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A vegetation field study in Changbai Shan Manchuria

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Preface

This report is the result of a vegetation field study carried out in August and September 1990 in the Changbai Mountain Reserve, on the Chinese side of the border with North-Korea, in the southern part of Jilin province.

This vegetation study is closely connected to the vegetation structure studies made by Professor Roland Gustavsson of the Department of Landscape Planning, Swedish University of Agricultural Sciences in Alnarp (1986). There is also a connection to the on-going studies made of Professor R. Gustavsson and research-leader Kenneth Lorentzon in the Landscape Laboratory at Alnarp, where small forest systems of East-Asian trees and shrubs have been established and where neighbour influence, self-regeneration and other factors of importance to development of shape, vitality and long-term vitality, are studied. The aims are to get more knowledge about the behaviour of trees and shrubs for ornamental use, as our knowledge today is restricted to their behaviour under nursery conditions. Our vegetation study "on site" can be of interest and will be used to see if some parallels can be drawn when the 12 year-old research plantations are evaluated during 1996.

People interested in acquiring the plant register from Changbai Shan or the report on the results of the proceeding work with plants collected in the area, are welcome to contact us. The plant register is available at cost price.

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We are deeply grateful to; Dr. Wang Fengyou, then employed as a scientist at the Faculty of Forestry of the Swedish University of Agricultural Sciences in Umeå, Sweden, who made this study possible by helping us to make the necessary contacts in Northeast China; to our host Professor Zhao Shidong, at Institute of Applied Ecology of the Academia Sinica in Shenyang, for helping us to visit the Changbai Mountain Reserve and to the director of Changbai Mountain Research Station of Forest Ecosystem in Erdao Baihe, where we stayed and worked. We also wish to thank the North East Forestry University in Harbin especially our guide Mr. Zhang Dongli who made it possible for us to visit their two forest farms, Maoershan and Liangshui, and thereby giving us the opportunity to get familiar with the forest and it's species.

Special thanks go to Britta Kinnermark-Lander and Per Neimar at the Swedish Embassy in Beijing who arranged our final contacts in China.

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Summary

This report describes a study of the vegetation in Changbai Mountain on the Chinese side of the border with North-Korea, in North East China.

The mountain provides an excellent example of altitudinal zonation of different vegetation types. We have described these vegetation types, according to a method developed by Gustavsson (1986) and specified and described the species found with the emphasis on the ligneous flora.

Four vegetation zones could be distinguished. A belt transect was laid out in each zone, the Alpine tundra excluded, and profile and a crown projection diagrams were drawn. Detailed descriptions of the vegetational structure were made together with descriptions of form development of various trees and shrubs of the major species. We also made sketches of various species of special interest (exclusively broad-leaved species) together with detailed descriptions.

Our identifications and descriptions of the species are based on the Chinese floras available, e.g. Ligneous Flora of Heilongjiang (Chou Yi-liang ed. 1986) and Flora Liaoningica (tomus 1,1988) and the plant register - An enumeration of the plants of Changbai Mountain - published by the Changbai Mountain Research Station of Forest Ecosystem, Academia Sinica.. These descriptions, together with the sketches we made in the field, were compared with descriptions made by Krüssmann (1984).

To get greater knowledge of the vegetation in North East Asia a literature study was carried out with literature concerning China, most of which, was written in Chinese. From this study a map of North East Asian vegetation was compiled from three different, existing maps (Hou, 1983; Yim, 1977 and "Atlas of occurrence and distribution of medical plants in the Soviet Union", 1976).

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1. Background

1.1. Why Changbai Shan?

Our reason for visiting Changbai Shan can be summarized in a quotation by Roy Lancaster; "It is, in short, a paradise of its kind to anyone interested in plants of the boreal (northern) regions" (Lancaster, 1989).

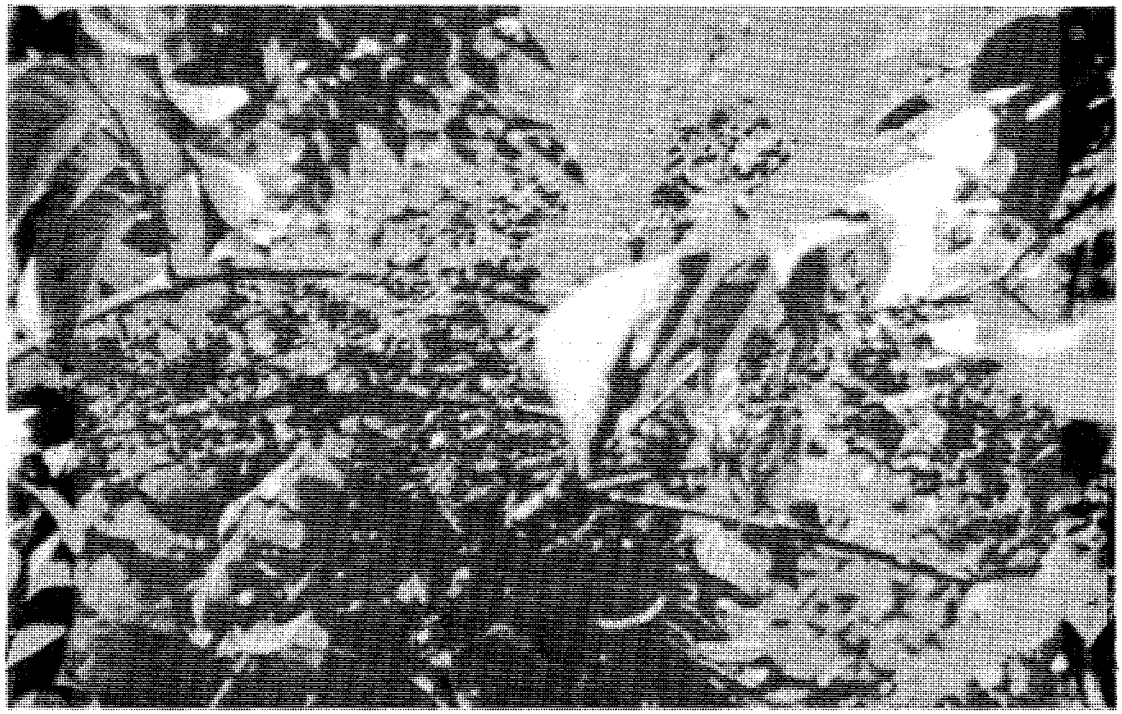


Fig. 1. ***Aralia elata*** **Seem., exotic to us.**

In Changbai Shan there is an extraordinary mixture of plants. Species well known to us from the Swedish flora, grows along with those which seem very exotic to us. Many species occurring here were first introduced to Europe via Korea, Japan and south-eastern Siberia, where they are equally common. The Changbai Shan is a region where several floral zones meet. The result is a diverse vegetation with a great number of species, which divides clearly into definite vegetation zones. Despite the rich diversity a surprisingly small part of this treasure is currently used in Sweden. Some species are definitely worth-while reintroducing whilst there are many plants of great ornamental value that have never been cultivated in the west.

1.2. The purpose of this paper is

- to study, for us, unfamiliar vegetation types in a familiar climate, (i.e. in central and northern Sweden).

- to apply and to compare the diverse flora of Changbai Shan under Swedish conditions which in many ways resemble those of the studied area.

- to gather as much information as possible on the various species in their natural environment, with an emphasis on woody plants.

An underlying aim has been to find plants which in the future could enhance the range of ornamental trees and shrubs adapted to the climatic conditions in northern Sweden.

1.3. Difficulties

To carry out a study of this kind in a country like China is an inspiring challenge, not always free from problems. Our arrives in a foreign culture with a foreign language, different rules and habits which one must learn and accept in order to achieve anything. On top of all this come the practical problems outside the adventure of getting there. How to identify plants never seen before? How to identify plants using only a Chinese flora? What Chinese institutions are worth-while contacting? How do you contact them and on what terms? What about local transport? Where to stay? Where to eat? What about necessary equipment? Is it possible to get a permission to move freely or must one have a guide?(China is a politically sensitive area in many respects.) We encountered all these difficulties plus a few more. However, if one is determined it is possible to go through with a study like this.

We became acquainted with the most common plants, focusing on ligneous species during two intensive weeks in the surroundings of the city of Harbin. Our guide was Zhang Dongli who is a scientist at the North East Forestry University. We visited the forestry research stations at Maoershan (the Hat mountain), south-east of Harbin and at Liangshui, outside the city of Dailing near to the Russian border. When we finally arrived at Changbai Shan, and the Changbai Mountain Research Station of Forest Ecosystem, Erdao Baihe we felt rather more familiar with the local vegetation. The species that we didn't recognise were identified with the aid of two Chinese floras and a plant register for the area, with a little help with translations. During this process we learnt to interpret the most important Chinese characters in the text. To find data on climate, soils, etc. was not easy. The data are published in Chinese and sometimes incomplete because all research work was only recently taken up after the stagnation of the cultural revolution, between 1967 - 1976.

1.4. Nomenclature

The nomenclature follows, as far as possible, Krüssmann (1984) and Vidakovic (1991). Certain species were difficult to identify as they are not mentioned in these works and in those cases we followed two Chinese reference floras; Ligneous Flora of Heilongjiang, 1986 and Flora Liaoningica, tomus 1,1988. Those species which we were not able to identify in any of the above mentioned literature were identified on site, using the plant register published by Changbai Mountain Research Station of Forest Ecosystem, Academia Sinica - An enumeration of the plants of Changbai Mountain.

Chinese names, geographical names etc. follow the new system of latinization - Pinyin ("phonetical spelling") which replaced the Wade-Giles-system in 1976.

2. Literature

2.1. Distribution of forest vegetation in North East Asia

To survey the forest vegetation of the cold-temperate and temperate regions of north east Asia three existing vegetation maps, one of eastern Russia (from "Atlas of occurrence and distribution of medicinal plants in the Soviet Union", 1976); one of north east China (Hou 1983) and one of the Korean peninsula (Yim 1977*a*, 1977*b*), were combined. The three sources have used somewhat different systems of vegetation classification. The Korean vegetation map differs from the others in that it is based upon the correlation between the temperature climate (Kiras warmth index = *WI*)) and the zoning of the vegetation (Yim 1977*a*, 1977*b*). The correspondence between the three different systems used is shown in Table 1.

The main outlines of the different systems of vegetation classification are the same in all maps used, e.g. Coniferous forest, Mixed deciduous broad-leaved and coniferous forest and Deciduous broad-leaved forest. Yim's system (1977*b*) is the simplest used from these three maps. He only deals with *forest vegetation* and therefore does not mention the Alpine tundra. Yim doesn't treat mixed forest as a specific vegetation zone but explains it as "a wide ecotone between a cool-temperate deciduous broad-leaved forest and a subarctic coniferous forest where both hardwoods and conifers grow in mixed stands". This ecotone is situated along the temperature gradient between 45°C·month and 55°C·month (*WI*) (where $(WI) = \sum(t\text{-}5)$, for months in which t>5°C) (Yim 1977*b*).

Both in the "Russian atlas" and in Hou's map (1983) further sub-divisions have been made. The coniferous forest is divided into evergreen coniferous forest (dark taiga) and deciduous coniferous forest (larch-forest). The "Russian atlas" distinguishes four types of larch-forests, and also divides the mixed forest and the broad-leaved forest into two subtypes, one montane and one growing at lower elevations. In the map (fig. 2) no distinction has been made between these subtypes.

Characteristic species for the different vegetation zones are mentioned both by Hou and Yim (see table 1.). The "Russian atlas" shows the ranges of some species, but they can't be used as characteristic species in the same way because the main emphasis is on medicinal plants.

Table 1. Approximate correspondence among the different systems of classification of Northeast Asian vegetation used in the three maps joined together including characteristic species.

HOU 1983	Atlas of occurrence and distribution of medicinal plants in the Soviet Union, 1976	YIM 1977
Mountain dwarf-shrub tundra (*Vaccinium vitis-idaea, Rhododendron aureum, R. confertissimum , R. redowskianum, Phyllodoce caerulea*)	**Montane tundra**	
Evergreen coniferous forest * dark taiga *(Picea jezoensis, P. koraiensis, Abies nephrolepis)* * *Pinus silvestris* var. *mongolica* woodland	**Dark coniferous forest** * dark taiga * *Pinus* forest	**Subarctic coniferous forest** from 15 to 45°C·month (*WI*) (*Abies nephrolepis, Picea jezoensis*)
Deciduous coniferous forest (light taiga) *(Larix gmelinii)*	**Larch-forest** (*Larix gmelinii*) * southern * intermediate * moist * in mountains with scattered *Pinus*.	
Mixed deciduous broad-leaved and evergreen coniferous forest (*Pinus koraiensis, Abies holophylla, Ulmus japonica, Fraxinus mandschurica, Tilia amurensis, T. mandschurica, Acer mono, Juglans mandschurica, Populus davidiana, P. koreana, Betula platyphylla, Quercus mongolica, Carpinus cordata*)	**Mixed broad-leaved and coniferous forest.** * in mountains	**Cool-temperate deciduous broad-leaved forest** from 45 to 90°C·month (*WI*). * from 45 to 55°C·month (*WI*) with "both hardwoods and conifers growing in mixed stands" (*Pinus koraiensis, Larix olgensis, Betula schmidtii, Quercus mongolica, Quercus serrata, Abies holophylla*)
Deciduous broad-leaved forest. * Deciduous oak forest (*Quercus mongolica* in the north, *Q. liaotungensis* in the south) * Mixed forest (*Acer* and *Tilia* species, *Fraxinus mandshurica, Ulmus japonica Betula platyphylla* etc.). * Montane microphyllous deciduous forest of Populus and Betula.	**Broad-leaved forest** * in mountains * Populus and Betula forest	

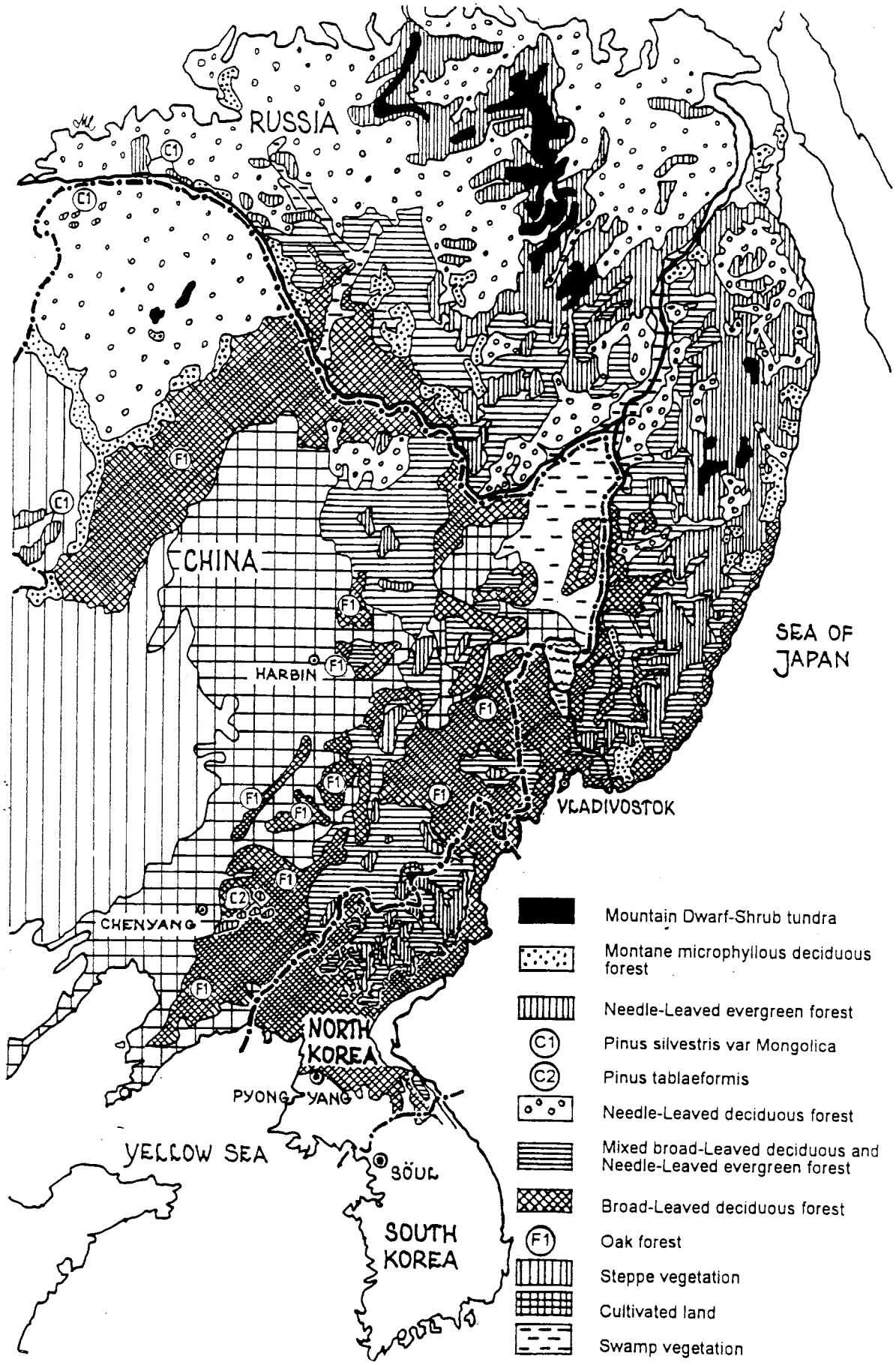


Fig. 2. Forest vegetation of North East Asia (from Hou 1983, Yim 1977 and Atlas of occurrence and distribution of medical plants in the Soviet Union, 1976)

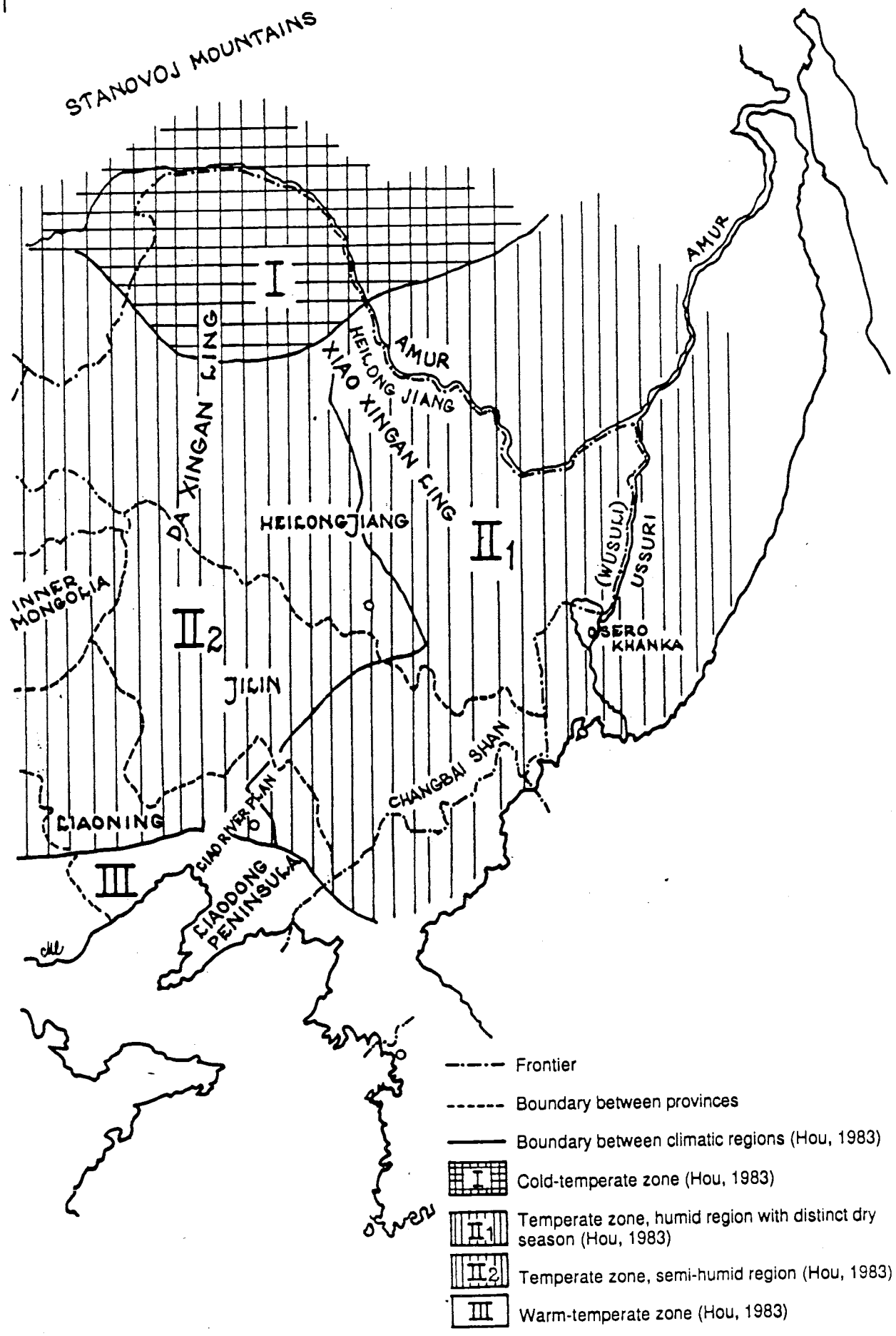


Fig. 3. Climatic regions of North East China (from Hou, 1983).

2.2. Vegetation in north-east China

References: Hou (1983); Watts (1969); Zhao (1988)
Northeast China (Manchuria) includes the three provinces of Liaoning, Jilin and Heilongjiang and the eastern part of Inner Mongolia, between 38° 40′ and 53° 30′N latitude and 115° 30′ and 134° 48′E longitude. The climate is temperate to cold-temperate (fig. 3). The longitudinal zonation of vegetation is closely related to the east-to-west variation in annual precipitation and the latitudinal zonation to the temperature gradient from north to south. In the mountainous areas the zonation is vertical. The enumeration follows the Forest Vegetation map of Northeast Asia (fig. 2)

A. Mountain dwarf-shrub tundra
The dwarf-shrub tundra in the temperate zone (II1) and in the cold-temperate zone (I) (fig. 3) is poorly developed on the summits of the high mountains in the Changbai Shan and in the Da Xinggan Ling. The climate is humid with strong winds, short growing season and local permafrost. The vegetation consists of evergreen dwarf-shrubs 10 to 20 cm high, mainly belonging to the Ericaceae. Representative species are *Vaccinium vitis-idaea, Rhododendron aureum, R. confertissimum, R. redowskianum, Phyllodoce caerulea, Arctous japonicus, Empetrum sibiricum* and deciduous shrubs as *Arctous ruber, Salix rotundifolia, S. polyadenia, Betula rotundifolia* and mosses and lichens.

B. Montane microphyllous deciduous forest
Betula and *Populus* are the dominant tree species of these forests. Usually they are secondary, replacing cold-temperate or subalpine conifers after felling or fires. Forests of *Betula platyphylla* are distributed in the cold temperate zone and on mountains in the temperate zone. *Betula ermanii* often forms pure, virgin stands at the upper limit of montane evergreen conifer forest in the Mixed Forest Region between 1000 and 1800 m a s l in the north-eastern mountains. In the Changbai Shan the *Betula ermanii* woodland occurs at the upper limit of the forest zone lying between 1800 and 2000 m a s l.

C. Evergreen coniferous forest
In the temperate zone (II1) (fig. 3) a vertical zonation occurs. At higher elevations, above the mixed broad-leaved and conifer forest, mixed forest of *Abies, Picea* and *Larix* occur (Zhao 1988). It is dominated by *Picea jezoensis, Picea koraiensis, Abies nephrolepis, Abies holophylla* and *Pinus sylvestris* var. *mongolica* (Hou 1983). In the Changbai Mountains this kind of forest occur between 1100 and 1800 m a s l and is dominated by *Abies nephrolepis* and *Picea jezoensis,* on the lower slopes, associated with *Betula platyphylla* and *Populus davidiana,* which usually replace cold-temperate or sub alpine conifers after felling or fires.

Small areas of more or less scattered woodlands dominated by *Pinus sylvestris* var. *mongolica* growing on sandy soils (Hou 1983) occur in the north-east of Inner Mongolia (**C1**.). This type of woodland has an undergrowth of steppe species, not forest species.
Forests consisting of *Pinus tabulaeformis* in the inland (and *P. densiflora* along the coast) are distributed on hills and mountains of the eastern part of the North China Plain (**C2**.) and on the Liaodong peninsula. This type of forest is usually associated with deciduous broad-leaved trees and shrubs. The climate is temperate to warm-temperate (fig. 3) and influenced by the summer monsoon.

D. Deciduous coniferous forest (light taiga).
This forest type consists of *Larix gmelinii*, and occurs in the northern part of the Da Xinggan Ling and further north across the Amur river (Heilong Jiang) towards the Stanovoj Mountains (in Siberia), and is the dominant type in the cold-temperate zone (fig. 3) at 480-1400 m a s l (480-820 m a s l in the northern part and 600-1050 m a s l in the southern part). It is sometimes mixed with *Pinus sylvestris* var. *mongolica.* The larch is light-demanding and endures aridity better than spruce and fir. It can be found on dry, sunny slopes as well as in moist valleys and lowland. A vertical zonation also occurs, and at higher elevations, 820-1100 m in the north and 1050-1380 m in the south, *Larix-Picea jezoensis* forests can be found. Above this is an open forest zone of larch, *Betula ermanii* and *Pinus pumila.* Scattered *Pinus pumila* also occurs as dwarf trees above the timberline. At lower elevations, below 480 m in the north-west and 600 m in the south-east, there are forests of *Quercus mongolica, Larix gmelinii* and *Betula davurica* together with *Populus davidiana, Tilia amurensis, Fraxinus mandshurica* and *Phellodendron amurense.*

The continental climate is dry and cold with a annual mean precipitation of 500 mm. The annual mean temperature ranges from -1 to -3°C with a mean temperature for the coldest month of -28 to -38°C. The extreme minimum is -50°C and the number of frost free days ranges between 70 and 110 (Watts 1969).

E. Mixed deciduous broad-leaved and evergreen coniferous forest
The mixed forest in the temperate zone (III) (fig. 3) is the most important forest resource in north-east China. It occurs on the Xiao Xinggan Ling and the Changbai Shan and extends eastward into "eastern Siberia" and south-eastward into Korea. The annual precipitation ranges from 600-900 mm and the annual mean temperature varies from 1°C to 8°C (Watts 1969). The orography contributes to an annual rainfall that exceeds 750 mm with a maximum in summer. The hottest month has temperatures below 22°C (Climatic regions of Lu 1949, as quoted by Watts 1969,). Mean annual temperature is less than +5 °C with a mean temperature for January of -29°C (Climatological Atlas of Korea 1962, as quoted by Watts 1969).

Pinus koraiensis-forest is characterized by a large element (up to 50% of stand volume) of broad-leaved deciduous species. The following broad-leaved trees are representative: *Ulmus japonica, Maackia amurensis, Fraxinus mandschurica, Tilia amurensis, Tilia mandshurica, Acer mono, Juglans mandshurica, Populus davidiana, Populus koreana, Betula platyphylla, Quercus mongolica, Carpinus cordata,*. The evergreen conifers are usually dominated by *Pinus koraiensis,* frequently by *Abies holophylla,* and rarely by *Taxus cuspidata.* Pioneer species are *Betula platyphylla* and *Populus davidiana.* The flora in this region is very rich and contains some relicts (e.g. *Phellodendron amurense).*

In the northern part of the temperate zone (III)this forest occurs up to 900 m a s l and contains more boreal species e.g. *Picea jezoensis* and *Abies nephrolepis.* There are also less broad-leaved species (about half as many) compared to the southern part.

