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Studies on the Accessibility of Forest and Forest Land in Sweden

Studier över skogens och skogsmarkens avsättningslägen

by

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Units of measurement

1 ha (hectare) = 10,000 m^2 = 2.47 acres
1 m^3sk (forest cubic metre) = 35.3 f^3 volume of whole trunk, incl. bark
1 m^3f (cubic metre solid volume) = 35.3 f^3 volume of round timber, excl. bark
1 Skr (Swedish crown) $\approx$ 0.193 US-dollars
1 öre = 1/100 Skr

1. Papers Discussed

In this thesis the following works, referred to in the text by the numerals I—V, are discussed:

I. *Nilsson, N.-E. & von Segebaden, G.* 1962: Undersökning rörande avsättningslägen för skog och skogsmark i Jämtlands län. (Investigation concerning the accessibility of forests and forest land in the province of Jämtland.) — Statens skogsforskningsinstitut. Medd. 51:4

II. *Janz, K., Nilsson, N.-E., von Segebaden, G.* 1963: Lövskogens avsättningsläge i Storumanområdet. Utredning rörande virkestillgångarna för en eventuell lövmassafabrik i Storuman. Kapitel 3—6. (Investigation concerning the accessibility of deciduous forests in a northern region of Sweden. Cap. 3—6.) — Skogshögskolan. Inst. för skogstaxering. Rapp. o. upps. 7.

III. *von Segebaden, G.* 1966: Skogens och skogsmarkens avsättningslägen. — Skogen och dess utveckling i Norrbottens län. Cap. 4. Luleå.

IV. *von Segebaden, G.* 1968: Virkestillgångarnas avsättningslägen. — Virkesbalanser 1967. SOU 1968: 9, Appdx B.

V. *von Segebaden, G.* 1969: Skogsbrukets avverknings- och transportkostnader i södra Sverige. — Skogsindustri i södra Sverige. SOU 1969: 21, Appdx A.

The papers referred to were written in connection with commissions carried out by the Department of Forest Survey of the Royal College of Forestry; this has influenced both their execution and presentation. This means, in part, that the original intention, of studying in depth and of refining the calculation methods within a relatively limited field, has been replaced in consequence of the successive commissions, by a more extensive treatment.

2. Statement of the Problem

2.1 The concept "accessibility"

The Swedish term "avsättningsläge" denotes the economic feasibility of exploiting the growing stock of a forest, especially in consideration of its situation relative to transport routes and places of delivery. This feasibility is determined on the one hand by the price or the value of the raw material, on the other by the cost of exploitation and transport, and in the long term, also by the cost of stand establishment and tending (*Anon.* 1935; *Streyffert & von Malortie* 1963). The German terms "wirtschaftlicher Standort" and "Absatzlage" (*Speidel* 1967, pp. 125—134) are equivalent. These terms, however, are more general. The English terms "accessibility", "accessible" and "inaccessible" often appear to refer rather to the physical approachableness than to the economic accessibility of the raw material (*Anon.* 1960 c; *Husch* 1968). From the purely technical point of view, however, it is feasible to exploit all forest stands, hence only a description of the economic accessibility is appropriate. This aspect of the term accessibility has been stressed by, amongst others, *Barbour* (1956): "Forests are often thus classified as 'accessible' and 'inaccessible'. The former group includes those forests that are sufficiently near to centers of population and well enough served by railways, rivers, or other means of transportation to make possible the marketing of forest products. The term 'accessible' is relative; a forest might be accessible for products of such high value, or low volume and weight, that they could stand a heavy transportation cost, but nonaccessible for bulkier and less valuable forest products. Moreover, accessibility changes with the development of transportation facilities, the growth of population, the depletion of the forests, and an increased demand for products." (See also *Rostlund* 1956; *Anon.* 1965 b, pp. 75—77 and 107—109.) Accordingly, in this report the term "accessibility" is used in the meaning of the Swedish term "avsättningsläge".

It is customary to simplify the assumptions by regarding the price or the value of the timber as fixed. The accessibility is then decided solely on the basis of the costs (*Anon.* 1940 & 1949; *Petterson* 1963; *Streyffert & von Malortie* 1963).

