine the effects of thinnings of varying intensity on the wood production and development of the birch stand.

The path continues straight on from crossing post 5.

M21. Young larch stand

■ Immediately after the crossroads on the left of the path is a young Siberian larch stand, planted in 1953 (Siberian larch, Point M14). It has grown well and is of extremely good quality. In 1988 the volume of the trees was 340 m^3/ha.

The stand was thinned in 1980 and, at the same time, the branches were pruned off to a height of 6 m. Removing the

branches from the lower part of the stem improves the quality of the sawtimber: knottiness considerably reduces the quality of the saw timber and also the value. However, pruning has to be done at the right time because the pruned surface is a favourable substrate for a range of rot fungi.

M22. Regeneration area

■ On the right of the path there is an area of about 4 ha which was clear cut in 1992. Owing to the stoniness and otherwise rather low fertility of the site, it is suitable for growing Scots pine. Norway spruce requires more fertile soil to grow well.

M23. Norway spruce stand

■ On the other side of the path there is a Norway spruce stand (spruce, Point M13). It was planted in 1928 with 4-year-old seedlings originating from Elimäki, southern Finland. For the first 20 years the young trees grew under an alder (*Alnus* spp.) shelterwood.

The effects of thinning intensity on the wood production of spruce have been investigated in the stand. According to the preliminary results, the total production of the stand has remained the same despite the fact that the stand density on the different plots has varied within a rather wide range. The more open the growing position, the smaller the number of stems in which growth is concentrated, and the trees develop more strongly in diameter. In Scots pine stands growth is more sensitive to thinning.

M24. Siira pine stand

■ On the left of the path (partly behind the row of Serbian spruces - *Picea omorika*) at crossing post 4, at the same point as the spruce stand, there is a stand called the **Siira pine stand** (pine, Point M5). This stand was named after a forest technician earlier employed in the Experimental Area. The area on the right of the path running through the stand was seeded in winter 1927 on top of a crop of rye, sown on the slash-and-burn area the previous summer. There is a comparison area on the left of the path: it has been established by planting pine seedlings on a clear-cut area where the logging residues were burnt. The pine weevil (*Hylobius abietis*) almost completely destroyed the seedlings and planting was repeated in 1931: these seedlings were killed by snow mould. Planting was repeated for a third time the following year.

The differences between sown and planted pine stands have been investigated in the experiment. Plots were established in the stand in 1948, and since then the stand has been thinned seven times. The sowing of pine is usually justified on quality grounds, and planting by the increase in wood production. In this experiment planted and sown pines have produced the same amount of wood. The growth has been excellent, due to the good fertility of the site – too fertile for pine. The effect of the fertile site can also be seen in the poor technical quality of the trees, e.g. branchiness (abundant dead branches), although the stand has grown extremely densely right up to the first thinning. Good quality sawtimber apparently cannot be expected from present day pine stands established on too fertile sites and grown at too low a density without pruning.

M25. Oak

■ An **oak stand** (*Quercus robur*), planted in 1927, is growing on the left of the path.

Oak grows naturally in Finland in the Åland Islands, southwestern Finland and along the south coast approximately to the west of a line running from Rauma to Porvoo. When planted it can grow much further to the north, individual trees are growing in Oulu and up to Tornio. Oak grows primarily in Finland as individual trees or in small stands.

Of the hardwoods growing in Finland oak is the least demanding as regards its site requirements. It can grow up to a height of 50 m. In Finland it rarely exceeds 20 m, but it can develop an extremely thick trunk. Oak is very long lived, it is claimed that it can live to an age of over 2 000 years. Nowadays 400–600-year-old oaks have been found in Central European forests.