In the southern part of the temperate zone (III) the climate is somewhat warmer and the flora is more varied. *Larix gmelinii* is replaced by *L. olgensis* and *Abies nephrolepis* by *A. holophylla* (Zhao, 1988). This kind of forest is found on the Changbai Shan between 500 and 1100 m a s l. In this region much of the land below 500 m a s l has been cultivated.

F. Deciduous broad-leaved forest
This occurs at lower elevations in the temperate zone, below the mixed broad-leaved and conifer forest and in the northern part of the warm-temperate zone (III, fig. 3). The broad-leaved deciduous forests are mainly composed of trees belonging to the Fagaceae, Aceraceae, Tiliaceae, Oleaceae, Ulmaceae, Fabaceae, Juglandaceae and Betulaceae but also include some conifers. Because of the continental influence of the climate these forests differ from those in Japan and the eastern United States in the absence of beeches (*Fagus* spp.).

Deciduous oak forests **(F1)** can be found in relatively open and light habitats. At the southern part of the lower Da Xinggan Ling and the Inner Mongolia (the northern part of the temperate zone, II2) most of the meadow-steppe has been transformed into agricultural areas. The remaining forest vegetation consists of scattered open forests of *Quercus mongolica, Populus davidiana* and *Betula platyphylla* (Zhao 1983). The precipitation ranges from 300 to 400 mm yearly. Average temperature in January is below -25°C and in the hottest month below 22°C. Fewer than four months have mean temperatures above 10°C (Climatic regions of Lu 1949, as quoted by Watts 1969). At the foot of the Changbai Mountains (200 to 500 m a s l) *Quercus mongolica* forest occurs on sunny slopes.

The Liaodong peninsula with its central ridge from 500-1000m a s l (the southern extension of the Changbai Shan range), in the north part of the warm-temperate zone(III, fig. 3), has typical forests of *Quercus* **(F1)**, *(Q. liaotungensis, Q. aliena, Q. dentata, Q. variabilis, Q. acutissima* from north to south*)* but also species from the Changbai Shan occur e.g. *Quercus mongolica, Acer mono, Phellodendron amurense* and *Tilia amurensis (*sometimes together with Pinus *koraiensis* and *Abies holophylla).* The mixed forest **(F2)** growing in shady and moist slopes and valleys consists of *Acer* and *Tilia* species, *Fraxinus mandshurica, Ulmus propinqua, Betula platyphylla* etc. On the Liao River plain and the coastal bogs, important tree species include *Populus simonii, P. pseudo-simonii, Salix matsudana* and *Ulmus pumila,* but most of the area, especially below 450 m a s l, has been changed into croplands and fruit orchards during the last thousand years. The climate is monsoon-like with hot rainy summers and cold dry winters but is still favourable to many species from milder southern regions. Annual precipitation is about 600 mm. Average January temperature is below -6°C. In winter the soil freezes and the rivers are ice-bound. Average temperature in July exceeds 22°C (Climatic regions of Lu 1949, as quoted by Watts 1969).

2.3. Vegetation in Changbai Shan

Changbai Shan on the boundary between North-Korea and China (see fig. 3 and Appendix) contains almost all of these vegetation types mentioned above. From the lowlands, at about 300 m a s l, up to the highest peak at 2700 m a s l, the following horizontal vegetation belts appear in succession (Hou 1983)(fig. 4):

* Broad-leaved deciduous forest (Oak-forest of *Quercus mongolica*).
* Mixed broad-leaved deciduous and needle-leaved evergreen forest.(*Pinus koraiensis* mixed with hardwood species)
* Needle-leaved evergreen forest(*Abies nephrolepis, Picea jezoensis)*
* Montane microphyllous deciduous forest (*Betula ermanii*)
* Mountain dwarf-shrub tundra.

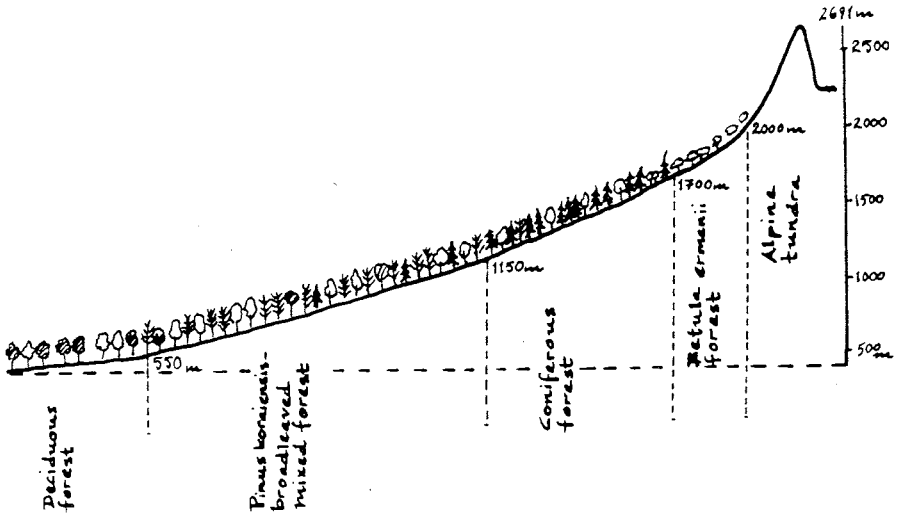


Fig. 4. Vegetation zones according to elevation on the northern slope of Changbai Shan.

2.3.1. Distribution of woody plant species along the gradient of warmth index.

References: Yim & Kira (1975), Yim (1977*a* and *b*) and Xu (1983).

Xu (1983) studied the distribution of woody plant species in Changbai Shan along the gradient of thermal climate. The range and occurrence of the species were examined in relation to Kiras warmth index (*WI*) (Yim & Kira, 1975) based on monthly mean temperature estimates (t) calculated from meteorological records at nearby stations (table 2):

Warmth index (WI) = $\sum(t\text{-}5)$, for months in which t>5°C

Yim (1977*b*) earlier made the same kind of study in the Korean peninsula. The results from the vegetation surveys in North-Korea including the Changbai area (Kor. Baegdu San) and on the Chinese side correspond quite well (see table 2).

Table 2. List of species with their ranges of distribution along the gradient of warmth index. A comparison between Xu (1983) and Yim (1977b).

Name of species	Optimal range (°C·month) Xu, 1983	Optimal range (°C·month) Yim, 1977*b*
Pinus pumila Regel	16-31	28-47
Abies nephrolepis Maxim.	30-59	34-65
Betula ermanii Cham.	20-32	30-63
Picea jezoensis Carr.	34-60	34-59
Taxus cuspidata Sieb.& Zucc.	51-73	37-62
Pinus koraiensis Sieb.& Zucc.	45-66	45-81
Betula davurica Pallas	46-71	45-88
Quercus mongolica Fisch.	47-72	46-90
Acer mono Maxim	45-62	48-88

They both distinguished well defined groups of species which are representative for this mountainous region.The results of both Yim (Yim & Kira, 1975) and Xu (1983) show (table 3) that more or less sharp changes in the arboreal flora take place along the thermal gradient at 45-55°C·month and 85-95°C·month. 45-55°C·month is the borderline between the **subalpine** and **cool-temperate zones** of Yim and between the **cool-temperate coniferous forest** and **temperate mixed coniferous and broad-leaved forest zones** of Xu where 85-95°C·month is the borderline between the **cool- and warm-temperate zones** of Yim and between the **temperate mixed coniferous and broad-leaved forest** and **warm-temperate deciduous broad-leaved forest zones**.

Table 3. Approximate correspondence of the groups of species and their warmth index (WI) in the different reports.

Xu, 1983	**Yim, 1977**
Alpine tundra (*WI*: 7-15°C·month)	-
Sub alpine short-bended forest (*WI*: 15-35°C·month)	Sub alpine species (*WI*: 30-70°C·month),
Cool-temperate coniferous forest species (*WI*: 25-65°C·month)	
Temperate mixed coniferous and broad-leaved forest species (*WI*: 47-75°C·month)	Cool-temperate species (*WI*: 50-90°C·month),
Warm-temperate deciduous broad-leaved forest species (*WI*: 55-95°C·month)	Warm-temperate deciduous species (*WI*: 80-100°C·month)

The number of species within a group decreases with lower *WI* as well as the number of structural vegetation layers, from multiple- to two- and single layers. The more similar *WI* two groups have, the more species they will have in common and, correspondingly, the more different *WI* two groups have, the less species they will have in common.(In Research of For. Ecosystem, Inst. of Forestry and Soil Sci. Acad. Sinica, no. unknown)

The lower limit value of warmth index for the groups of species may be lowered (especially in the sub alpine zone) if more collections are made on high mountains (Yim, 1977*a*). More climatic data has been available from the Chinese side than from the North-Korean side which has been less intensively surveyed. This can explain the lower values of warmth index in the study made by Xu (1983).

2.3.2. The mixed broad-leaved deciduous and needle-leaved evergreen forest

Reference: Yang & Wu (1987).

In north-east China the mixed broad-leaved deciduous and needle-leaved evergreen forest (often called "the mixed broad-leaved-*Pinus koraiensis* forest") is considered to be the most important forest resource both from economic and biologic point of view (Burger & Zhao, 1988). The forest type has therefore been intensively surveyed in Changbai Shan.

Composition of tree species.

In this vegetation type the canopy is dominated by six major tree species (percentage of numbers of trees per hectare): *Pinus koraiensis* 33,8%, *Tilia amurensis* 23%, *Quercus mongolica* 12%, *Fraxinus mandschurica* 8,4%, *Acer mono* 12% and *Ulmus propinqua*

4,6%. Small patches of pure *P. koraiensis* stands can occasionally be seen, but in general the conifer is mixed with more than ten different broad-leaved tree species. Occasionally *Populus ussuriensis* and *P. koreana* occur as pioneer trees. *Populus davidiana* and *Betula platyphylla* are pioneer species usually appearing in gaps or at the forest edge. These pioneer species account for 4,5% of number of trees per hectare. When it comes to size (basal area) species distribution is different. Oak and ash have a larger percentage of basal area per hectare compared to their number. *Quercus mongolica* and *Acer mono* account for the same percentage in number but the oak has three times the basal area compared to that of the maples implying that oak and ash are represented by larger trees than *Acer mono.*

The canopy can be divided into 2 storeys. The upper storey has an average height of about 25 m and contains 4 species: *Pinus koraiensis, Tilia amurensis, Fraxinus mandschurica* and *Quercus mongolica.* The lower storey is 16-20 m high and includes all species in the first storey together with *Acer mono, A. mandshuricum, Ulmus propinqua, U. laciniata* and *Betula costata.* Below the canopy (16m) there is a layer of small trees, about 10 m in height, which includes shade tolerant species. In this layer several maple-species can be found e.g. *Acer tegmentosum, Acer tschonoskii* var. *rubripes* as well as *Maackia amurensis. Acer barbinerve, Syringa amurensis* and *Philadelphus schrenkii* occur in the shrub-layer.

Regeneration of the major species

The regeneration strategy is closely related to the ability of the species to grow under the shade of their own canopies or those of other species.

This study indicates that the most common seedling- and sapling-species with a dbh (diameter breast height) <2,5 cm is *Acer mono* (table 4). It grows most frequently under the canopies of *Pinus koraiensis* and *Quercus mongolica. Tilia amurensis* is the second most common species in this dimension, growing mostly under *Quercus mongolica, Pinus koraiensis* and its own canopy. Third in line is *Fraxinus mandshurica* occurring mostly under *P. koraiensis, Quercus mongolica* and *Tilia amurensis,* followed by *Quercus mongolica* which most frequently regenerate under its own canopy. *Pinus koraiensis* which is the most common upper-canopy species, is only the 5th most frequent regenerate occurring under *Quercus mongolica*

Table 4. Percentage of seedlings and saplings of the major species.

Seedling-species	All seedlings and saplings (%)	Seedlings and saplings >2,5 cm dbh (%)
Acer mono	60	20
Tilia amurensis	16	33
Fraxinus mandshurica	12	12
Quercus mongolica	6	5
Pinus koraiensis	4	18

When seedlings and saplings less than 2,5 cm in dbh are excluded the picture changes and gives an indication of the shade tolerance of the species and which species survive the juvenile stage. Saplings >2,5 cm are dominated by *Tilia amurensis* one of the most common species in the upper storey followed by *Acer mono* and *Pinus koraiensis* (table 4).

Most of the seedlings grow under the canopies formed by *Pinus koraiensis, Tilia amurensis* and *Quercus mongolica,* which also are the most common canopy species (table 5.).

Table 5. Percentage of seedlings and saplings under different canopy-species.

Canopy-species	All seedlings and saplings (%)	Seedlings and saplings >2,5 cm dbh (%)
Pinus koraiensis	36	21
Quercus mongolica	23	25
Tilia amurensis	17	20
Fraxinus mandshurica	9	4
Populus & Betula	8	10,5
Acer mono	5	14
Ulmus propinqua	3	6

The regrowth of *Acer mono* is present as numerous small seedlings but few are present as saplings and small trees. They do not seem to survive the seedling-stage. Very few seedlings and saplings of *Quercus mongolica* are present although the proportion of the species is high in the upper storey. *Populus* and *Betula* comprise only 4,5 % of the total number of trees in the main storey but have 11% of the seedlings and saplings > 2,5 cm growing under their canopies.

Age structure of the major species

The 5 major species can be divided into 2 regeneration types, **discontinuous** e.g. *Pinus koraiensis, Quercus mongolica* and *Fraxinus mandshurica* which enters the forest in 'waves', and **continuous** e.g. *Tilia amurensis* and *Acer mono* which have trees of all age classes. *Ulmus propinqua* shows more affinity with the continuous regeneration species (fig. 5.). The regeneration strategy is also closely related to the shade tolerance of the species. In increasing order of shade tolerance, the scale is as follows:

Quercus mongolica → *Fraxinus mandshurica* → *Pinus koraiensis* → *Ulmus japonica* → *Tilia amurensis* → *Acer mono* (Yang & Wu, 1987).

Quercus mongolica

Quercus mongolica has a discontinuous regeneration strategy as does *Fraxinus mandshurica,* with two age classes present, 0-60 and 160-220 years. Few saplings are present which reflects it's demand for light. Maximum age is about 270 years. The oak grows 1,3 m in 7-10 years and into the canopy after about 60 years.

Fraxinus mandshurica

Fraxinus mandshurica is a species with discontinuous regeneration strategy and is represented in the forest by two age classes of 0-60 years and 160-240 years. Maximum life span is 280 years. Seedlings and saplings are limited in number, which indicate its shade-intolerance, and are usually growing in moist sites. Saplings reach 1,3 m in 5-7 years, and grow into the main storey after 50 years.

Pinus koraiensis

Pinus koraiensis enters the forest in waves of 40-60 years (discontinuous regeneration) and 3 generations are present at the same time in a mature forest . The re-growth is irregular and the age classes from 20 to 80 years are missing. Correlation between age and stem diameter shows suppressed growth between 80 and 160 years of age. The pine will resume normal growth and grow into the main storey when light becomes sufficient. It takes about 30 years to reach 1,3 m and 90 years to enter the main storey. *Pinus koraiensis* in natural stands begins to reproduce at about 80 years of age and the cone bearing increases with age until 180-220 years.

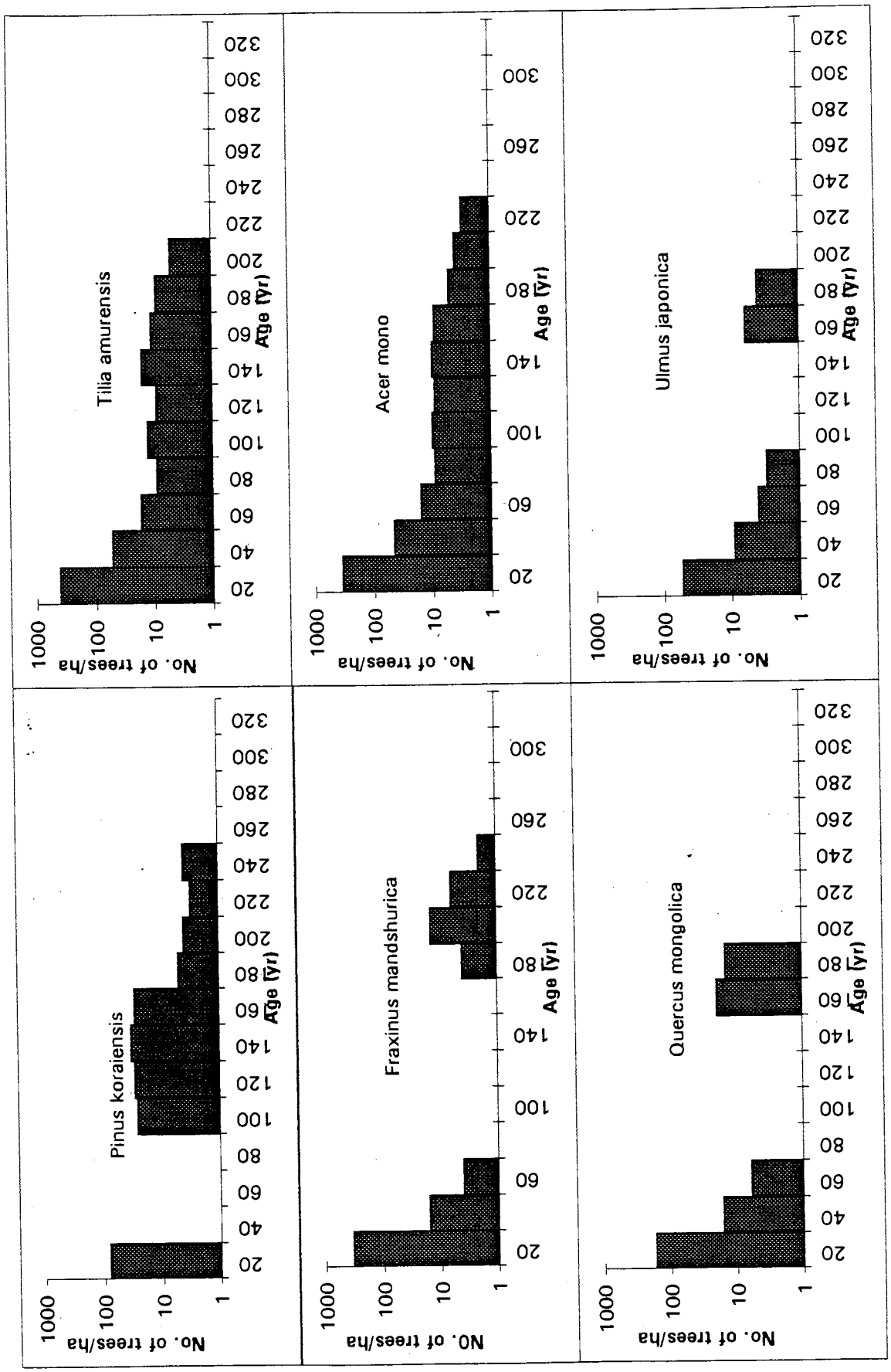


Fig. 5. Age structure of the five major species (from Yang & Wu, 1987)

The oldest tree they measured is 280 years old but it is estimate that the species can attain a maximum age of about 450 years.

Ulmus propinqua
The elm is a wind-dispersed species with continuous regeneration. The age structure shows a higher concentration of the age class 140-180 years. Maximum age is estimated to be 260 years. *U. propinqua* requires 4-5 years to grow to 1,3 m, and 60 years to reach the canopy.

Tilia amurensis
The lime appears to be a stable species with a continuous regeneration strategy. It is highly shade tolerant. The maximum life span is about 240 years. *Tilia amurensis* grows to a height of 1,3 m in 6-9 years and will enter the main storey in about 60 years.

Acer mono
This maple has a continuous regeneration strategy. Characteristic of *Acer mono* is the numerous amount of seedlings which indicates its shade-tolerance. Maximum life span is 250 years and it needs 6-7 years to reach 1,3 m and 50 years to enter the main storey.

2.4. Climate

Reference: Watts I.E.M. (1969); Zhan Fengshan et al. (1984); Alexandersson et al. (1991); Holmer B. (1982).
The climate in north-eastern China is extremely continental and dominated by the monsoons, which means, in short, cold dry winters and warm humid summers. The winter-monsoon (the north-east-monsoon) is formed over Siberia and Mongolia and causes a dry period with precipitation only in the north-eastern mountain areas including Changbai Shan, where the air is forced to climb rapidly. In October there is a dramatic fall in temperature, which is caused by cold and dry air from the inner of Asia spreading south-east to China. The winter-monsoon finishes in April and is gradually replaced by the humid summer-monsoon (the south-east-monsoon) which forms over the Pacific Ocean. This monsoon effects the eastern half of China and generates a high summer rainfall on the Chinese east coast.

According to Watts (1969) the annual mean temperature on the 42° N latitude in northern North-Korea is <+5° C, the same latitude goes through the mountain area of Changbai Shan. Readings from the research station in Changbai Shan, 1982 and 1983 (Zhang Fengshan et al., 1984) show an annual mean temperature of about +3,8° C at an altitude of 740 m. That corresponds with the mean annual temperature on the coastline of central Sweden (the coast of Ångermanland) (Alexandersson et al.,1991)). However the amplitude in temperature between summer and winter is much larger in Changbai Shan than for instance in Härnösand. Mean temperatures during summer and autumn (May-September) are considerably higher in Changbai Shan. The cold weather however comes more rapidly and levels out to the temperature at Härnösand in October (see table 6.).

Table 6. Some comparisons of temperature records between Erdao Baihe 1982-1983 (Zhang Fengshan et al., 1984) and Härnösand (Alexandersson et al. 1991) in °C.

		Erdao Baihe	Härnösand
Monthly mean temperatures:	July	18,5	15,3
	August	19,9	14,2
	October	5,2	5,2
	January	-14,5	-7,1
Annual mean temperatures		3,8	3,8

Annual mean precipitation on the Changbai Shan plateau exceeds 750 mm according to Watts whereof the major part falls during the summer. Snowfall is not unusual particularly at the beginning and towards the end of the winter. Readings from the station in Erdao Baihe (740 m a s l) during 1982 and 1983 show an annual mean precipitation of 723 mm (table 7) which equivalent to that in the mountains in north-western Sweden (Västerbottensfjällen). However, it is not greater than that Härnösand annually receives (703 mm) (table 7), which is unusually high for the central east coast of Sweden. The precipitation along this part of the Swedish coastline is spread out more evenly over the year due to the fact that the climate is not as continental as in north-eastern China. The Swedish climate is dominated by westerly winds (cyclones) and depressions moving in from the Atlantic which gives the climate maritime features. However, Sweden being on the western outskirts of a vast continent, the climate in it's north-eastern parts show to some extent continental features. There is a monsoon-like air current from the east during some of the winter and a marked maximum in the summer rainfall (Holmer, 1982).

Table 7. Some comparisons of precipitation records between Erdao Baihe (1982-1983), (Zhang Fengshan et al., 1984) and Härnösand (Alexandersson et al. 1991) in mm.

		Erdao Baihe	Härnösand
Monthly mean precipitation:	August	176	77
	January	8	50
	March	17	46
Annual mean precipitation:		723	703

The first snow comes early in the N. E. Chinese mountains, normally some time during late October and mid November and the last snowfall occurs round about mid April (Atlas of Korea, 1962 as quoted by Watts 1969). This corresponds well with the conditions on the central/northern coast of Sweden, (Ahlstöm B., Pohlman J., Vårt svenska väder, Känn ditt land, Nr 20).

The length of the growing season (defined as number of days when the daily mean temperature permanently exceeds +10° C) in the investigated area varies between 130 days at 740 m a s l and 56 days at 1950 m a s l (Zhan Fengshan et al., 1984). In northern Sweden the growing season (defined as number of days when the daily mean temperature permanently exceeds +6° C) is approx. 140 days at the coast and between 100 and 120 days in the interior highlands (Holmer,1982). However it is difficult to compare the length of the growing season since different temperature limits have been used.

3. The vegetation study

3.1. Method and equipment used

This vegetation study is based on the method used by Gustavsson (1986) in his vegetation structure studies at the Swedish University of Agricultural Sciences, Department of Landscape Planning in Alnarp.

A vertical belt transect was laid out in each vegetation zone, the alpine tundra zone excluded. Every transect was classified regarding: type of forest, stand structure, individual species' form of growth plus dominating species in the different layers. Furthermore we made detailed descriptions, as well as on site sketches, of certain species which we considered to be of particular interest (see chapter 4.). These descriptions have been compared with those from Krüssmann (1984) and supplemented with quotations in those cases where the descriptions do not correspond.

The transects were laid out with measuring tape and a cord. A compass was used in order to keep as straight align as possible. All trees within 2,5 m from the cord were given a number. The height (h), the height to first live branch (h f l b) and the stem diameter at breast height (d b h) were measured and transferred to a map of the transect on the scale of 1:200. (h) and (h f l b) were estimated using a straight stick which was the same length as the distance between the hand and eye, when the arm is held outstretched. The stick is held vertically so that top and bottom of the tree coincides with top and bottom of the stick. Then, tree height is the same as the distance between yourself and the tree. It is a simple but reliable method. The highest trees were identified with the help of a pair of binoculars. The altitude was measured with an altimeter (K&R Altimeter/Barometer Mod 7020).

Every transect has been supplemented with a tree crown projection diagram to illustrate the position of individual crowns in relation to each other, for instance when the forest consists of more than one layer. Fallen trees were also included in the maps of the different sections, but not stones, creeks and paths. Crown projection diagram was not drawn for the subalpine birch forest, instead a map of the undergrowth, which was considered to be of greater interest, was made.

The three transects were laid out, in as representative parts as possible, in the respective vegetational zones. In the Mixed pine and broad-leaved forest and in the Coniferous forest we used standard spots selected by people from the research station. In the subalpine birch forest, we picked a spot ourselves after having explored the area for three days. In the two lower zones we made the transects 5 by 50 m and in the subalpine birch forest 2 by 40 m. Many species growing in the Mixed pine and broad-leaved forest are not included due to the enormous diversity. In order to cover the whole range the transect would have needed to be at least 100 m long but that was not practical. The chosen length of the transect, however, was enough to give a good idea of the structural character. The structure of the subalpine birch forest was evident in a much shorter distance but due to the interesting undergrowth it was made 40 m long. We made the transect only 2 m wide because of the steepness of the slope - 40-45° - a wider transect would have made the work much more difficult.

3.2. Belt transect no. 1

Mixed forest of pine (Pinus koraiensis) and broad-leaved trees.