2.2 Problems in which accessibility is relevant

Those problems in which the accessibility of the growing stock is relevant may be classified into the following three types, namely questions concerning

a) the intensity of forestry,
b) the prospective supply of timber,
c) the valuation of forest and forest land.

Questions of intensity may concern not only forestry in its entirety (*Hagner* 1967; *Speidel* 1967), but also its constituent parts, e. g. regeneration measures (*Anon.* 1966 a) and forest inventory (*Anon.* 1958 a). Where the prospective supply of timber is concerned, it is often a question of reducing a gross potential cut[1] in respect of that part which may not be economically accessible (*Anon.* 1919, 1968 a, pp. 34—35 & 1969 a). Forest and forest land are valued e. g. on the exchange, purchase and sale of real estate, and for taxation purposes (*Anon.* 1949). Forest valuation may, however, be also involved in the analysis of problems of intensity. As an example of the latter may be mentioned the system of marginal cost calculations, worked out at Svenska Cellulosa AB (SCA) for the economic control of silvicultural measures, in which accessibility (equivalent to "harvesting cost") is an included variable (*Hagner* 1969; *von Heideken* 1969). Furthermore, questions, for instance of labour requirement and the effect on employment, which simultaneously affect several aspects of the problem, may occur (*Anon.* 1966 c, pp. 118—121).

In papers I—V discussed here, only problems of types a and b have been considered.

Paper I. This study was initiated by a committee appointed in 1960 by the county administration of Jämtland[2], to investigate means of better utilising the forest resources of the county. The aim of the study is primarily to elucidate the effects of the proposals presented by the committee for an extension of the forest road network (*Anon.* 1962).

Paper II is part of the report of an enquiry begun in 1961 by the then Forest Research Institute of Sweden, by order of the Crown. The task of the enquiry was to investigate the resources of pulpwood suitable for, and accessible to, exploitation for supplying a planned hardwood pulp mill at Storuman in inner Norrland.

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[1] For the definition of the concept "potential cut", see section 5.2.
[2] For the geographical divisions employed, see Appdx C.

Paper III, reporting an enquiry which began early in 1964, is part of a study commissioned by the county forestry board in Norrbotten (*Anon.* 1966 c). The aim of this study was to provide the basis for a working programme for the exploitation and tending of the forest resources of the county. This was to be part of a more extensive enquiry into measures for promoting the economic development of the county (*Anon.* 1966 b). In project III questions both of the profitability of a planned extension of the forest road network, and of the economic accessibility of the growing stock, were primarily to be elucidated.

Paper IV. The work discussed here began in autumn 1964 and was part of a commission to the Royal College of Forestry to prepare for a government expert committee a statement of the potential forest resources and their economic accessibility. The committee had the task—as one of various studies of the structural problems of forestry and the forest industries—of drawing up balance sheets for the forest resources of the country, in which the felling possibility for various alternative silvicultural programmes was to be shown in relation e. g. to the raw material requirements of the processing industries for an expected capacity (*Anon.* 1968 a).

Paper V, the work on which began in 1967, was in connection with an enquiry into developmental trends in, and prerequisites for the establishment of, saw mills and pulp mills in southern Sweden (*Anon.* 1969 d). The aim of the work is to compare northern with southern Sweden in respect of the exploitation and transport costs of timber, and to discover how transport costs are affected by the re-structuring of the pulp and board industries in southern Sweden, as outlined by the report for the period 1970—1980.

3. Methods

3.1 General

Forest inventories should provide adequate data as a basis for the long term planning of forestry and forest industries. When designing forest inventories the problem of the accessibility, however, has been very much neglected. Owing to lack of feasible methods the accessibility of the forests is sometimes not described at all in the inventory reports (no reference is made) or is only described very broadly. In the latter case the forests are classified into only two classes, "accessible" and "inaccessible", which often are not more exactly defined (e.g. *Anon.* 1958 a & 1965 b), or into a few variously defined situation zones (e.g. *Anon.* 1940).

In 1954 "logging factors" which describe the operational conditions of the forests were introduced as part of the Norwegian National Forest Inventory (*Samset* 1957). The methods to be discussed below may be considered as a further development of this principal approach, but with the given restriction that for economy of time and cost the inventory data already available should be used and the additional field work, if any, should be kept to a minimum.