This oak stand is among the northernmost of planted oak stands of this extent. The seed the trees were grown from is from near Tammisaari. The trees were initially raised under a birch shelterstand. During the first few years hares often ate the crowns during the winter. During the severe winter in 1939/40 about 15% of the trees died down to the snow cover, and the 1955/56 winter also caused a considerable amount of damage. The most recent severe winters during the 1980's (1984/85, 1986/87) did not cause any permanent damage to the trees. The buds were damaged in winter 1986/87 when the temperature dropped to –40 °C,

and the trees were still without leaves by midsummer 1987. Some of the trees died.

The stand was thinned in 1992. The oak and rowan (*Sorbus aucuparia*) sprouts which have developed under the oaks will not be cut back because they prevent the formation of so-called adventitious shoots on the oak stems. The formation of such branches reduces the quality of the timber. In Central Europe beech (*Fagus sylvatica*) is grown as an understorey under quality oaks.

M26. Douglas fir and Macedonian pine

Douglas fir cone

■ On the left of the path there is a small stand of **Douglas fir** (*Pseudotsuga menziesii*) planted in 1946, and after it a stand of **Macedonian pine** *(Pinus peuce*) planted in 1937 (Point M7).

Douglas fir is the most important tree species in the western parts of North America; it is estimated that about 60% of the forest reserves are Douglas fir. The tree grows rapidly when young, and the growth continues strongly up to 200 years or more even. Douglas fir can attain an age of 1 000 years, a height of almost 100 m and a diameter of almost 3 m. The best distinguishing features of this species are the three-pronged scales protruding out of the hanging cones.

Douglas fir requires a lot of light and in nature is able to spread effectively only on burnt areas. If no fires occur other species that can better withstand shade dominate the growing space. The wood rapidly darkens to a reddish brown colour after felling. It is very rot resistant and an excellent sawtimber; the sawtimber is often called "Oregon pine". Veneers of Douglas fir wood are ideally suited as an interior and furniture material.

Douglas fir has been cultivated ever since the beginning of the 19th century in areas other than its natural range. In Finland it has been grown since the beginning of this century. In its natural distribution range it is not threatened by fungus or insect damage, but there has been a lot of damage in new cultivation areas. In Finland, for instance, fungi have either killed or severely weakened most of one strain of Douglas fir. Provenances from central parts of British Columbia in Canada have thrived the best in Finland.

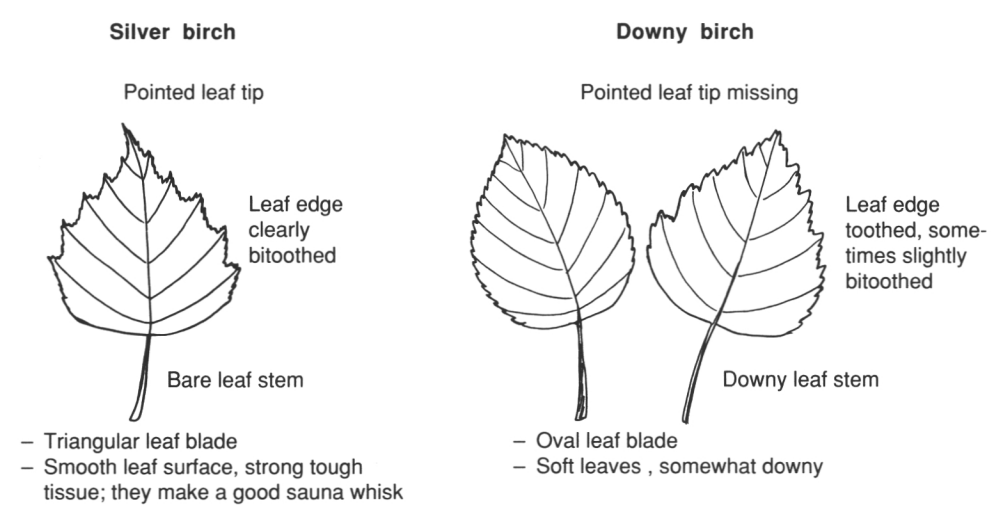
M27. The Heikinheimo larch stand

■ On the right there is a larch stand called the Heikinheimo larch stand after the first director of the Finnish Forest Research Institute, Professor Olli Heikinheimo. This stand of Siberian larch was planted on an abandoned field in 1929. Later on the stand had to be supplemented because larvae of the cockchafer (*Melolonthinae*) continuously killed off the seedlings. The stand suffered from severe storm damage in 1977 and 1985, and at present there are many gaps.