Altitude: **740 m**
Annual mean temperature (**650 m a s l**): **3,1° C**
Monthly mean temperature for July 1980-83: **18,5° C**
Monthly mean temperature for January: **-14,5°C**
Maximum temperature 1980-83: **31,5° C**
Minimum temperature 1980-83: **-32,0° C**
Annual mean precipitation: **723 mm**
Number of days > 10° C (**650 m a s l**): **130**

3.2.1. Description of the area

The area is located on the outskirts of the reserve, close to the village of Erdao Baihe between, on the western side, a small gravel road which goes into the reserve, and on the eastern side the river Erdao Baihe. The river runs in a wide approximately 10 m deep ravine. The forest is lush and very dense. From above it looks like a thick green quilt, billowing tree crowns now and then interrupted by small groups of straggly blue-green pines. The shrub layer is poorly developed in places which is compensated for by a thriving field layer. The small openings in the forest, caused by old fallen trees, are rapidly colonised by shrub vegetation which is so dense as to be almost impassable in places. The diversity of the area is incredible. Apart from the species accounted for on the transect we would like to mention; *Tilia mandshurica* Rupr. et Maxim., *Ulmus laciniata* Mayr., *Betula costata* Regel. and *B. davurica* Pall. all belonging to the upper storey. The lower layer is totally dominated by maples and apart from those maples recorded on the transect we identified *Acer tschonoskii v. rubripes* Kom. and *Acer ukurunduense* Trautv. et May. Along the road leading away from the "village" towards the investigated area we noticed saplings of *Juglans mandshurica* Maxim. but we did not see any fully grown specimen either in the forest or on the edges. *Maackia amurensis* Rupr. et Maxim., *Phellodendron amurense* Rupr., *Prunus maackii* Rupr. and *Abies holophylla* are

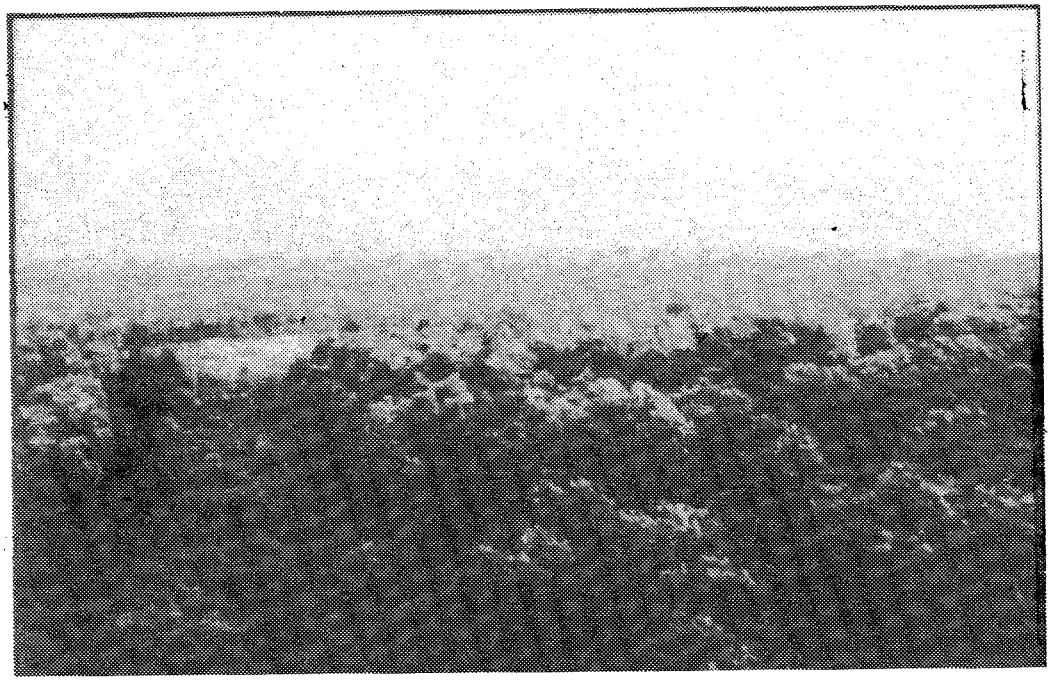


Fig. 6. Mixed forest of pine *(Pinus koraiensis)* and broad-leaved trees.

primarily found on the river bank approximately 1 km east of our transect.
The field layer in the darker parts of the vegetational zone is very much like that of a deciduous forest in southern Sweden, but instead of *Mercurialis perennis* a similar-looking species, *Brachybotrys paridiformis* Maxim. of the Boraginaceae dominates. Two other prevalent species are; *Sanicula rubrifolia* Fr.Schm. and *Filipendula* sp. Furthermore we noted some

spectacular genera like *Lilium*, *Paeonia* and *Trillium* plus a peculiar plant, *Phryma leptostachya*, which resembles a mixture between a grass and a dead-nettle.

3.2.2. Description of the belt transect

The transect was laid out 740 m a s l approx. 1 km inside the reserve in an east-westerly direction on flat ground (see Appendix). A creek passes about 30 m south of the transect and has developed a small depression - apart from that the area is flat. The soil type is clayey silt with a poorly developed structure. The pedogenesis is also poorly developed and thin with evident gley formation. The majority of all roots are found within a depth of 10 cm.

Upper storey (upper tree layer)

No.	Species	h[1] (m)	dbh[2] (cm)	h f l b[3] (m)
7	Tilia amurensis	24	31	17
9	Quercus mongolica	30	97	22
16	Quercus mongolica	23	88	17
17	Pinus koraiensis	20	30	13
18	Pinus koraiensis	26	40	16
23	Ulmus japonica	32	53	17
24	Tilia amurensis	29	46	18
25	Betula platyphylla	30	53	18
27	Fraxinus mandshurica	32	39	17
29	Quercus mongolica	31	35	7

Intermediate storey

No.	Species	h[1] (m)	d b h[2] (cm)	h f l b[3] (m)
1	Acer mandshuricum	13	11	8
11	Pinus koraiensis[4] (hidden)	14	11	9
12	Pinus koraiensis[4]	15	11	10
13	Pinus koraiensis[4]	18	18	6
14	Pinus koraiensis[4]	17	16	10
22	Acer mono	16	16	6
26	Acer triflorum	16	22	5
28	Acer triflorum	16	14	3

Under storey

No.	Species	h (m)	d b h (cm)	h f l b (m)
2	Acer mono	6	4	2
3	Acer pseudo-sieboldianum	8	6	4
4	Acer pseudo-sieboldianum	9	10	6
5	Acer pseudo-sieboldianum	8	7	3
6	Acer pseudo-sieboldianum	7	6	3
10	Acer pseudo-sieboldianum	8	7	4
15	Acer pseudo-sieboldianum	9	11	4
19	Acer pseudo-sieboldianum	7	11	4
20	Pinus koraiensis[4]	11	11	7
21	Acer pseudo-sieboldianum	8	10	6

[1] h = height
[2] d b h = diametre at breast height
[3] h f l b = height to first live branch
[4] outsider (runner up)

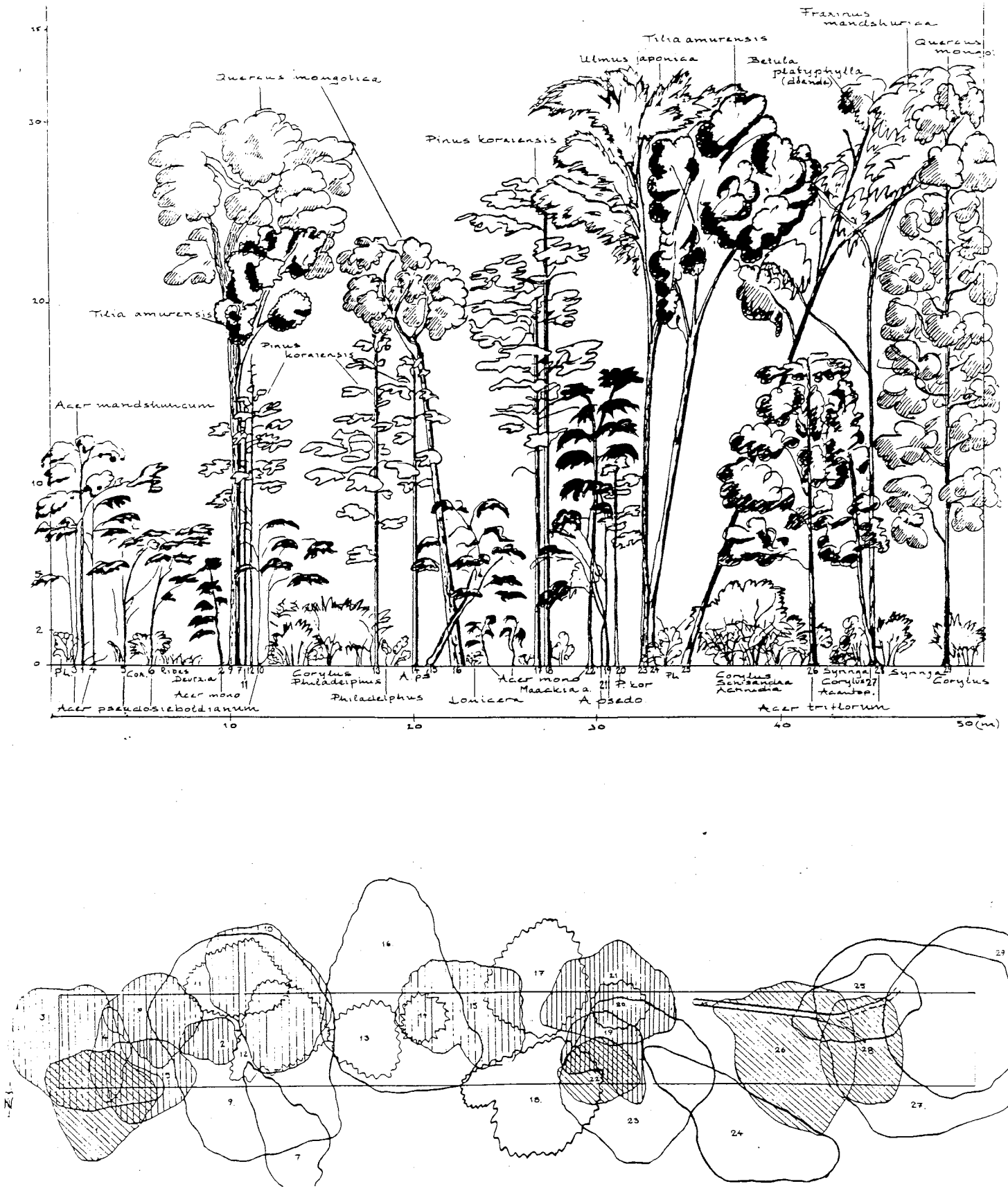


Fig. 7. Vegetation profile (above) and crown projection diagram (below) in belt transect no. 1 in the Mixed forest of *Pinus koraiensis* and broad-leaved trees.

Shrub layer
Acanthopanax senticosus
Acanthopanax sessiliflorus.
Acer tegmentosum
Acer barbinerve
Acer pseudo-sieboldianum
Acer mono
Aralia elata
Corylus heterophylla
Corylus sieboldiana v. *mandshurica*
Deutzia glabrata Kom.
Deutzia parviflora v. *amurensis*
Euonymus pauciflorus
Lonicera tatarinovii Maxim.
Philadelphus schrenkii.
Prunus maximowiczii
Rhamnus davuricus.
Ribes mandshuricum
Ribes distans
Sorbaria sorbifolia
Syringa reticulata var.*mandschurica*
Viburnum burejaeticum
Viburnum sargentii

Climbing species
Actinidia kolomikta
Schisandra chinensis
Vitis amurensis

Field layer
Aconitum volubile Pall. ex Koelle
Agrimonia pilosa Ledeb.
Brachybotrys paridiformis Maxim.
Cacalia hastata L.
Cimicifuga simplex Wormsk.
Euphorbia lucorum Rupr.
Filipendula intermedia Maxim.
F. purpurea Maxim.
Hylomecon vernalis Maxim.
Jeffersonia dubia Benth. et Hook.
Lamium album v. barbatum Franch. et Sav.
Lilium distichum Nakai
Matteuccia struthiopteris (L.)
Paeonia obovata Maxim.
Phryma leptostachya (L.)
Sanicula rubrifolia Fr.Schm.
Saussurea mandshurica Kom.
Solidago virgaurea v. dahurica Kitag.
Trillium kamtschaticum Pall. ex Pursh.

Fig. 8

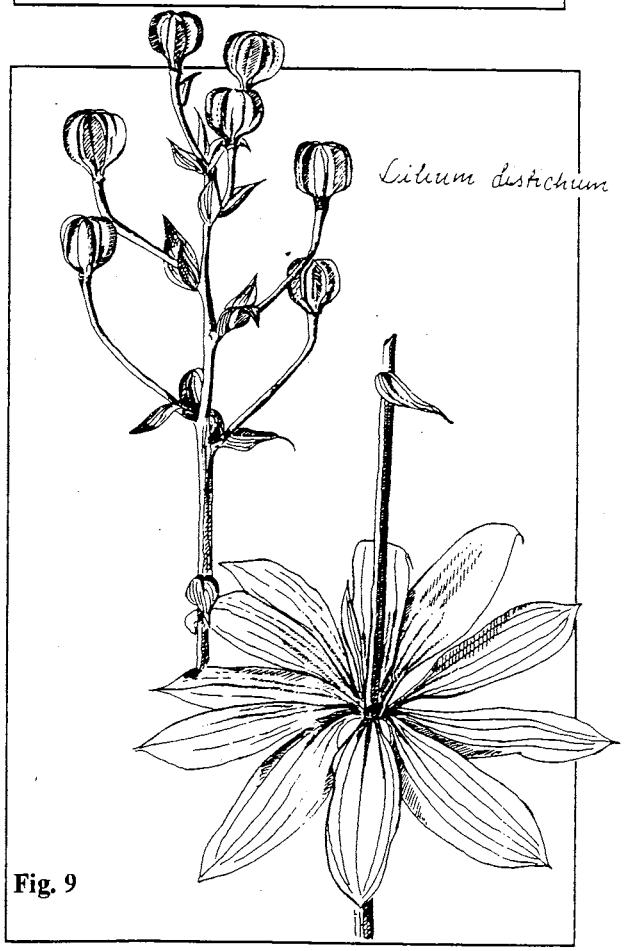


Fig. 9

3.2.3. Structure of the vegetation

The forest in this zone is fully layered. The most characteristic feature of the plant community is that the space seem to be utilized to 100% (fig. 7). There are species adapted to all the different layers. The vegetation in the zone looked like virgin forest and we did not see any signs of human activities. The stand is high, stable and fully layered with a field layer of herbs. The different layers are easily distinguished; **upper storey 20-30 m, intermediate storey 10-20 m, understorey 5-10 m, shrub layer < 4 m and field layer.** The different layers can be considered distinct, each with its own characteristic species. Diverging trees, so called *outsiders,* are trees of a younger generation providing for the regeneration.

The degree of crown cover (all layers included) is almost complete (fig. 7). Despite that the forest is amazingly light. The degree of crown cover in the upper storey is only about 70% which allows light to reach the lower layers. The intermediate layer covers approx. 30% if the outsiders are included and the degree of crown cover for the understorey is about 40%. In a small opening of the canopy, caused by a dying *Betula platyphylla* (no.25, fig. 7) leaning against a *Fraxinus* (no.27), the shrub layer is well developed, thick and almost impassable. This is also seen where a *Tilia amurensis* (no. 24) is leaning southwards and lets in light, otherwise the shrub layer is semi-open.

Many different species are represented in the shrub layer, which is well developed but seldom covers the ground totally. The shrub layer forms groups or small stands, preferably in openings, including a wide variety of species. The shrubs, however, are individually low-growing and rather poorly developed, which is probably due to a combination of lack of light and competition for water and nutrition. The field layer is made up of shade tolerant species, typical of a deciduous forest.

3.2.4. Form development in some trees and shrubs

Betula platyphylla. That this species of birch is a typical pioneer tree was easily seen in cut areas outside of the reserve. In this rather dense stand the stems are thin and crooked and the crowns are high up in the canopy with dead branches still attached lower down. This particular individual was dying and close to falling. It is probable that the birch in question along with the lime-tree and the elm, came up in an opening caused by a fallen tree. The *Tilia* and the *Ulmus*, being secondary successional species in due time surpassed and slowly smothered the birch.

Fraxinus mandshurica. The only ash in the transect is found in the upper storey. It has a wide but relatively thin crown, high up, with a clean stem. The crown is somewhat deeper than those of the elm and the oldest oak individuals. An old and dying *Betula platyphylla* had fallen into the crown of the ash. Nearby ashes show a similar form of growth.

Pinus koraiensis. The pine, more than other species, seems to occur together in smaller groups of relatively varied ages, which might possibly be due to its dissemination pattern. Two of the six pines on the transect belong to the upper storey. They are not quite as tall as the deciduous trees but stay on the 20-25 m level. The crowns are rather deep and narrow with a number of suppressed and dead branches. Judging from the rounded tops of the crowns the pines have reached their maximum height. The pines in the intermediate layer - the outsiders - are younger and still on their way up (still growing strong), as shows by their pointed crowns.

Quercus mongolica. All oaks on the transect are found in the upper storey. The crowns of the two old oaks are high up in the canopy, wide, round and the stem is branch-free up to 20 m. The younger oak which have probably only just reached the upper storey have a very deep, pyramidal crown with live branches down to 7 m above ground and no dead branches. The deep crown as well as the absence of dead branches might be explained by the fact that the younger oak was surrounded by thin-crowned trees (*Betula platyphylla* and *Fraxinus mandshuricum*), which allow a large portion of light to pass through.

Tilia amurensis (closely related to *Tilia cordata*) is one of the two species of lime in the area . The two individuals on the transect belong to the upper storey, whereof one has not quite made it all the way up. The crowns are set high up, are oval and somewhat bowed. The trees grow as suppressed individuals close to the dominant trees, which shows in the characteristically narrow stems in relation to tree height. The two lime-trees on the transect grow next to an oak and an elm respectively. In an attempt to overcome the suppression and enable development of their own crown, they lean out, away from their dominating neighbours. It is difficult to say whether the Tilias and their neighbours are of the same age or not.

Ulmus japonica uses the same strategy as do the two previously described species. They are found in the upper storey with a highly set crown. The elm is one of the tallest trees in our transect and appear to try to spread its crown on top of all the other species in the upper storey.

Acer. Almost all maples are found in the intermediate layer or in the understorey apart from *Acer barbinerve* which grows in the shrub layer. *Acer mono* reaches the upper storey in many places outside the transect.

Acer mandshuricum. The only individual on the transect grows partly covered in the intermediate tree layer and has a rounded to oval, highly set crown.

Acer mono grows in the intermediate storey under a fully closed canopy. It has a narrow, deep and columnar crown. The stem is extremely straight. Smaller (3-5 m), bowing individuals grow under the pine stand. *Acer mono* regenerates well under pine-trees.

Acer pseudo-sieboldianum. This species of Acer stays in the understorey with suppressed, bowing crowns resembling a large platform, 6-8 m high. Several stems originate from the same stump. They die and fall successively so that the tree mostly have only one or two stems at the time with a somewhat higher main stem. Characteristic for the species is that the leaves do not overlap, so that each and every leaf can utilize what little light is coming through the canopy. It is the dominating species in the understorey.

Acer triflorum grows in the intermediate tree layer under a fully closed canopy. It resembles *Acer mandshuricum* with the same oval-shaped but not quite as deep crown. The crown goes all the way down to the ground - no dead branches.

Acer barbinerve. This species is a bushy shrub up to 5 m. It has a vase-like form similar to *Corylus avellana* but wider, bushier and rounder.

3.3. Belt transect no. 2

Coniferous forest

Altitude: 1250 m
Annual mean temperature (1300 m a s l): - 0,2° C
Monthly mean temperature for July 1980-83: 15,5° C
Monthly mean temperature for January: no records
Maximum temperature 1980-83: 24,5° C
Minimum temperature 1980-83: -33,6° C
Annual mean precipitation: 840 mm
Number of days > 10° C (1300 m a s l): 90

3.3.1. Description of the area

Belt transect no. 2 is located between the road leading up the mountain and the deep ravine of the river Erdao Baihe, about one hour (20 km) by car from the research station (see Appendix).

On the edge of the forest facing the road we noticed some *Sorbus pohuashanensis* and *Acer ukurunduense*. This type of coniferous forest was classified as "dark coniferous forest" by people at the research station. The forest is dark and dense, rocks and fallen trees are overgrown with moss. It is the kind of forest where you would expect to meet a troll at any time. Old branches are draped with lichens. The forest is so dense that it makes it difficult to walk and quite often we have to go round little stands of fishing rod-like, moribund *Abies nephrolepis*. The trees are mainly coniferous species but a number of deciduous trees are represented. The deciduous trees appear at intervals of 15-20 m, in openings easily seen in great distance because of the different crown colour.

Fig. 10. Coniferous forest

Apart from those species recorded from the transect, *Picea koraiensis*, *Acer tschonoskii v. rubripes*, *Sorbus pohuashanensis* , *Tilia amurensis* and *Prunus maximowiczii* deserve mentioning.

Generally speaking we felt rather at home in the area where we recognised many plants and mosses common to Sweden.

3.3.2. Description of the belt transect

The transect was laid out in an east-westerly direction approx. 15 m west of and perpendicular to the deep ravine of the river Erdao Baihe in the lower part of the zone classified as "dark coniferous forest".

Upper storey (upper tree layer)

No.	Species	h (m)	d b h (cm)	h f l b (m)
1	Betula costata	18	16	11
4	Pinus koraiensis	18	26	11
5	Pinus koraiensis	20	23	9
8	Pinus koraiensis	23	33	16
9	Picea jezoensis	21	29	16
10	Pinus koraiensis	25	41	11
14	Pinus koraiensis	21	32	12
15	Pinus koraiensis	21	34	12
23	Pinus koraiensis	18	36	13
27	Pinus sylvestris ssp.	24	48	15

Understorey

No.	Species	h (m)	d b h (cm)	h f l b (m)
2	Abies nephrolepis	15	13	12
3	Acer ukurunduense	16	12	9
6	Abies nephrolepis	11	8	9
7	Abies nephrolepis	10	8	9
11	Abies nephrolepis	10	11	8
12	Acer ukurunduense	8	6	5
13	Pinus koraiensis*	12	21	6
16	Abies nephrolepis	10	7	8
17	Acer ukurunduense	12	8	6
18	Abies nephrolepis	8	8	7
19	Abies nephrolepis	10	8	8
20	Abies nephrolepis	8	8	7
21	Acer tegmentosum	10	7	6
22	Abies nephrolepis	9	9	7
24	Acer tegmentosum	13	13	6
25	Salix sp.	9	4	7
26	Picea jezoensis	14	16	12
28	Alnus fruticosa	7	5	0,5

* outsider (runner up)

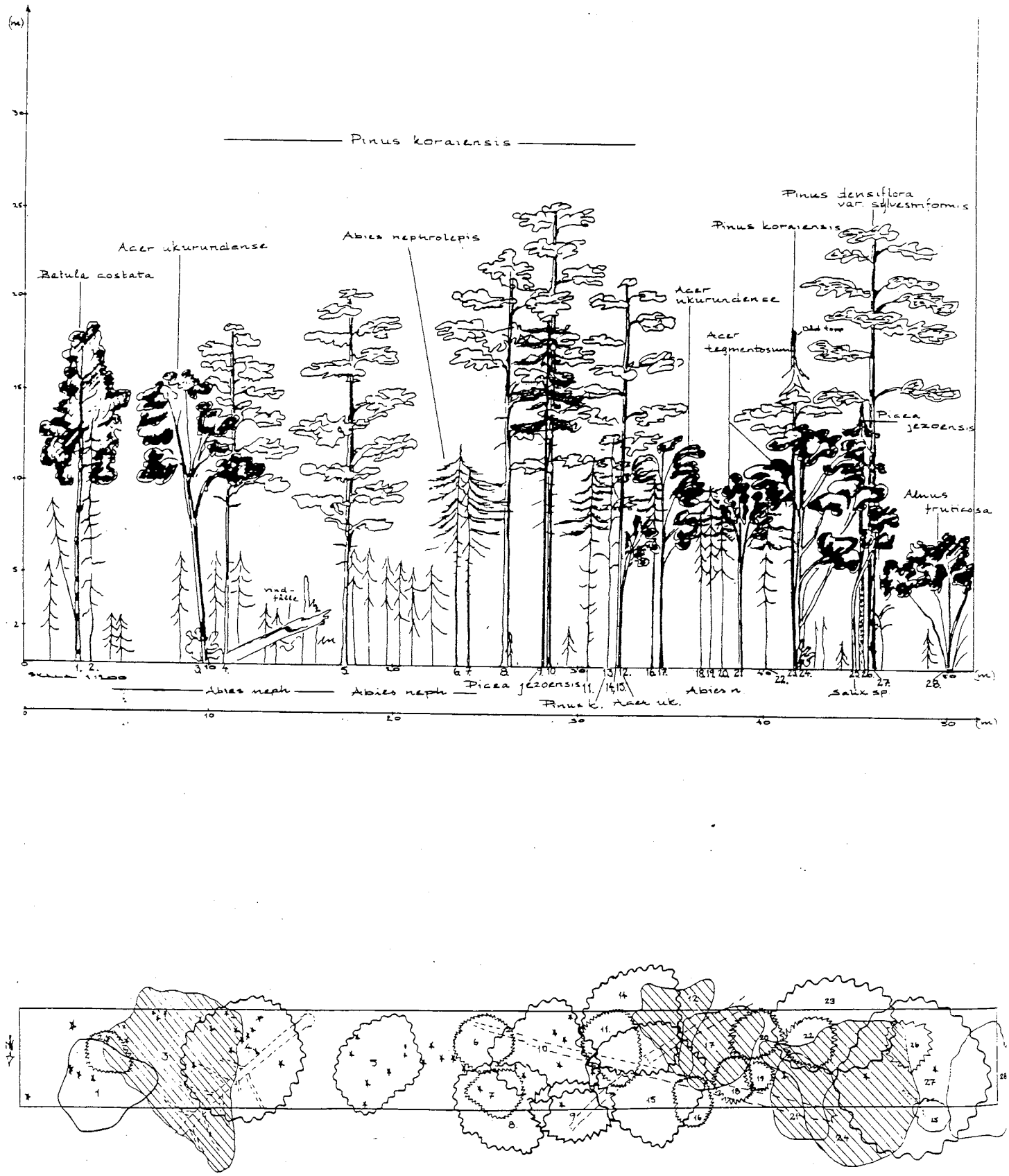


Fig. 11. Vegetation profile (above) and crown projection diagram (below) in belt transect no. 2 in the Coniferous forest.

Shrub layer (0,5-5 m)
Rhododendron dauricum
Ribes komarowii Pojark
Acer tegmentosum
Acer tschonoskii v. rubripes
Acer ukurunduense

Field layer (below 0,5 m)
In the lighter parts of the transect we identified:
Daphne koreana Nakai
Juniperus communis
Lonicera caerulea v. *edulis*
Lonicera sp.
Ribes komarowii Pojark.

In the field layer we also found seedlings of the following trees:

Acer tegmentosum
Acer tschonoskii v. *rubripes*
Acer ukurunduense
Pinus koraiensis
Picea jezoensis
Sorbus pohuashanensis

In the remaining parts of the transect the following species were registered:

Chimaphila umbellata (L.) Barton
Clematis sp.
Clintonia udensis Trautv. et Mey.
Fragaria orientalis Losinsk.
Gymnocarpium dryopteris
Linnaea borealis
Maianthemum bifolium
Orthilia secunda (L.) House.
Rosa acicularis
Solidago virgaurea v. dahurica Kitag.
Trientalis europaea
Vaccinium vitis-idaea
Viola sp.

3.3.3. Structure of the vegetation

The vegetation in this zone has the character of a virgin forest and we did not see any signs of human activities. The structure is made up of a high and stable stand in two storeys with undergrowth of dwarf-shrubs and moss in the bottom layer (fig. 11). The shrub layer is virtually non-existent throughout the transect. The different layers can be considered distinct and well apart. In the eastern part of the transect the understorey is somewhat lower. The degree of crown cover - all layers included - in the western part of the transect it is almost 100%, in the eastern parts there are two openings due to fallen trees (fig. 11). The degree of crown cover in the upper storey was estimated to 50% and for the understorey nearly 100%. The majority of trees around 5 m in height are made up of dying *Abies nephrolepis*. Those individuals have only been marked as crosses on the crown projection diagram but are included in the record of the transect.

The field and shrub layer is only found in the lighter western part of the transect and under the deciduous trees which also host large numbers of their own seedlings. Because of the sparsely developed shrub layer the lower part of the transect gives an open impression but the groups of rod-like *Abies nephrolepis* makes it impenetrable in parts. The ground layer is made up of various mosses but is lacking in the darker parts. Dead fallen trees in the central and eastern parts of the transect strengthen the feeling of being in a primeval forest.

3.3.4. Form development in some trees and shrubs

Abies nephrolepis. The **East Siberian silverfirs** are all found in the understorey (5-15 m) where they totally dominate the scene. They are entirely, or almost entirely, dominated by the upper storey. They are suppressed with extremely thin, rod-like stems with many dead twigs and branches still on the trees. Nearly all individuals are dying with only a few live branches high up in the crown. Often, only the two top whorls of branches are alive. We did not notice any fully grown *Abies nephrolepis* at all in the area.