The methods of study employed imply in principle that the sample material concerning site, stand and tree characters, assembled from sample plots by the National Forest Survey, is subsequently complemented with information concerning the location of the sample plots in various respects, such as their distance from a motor road, floatway, settlement and the coast. This complementary information is obtained from maps.

On the basis of this information about the stand and tree characteristics and the location of the individual sample plots, costs are calculated for the exploitation and transport of the timber, for different methods of transport and delivery.

The method is most fully described in papers I and II (see also *von Segebaden* 1964 a & 1967).

3.2 Collection of data

Inventory information. Since 1953, the whole country has been covered each year by a low-percentage inventory, consisting in enumeration along the sides of systematically laid out squares, the "inventory tracts". These are laid out for any one year's survey in an approximately rectangular network with the spacing 22×25 km in northernmost and 10×12 km in southernmost Sweden. At each subsequent year's inventory, the network for that year is moved in a direction parallel with its original position so that the tracts are as evenly distributed as possible. A ten-year cycle is used, implying that the network returns to its original position every tenth year (Fig. 1).

On each edge of the tract, four circular sample plots are laid out—in southernmost Sweden, seven—on which site, stand and tree characters are recorded. Every hundredth metre along the edge of the tract, "stump inventory" plots are laid out, for estimating the felling removal

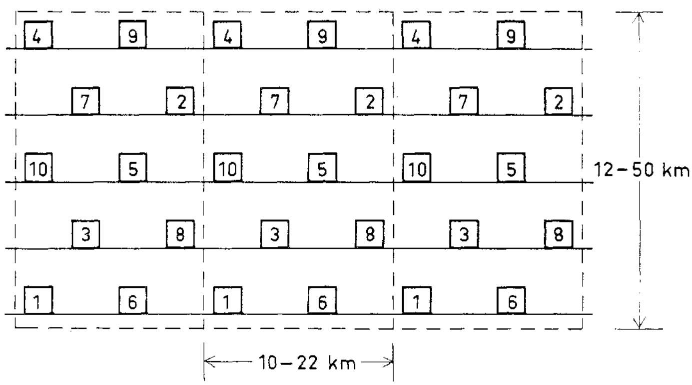

Fig. 1. The layout of the inventory tracts.

Thin full line	— "Survey line" at the second National Forest Survey (1938—1952), now replaced by "tracts" located along the former line
Thick full line	— "Tract"
Dashed line	— Boundary of "survey area" with one tract surveyed per year

Tract with figure 1 is surveyed in year 1 and 11, with figure 2 in year 2 and 12, a.s.o.

in the past felling season (Fig. 2). These plots are also circular, and are laid out in pairs with 20 metres between centres.

The sample plots have an area of only ca 140 m^2 (radius 6.64 m), which is of advantage as regards the attainment of precision in enumeration. However, the plots are often too small to be suitable for describing characteristics such as site quality class, stand age and stock density. For the description of such characteristics, a sample plot about ten times larger (radius 20 m and having the same centre) is used.

In accordance with the system for classifying different inventory methods, given by *Loetsch & Haller* (1964), the design of the Swedish National Forest Survey is described as "a lay-out of sampling units in clusters as a two-stage or multi-stage sampling".—For a more detailed presentation of the design and execution of the Swedish forest survey, see *Hagberg* (1957) and the field instructions for e. g., the year 1969 (*Anon.* 1969 b).

Information about location. Data concerning the situation of the sample plots in various respects are obtained from maps. This work has mostly been done under the supervision of the staff of the county forestry boards, and in consultation with local representatives of various forest owner groups.

The number of sample plots in the investigations is very large. To

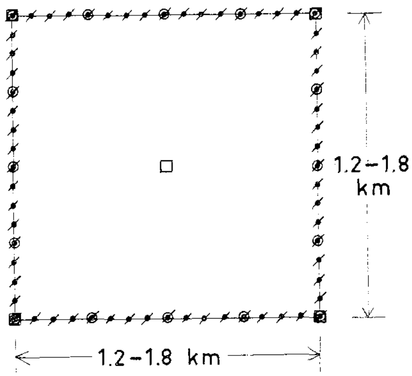

Fig. 2. An inventory tract.