Here you can compare the development of Siberian larch and Scots pine: the Heikinheimo larch stand is almost the same age as the Siira pine stand at Point M24. The volume of this stand in 1989 was 475 m^3/ha, and the dominant height (height of 100 thickest trees/ha) 32 m.

M28. Silver birch and downy birch

■ There is a birch stand growing on the left of the path at the same point as the Heikinheimo larch stand. The birch stand on the left of the path running through the stand consists of **downy birch** (*Betula pubescens*) and on the right of the path **silver birch** (*Betula pendula*). The stands were planted on an abandoned field in 1937. The purpose of the trial is to compare the wood production of silver and downy birch. According to the results, the wood production of downy birch by 1982 was about 70% of that of silver birch; the wood production of downy birch is usually considered to be about 75% that of silver birch. The mean height (height of the 100 thickest trees/ha) of downy birch in 1982 was 23.4 m, and that of silver birch 28.6 m.



The accompanying picture shows the differences between the leaves of silver birch and downy birch. Silver birch bursts into leaf about a week later in the spring than downy birch, and its leaves start turning yellow later in the autumn than the leaves of downy birch.

Downy birch thrives better than silver birch on poor sites: peatlands, along the coast, in the archipelago and in Lapland. In Lapland downy birch grows as a twisted and bushy form, fell birch (*Betula tortuosa*).

Silver birch is more important from the point of view of commercial forestry, although downy birch can be made to produce plywood birch when grown on suitable sites and with good management. Birch is used as a raw-material for pulp manufacture and as sawtimber, and also as a raw-material for the furniture industry. Xylitol (birch sugar) is also obtained from birch. Birch bark has traditionally been used for producing a wide range of articles.

Birch accounts for 16% of the forest reserves in Finland; birch is the dominant tree on 7% of the forest land. Nowadays birch (primarily silver birch) is regenerated annually on about 10% of the total area regenerated artificially. When the numbers of the most serious damaging agent of young birch plantations, the elk (*Alces alces*), increased tremendously during the 1970's, the growing of birch decreased. The elk stocks have been reduced by increasing the number of hunting licences and the popularity of birch is again on the increase. The cultivation of birch is expected to further increase during the 1990's.

Nowadays birch is recommended as an admixture in conifer-dominated stands because its litter improves the properties of the soil and it is considered to be more resistant to air pollution than conifers. Birch also increases the aesthetic value and illumination of Finnish forests.

M29. Young Masur birch progeny trial

■ After the mature birch stand on the left of the path there is a young Masur birch progeny trial (Masur birch, Point M8), established by planting in 1984. The growth and development and curly-grain formation of the progeny of known mother trees is being investigated in this forest genetics experiment. The mother trees are from Punkaharju and Kerimäki.

M30. Larch and pine graft collections

■ There is a larch collection and a pine collection opposite the Masur birch stand on the right of the path. Grafts from plustrees (Point M12) growing in different parts of Finland have been planted here since 1952 to act as a living gene bank for the needs of tree breeding. The pine collection also contains grafts from plustrees of foreign origin. The genetic properties of the trees remain unchanged when they are reproduced vegetatively, thus preserving the good properties of the selected trees.

Forest tree breeding

Because the Punkaharju Research Station has specialised in forest tree breeding, the principles and techniques applied in such work that can be seen along the route will now be shortly described. In forest tree breeding, genetic methods are used to improve the growth of the trees, their acclimatisation, and their resistance to damaging agents, as well as the technical quality of the wood.