Acer tegmentosum. These **Manchurian maples** belong primarily to the understorey and are partly dominated by the upper storey. However like other maples on the transect they are often found in openings with more generous light conditions. Despite the heavy shade their crowns are relatively deep, round and fully leafed with no dead branches whereas the undergrowth of firs is effectively suppressed. The same species is represented in the "mixed forest zone" (700-1100 m a s l) with the same appearance. Another maple with similar habit of growth is *Acer tschonoskii* v. *rubripes* which we found just outside the transect.

Acer ukurunduense belongs to the understorey. It is more light demanding than *Acer tegmentosum.* The crown is set rather high up and is somewhat bowing. The branches turn upwards as if reaching for light. The individual in the eastern part, which is generally better developed, grows under better circumstances than the one further west.

Alnus fruticosa grows in the opener woodland, on the edge of the ravine and forms a large vase-shaped shrub with several stems. The alder turns its branches up towards the light, standing in the shade of a pine, to the west, and a larch (*Larix gmelinii* var. *olgensis*), to the east side outside the transect, not included in the diagram.

Betula costata. The only deciduous species that is represented in the upper storey. It has a long slender, somewhat crooked, stem. The crown is very thin and is approx. 1/3 of the tree. The species is of a secondary successional character and only attains upper storey in semi-light

conditions in stands that are not fully closed. Although it is one of the most common broad-leaved trees in the coniferous forest, no seedlings were found! *Betula platyphylla* also occurs in the area.

Picea jezoensis. Two specimens grow on the transect. One is an "outsider", in the understorey and the other is in the upper storey (concealed in the middle of the transect). It has a very thin, spire-like crown, high up, with a clean stem, particularly with the younger individual. The species seem to thrive in deep shadow and to reproduce well - judging from the large numbers of seedlings in the lighter part of the transect.

Pinus koraiensis. The Korean pine occur frequently in the upper storey. Pines standing close together in groups are subject to more competition, therefore their narrow crowns are pushed up and the lower branches are dead. Other individuals growing under more open conditions are not subject to the same kind of competition and still have narrow crowns, although they are deeper and more even. The species is well represented in the field layer, especially below the broad-leaved species and in the western part of the transect.

Pinus sylvestris ssp. (syn. *Pinus sylvestriformis* T. Wang) is said to be an endemic species in Changbai Shan (Wang Zhan et al., 1987). This pine has a wider crown than ***Pinus koraiensis.*** It has a straight stem with a d b h of upto 48 cm. The species occur more often as scattered individuals rather than in groups or stands. There are no seedlings or saplings of *Pinus silvestris ssp.*

Fig. 12. ***Acer tegmentosum*** (the slender stem to the right of the small *Abies)* in the coniferous forest zone.

3.4. Belt transect no. 3

Subalpine birch forest
(Betula ermanii)

Altitude:**1900 m**
Annual mean temperature (**1950 m a s l**): **-3,6° C**
Monthly mean temperature for July: **12,7° C**
Monthly mean temperature for January: no records
Maximum temperature 1980-83: **21,7° C**
Minimum temperature 1980-83: **-36,5° C**
Annual mean precipitation: **1057 mm**
Number of days > 10° C (**1950 m a s l**): **54**

3.4.1. Description of the area

The subalpine birch forest, i.e. *Betula ermanii*-forest, resembles in many ways the subalpine birch forest (*Betula pubescens* var. *tortuosa*) in Sweden. The pure birch forest begins at approximately 1700 m a s l in the deep ravine cut out by the river Erdao Baihe, just north of the volcano crater. The forest clings to steep, landslide-prone slopes on the eastern and western sides of the valley. The western slope is much steeper and there are definite traces of landslides or even avalanches that have left gashes in the forest, 40-50 m wide. These gashes, deprived of their forest, are now meadows with a luxuriant flora of tall herbs such as; *Sanguisorba, Cimicifuga, Veratrum, Ligularia, Thalictrum, Aquilegia* and in the more open parts; *Aconitum, Trollius,* a type of thistle and various other species. At the bottom of the steep slope the terrain is rocky, there is no forest, the vegetation is instead dominated by a rose (*Rosa koreana*) and other drought resistant species. The forest on the western slope is old and rather open in places with a number of large birches that have fallen because of old age. In the depressions the undergrowth is dominated by tall herbs and grasses. Various mosses and sedum-species dominate in the rockier and drier parts, with more light, roses become more frequent. Scattered specimens of *Sambucus williamsii* Hance. grow in well-watered depressions - a species that we did not find on the eastern side. On the crest of the slope the forest is younger and becomes more prostrate higher up.

Fig. 13. Subalpine birch forest of ***Betula ermanii***

The forested part of the eastern valley is not as steep as the western and the forest is somewhat younger. The field layer at the bottom of the slope is dominated by a luxuriant flora of tall herbs similar those on to the western slope. This herbal flora is gradually replaced by shrubs which become dominant on the rest of the slope. The dominant species is Rhododendron aureum. However, there are depressions further up that are moister and a lush flora appears there. On the eastern slope tree of; *Abies*, *Picea*, *Larix* and *Alnus* are more common. Both *Abies nephrolepis* and *Picea jezoensis* develop a narrow stem up to 10 m, and the lowest branches take root and create a thicket around them. As you pass the crest the subalpine birch forest gives way to pure larch forest (*Larix gmelinii* var. *olgensis)*. The larches are broad and have several stems, 8-10 m in height with a d b h of approx. 50 cm. We counted the annual rings on a tree stump on the crest of the slope and came to 150 years. (The timber had probably been used for road construction nearby.) When studying pure stands of larch at the same elevation some 4-5 km to the east, the stand seemed to consist of two varieties of larch. One straight one-stemmed type with bark typical of the *Larix gmelinii* var. *olgensis*, that grows in the coniferous forest 1200 m a s l. The other type was multi-stemmed, crooked and wide with a platey bark structure. Furthermore we found some seedlings of *Pinus koraiensis* or possibly *Pinus pumila* on the slope, but no larger individuals. Other species worth mentioning are: *Lonicera caerulea v. edulis*, which grows together with another species of *Lonicera*, either *L. tatarinovii* Maxim., *L. chrysantha* or *L. maximowiczii*. At the top of the slope shrubs such as *Viburnum sargentii* and *Rosa koreana* thrive on stony sites. *Ribes burejense* of gooseberry affinity, with black, hairy, edible fruits and *Ribes mandshuricum*, a red currant type, also grow on the slope.

The crest of the eastern slope is at 1950 m a s l and the forest continues up to 2000 m a s l further south. The crest of the western slope reaches about 2000 m elevation and borders on alpine tundra.

When walking away from the valley eastwards we also noted pure larch forest, *Larix gmelinii* var. *olgensis* forming the timber line instead of *Betula ermanii*. On the western slope, which is flatter, we saw large areas of meadow land. Perhaps due to deer grazing.

Fig. 14. Field layer on the eastern slope of the subalpine birch forest.

3.4.2. Description of the belt transect

The belt transect, 40 by 2 m, was laid out on the eastern side of the mountain (facing westwards) at approx. 1900 m a s l. (see Appendix). The mountainside is very steep, sloping down towards the valley of the river Erdao Baihe at an inclination of 45°. Mountainsides cast a shadow on the area until noon. The transect was laid out horizontally on the slope, and included two depressions with three small, rather dry, ridges in between..

Tree layer

No.	Species	h (m)	dbh (cm)	h f l b (m)
2	Betula ermanii	9	19	4,0
3	Betula ermanii	6	11	3,0
5	Betula ermanii	6	13	3,0
9	Betula ermanii	10	17	1,6
14	Betula ermanii	10	21	3,3
23	Betula ermanii	9	21	4,0
25	Betula ermanii	8	14	3,0
26	Betula ermanii	11	24	6,0
27	Betula ermanii	9	22	3,0
29	Betula ermanii	10	22	2,0
30	Betula ermanii	9	18	5,0
31	Betula ermanii	7	20	3,5

Upper shrub layer

No.	Species	h (m)	stems	d b h (m)
20	Alnus fruticosa	5	5	5
21	Betula ermanii*	3	1	5
22	Alnus fruticosa	5	4	4
32	Alnus fruticosa	5	3	4

Lower shrub layer

No.	Species	h (m)
1	Rhododendron dauricum	1,2
4	Rhododendron dauricum	1,3
6	Rhododendron dauricum	1,3
7	Rhododendron dauricum	1,2
8	Rhododendron dauricum	1,2
10	Rhododendron dauricum	1,1
11	Rhododendron dauricum	1,1
12	Rhododendron dauricum	1,0
13	Rhododendron dauricum	1,0
15	Rhododendron dauricum	1,0
16	Rhododendron dauricum	1,5
17	Rhododendron dauricum	0,9
18	Rhododendron dauricum	1,2
19	Rhododendron dauricum	1,1
24	Rhododendron dauricum	1,2
28	Rosa acicularis	approx. 1

* outsider

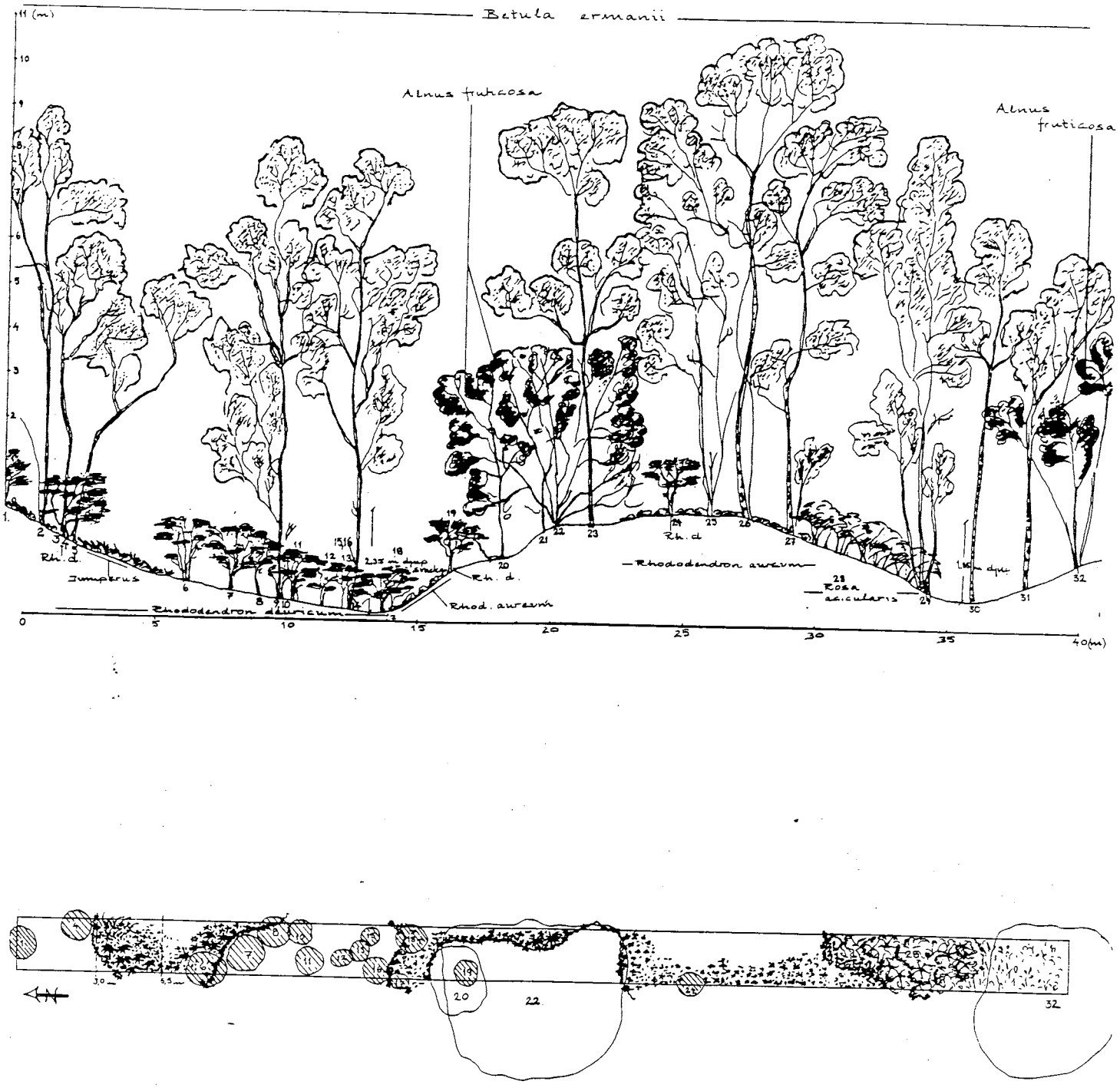


Fig. 15. Vegetation profile (above) and projection diagram of the shrub and fileld layer (below) of belt transect no. 3 in the subalpine birch forest.

Field layer

Actaea spicata L.
Cacalia hastata L.
Juniperus communis
Rhododendron aureum.
fine-leafed grass

3.4.3. Structure of the vegetation

A subalpine, tree line-forming, stable, two-layered, low stand of Betula ermanii with an abundance of shrubs and herbs underneath (fig. 15). The crown coverage was estimated to be 100% if the upper shrub layer was included, but the birches let a good deal of light through which favours a rich undergrowth. Due to the steepness of the slope the trees lean heavily from the slope, which means that the crown projection diagram for the transect would not correspond with the trees measured on the transect. *Alnus fruticosa* developed a lower tree layer in one part of the transect where we noticed that *Rhododendron aureum* could not compete - whether due to lack of light or root competition. However, outside the "Alnus-shade" the *Rhododendron* rapidly regained dominance (fig. 15).

The shrub layer on the transect is totally dominated by *Rhododendron dauricum*. *Rhododendron aureum* appears in places and reaches 30 cm in height under good conditions. *Rhododendron dauricum* makes up a tender lower layer under which one finds mosses, lingonberry (*Vaccinium vitis-idaea*) and a narrow-leaved grass species. On the southern edge of a depression there is a shrubbery of *Rosa acicularis* with *Rhododendron aureum* and fine-leafed grass underneath.

The fieldlayer is dominated by *Rhododendron aureum* and *Juniperus communis* (see fig. 14, 15). Lingonberry, a fine-leafed grass, moss and *Juniperus* sp. grow in higher and therefore, drier parts of the transect. *Rhododendron aureum* prefers lower and damper sites. In the southern most depression a flora of tall herbs dominate of which *Cacalia hastata* L. is most common but *Actaea spicata* L. also occurs.

3.4.4. Form development in some trees and shrubs

Alnus fruticosa can be characterised as a broad bush or a multi-stemmed tree with a wide and deep crown. In two different places on the transect *Alnus fruticosa* actually formed an intermediate layer between the shrub and the tree layers. Below this intermediate layer there is dense shadow and no vegetation in the field layer. No young alders were found throughout the transect.

Betula ermanii totally dominates the tree layer. The crowns are thin, irregular, often one-sided and deep. It is evident that they are equal-aged and that they continuously compete with each other. The branches carry leaves all the way down and the branches in the canopy are more often than not entwined. The stems are crooked and leaning owing to the steep slope and the harsh climate. No seedlings of *Betula ermanii* occur in the undergrowth!

Rhododendron aureum makes up a dense, mat-like, field layer on the whole transect except for the southern part where *Rhododendron dauricum, Alnus fruticosa* and *Rosa acicularis* effectively block out the light. It is very probable that light is the limiting factor for

Rhododendron aureum since it grows on both dry and moist sites providing the shade is not too much.

Rhododendron dauricum. This species make up the major part of the shrub layer on the transect. In the northern depression there is a dense stand, the other grow as scattered individuals. The shrubs all grow below a closed canopy. They are vital and have a beautiful, characteristic form which is maintained also by the individuals in the dense stand. The branches of the different individuals are never entangled but only just touching each other. The shrubs look like small elegant multi-stemmed trees with knotty leaf-carrying branches that seem like small platforms striving upwards. No seedlings were found on the transect!

Rosa acicularis. This rose has formed a dense, impassable, luxuriant shrubbery and tolerates well canopy shade.

3.5. Research area no.4

Alpine tundra

Although we did not lay out a transect in this vegetational zone we would still like to give an account of what we saw during the two days we spent on the tundra. The area climbs from 2000 m a s l to the top of the volcano at 2691 m a s l (the highest peak on the Chinese side). The vegetation is primarily made up of dwarf-shrubs, e.g. low prostrate individuals of *Rhododendron aureum*, up to about 2300 m a s l. They seem to thrive particularly well in small ravines where water accumulates in spring and also by small springs in the mountainside. In the same environment we noticed scattered specimens of *Phyllodoce coerulea.*

Fig. 16. Alpine tundra with *Aconitum* and *Trollius* close to the camera - 2200 m a s l.

Rhododendron redowskianum Maxim., a very low-growing species forming the hardiest sub-shrub, surviving upto 2500 m a s l on steep slopes which are exposed to the north on poor, rocky ground. Sometimes it looks like the plants grow out of the rock, especially at higher altitudes. It colours the northern mountainside bright red in September, at approx. 2300-2500 m a s l. A little further down *Rhododendron redowskianum* often grows together with *Rhododendron lapponicum* and *Vaccinium uliginosum*. (The latter is picked and used in the same way as *Vaccinium myrtillus* in Sweden). Furthermore there were two small species (5-7 cm) of Liliaceae that had ceased flowering, *Fritillaria ussuriensis* Maxim. and *Tofieldia coccinea* Rich. plus a tiny, strange umbelliferous plant; *Bupleurum euphorbioides* Nakai. The two last-mentioned species subsisted up to approx. 2200 m a s l. In the same, difficult, environment mats of *Dryas octopetala*. *Gentiana algida* Pall., which brighten up the barren landscape with its cream-coloured flowers, grow up to 2400 m a s l. At the same elevation, but restricted to steeper sites where small landslides have exposed bare ground, we recorded *Papaver pseudo-radicatum* Kitag. with bright yellow flowers. However, we noted that the same species occur as low as 1650 m a s l, next to the Erdao Baihe river, often on sites cleared by spring floods. In small ravines and on other damp places at 2000-2300 m a s l is found a lush alpine meadow vegetation, with mats of white-flowering *Sanguisorba* sp., *Aquilegia amurensis* Komar., *Aquilegia oxysepala* Trautv. et Meyer upto 2200 m a s l, plus a strongly scenting *Saussurea*. A tiny, blue-flowering gentian, *Gentiana jamesii* Hemsl., grows in moist crevices. *Rhodiola angusta* Nakai often grows in connection with the creeks in the ravines on sites with shallow soil.

Fig. 17. ***Rhododendron redowskianum*** **thrive in this kind of steep, rocky slopes exposed to the north.**

4. Plant descriptions with illustrations made in the field

Acer barbinerve Maxim.

This species grows in "the mixed forest of pine and broad-leaved trees" and is very common on the river bank of the Erdao Baihe river. It forms a vase-shaped shrub, 2-6 m high, with new shoots sprouting continually from the base. It's leaves are 7-9 cm long, 5 lobed, the two basal lobes being smaller, coarsely double serrate, dark green above with brown to red-brown veins, somewhat paler beneath, light-brown to white pubescence on both sides, also on the venation (This description differ somewhat from Krüssmann's, which says: "young leaves pubescent underneath, later only on the venation"). Deviating leaf-shape occurred on strong growing shoots. Young twigs are green but become reddish towards the light. The maple is sometimes very hard to distinguish from young specimens of *Acer ukurunduense* (see below) but the fruit is yet twice as large, forming short clusters of 4-5 together. Fig. 18.

Acer mandshuricum Maxim.

The "Manchurian maple" is a fairly narrow tree to 15 m tall (Krüssmann: "occasionally to 10 m") growing in the "mixed forest zone". Leaves are trifoliate with 7-10 cm oblong-lanceolate leaflets. The middle leaflet has a longer petiole. The blade tips are acuminate and the leaf margins are sparsely obtuse serrate. The leafstalk is long, 5-9 cm, often longer than the leaf. The leaves are dark green above, lighter green beneath, with sparse white to light-brown pubescence along the midrib underneath and with small, pale-brown tufts of hair at the bottom vein axis (not mentioned in "Krüssmann"). The stem-bark is smooth and grey. The bright red autumn colour comes early, and already, in the end of August, we saw leaves beginning to change in colour. Fruits are usually in groups of 3. Fig. 19.

Acer mono Maxim.

This is the largest maple growing in the area, up to 20 m in height (according to "Krüssmann": "to 10 m high"). We found it only in the "mixed forest zone". Under shade it develops a narrow, deep and column like crown but in open sites the crown is more oval to rounded. Branches are ascending and form irregular storeys. Foliage is bright-green. Leaves are 7-8 cm long and 10 cm wide, 5-7 lobed. Lobes are triangular with apiculate, acuminate blade tips. Leaf-margins are entire. Leaves are glabrous except for the veins beneath which are pubescent. Leaf-stalk is long and slightly pubescent. Young twigs are grey-brown and pubescent (Differing from "Krüssmann" which says: "twigs glabrous"). Fig. 20, 21.

Acer pseudo-sieboldianum (Pax.) Komar.

A small tree, to 10 m high, often with several stems, which one forms the main stem. The branches form distinct storeys looking like thin, wide fans. Leaves are palmate, with 9-11 lanceolate deep lobes with cuspidate tips. They are thin, glabrous and doubly serrate, glossy green and glabrous above, more dull green beneath, with scattered pubescence on the veins beneath and small hair tufts in vein axis at the leaf base ("Krüssmann" says: "fine silky pubescence beneath").

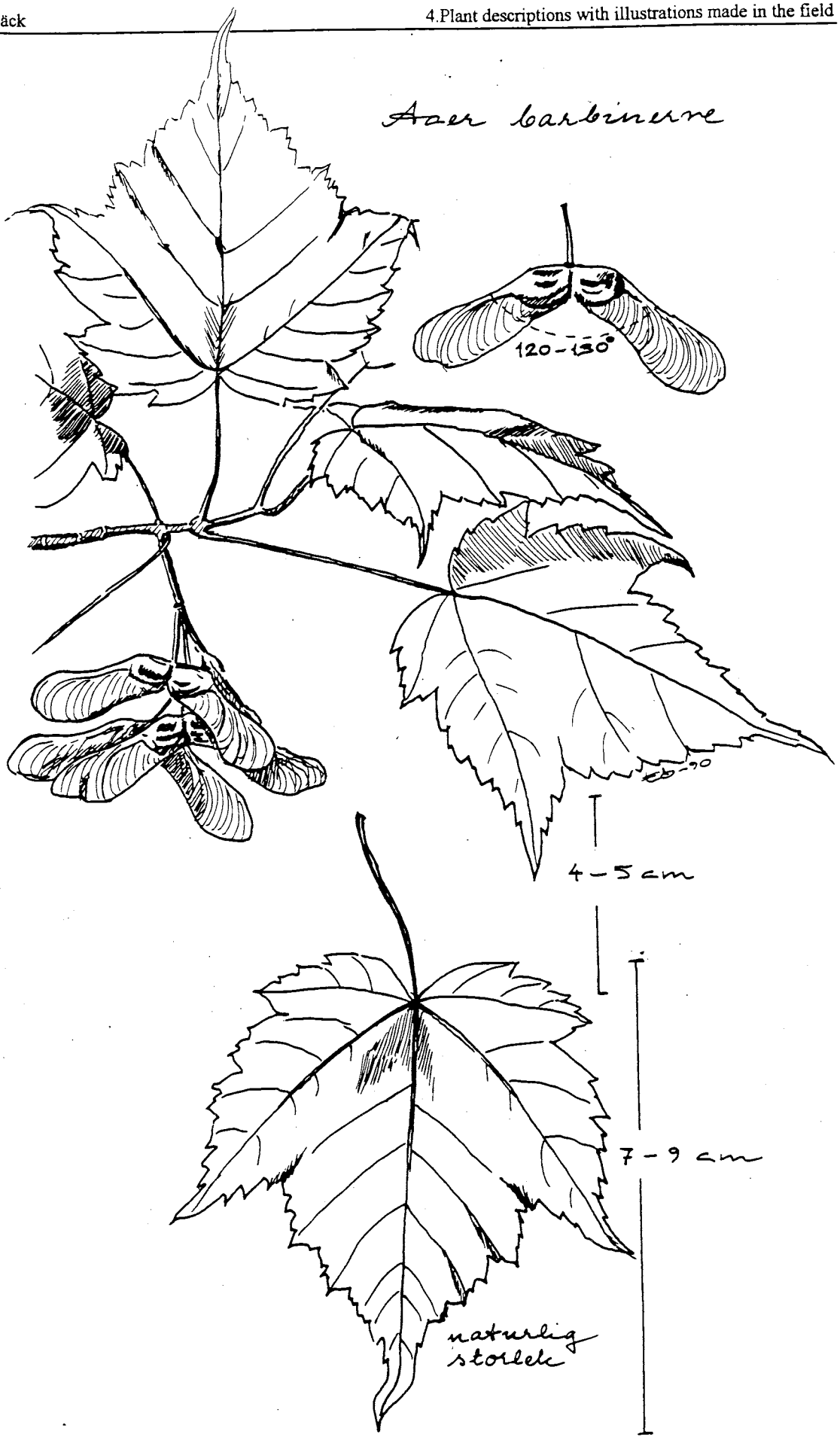


Fig. 18. *Acer barbinerve* Maxim.

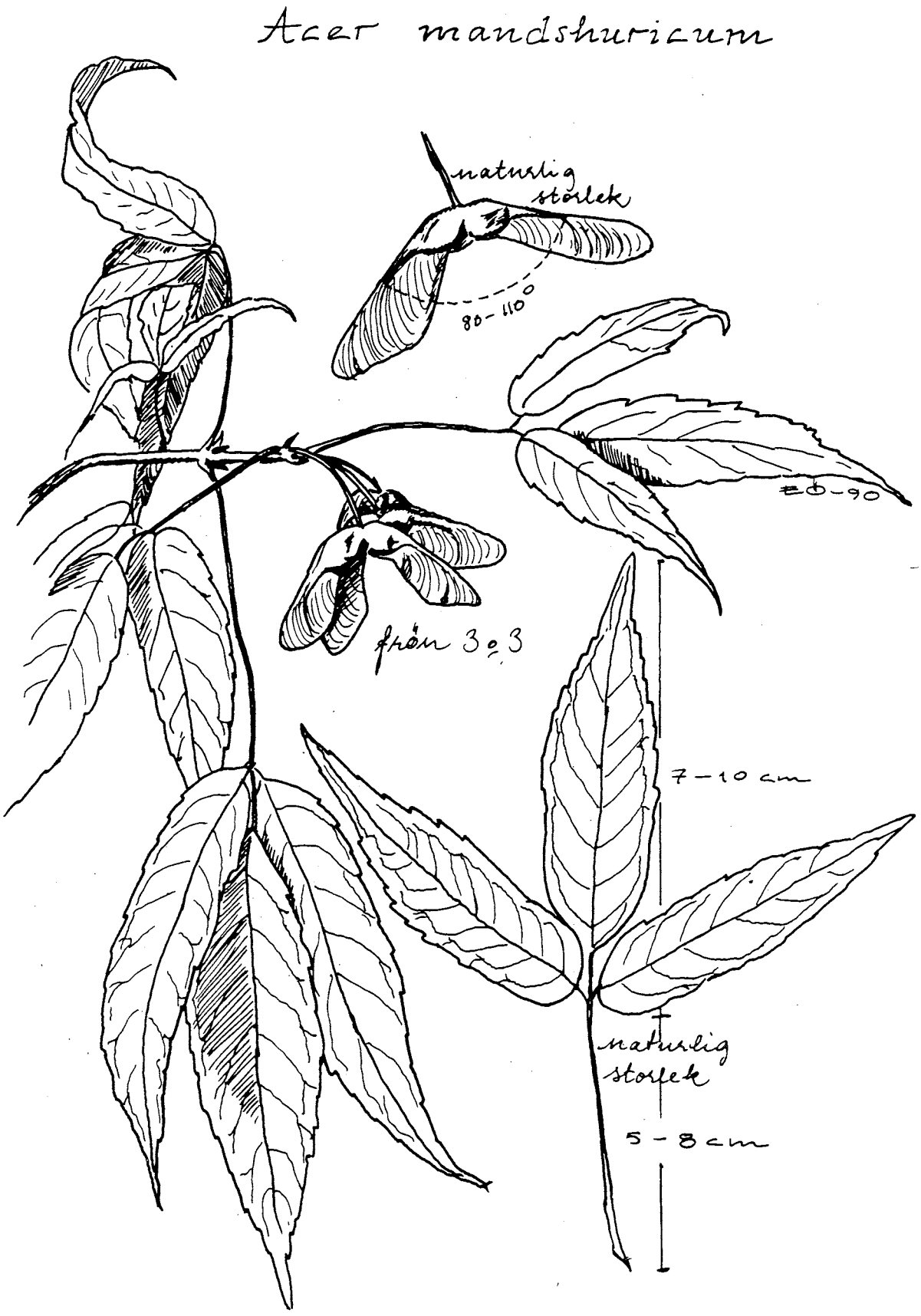


Fig. 19. *Acer mandshuricum* Maxim.