○ Sample plot for tree counting, and for measuring basal area, radial increment, etc. (16 or—in southernmost Sweden—28 plots per tract)
➘ Sample plot for stump enumeration (1 "double plot" per 100 m)
□ Point for measuring distances to waterway, road, etc. (5 points or—when measuring only from the tract centre—1 point per tract)

reduce the amount of work involved, measurements were not made for every sample plot, but only for the centre or corners of the inventory tract, on the basis of which all sample plots in that tract, or those closest to the point of measurement, are assigned the value for that point. (In paper IV, for instance, the number of tracts was 4,100 and the number of sample plots on forest land 39,700.)

The precision of this procedure was investigated for project I by a pilot study. On a map containing in all 24 tracts (with the side 1.8 km), the shortest straight-line distance to a permanent road was measured, both for each of the 16 plots and for the centre point of each tract. The distances for the plots ranged from 0.0 to 6.8 km with the average 1.96 km. The standard deviation of the individual sample plots' distance from the distance of the tract centre to the road in any one tract was 0.65 km, while the standard deviation for the four sample plots which were assigned the values for the tract corners was 0.34 km. The corresponding maximum error was 1.3 and 0.9 km, respectively (cf. Fig. 2). The errors can be considered as small in comparison with the actual distances. For the influence of these errors on the cost calculations, see section 4.3.

On the basis of this discussion all measurements concerning the extraction distance have been taken from the tract corners, and the other recordings (lorry transport distance to floatway and coast, etc.) from the centre. In project V, however, all measurements for southern Sweden were taken from the centre, for economy of time and cost.

As a rule, the information about situation has been recorded for various degrees of development of the permanent road network. For instance, in paper II, three different degrees of development are considered:

(1) the present extent of permanent roads and winter lorry haulage roads,

(2) the calculated degree of expansion after five years, according to current plans,

(3) a schematic "ideal" road network which may be taken as corresponding to the expansion attained in 10—15 years' time.

For northern Sweden—where there was a choice of method of extraction and transport, e.g. extraction to floatway followed by floating, or extraction to motor road and subsequent lorry transport—that transport combination was chosen which gave the lowest total cost. The choice was made manually from information about distance and cost. To facilitate this work, tables were prepared (see Appdx A, which gives the instructions used in papers III and IV for classifying the inventory tracts). The choice may with advantage be made not manually, but by computer, although in that case further information about distance must be recorded.

The possibility of also considering rail transport of timber was studied during the planning of projects III and IV. This means of transport had, however, to be excluded, because of the difficulty of obtaining at that time adequate information about freight charges, and because the terminal problem cannot be treated in general terms in rail transport.—It should be noted that until a few years ago rail transport of timber was not very common in Sweden.

Cost information. In paper I, which deals with the costs for certain "type trees", the *felling cost* is calculated from information obtained from work study about the relative time requirement for felling trees of various diameters and different species (*Anon.* 1959 a; *Kilander* 1961). The cost level is then determined with the aid of the current forestry wage agreement for the area (*Anon.* 1960 a). Information as to the felling cost for the type trees could not be obtained directly from the wage agreement, since this was not designed to express the true cost relations in the felling and primary conversion of individual trees, but was intended to represent the average for a specified stand type and for primary conversion according to defined principles.

In paper II the cost calculation refers to the felling of hardwoods in different access situations relative to a proposed pulp mill. On the basis of information from a special estimate by the National Forest Survey of the outturn of hardwood in various types of stand ripe for felling, the felling cost could in this case be obtained from the forestry wage agreement. With the guidance of other available statistics, however, the costs were differentiated for various geographical zones beyond those given in the agreement.

The calculation of the exploitation costs in papers III—V is related directly to a calculation of the potential cut made at the same time. The functions for the time requirement per tree in felling work under various conditions (*Järvholm & Kilander* 1964) are used as a basis for the felling costs. These functions are based on work study material and apply primarily to felling methods and output levels for the years 1961—1962. The functions were adjusted for the present author's purpose to relate approximately to conditions in large-scale forestry in Norrland in 1964, at the same time as the influence of snow depth on the time requirement was being separately treated (*Ager* 1965 a & b).