Selection breeding is based on natural variation. The best stands in natural forests are selected, and then the best individual trees. Over 25 000 high-quality plustrees (e.g. Points M4, M12, M30) which clearly differ from the surrounding trees have already been selected in Finland for breeding purposes. In addition, over 1 000 seed-collection stands (totalling almost 6 000 ha) have also been chosen. The best trees in these stands have been marked as seed-collection trees.

Crossbreeding is a means of combining the best qualities of the mother trees in their progeny. Crossbreeding presupposes that the pollination is controlled, and hence the female flowers have to be isolated during the flowering period. During the flowering period the trees in the grafted seed orchards in Punkaharju are full of crossing bags that enable the female flowers to be pollinated with the desired pollen.

Testing is used to determine which mother tree crosses produce the progeny that have the most favourable properties for commercial forestry. Such properties include good growth, good damage resistance and good technical quality (low branchiness, straight trunks etc.). Progeny trials of this sort can be found at Points M2 and M29.

After the graft collections the path turns right at crossing post 19 towards the railway and the Punkaharju by-pass (trunk road

14). There is a wonderful stone pine stand (M6) to the left of the road junction.

M31. Pine provenance (origin) trial

■ On the left immediately after the junction there is a provenance trial established in 1931. The purpose of provenance trials is to determine the adaptability and success under changed conditions of tree strains and provenances originating from different conditions. In addition to Punkaharju, the FFRI has provenance trials at Ruotsinkylä (Tuusula), Tenhola (near Tammisaari), Rovaniemi, Kivalo and Puolanka (Oulu province). These trials are also of considerable value when investigating the effects of climate change on Finland's forests and native tree species.

12 geographical strains of Scots pine have been planted in this trial; trees from Kivennapa (Karelian Isthmus) have grown the best, and ones from Petsamo (on the Arctic Ocean coast) the poorest.

Behind the pine provenance trial there is a similar spruce trial established in 1931.

M32. Masur birch, the "Olli" birch

■ On the left of the road after the pine trial there is a Masur birch stand (Masur birch, Point M8). The seeds were collected from a Masur birch stand growing in a natural state in Aulanko, and seedlings grown from the seed planted in 1932. Studies carried out in this stand demonstrated for the first time in the world that the mutation causing curl-graining (change in the genes) is inheritable.

The world's first known giant Masur birch is growing in the centre of the stand (marked with a blue painted band around the trunk). It has been named the "Olli" birch after Professor Olli Heikinheimo. It has triple chromosomes (triploid) – birch normally has double. Progeny of the "Olli" birch are growing at Point M2.

M33. Serbian spruce

■ **Serbian spruce** (*Picea omorika*) is growing on the right of the road, just before the trail turns back into the school yard. Before the last Ice Age this beautiful spruce species grew throughout most of Europe and in parts of Asia and North America. The amber found along the Baltic coast is the fossilised resin of this or related species. The Ice Age pushed Serbian spruce far

to the south, and its last refuge was a small mountainous region (altitude 1 000–1 500 m) in Serbia. It was not discovered until the year 1877. There are only about 30 uniform stands remaining, with a total area of less than 100 ha. Almost all the natural occurrences of this species are protected, and they can only be used for seed collection.

Serbian spruce has short, slender branches and does not develop into a wide-crowned tree even when growing at a low stand density. Its crown is narrow and columnar. The branches of Serbian spruce are usually slightly turned up at the tips, revealing the beautiful silver-white underside of the foliage. In Serbian ethnic poems it is the epitome of tenacity and slenderness.

Serbian spruce grows slowly and cannot compete with other tree species. It is of no economic importance, but it is a popular ornamental tree in central and northern Europe. It adapts well to new climates and withstands the smoke and dust of cities better than most conifers. Owing to its regular form it is also a popular Christmas tree; during the last few year it has appeared on the Christmas tree market in Finland.

The trail ends where it began, at the old school. The Finnish Forest Research Institute hopes that the trail has provided you with new information about Finnish forests, forestry and the research done on their behalf. Please visit us again.

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Notes

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