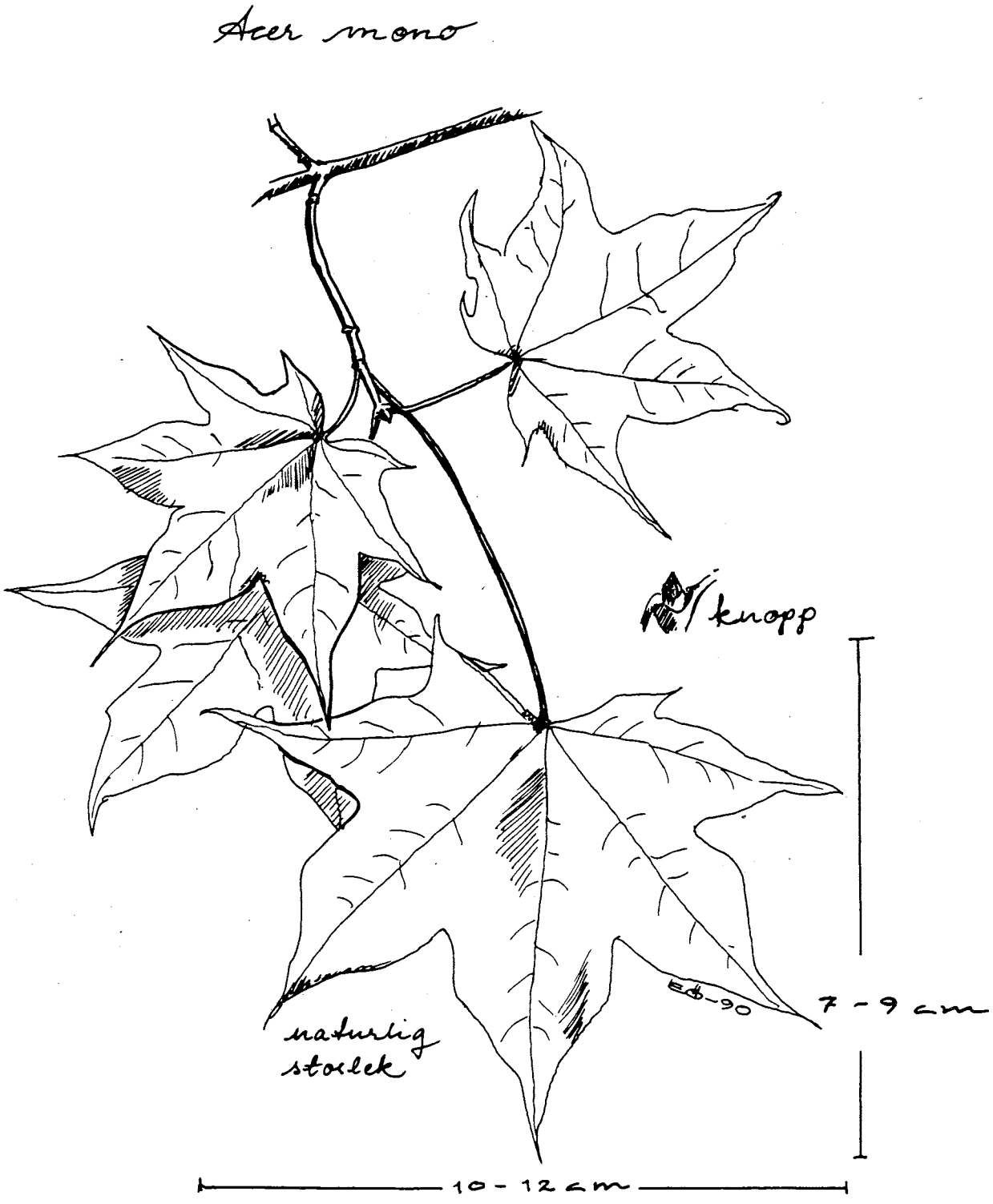


Fig. 20. *Acer mono* Maxim.

Fig. 21. A solitary growing *Acer mono*.

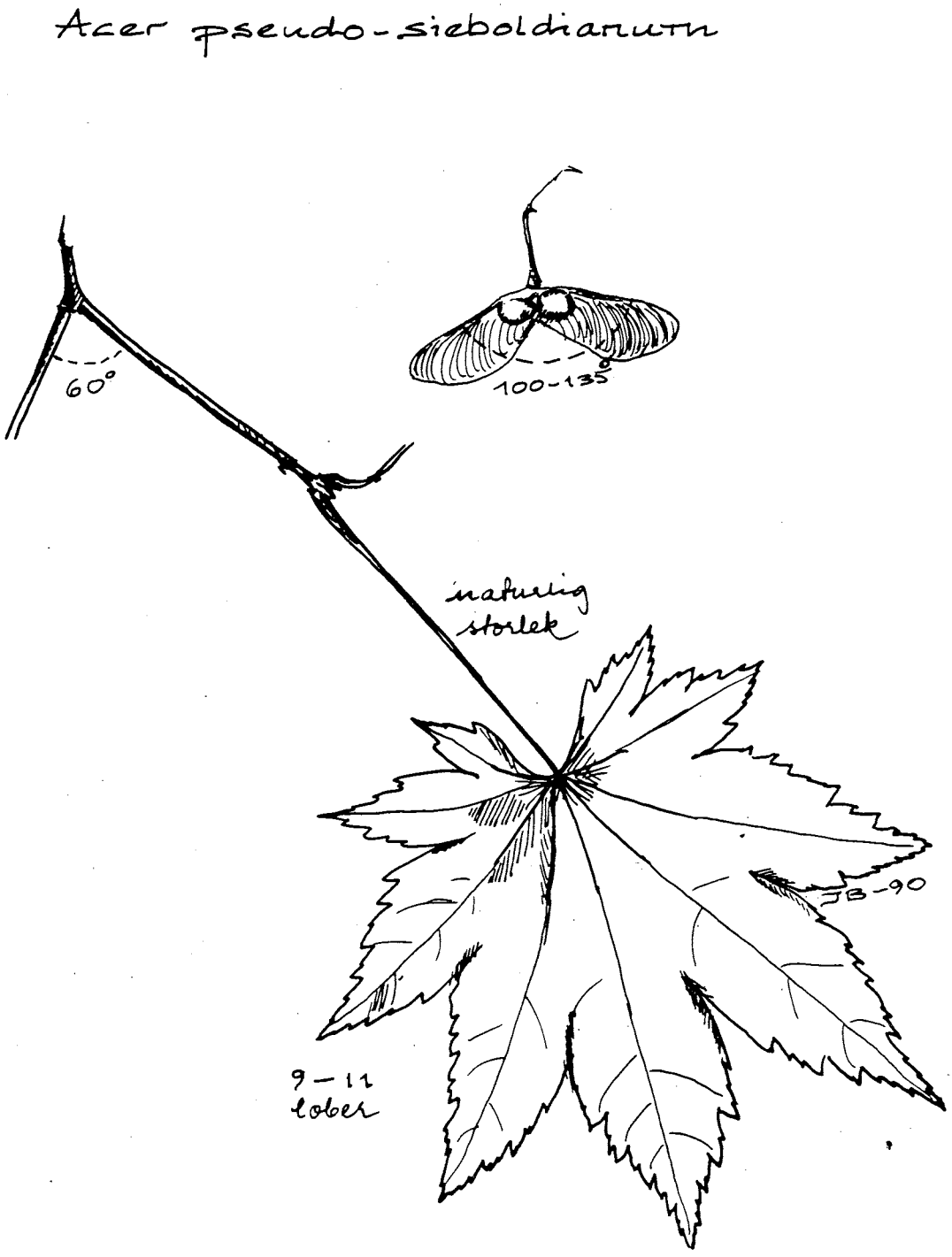


Fig. 22. *Acer pseudo-sieboldianum* (Pax.) Komar.

Leaf-stalk is red above, towards the light, and green underneath. One year old growth is green and glabrous becoming violet-red and pruinose. Bark on stems is smooth, grey-green with lighter spots (probably some kind of lichen). Fruits are single or two together, red-brown, fruit wings at obtuse angle. The Korean maple is the dominating species in the understorey of the mixed forest zone. Fig. 22.

Acer tegmentosum Maxim.

Striped maple, to 15 m high with green-grey, slightly striped (stripes white) stembark. Young twigs are green and more distinctly striped. Older trunks was always covered with lichens which conceal the stripes. The crown is relatively deep, round to oval with large leaves that overlap and form a shady screen. It keeps its crown shape even in more shady sites. Foliage is bright green. Leaves are 3 lobed often with 2 small basal lobes, doubly serrate. Fruits 7-8 together with nearly horizontal wings. Autumn colour occurs as early as the beginning of September. The species is found between 740 to 1650 m elevation, through out the mixed forest zone as well as in the coniferous forest zone. Fig. 23.

Acer triflorum Komar.

Tree to 15 m high ("to 8 m in the wild" according to Krüssmann), resembling *A. mandshuricum* (belongs to the same section, *Trifoliatae* Pax.) and with which it often grows. The bark is rough and flaky (peeling) as distinguished from *A. mandshuricum*. Leaves trifoliate, pubescent above and beneath on the veins (Krüssmann: "somewhat pubescent only along the midrib") Leaflets 8-10 cm long, narrowly ovate, margins with few large teeth but sometimes entire, middle leaflet is longer petiolated. Petiole 5 cm, shorter than leaf, sparsely pubescent and slightly red above. Buds are brown, pointed and somewhat pubescent. Fruits 3 together, large with wings to 5 cm at about 90° angle (Krüssmann: "wings obtuse angled"), nuts densely pubescent. Three-winged fruits are not unusual. Fig. 24.

Acer tschonoskii var. **rubripes** Komar.

A 10 to 12 m high maple (Krüssmann: "shrub or small tree, usually not over 5m") also belonging to the section *Tegmentosa* Pojark. The bark on stems is grey and smooth without stripes but with distinct lenticel spots. The crown is relatively deep - even in deep shade - round to oval with nodding twigs. Leaves are green, glabrous, 6-8 cm long, 5-7 lobed. Lobes are ovate-caudate, finely double serrate, beneath pale-green with brown curving hairs on the venation. Leafstalk is shiny red above as well as annual growth and buds. Older twigs more dull-red. We did not see any fruits. This species occur both in the mixed and the coniferous forest zones. Fig. 25.

Acer ukurunduense Trautv. et Mey.

A small tree, to 10 m high (Krüssmann: "Small tree or shrub, 3-6 m"). Younger trees are often multi-stemmed, older trees single-stemmed. Stembark is rough, coarse and flaky. When growing inside a stand the crown is set high up due to shading. Leaves are 5 lobed, thick, coarsely dentate, 9-10 cm long and somewhat wider (Krüssmann: "leaves small, 5-8 cm wide), light olive-green above, light green and more or less pubescent beneath (depending of age) with light yellow-brown hairs (1mm long) more frequent on the veins (Krüssmann: "densely grey tomentose beneath"). Lobes are deeply incised and overlap at the base. Petiole pubescent towards the base, often longer than the leaf. Young twigs are dull-red. Fruits are small, sitting many together in a long raceme. Fruit wings acute angled. This species occur both in the mixed and the coniferous forest zones. Fig. 26.

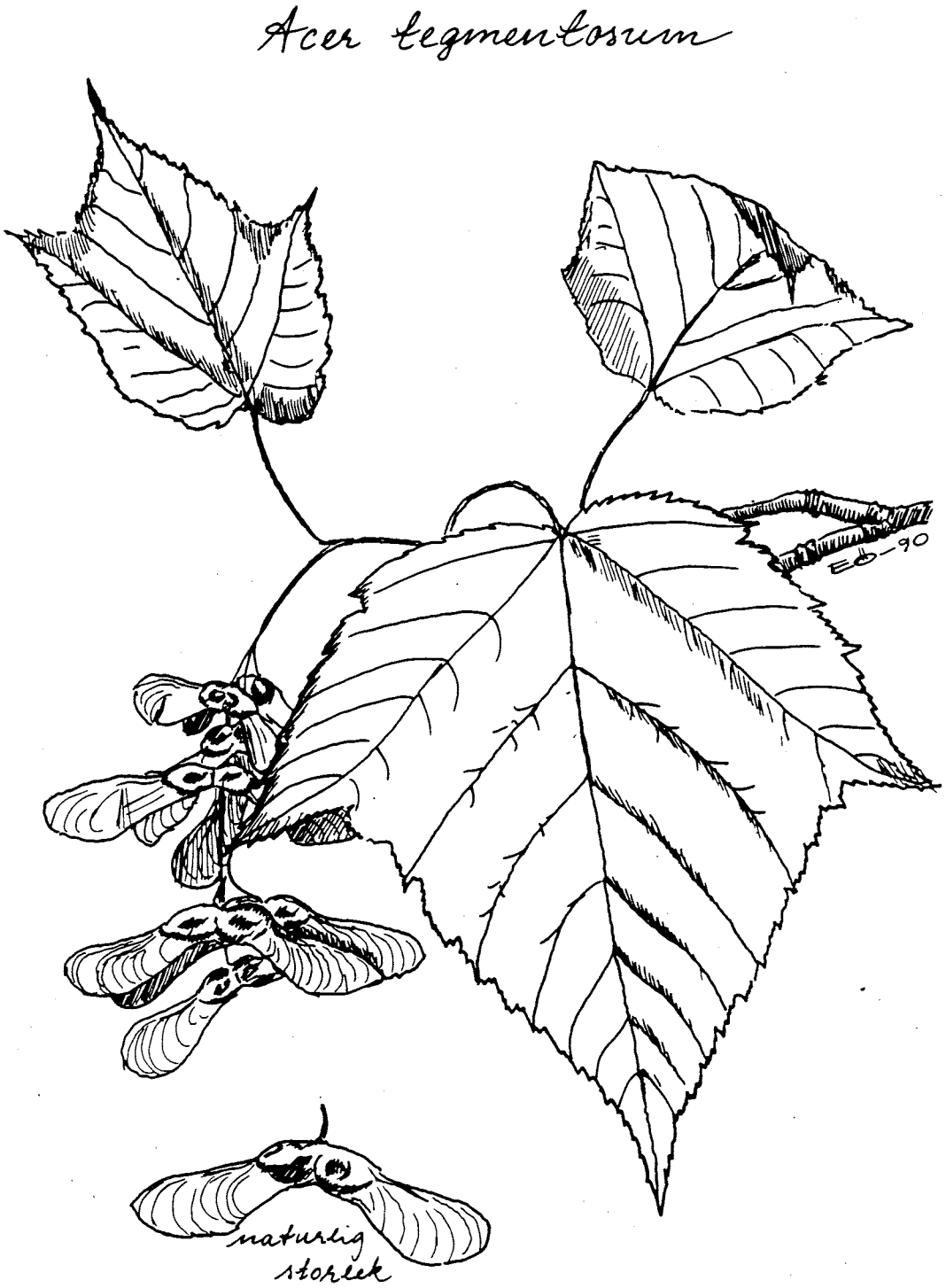


Fig. 23. *Acer tegmentosum* Maxim.

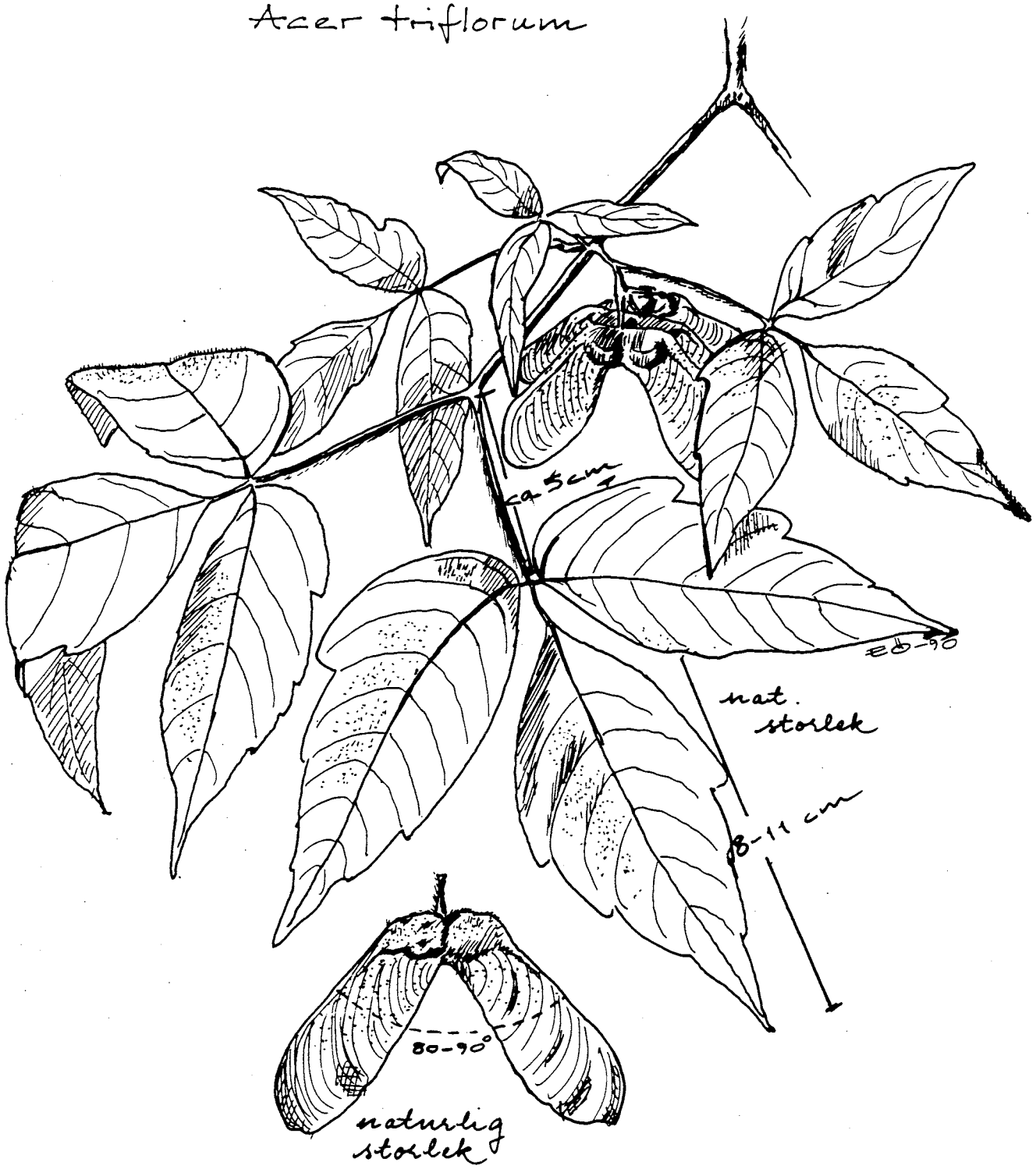


Fig. 24. *Acer triflorum* Komar.

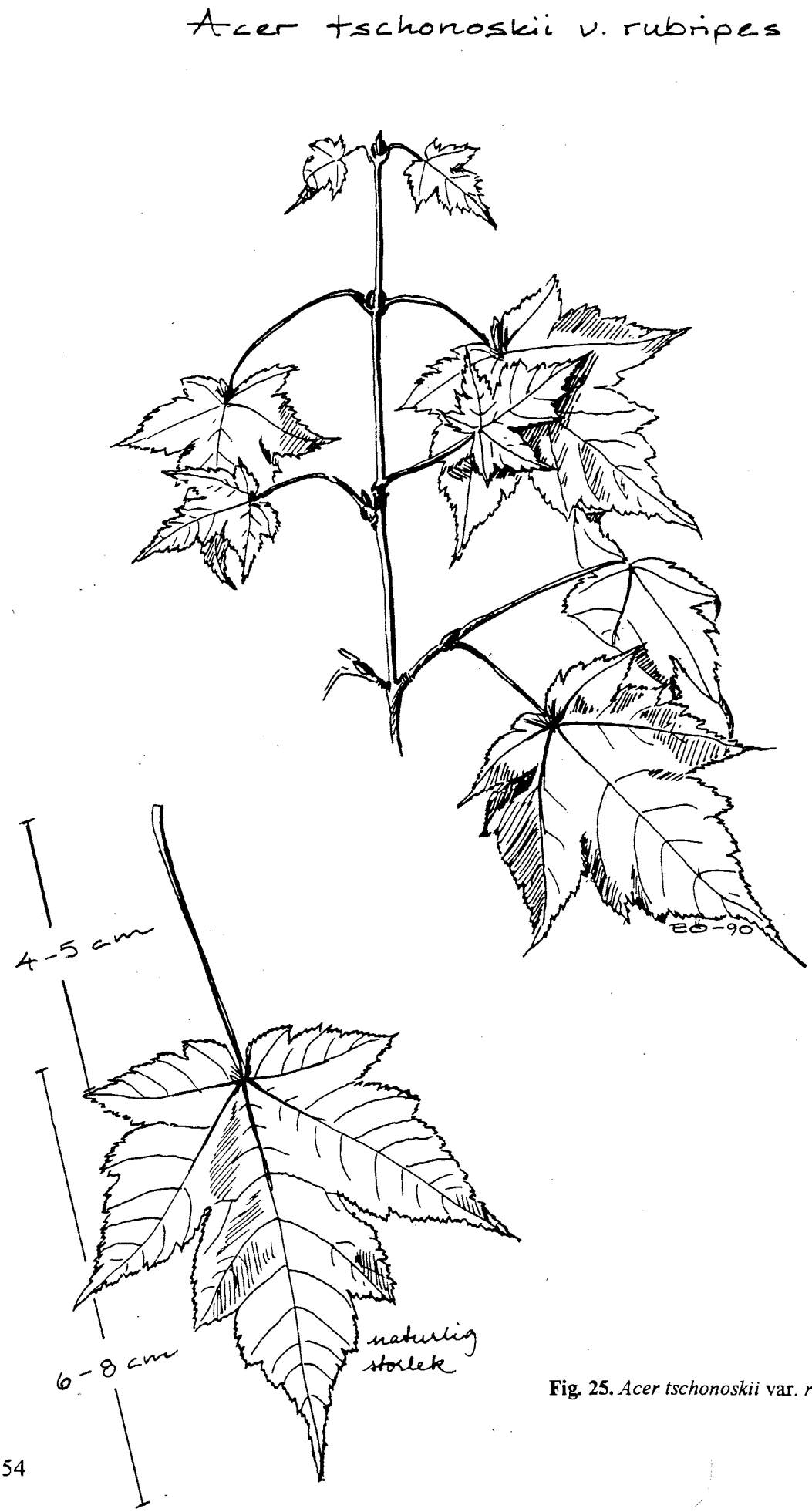


Fig. 25. *Acer tschonoskii* var. *rubripes* Komar.

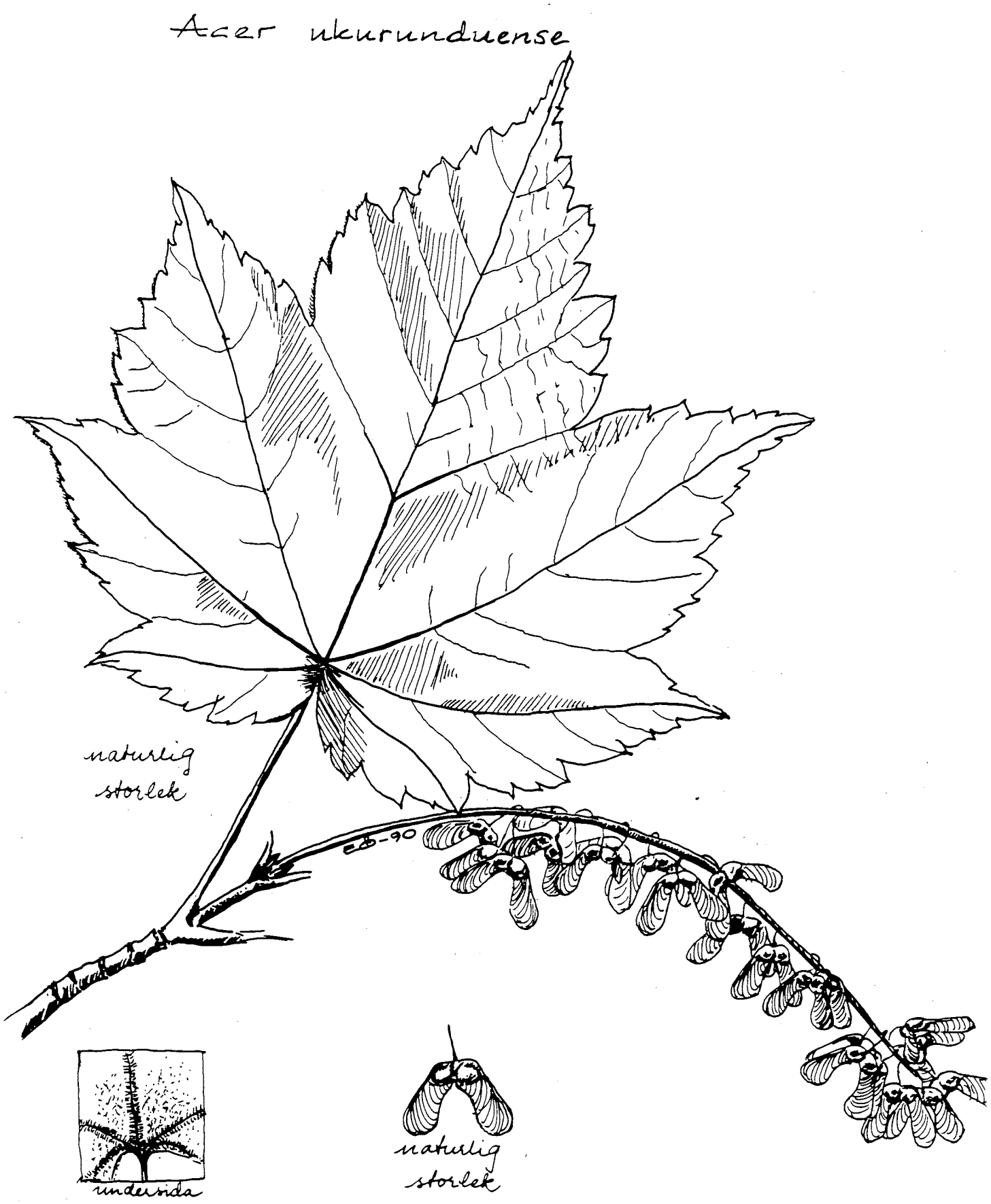


Fig. 26. *Acer ukurunduense* Trautv. et. Mey.