The partial function for de-branching during the snow-free period is given below, as an example of the time functions:

$$t_2 = K \cdot F\ (0.300 + 0.012\ D)$$

where

t_2 is the effective time[1] requirement, minutes per tree
D is the tree diameter o. b. at breast height, cm
K is the de-branched merchantable length of the tree, m
F is the degree of de-branching difficulty (in five classes, with limits 0.75 in the class "easy" and 1.35 in the class "difficult").

For further information about the functions, see paper III (p. 59).

The rate per effective minute in felling is calculated with the guidance of statistics concerning the length of the working day and the average earnings of fellers, as recorded by the Logging Research Foundation (Forskningsstiftelsen SDA) and the Society of Forestry Employers (Föreningen Skogsbrukets Arbetsgivare).

The cost for extraction is obtained in papers I and II via the wage agreement for horse extraction and from the price lists for lorry transport of timber. From these a basic cost series is constructed which for short distances considers only horse extraction and for longer distances, horse extraction in combination with lorry transport (see I, Fig. 3) or horse extraction combined with tractor and lorry transport (paper II). The grounds for differentiating the basic costs for various extraction conditions are obtained from wage agreements

[1] By "effective time" is meant in Nordic forestry work study terminology "that time required for a specified work element in the actual performance of the task" (*Anon.* 1963b).

and price lists as well as the results of work study (*Bengtsson* 1959).

In papers III—V, in which all extraction is considered to be by means of one-man tractors equipped with grapple loaders, the cost for extraction is calculated—as is that for felling—via a time function (*Järvholm & Kilander* 1964; see III, p. 64). For the total time requirement a basic curve is constructed, to apply for certain terrain conditions and a specified density of cut. The curve is fitted to lie at a level of production per day equivalent to that given by available statistics for large-scale forestry, collected by the Society of Forestry Employers. For other terrain conditions and densities, adjustments are made relative to the basic curve with the help of information from the paper by *Järvholm & Kilander* (1964). The rate per effective minute for the tractor driver is obtained from the available statistics, while that for the tractor unit is based on a machinery cost calculation.

To the costs for felling and extraction a supplement is added for the daily movement of the labour force between home and place of work, the travel allowance for commuting, the size of which is obtained from the wage agreement (see III, p. 102). A more detailed analysis of the work and service travelling of forest workers at the time when projects III and IV were carried out is given by *Bendz & Yttermyr* (1966).

The cost for timber transport by lorry is based throughout on price lists and available statistics.

Floating costs for softwood are calculated as the mean of four or five years' costs debited to the floating associations. In papers III and IV a special supplement is made to this for the cost of preparing and breaking up log landings. In the above-mentioned papers, only those floating districts considered by local experts to be likely to be used during the next four to five years were included.

In papers I and II the so-called *indirect felling costs* are also considered, i. e. the costs for haulage roads, workers' huts, supervision, etc., which are added to the direct costs for felling and extraction in the form of a fixed percentage supplement, 25 per cent in paper I and 35—40 per cent in paper II. The magnitude of this was decided in the light of the conception of the level of indirect costs which is applied, for instance, in connection with the re-allocation of land (*Lundberg* 1958).

Since there are objections to the use of such fixed percentage supplements for these types of cost, as for instance, their dependence on the size of the treatment units and the intensity of forestry (*Staaf* 1955; *Anon.* 1963 d), the indirect exploitation costs have been omitted from the calculations in papers III—V. It was considered more appropriate to be able to allocate these costs, e. g. in the form of a fixed supplement in crowns per cubic metre, on the subsequent employment of the results for a given purpose (see III, p. 268).

No indirect costs have been allocated for lorry transport and floating, with the exception of costs for winter lorry haulage roads in papers III and IV. These costs must, however, be considered if the result of the calculation is to be used for comparing different methods of transport (*Anon.* 1961, Pt 1, Cap. 2).

3.3 Processing of data

All data collected in the field by the National Forest Survey were earlier recorded on forms. After manual checking the information was punched for further processing in simple types of punch-card machine. Only in exceptional cases were magnetic tape and more advanced forms of equipment employed. Since 1967 all field recording has been done on "pen-punch cards". These are mechanically tested to identify for correction all cards which are invalid, incomplete or otherwise unacceptable. The information is then read off directly onto magnetic tape, for further processing by computer. A more detailed account of this is available in the report "The notation, checking and storage of data at the National Forest Survey" (*Backlund* 1968).