Alnus fruticosa Rupr.

Occur from 1250 m a s l to the timberline at approximately 2000m a s l. It forms a large vase-shaped shrub or a small multi-stemmed tree, 5-7m tall. Bark on stems and branches is grey, annual growth is red-brown. Leaves are somewhat glutinous with a faint balmy fragrance, ovate, finely serrate with somewhat uneven teeth and 10-12 paired veins (Krüssmann: "with 7(-9) paired veins"). They are dark green and glabrous above, paler and shiny beneath and sparsely pubescent. The veins are more densely covered with light-brown hairs and with hair tufts at the vein angles (Krüssmann: "glabrous beneath"). Buds are sessile, green to red-brown in August. Fruit cones are 1 cm long. Fig. 27.

Aristolochia manchuriensis Komar.

Grew in the field layer together with *Scissandra chinensis,* seedlings of *Maackia amurensis, Philadelphus schrenkii* etc. on a northern slope, 740 m a s l and about 100 m from the River Erdao Baihe. It was winding its way among moss-covered boulders, occasionally climbing 2-3 m up a nearby tree or shrub under a canopy of *Maackia amurensis, Phellodendron amurense, Acer mono* and *A. pseudo-sieboldianum.*

Leaves are large, 18 x 18 cm, very broadly ovate with cordate blade base, dark green above with red-brown downy veins, light-green beneath and downy (white hairs). Young twigs are green, slightly furrowed and downy. Older twigs furrowed and look like an oak-trunk in miniature, or like basket-work. Buds are round and downy. We did not find any flowers or fruits. Fig. 28.

Betula costata Trautv.

A tree to 20m tall with very characteristic bark. Bark on old stems are dark grey-brown to black, very scaly and rough with a pink tint beneath. Young stems have a pink-apricot beige, paper-thin, peeling bark (Krüssmann: "bark light yellow to grey-yellow, paper thin, peeling"). Young twigs are green-brown to brown with round glands. Leaves are narrowly ovate to ovate with cuspidate to acuminate blade tips, twice as long as wide, with 9-16 pairs of veins and are finely serrate, somewhat downy above, glandular-warty and dark green on older trees. Lower surface is paler, glandular-warty with pubescent venation and brown hair tufts in the vein angles. Leaves on young, strong growing shoots are finely, double serrate. Fig. 29.

This birch is a secondary successional character. It is one of the most common broad-leaf species in the coniferous forest and occurs between 740 and 1650 m a s l.

Betula davurica Pall.

Tree to 25 m high (Krüssmann:" Trees 5 - 9 (to 20 m)") with the same growth strategy as *Betula costata.* It occurs in the mixed forest zone. Young trees have a beautiful dark silver-grey, peeling bark which form lilac-brown rolls. The stem bark on old trees did not resemble any birch-species we have seen before. At a distance the stembark reminds one of the Scots Pine (*Pinus sylvestris).* A closer look showed a very rough bark, consisting of firmly packed layers of paper-thin bark forming plates. Colours from yellow-orange to different shades of brown and black. Young twigs are green-brown, slightly pubescent with warty white glands. Leaves are 5-7 cm long with 5-7 paired veins, ovate to rhombic, unevenly serrate with a cuspidate blade tip. Above the leaves are yellow-green and glandular-hairy, beneath paler, glandular-hairy with hair tufts in the vein-angles. Buds on strong growing shoots have a lilac-blue tint. Fig. 30.

Fig. 27. *Alnus fruticosa* Rupr.

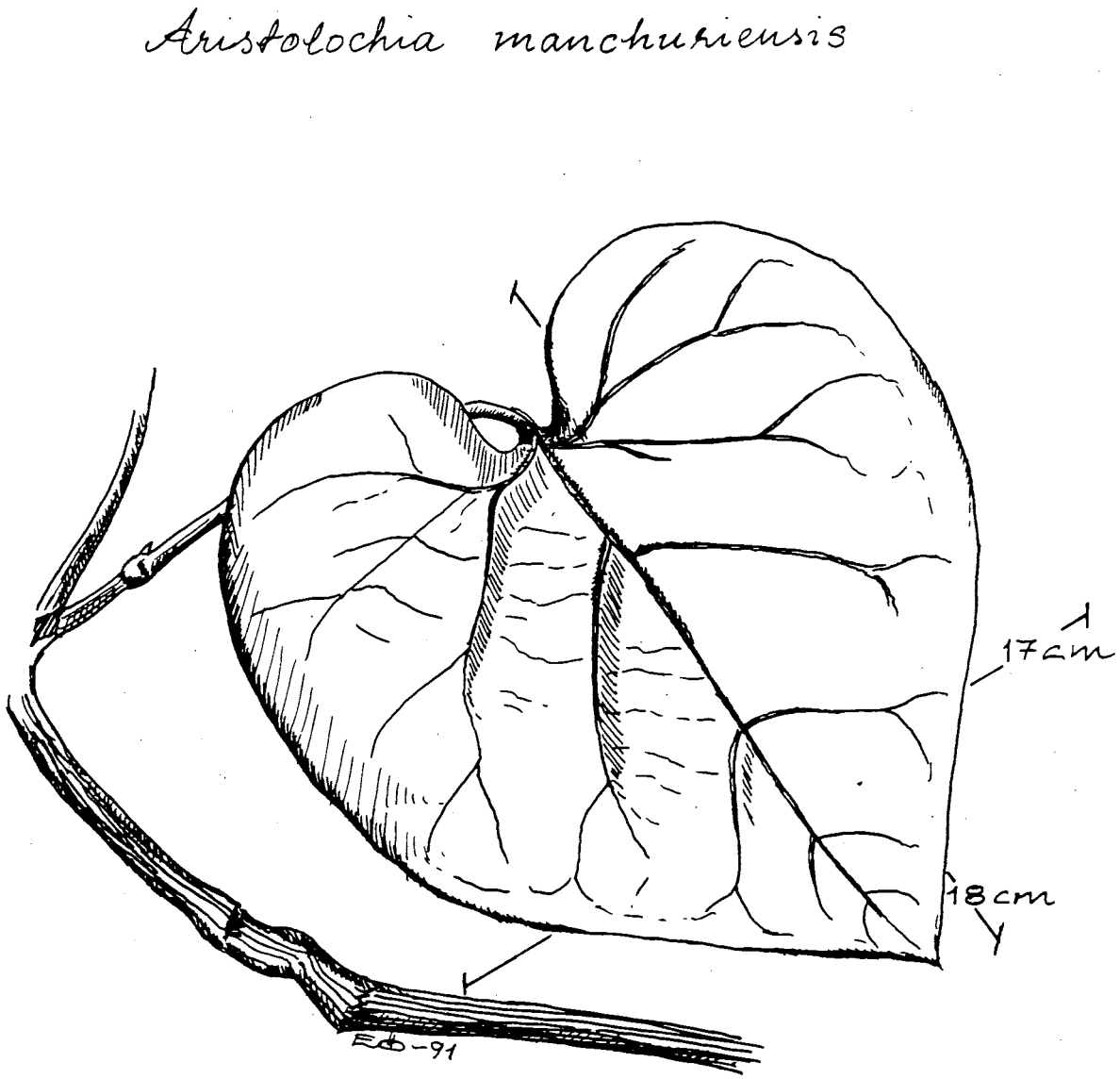


Fig. 28. *Aristolochia manchuriensis* Komar.

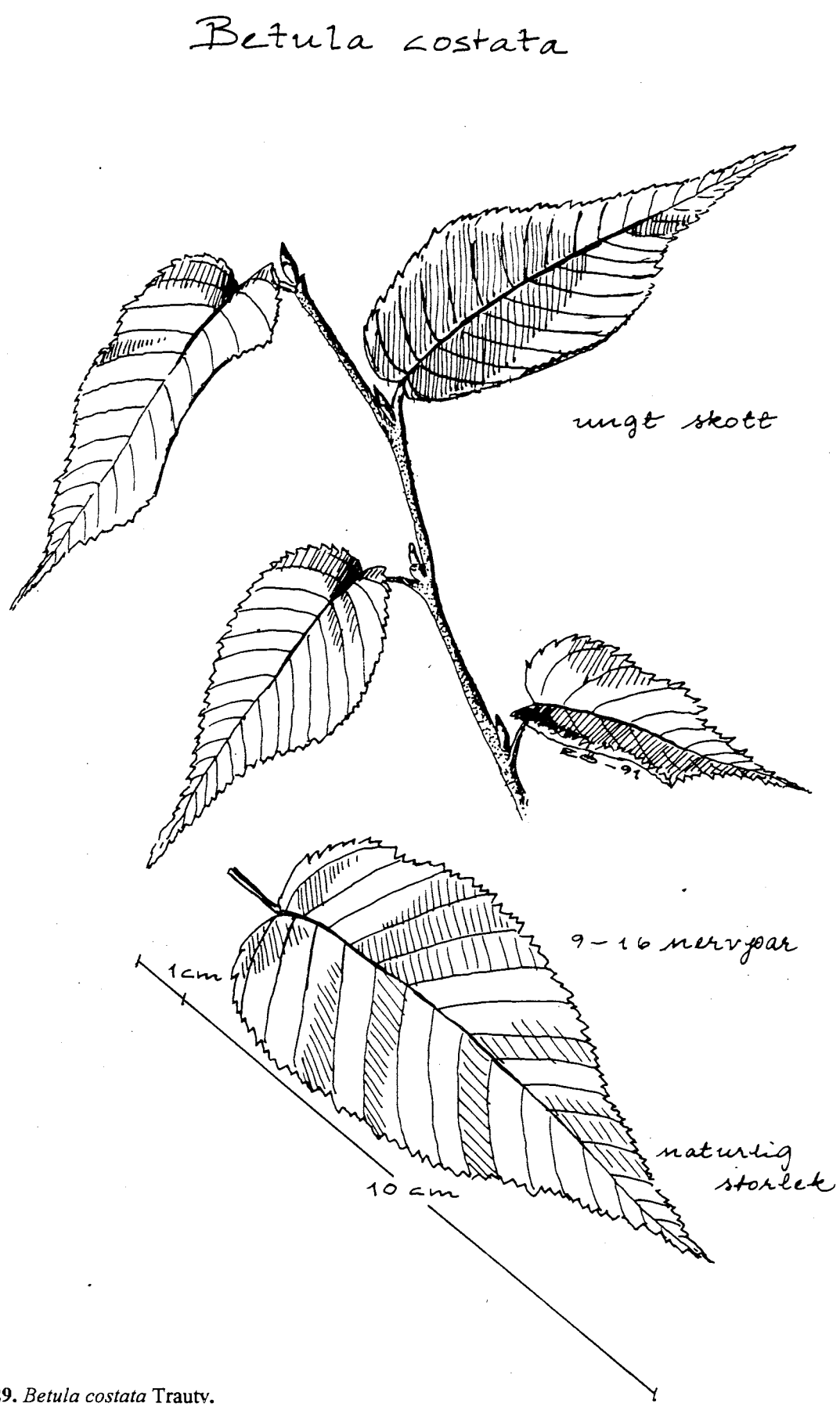


Fig. 29. *Betula costata* Trautv.

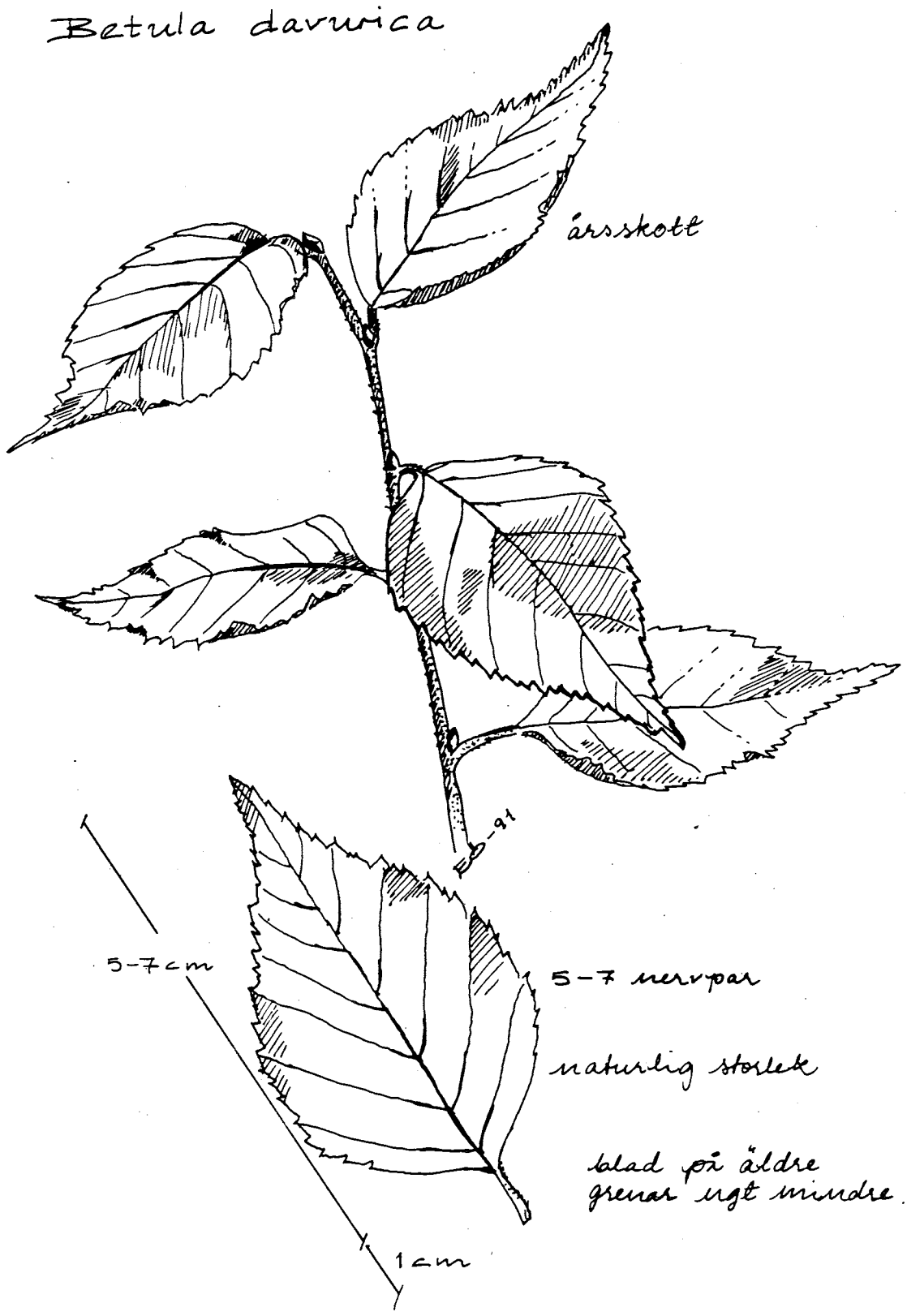


Fig. 30. *Betula davurica* Pall.

Betula ermanii Cham.

Principal species of the subalpine forest between 1700-2000m a s l at which elevation it becomes 5-10 m high (maybe higher at lower altitudes), sometimes growing together with *Larix olgensis* and *Alnus fruticosa*. The bark on old trees is grey-white, farinose, very fissured with numerous black small lenticels, peeling in paper-thin small flakes. It is very similar to *Betula tortuosa* Ledeb. (the Swedish Mountain birch). This kind of *Betula ermanii* is very different from the Japanese form we have seen in Swedish Arboreta and gardens ("Extraordinarily variable!" according to Krüssmann.). Bark on branches is white to cream-yellow. Young shoots are green-brown to brown with resin glandular warts and white lenticels, whilst one year shoots are also pubescent. Leaves are thick, dark green above, yellow-green beneath, broadly ovate to triangular with a somewhat heart-shaped base, blade-tip cuspidate, margins finely double serrate. Leaf-veins occur in 8-11 pairs with hairs on both sides and the petiole is pubescent. Buds are big, pubescent and were green, when seen in the end of August. Fig. 31.

Betula platyphylla var. **japonica** (Miq.) Hara

A slender, straight-stemmed birch to 20 m high with pure white, farinose bark. It is very similar to the *Betula verrucosa* Ehr., growing in the coastal part of northern Sweden, and does not form the characteristic cork-bark at the bottom part of the trunk. One year shoots are green-brown, densely covered with grey-blue glandular warts. Leaves are warty above and pubescent, triangular to ovate with an almost truncate base (sometimes somewhat heart-shaped), coarsely double serrate, 8 cm long and 6-7 cm broad (strong growing shoot), usually smaller on older twigs with pubescent petiole. Veins occur in 6-8 pairs. It is pronounced, early-successional species. Fig. 32.

Corylus heterophylla Fisch. ex Trautv.

A vase-shaped shrub, 3-4 m high. Growth habit resembles greatly *Corylus avellana*. Easy recognised by the leaf-shape which is broadly obovate (broadest near the tip), cut off straight to emarginate at the blade-tip, but always with a small apex in the middle. The leaf-base is cordate. Margins are coarsely, unevenly-serrate, and gives the impression of being three-lobed. All lobes are of the same size, pointing forward. Leaves are pubescent beneath. At first sight, when walking around in the area, it is easily confused with juvenile *Ulmus laciniata* (not described) whose leaf-shape greatly resembles the hazel. We did not find any nuts. Fig. 33.

Corylus sieboldiana var. **mandschurica** (Maxim. et Rupr.) Schneid.

Shrub to 4-5 m high. Leaves elliptic to broad elliptic, widest above the middle with a acuminate tip, double serrate, margins shallowly lobed. Remarkable fruits! The husk covering the nut is exceeding in a narrow tube and is pubescent with light brown, stiff, hairs. Fruits 2-3 together. Fig. 33.

Both hazelnutspecies were only found in the Mixed Forest zone.

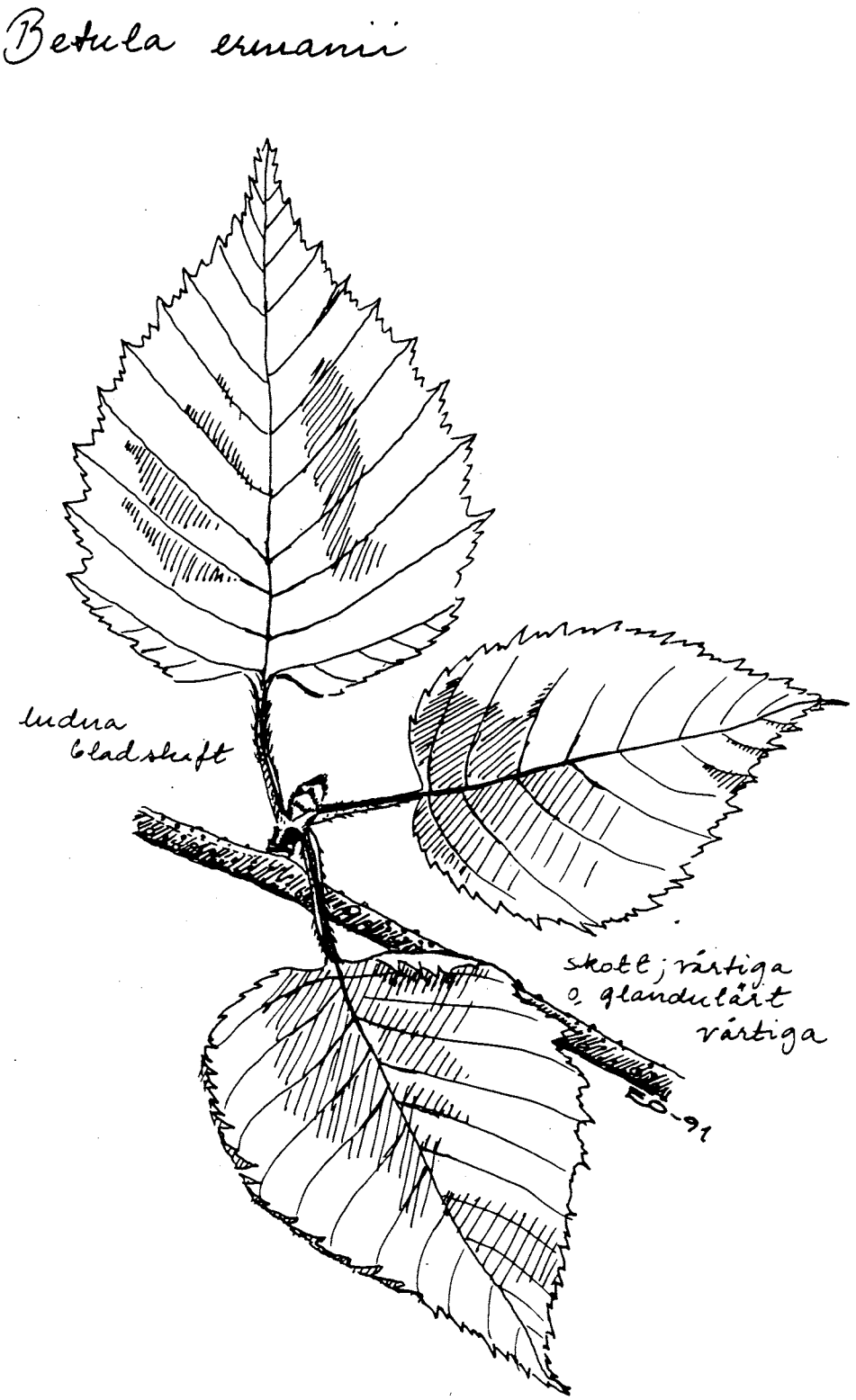


Fig. 31. *Betula ermanii* Cham.

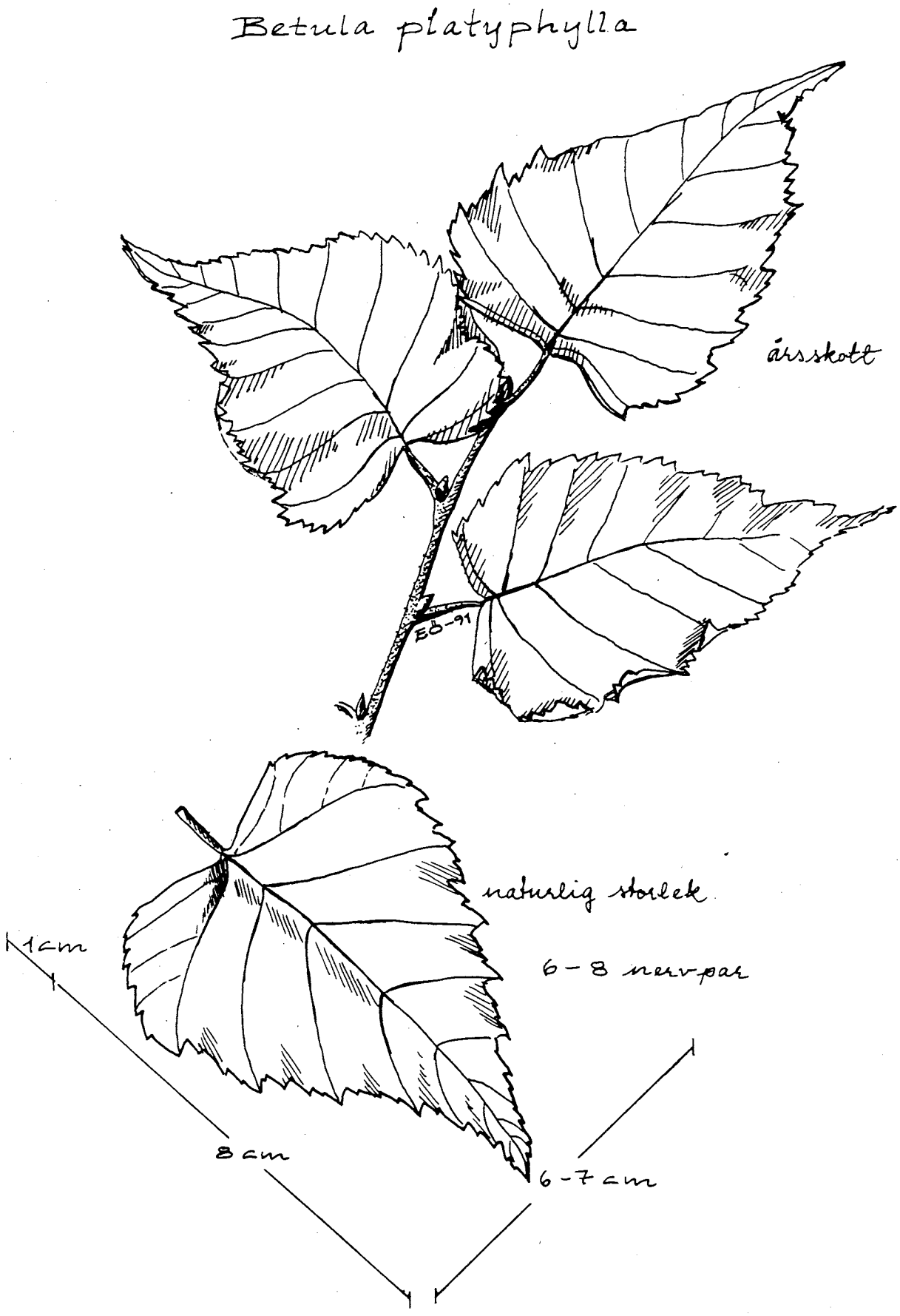


Fig. 32. *Betula platyphylla* var. *japonica* (Miq.) Hara.

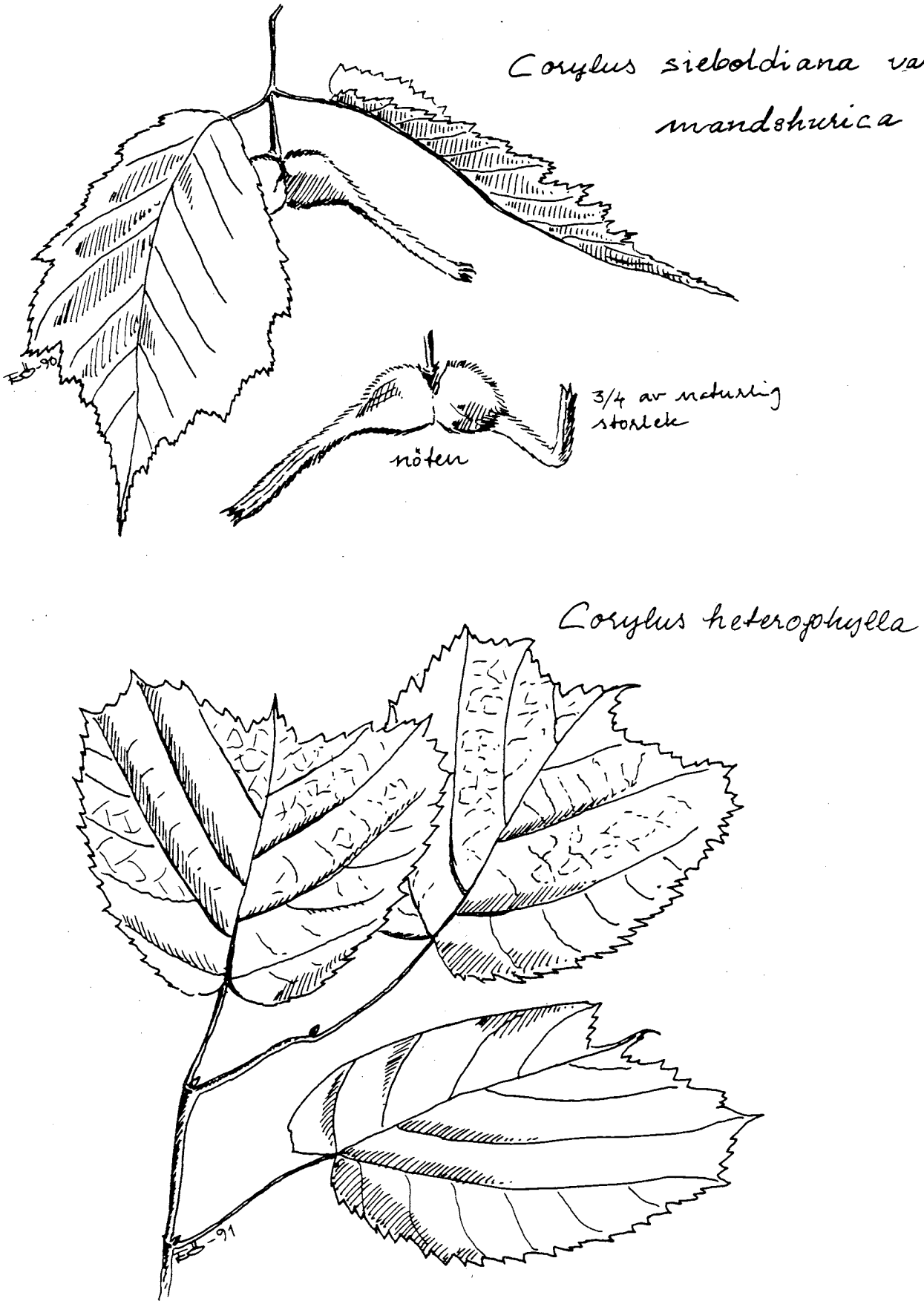


Fig. 33. *Corylus heterophylla* Fisch. ex.Trautv. (below) and *Corylus sieboldiana* var. *mandschurica* (Maxim. et Rupr.) Schneid. (above).

Fraxinus mandshurica Rupr.

A tall wide-crowned tree. We measured one specimen to be 32 m. This ash occurs in the Mixed forest zone. Old stems are regularly furrowed. Twigs are grey-green, terminal bud black-brown and glabrous. Leaves are 30-36 cm long, stiff, thick, with 9-11 stalk-less leaflets, 10-12 cm long. Leaflets are finely serrate, oblong to lanceolate with cuspidate tip, dull green above, paler beneath, somewhat pubescent on veins and midrib. The midrib has a deep groove above with red-brown hair tufts on the vein axils. Fig. 34.

Prunus maackii Rupr.

Tree to 12 m ("Tree to 10 m high" according to Krüssmann) which seems to thrive close to water and we always found it along or near to the river in the Mixed Forest Zone (actually we saw one, the only one, in the lowest part of the subalpine birch forest at 1700 m a s l). Leaves are oblong-oval, irregular finely serrate, beneath with brown glandular hair and somewhat pubescent venation. Fruits are small, round, shining black, approximately 10-15(20) grouped in irregular racemes, one specimen was extremely rich in fruit with 10-20 racemes on each twig (Krüssmann: "flowers grouped 6 - 10"). Bark on older stems is shining and peeling and we saw a great diversity of stem-colouring, varying from copper to a combination of yellow and silver-grey. Fig. 35.

Quercus mongolica Fisch.

Tree to 30 m with very straight stem. Young crowns deep pyramidal even in deep shade. Old stems are free of branches, forming a rounded and high crown. Leaves are densely clustered at the shoot tips, 17-20 cm long and 11-13 cm wide (wider above the middle), 12-15 acute teeth on each margin (but Krüssmann says: "with 7-10 broad, usually obtuse, coarse teeth", he describes on the other hand *Q. m.* var. *grosseserrata* (Japan, Sakhalin) "with leaves somewhat smaller, more acute, the teeth acute") with one vein to one tooth, auriculate at the base, pointed at the apex, dark green and glabrous above except for the light-brown pubescence on the venation, pale green with light-brown pubescence beneath. The very short petiole is also pubescent. Acorns are 1,5 cm in length, half covered by a thick cupula with scales (Krüssmann: "acorns $^1/_3$ covered by a thick cup"). Fig. 36.

Rhododendron aureum Georgi.

A 20-60 cm high ("15- 30 cm high" due to Krüssman") evergreen shrub growing between 1700-2300m a s l and forming dense mats, both under *Betula ermanii* in the subalpine forest (40-60 cm high) and on the Alpine tundra (20-30 cm high) where it grows commonly in moist parties and in stream gullies. Leaves are obovate with almost acute tip, 3-7 cm long, margins involuted, glossy dark green above and strongly net-veined, yellow-green and glabrous beneath. Petiole is brownish, somewhat pubescent. Fruit capsules are in groups of 4-5 together. Buds are thick, glutinous and pubescent with red-green scales. Fig. 37.

Rhododendron dauricum L.

Ornamental shrub with curving branches, 1-1,3m high, growing between 1250-1950m a s l. Leaves are elliptic, 1-3 cm long, aromatic, green above (beginning to get a red autumnal colour) with glandular spots, scaly beneath and paler. Shoots are somewhat pubescent and scaly. Fruit capsules are solitary. Fig. 38.

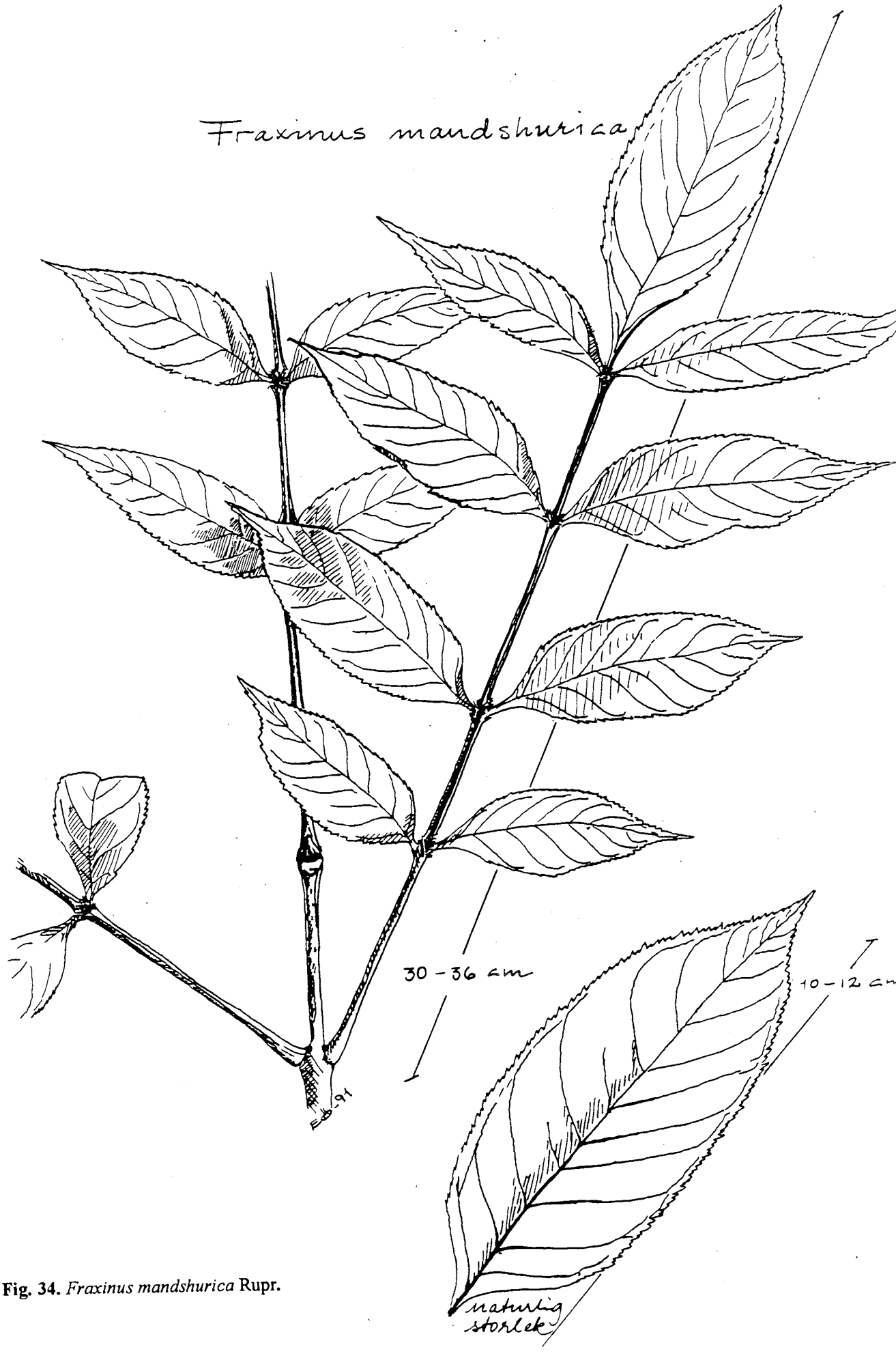


Fig. 34. *Fraxinus mandshurica* Rupr.

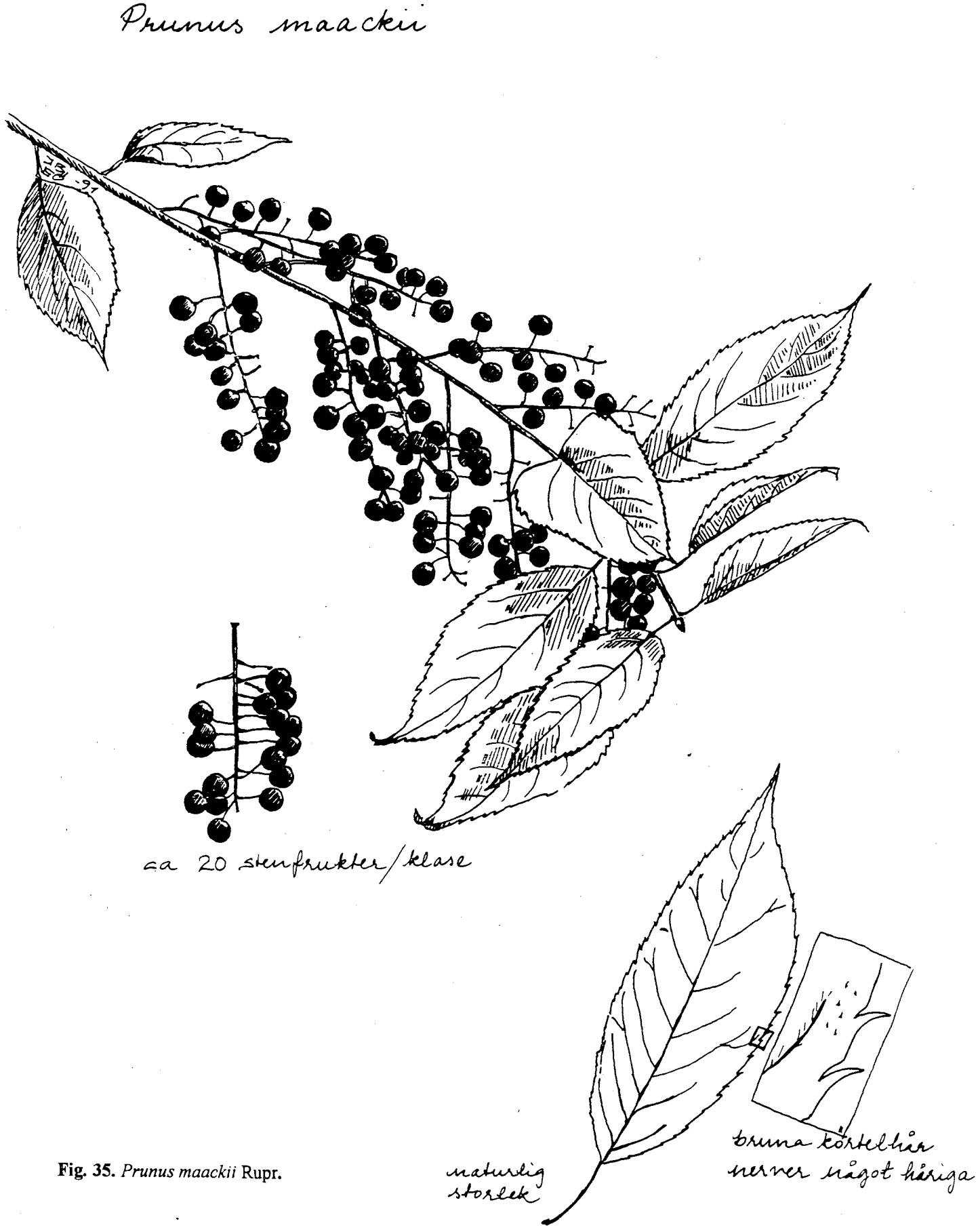


Fig. 35. *Prunus maackii* Rupr.

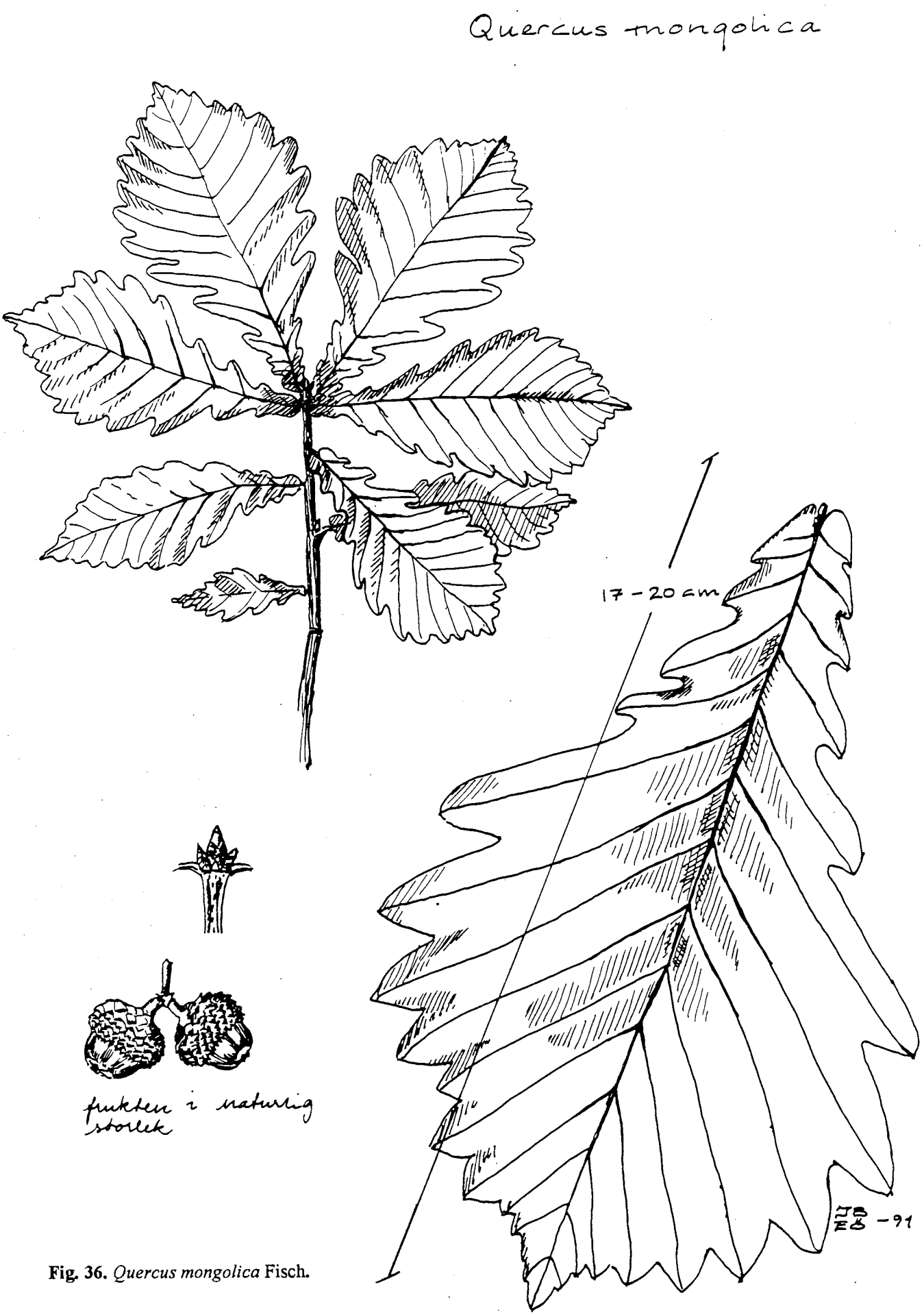


Fig. 36. *Quercus mongolica* Fisch.

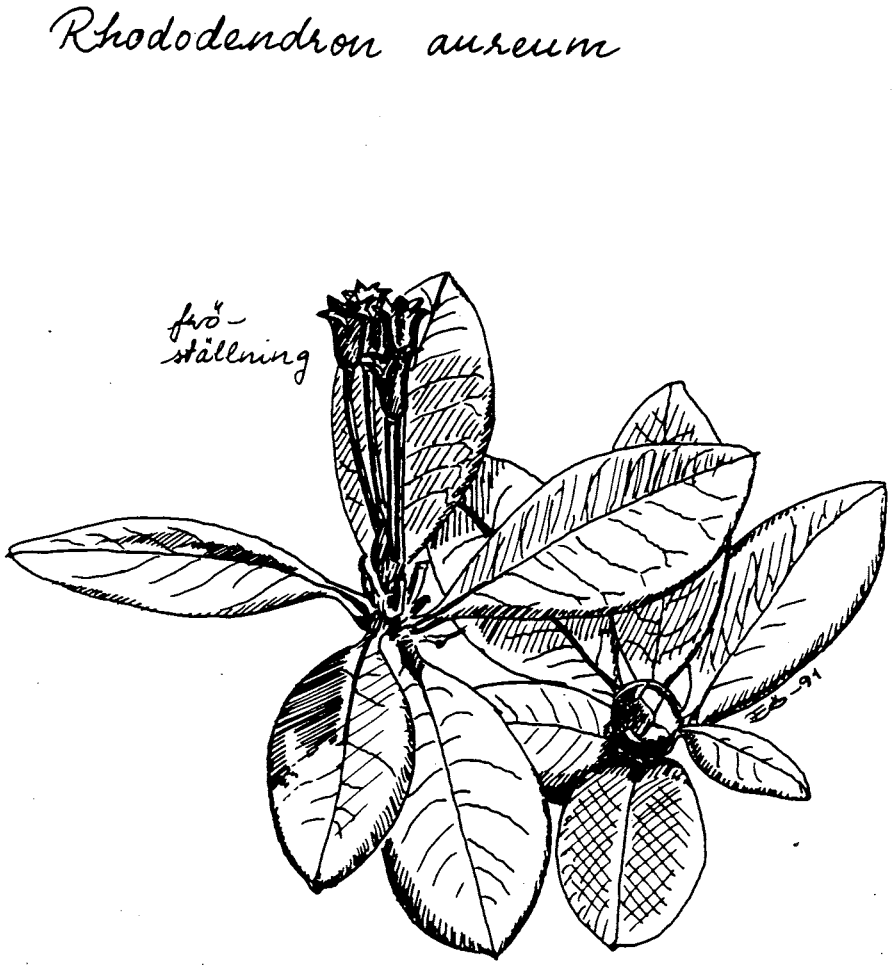


Fig. 37. *Rhododendron aureum* Georgi.

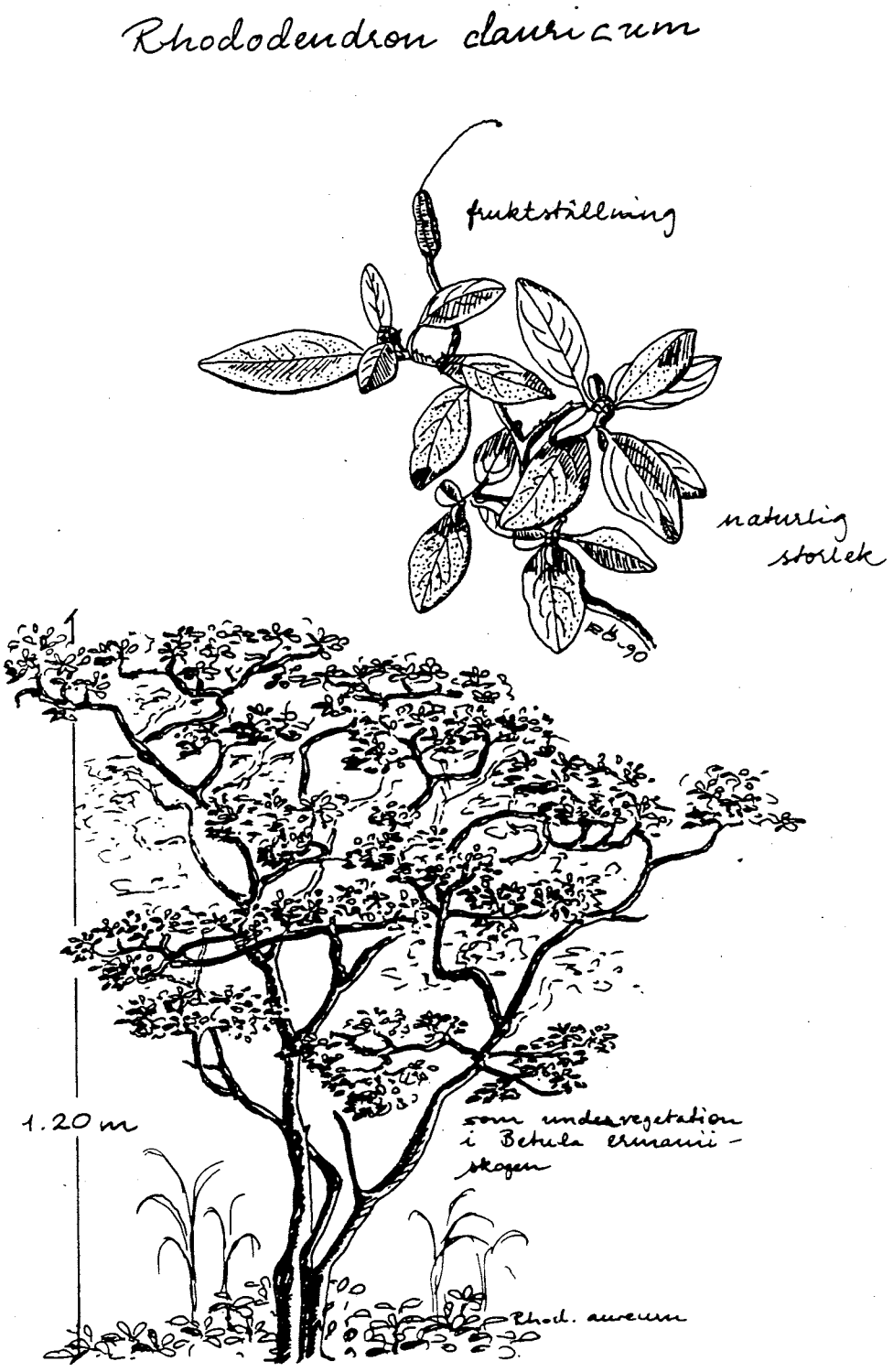


Fig. 38. *Rhododendron dauricum* L.

Rhododendron redowskianum Maxim.

A prostrate alpine shrub, 5-10cm high, forming carpets preferably on western slopes above 2300m a s l in the Alpine tundra. It sometimes grew almost directly on the rocks, often with *Dryas octopetala.* Leaves are glandular leaves, about 1,5cm long, almost oblong, but somewhat broader above the middle and with ciliate margins. Already in the beginning of September it had a bright red autumnal colour, which tinged the higher parts of the slopes with red. Seeds were sent to the Botanical garden in Gothenburg, which by now have a few plants in their rock garden. Fig. 39.

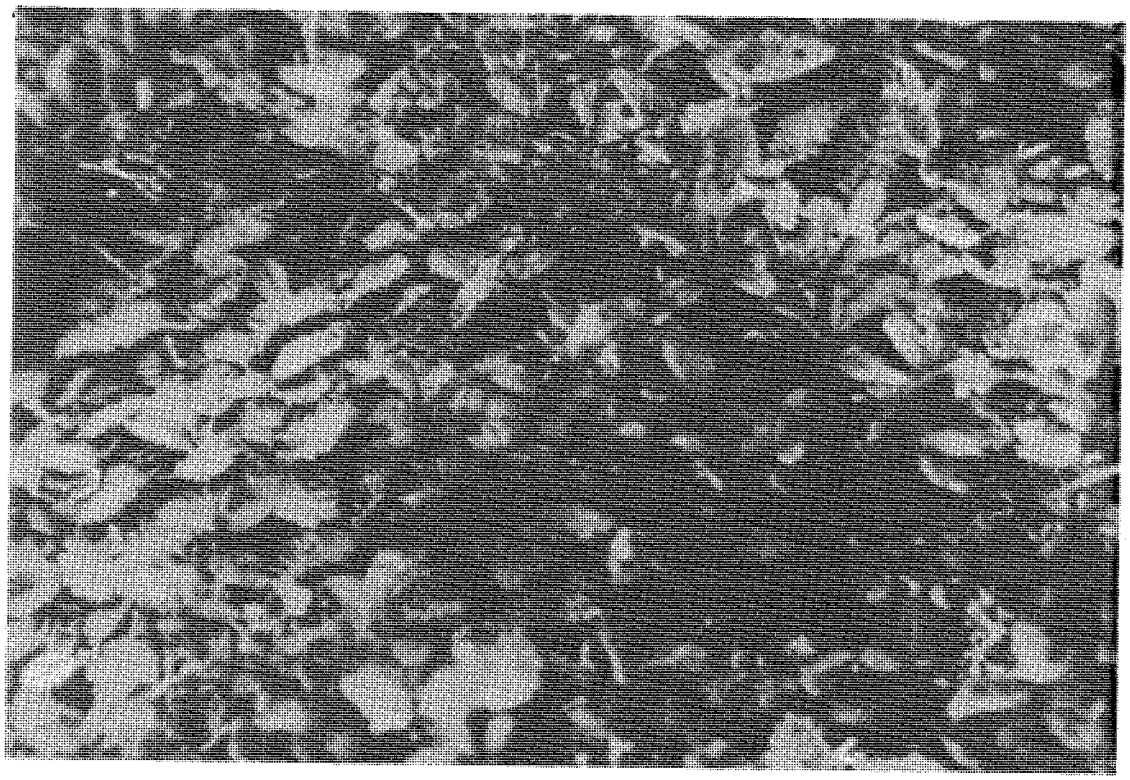


Fig. 39. *Rhododendron redowskianum* together with *Dryas octopetala* at 2300m a s l.

Rosa acicularis Lindl.

Shrub, 70-100 cm tall. Foliage is ethereal-green. Leaves are glossy above (Krüssmann: "dull green above"), paler and dull beneath (Krüssmann: "soft pubescent beneath"), leaflets 7-9 (Krüssmann: "leaflets 3-7"), single serrate, with bristles on the midrib and main vein of the leaflets. Stipules broad, entire with glandular hairs on the margins. Fruits are 2-3 cm, single, oblong, broader towards the tip (Krüssmann: "fruits rounded, pear-shaped"), almost glabrous, sparsely bristled, orange-red. Sepals are longer than the hip, densely glandular-hairy, bristled. Fruit stalk is also with bristles. One year shoots are almost thornless, red-brown in full light, but green-brown in the shade. Older twigs are red-brown, densely bristled towards the base with thin, straight, 0,5cm long prickles. Fig. 40.

Rosa acicularis f. **pubescens** (Liou) Kitag.

This subspecies is only mentioned in our Chinese reference literature. It differs from *R. acicularis* in that the petiole is both pubescent (long white hairs) and bristled. Hips are pear-shaped and densely pubescent and glandular as are the sepals and fruit-stalk. Stipules have hairy margins (no glands). It has an aromatic balmy fragrance. Fig. 40.