Situation data for a sample plot, after being transferred to punch-cards or magnetic tape, are assorted together with the inventory information for that plot (see I, p. 14).

The further processing, which includes amongst other things, cost calculation, was carried out in projects I and II both manually and with the aid of simple types of punch-card machine, while the computer alone was used in projects III—V. In computer processing, the time requirement for felling and primary conversion is calculated for every "marked tree" on each sample plot. Subsequently, the total time for each tree species is divided by the total volume of merchantable timber for that species, giving the average time requirement per unit volume merchantable timber for all tree species on the sample plot. Multiplication by the time rate then gives the cost per unit volume. The costs for extraction and lorry transport are calculated with the help of functions which give the time requirement and the cost per unit volume merchantable timber respectively, without considering either species or diameter of the "marked trees". From the information about the time requirement for felling and extraction the labour requirement, expressed in man-days per forest cubic metre, may also be calculated.

3.4 Results

After the collection and processing of data, as described in the foregoing sections, a material is obtained which comprises, besides the normal information of the forest survey, a description of the situation of every sample plot and—as in papers III–V—gives also the exploitation and transport costs per unit volume timber. As a rule, the material contains situation and cost data relevant to various degrees of development of the road network and different transport methods.

From this material, it is possible to describe the accessibility of the forest and forest land in many different ways. The descriptions given in papers I—V primarily concern both the situation of forest land and growing stock in relation to motor road, floatway, etc., and the exploitation and transport costs for the potential cut and the actual cut according to the forest survey's stump inventories. These descriptions are intended not only to give a general picture of the accessibility, but also to serve as a basis for further calculation. Examples of description and of problems elucidated by means of the material, are given in Cap. 5.

The material is, however, a sample, as regards both the inventory information and the situation data. The reliability of the results presented depends therefore on the precision of the sampling methods (see, e.g. *Matérn* 1947, 1960, 1961 & 1962/63). In addition, uncertainty of another type is present, namely that caused by differences between the field estimates of observers and that associated with inadequacies in the time functions and costs, etc.

Some analyses of the statistical precision when the material is subdivided into, e.g. ownership groups and cost classes, are given in papers I and II. The analyses (based on *Matérn* 1947 and *von Segebaden* 1964 b) concern the estimation of the average growing stock per hectare, and of the average distance to a motor road. The formula used for calculating the standard error of the estimate of the growing stock per hectare is valid only for Swedish stand conditions and for the sampling design used by the Swedish Forest Survey. The formula for assessing the precision of the estimate of mean distance to road —given in Appdx B—may, however, be considered more generally applicable. Its relevance in a given case may easily be tested by laying out a network of points with successively increasing density.

With the assistance of that analysis of the variation of various cost factors which is given in section 4.3, the extent to which uncertainty in different data influences the total cost for felling and transport can be estimated.

It might be added that a general review of the inventory methods used is at present on the research programme of the department. In this, the design both of the sampling system as regards statistical efficiency, and of the methods of measurement as regards systematic errors and possibilities of checking, is to be investigated. The recent experience of the department, gained in connection with analyses of inventory material and in control enumeration, indicates that systematic errors are more serious than errors associated with the statistical design; hence increased attention must be paid to the systematic errors in inventory (*Anon.* 1969 c).

4. Cost Factors

The presentation in this chapter is based primarily on the factors present as variables in the time functions and cost relations employed in these studies. If based on assumptions other than those used, e. g. highly mechanised exploitation systems, and on a refined method of calculation, including, amongst other things, a better knowledge of the actual cost relationships, the analysis might lead to other conclusions.

4.1 Location and terrain factors

As regards, in the first place, the costs for exploitation and transport of the timber, the location may be described by means of
a) geographical position,
b) extraction distance,
c) terrain conditions,
d) transport distance,
e) distance to settlement.

The geographical position may, in consequence of climatic differences, influence the costs by making the use of certain exploitation systems possible or impossible. Thus, for instance, in northern Sweden it is possible to intensify the permanent road network by means of haulage roads negotiable during winter, and thereby to decrease the extraction distance to a motor road (*Andersson* 1960). This opportunity, however, is not available in southern Sweden. Similarly, snow conditions vary with the geographical situation (*Ager* 1964 & 1967).