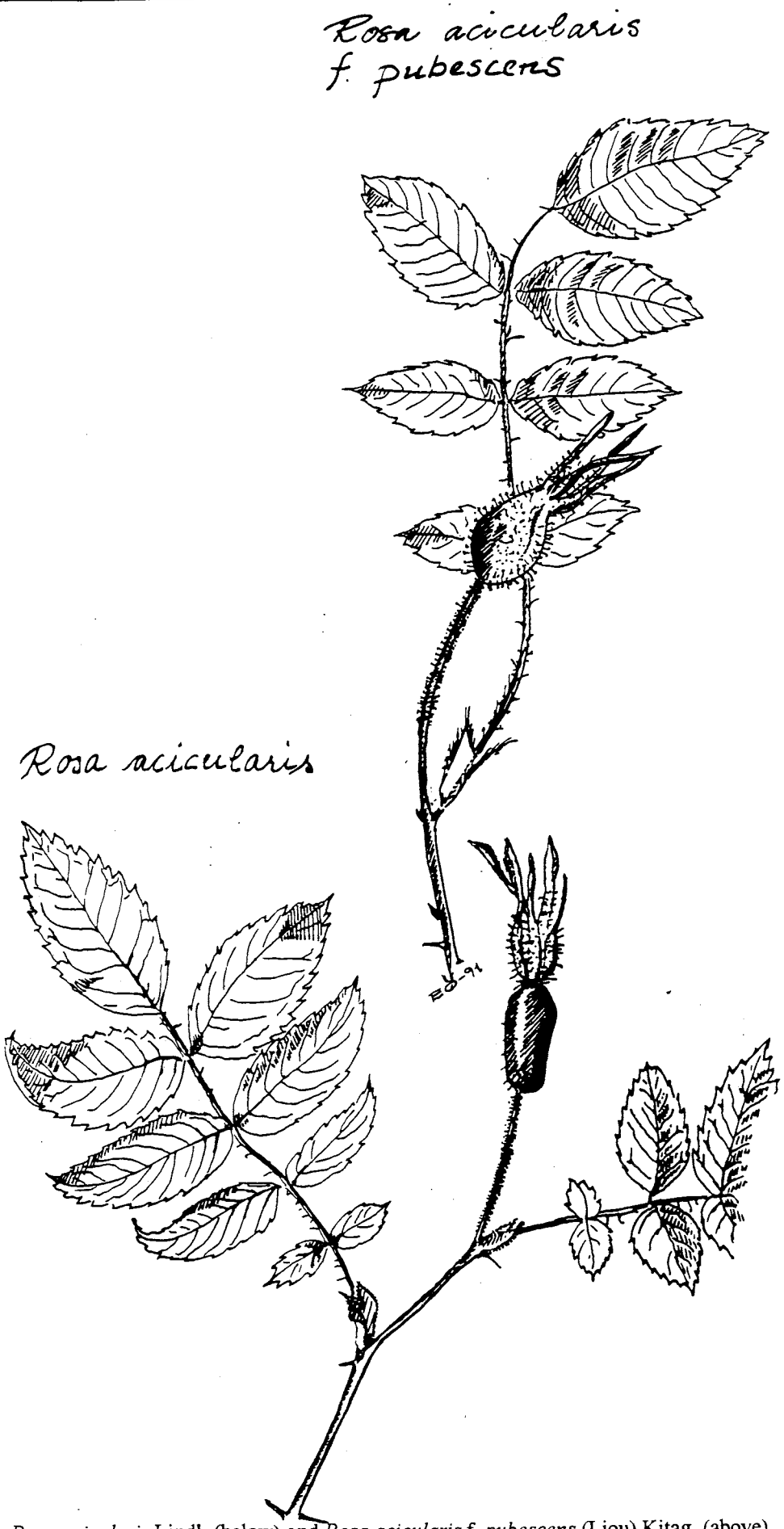


Fig. 40. *Rosa acicularis* Lindl. (below) and *Rosa acicularis* f. *pubescens* (Liou) Kitag. (above).

Rosa koreana Komar.

A 80-100 cm high, slender growing shrub, similar to *Rosa pimpinellifolia* but with an aromatic scent. Occurred between 1650-1800m a s l., growing on the steep, rocky, western slope facing the valley. Twigs are brown-red with a blue tinge, densely bristly. Leaves with 5-11 small, elliptic, finely serrate leaflets, blue-green above, paler beneath. Leafstalk and midrib somewhat bristled, red above towards the light, green beneath. Hips are small, oval-oblong, bright orange-red, glossy and very beautiful together with the blue-green-red foliage. Sepals are $^2/_3$ as long as the hip. Fruitstalk is glandular hairy. Stipules broad, with glandular margins. Fig. 41.

Rosa sp.

Shrub about 1 m high, growing on the river bank of Erdao Baihe River 740m a s l. Young branches are green, older ones are cinnamon-brown, nearly smooth, only sparsely prickled. Prickles are straight and slender, paired under the base of the leaf-stalk. Leaflets 5-(7), are oblong-oval, serrate except towards the base, glossy green and almost glabrous above, pubescent beneath. Stipules entire, quite broad and pubescent with glandular-hairy margins. Petiole with few bristles and long white hairs. Fruits are glossy orange, glabrous and narrowly elongated. Sepals are as long as the hip, thin, bristly and glandular-hairy. This species shows similarity to *Rosa davurica* except for the fruit shape which is more narrow, the stipules which are broader and ciliate, the bristly petiole and the more oval leaflets. Fig. 41.

Sambucus williamsii Hance

A large, wide shrub, about 180 cm high. It grew in the shrub layer the western slope about 100 m above *Rosa koreana* at 1900m a s l. All parts are glabrous. Foliage is dull dark-green above, lighter beneath. Leaflets, usually 5(-7), are 4-10 cm long, narrow ovate, acuminate, coarsely serrate and nearly sessile. Young branches are somewhat furrowed. Pith is light brown. Fruits are pink-red, shining, in pyramidal racemes. Fig. 42.

This species is only mentioned in our Chinese reference literature. The specimen described is very similar to *Sambucus racemosa* but the shape of the panicle is different. It is less dense and has a pyramidal, broader shape, more like that of *Sambucus sieboldiana* but that is the only similarity. The described specimen lacks the two blue rings in the pith at the nodes, typical of *Sambucus sieboldiana*, and the leaflets are fewer (5 instead of 7-11), broader and not as long.

Tilia amurensis Rupr.

Tree, 20-25m high, growing in the mixed forest of pine and broad-leaved trees (se Vegetation study). Very similar to *Tilia cordata* Mill. Leaves are rounded, coarsely serrate, heart shaped or cut of straight at the base, with acuminate tip and a somewhat oblique blade base, dark green and glabrous above, much lighter with tufts of brown hairs in the axils of the veins beneath. Stem bark is thin and scaly.

Tilia mandshurica Rupr. et Maxim

A 20 m high tree, growing in the same area as *Tilia amurensis,* often used in forestry in north east China. Leaves are broadly ovate, large (about 10cm long), heart-shaped or often oblique at blade base, green, thinly pubescent above, grey-white tomentose beneath. Leaf margins are coarsely toothed with long and acuminate teeth.

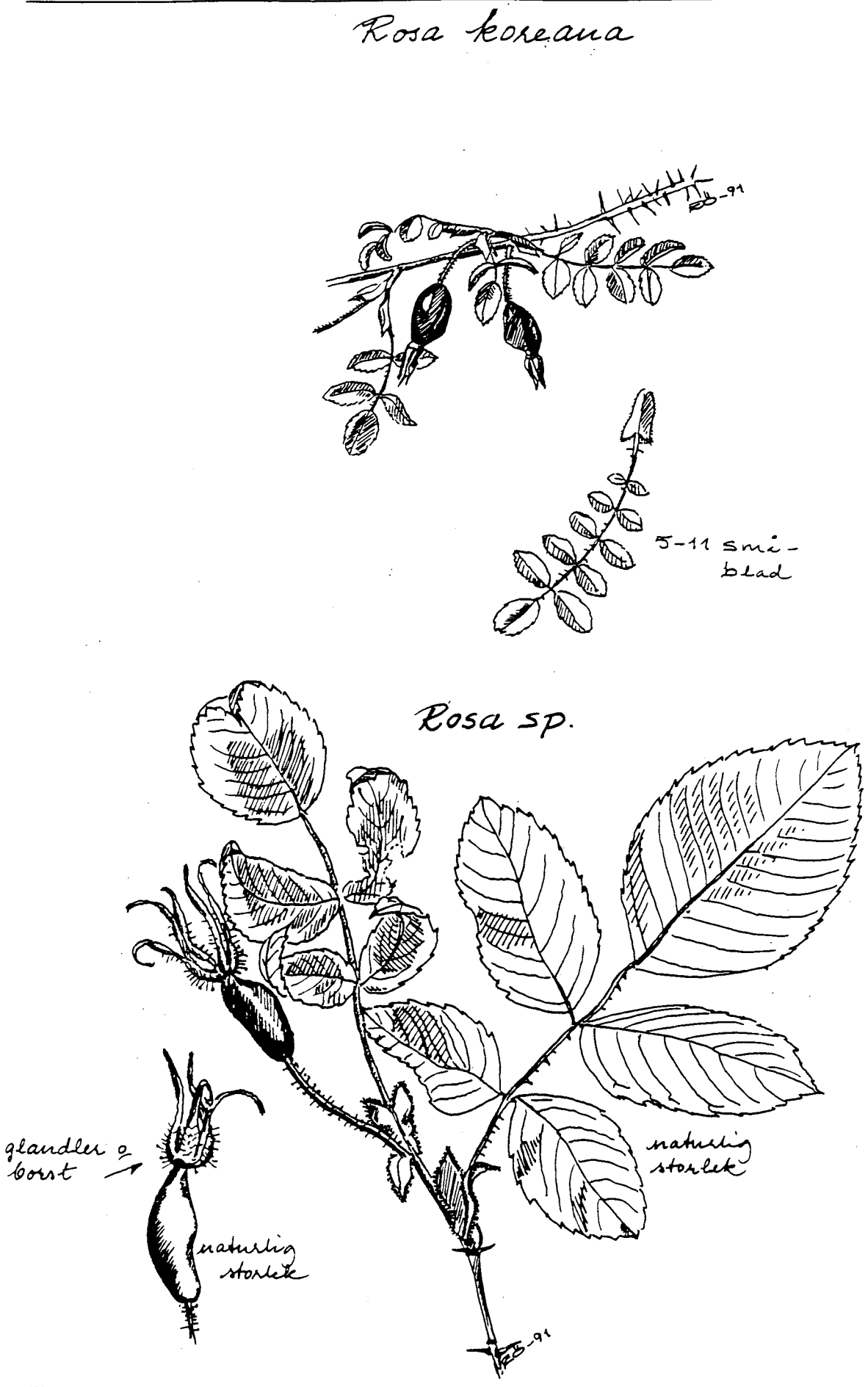


Fig. 41. *Rosa koreana* Komar. (above) and *Rosa sp.* (below).

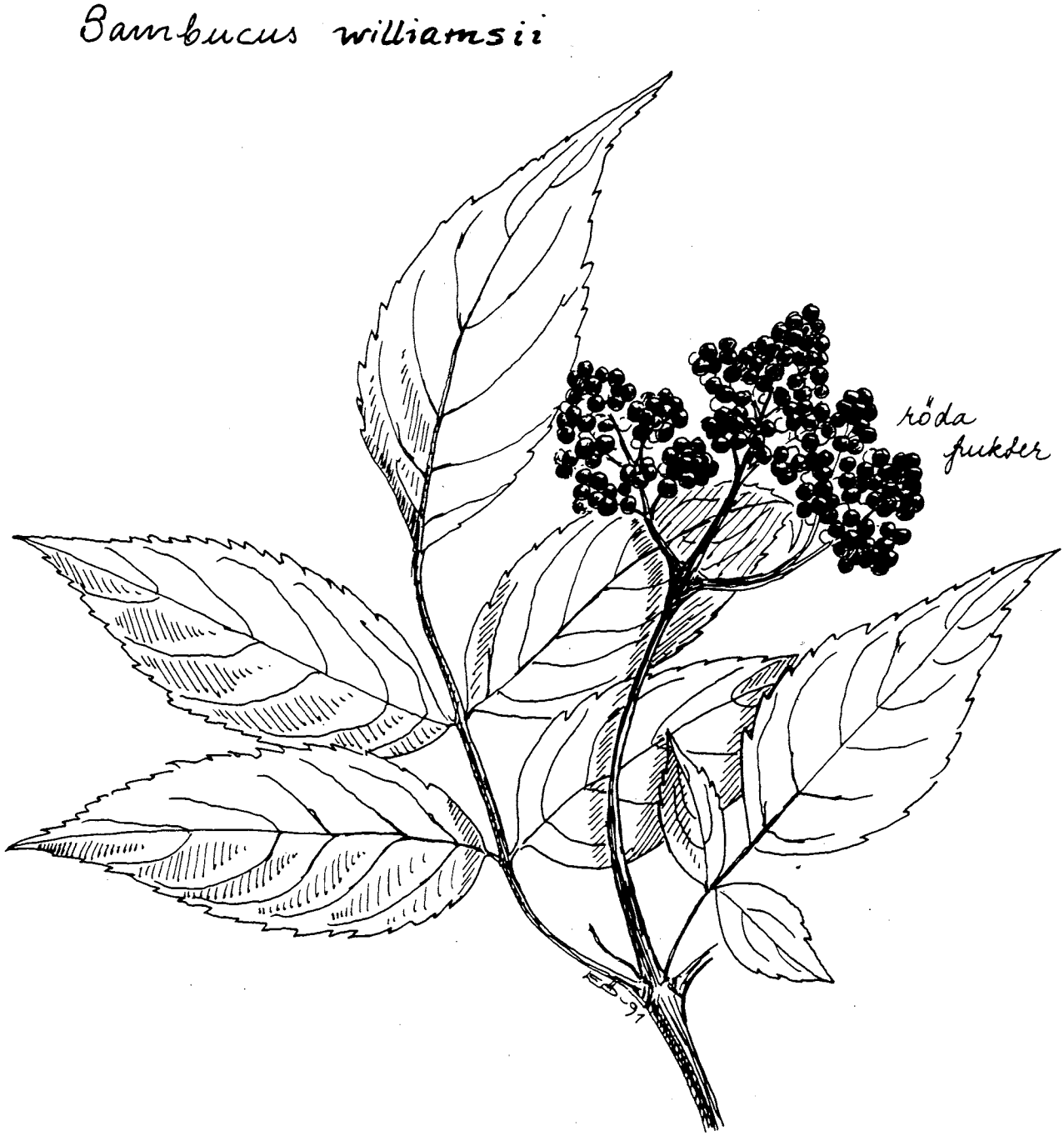
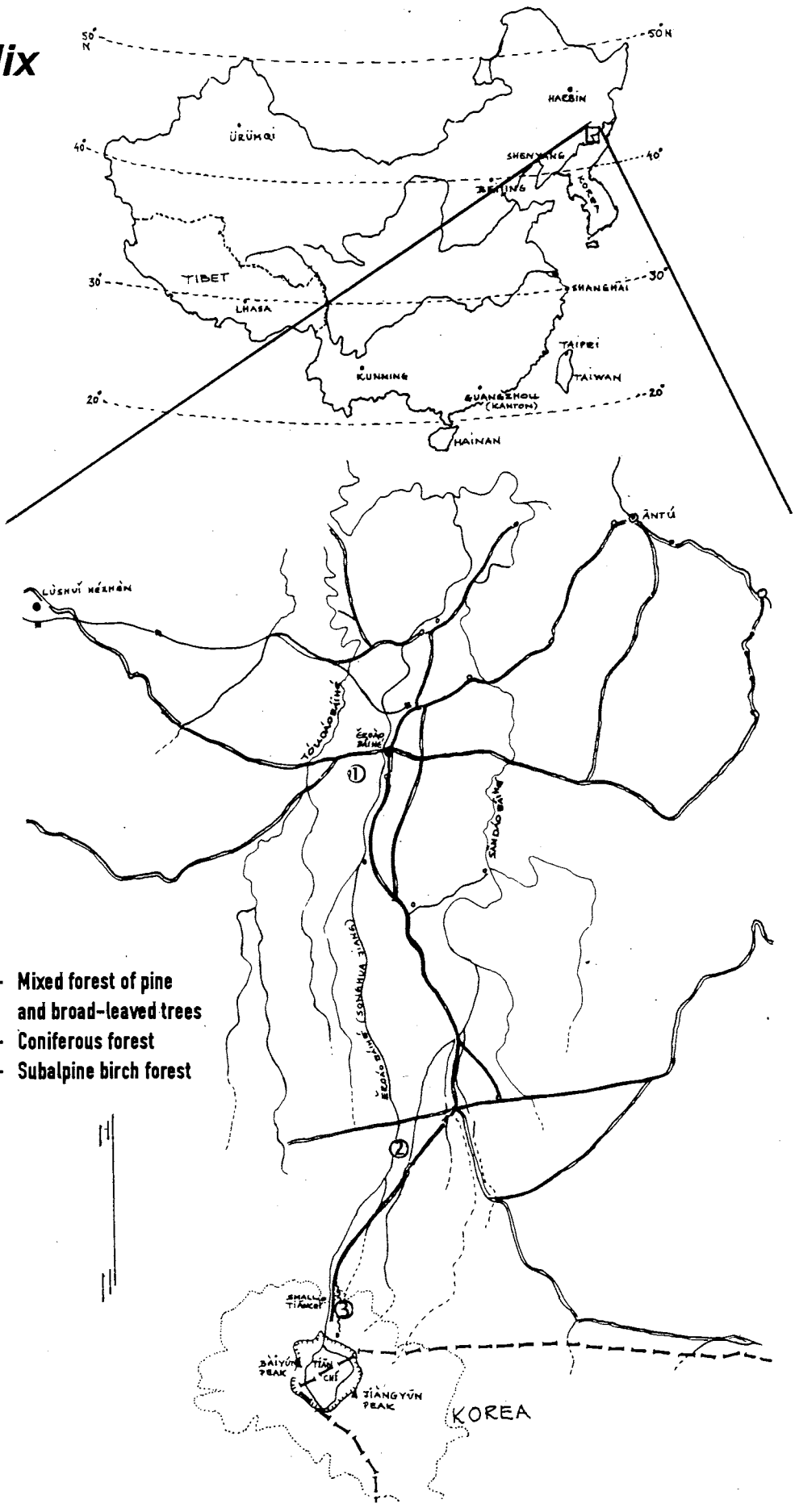


Fig. 42. *Sambucus williamsii* Hance.

Appendix

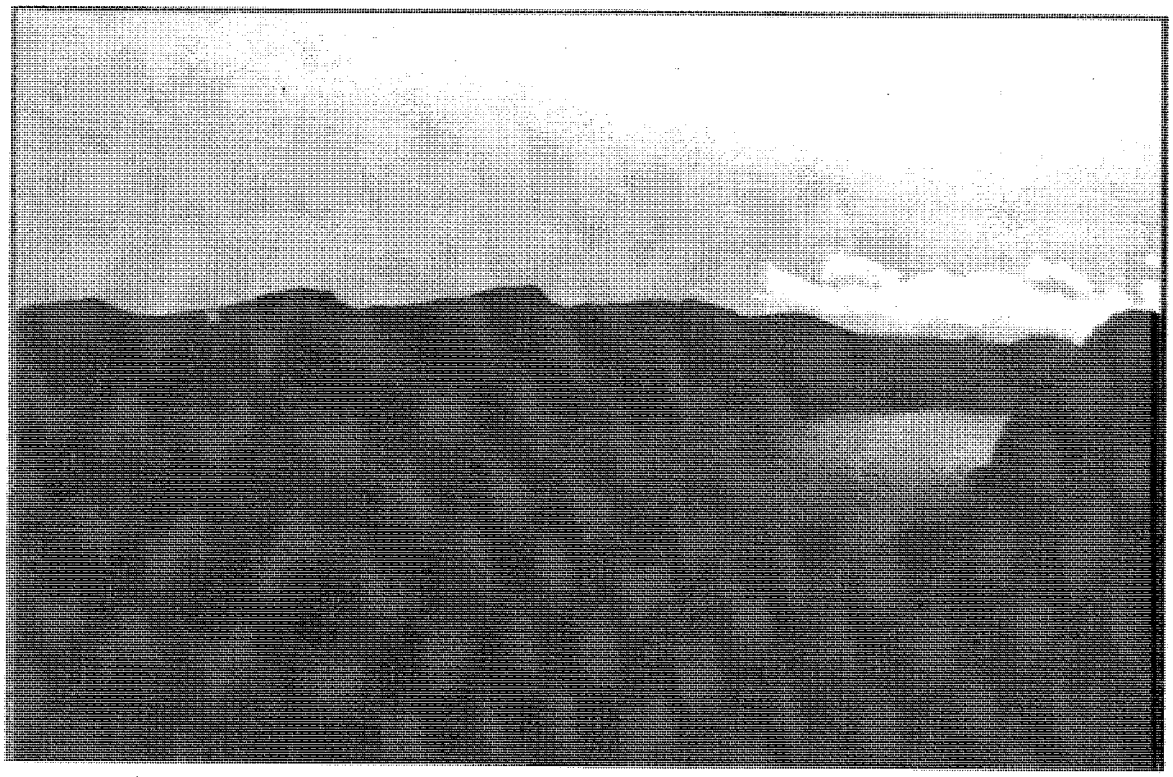


① Transect no. 1 - Mixed forest of pine and broad-leaved trees
② Transect no. 2 - Coniferous forest
③ Transect no. 3 - Subalpine birch forest

Changbai Shan - Studied area with transect locations

Changbai Shan - the mountain of the Manchu people

Changbai Shan is a mountain chain that stretches along the border between China and North-Korea in the southern part of the province of Jilin. The name means "the eternally white mountain", however, according to the story it is not referring to snow-covered peaks but to the light layer of pumice which covers the highest peak and which was visible earlier from a great distance. Nowadays the layer of pumice is covered by vegetation and for that reason the mountain no longer lives up to its name in the way it once did. The mountain chain covers an area of 8000 square kilometres, the altitude varying between 500 and 2691 m a s l. The highest peak - Baitou Shan (Korean; Baegdu San, also Baiyun in some literature) is a volcano on a large lava plateau. Inside the crater there is a lake - Tian Chi, "The heavenly lake" - which is between 200 and 350 m deep. The border between China and North-Korea runs straight through the middle of the lake. The outlet is in the northern part of the lake and forms a 68 m high waterfall. Changbai Shan and Tian Chi are famous places in China.



Tian Chi - The Heavenly lake

There is a legend which tells of three divine nymphs that descended from heaven to seek earthly pleasures. When they went for a swim in the lake an enchanted bird came and left a beautiful red Ginseng berry on top of one of the virgins' clothes. As she was getting dressed after her swim she discovered the berry. She picked it up to smell it, the berry jumped into her mouth and in the fright she swallowed it. The nymph became pregnant and gave birth to a beautiful baby boy. He was the first of the Manchu people. There is a certain degree of truth to the story in the sense that the Manchu people actually came from the Changbai Shan - area. The child founded a dynasty which eventually became so powerful that it conquered the whole of China. The Manchu emperors came to be the last Chinese dynasty (Qing).

The mountain itself lies within the large Changbai Mountain Reserve, which was established only 30 years ago, in 1960. During the cultural revolution all forestry research and nature conservation ceased - the technical staff and their assistants were scattered. The present reserve was founded in 1979 by UNESCO as one out of three "Biosphere reserves" in China. It covers an area of 190 000 hectares. The environment in the reserve is amazingly untouched. There are few signs of human activities in recent times - possibly due to the fear of volcanic eruptions. The most common reason for nature being saved and exempted from exploitation in China is otherwise due to the place in question being sacred. Changbai Shan was for a long time a sacred place to the Qing-dynasty. There was earlier a temple by the lake but it was destroyed during the cultural revolution. A rather large area was also used as a hunting park for the Qing emperor and his court.

The forest is the major resource of the area. Academia Sinica runs a research station - Changbai Mountain Research Station of Forest Ecosystem - situated in Erdao Baihe just outside the reserve. Forestry research is primarily concentrating on how to carry on a sustainable forestry in north-east China and how to restore the deforested parts of the region, where erosion is a big problem.

The flora within the reserve is extraordinarily rich, with 1477 species of phanerogams and 510 species of cryptogams distributed between 430 genera and 122 families (Tao Yan, 1987). The fauna is also well represented in the area, with approx. 50 different species of mammals, 200 species of birds and over a 1000 species of insects. However, some of these species are no longer found within the reserve. According to our sources it is more than ten years (1980) since a Manchurian tiger was seen.

History in brief

The shape of the landscape and the vegetation is a result of volcanic activities. According to historical sources the volcano in Changbai Shan has erupted four times since the 15th century; 1413, 1597, 1668 and 1702. In recent years the validity of these reports have been questioned. C14-analyses made on charred trees show that the last eruption must have taken place about 1000 years ago, i.e. some time at the end of the 10th century. This eruption destroyed the forests within a radius of 30 - 60 km from the crater (Machida H. et al., 1987). Investigations show that before the last eruption the forest had a similar structure as today. Therefore the forest of today is considered to be a climax forest (Zhao, 1987).

The first signs of human activity in the area derive from the Sushen-people that lived there approx. 3000 years ago. The Korean Bohai-dynasty 698 AD were the first to exploit the Changbai area (Tao, 1987). In the 16th century a Manchu-chief, from a valley on the fringe of the Changbai massif, appeared and laid claim to the Chinese throne. His sons eventually conquered the "Heavenly kingdom" and founded the Manchu-dynasty (Qing) which was in power from 1644 to 1911. The first Europeans to visit Changbai Shan were Jesuits who were sent out in the early 18th century by the emperor to survey the area (Lancaster, 1989).

During the realm of Bohai, people survived by hunting, fishing and cattle-keeping. On large areas, especially along the rivers, virgin land was cultivated and apart from agricultural activities they engaged in ship-building and in the production of textiles and ceramics. Wood was needed for the above mentioned activities as well as for construction and fuel. Since the population was rather small the stability of the ecosystem was never endangered. An

administrative system was introduced by the Qing-dynasty towards the end of the 19th century - the population of Manchuria increased due to a large scale emigration from the overpopulated parts of northern China. Land was brought into cultivation at a dramatic pace. All river valleys, plains and mountain slopes were transformed into agricultural land. In 1907 the four districts of Changbai had a population of approx. 200 000 people (Tao, 1987). During the 1950's Mao moved people about within China. The policy followed during the cultural revolution, plus a substantial emigration from North-Korea, have resulted in the population increasing to about five million people. That means 76 inhabitants per square kilometre out of which 52,8% are employed in agriculture. The Changbai Shan area is located in Yanbian (Chaoxian) a Korean autonomous prefecture where the majority of the population have their roots in Korea. This very dense population exposes nature to great strain and primarily for that reason the Changbai Shan Nature Reserve was established. Today an average family consumes about 7 m^3 firewood per year which means that the total annual consumption of firewood is around 2,63 million m^3. That is equivalent to 50% of the annual governmental timber production in the area. The total yearly consumption of timber outside the reserve is 21 million m^3 per year (Tao, 1987) and judging from what we could see it is to a great extent due to the cultivation of Ginseng. During the six years of cultivation the ginseng plants must be replanted once and for that purpose new land is cleared. This form of land use has in many places resulted in considerable problems with erosion since once clear-cut, the areas are rarely replanted with trees, but are incorporated in the agricultural acreage.

Alphabetic list of synonyms in chapter 2. Literature

Larix gmelinii var. *olgensis* (Henry) Ostenf. et Larsen
Populus tremula var. *davidiana* (Dode) Schneid.
Quercus acutissima Carruth.
Rhododendron parviflorum Adams.
Syringa reticulata var. *mandschurica* (Maxim.) Hara.
Ulmus japonica (Rehd.) Sarg.
Populus maximowiczii Henry.

Larix olgensis Henry
Populus davidiana Dode
Quercus serrata Sieb. et Zucc.
Rhododendron confertissimum Nakai.
Syringa amurensis Rupr.
Ulmus propinqua Koidz.
Populus ussuriensis Komar.

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