Information associated with climatic conditions may be difficult to obtain and the effect of climate on costs difficult to quantify. This may be exemplified by the way in which the snow conditions are discussed in papers III och IV.

In the functions used in these papers for the time requirement in felling and primary conversion, the influence of snow conditions has been separately treated, as mentioned above. The calculation of the influence of snow conditions is based on a special study of the time supplement for various snow depths, tree diameters and densities of cut (*Ager* 1965 b; see III, Fig. 11). The duration of various snow depths at different altitudes is obtained by point sampling on maps showing the average number of days per year with a given snow depth (*Ager* 1964); these are supported by information about altitude (*Lundqvist* 1957). By weighting with figures obtained from the Forest Service for the percentage distribution of exploitation throughout the year, average time supplements are finally calculated for various tree diameters (see III, p. 63).

No attention has been paid "as regards extraction" to different snow depths. The reason for this is that the occurrence of greater snow depth is usually compensated for by a longer period of good haulage conditions.

The extraction distance, which usually refers to the distance to motor road, floatway, or railway, influences the direct costs for the movement of the labour force and of timber, and the indirect exploitation costs. In papers III—V, in which the extraction of timber is assumed to be by means of one-man tractors equipped with a grapple loader, the direct transport costs are altered by 1—2 Skr/m^3f [1] for a change of 1 km in the extraction distance.

Our knowledge of the dependence of the indirect costs on the extraction distance is still very incomplete. The same applies to the problem of setting a value on the more intensive forestry made possible by a dense permanent road network in relation to a sparser one (see section 5.4).

The terrain conditions affect, in the first place, the cost for the extraction of timber, and also—although to a lesser extent—the felling

[1] For units of measurement, see p. 3.

cost. In papers III—V the "degree of terrain difficulty" for the case of extraction by tractor has been estimated, commune by commune, by experienced observers. The estimates were divided into nine classes, of which the two extremes have in no case been used. The difference in the haulage cost between the best and the worst class (of those used in the estimate) is 1.6 Skr/m^{3}f. Where terrain types other than those obtaining in Sweden are concerned, or where exploitation methods more sophisticated than manual felling and primary conversion combined with tractor extraction are used, the terrain conditions probably have a greater effect on the exploitation costs than that given above.

Terrain classification in connection with forest inventory has been carried out in Norway since the middle 1950s, to a system worked out by *Samset,* in which the description is largely based on the use of given exploitation methods (*Samset* 1957). The system has been further developed and has, for instance, been adapted to conditions obtaining in Greece (*Samset* 1967). In recent years schemes for describing terrain have been developed which are more directly descriptive (*von Segebaden, Strømnes, Winer* 1967; *Anon.* 1969 f) and which may therefore in some cases be more suitable than a system tied to given exploitation methods. As an example of the construction of such a scheme, the "major headings" from the proposal for an international classification system presented to IUFRO, Section 32, are given below (*von Segebaden et al.* 1967):

A. *General description of the whole*
   1. Geographical location
   2. Climatic characteristics
   3. Geomorphological characteristics

B. *Detailed description of the component parts*
   1. Slope
   2. Ground roughness
   3. Surface and subsurface (with special reference to bearing capacity and thrust)
   4. Susceptibility to erosion
   5. Accessibility

A factor such as "susceptibility to erosion" can affect the costs in that, for instance, thinning alone may be carried out in some areas. In this way the cost for the protection function may also be estimated. This is certainly no problem in Sweden, but may be of considerable importance in some countries.

As regards systems for soil classification in connection with forest survey, see, amongst others, *Låg* (1955), and *Troedsson* (*Anon.* 1969 b, pp. MA 1—8; *Troedsson* 1967).

The transport of timber by motor road, railway or floatway to industry, rafting site, export harbour, etc., is a cost factor which is of considerable weight as regards economic accessibility. In northern Sweden, where by far the greater part of the forest industries are situated on the coast, the transport distance may vary from a few kilometres to 400 km, which for lorry transport gives a cost difference of ca 30 Skr/m^{3}f (papers III and V). The direct variable transport cost for lorry transport is 0.06—0.07 Skr/m^{3}f and km for distances of over 50 km, and increases to ca 0.10 Skr/m^{3}f and km for shorter distances. The corresponding cost for rail transport is ca 0.04 Skr/m^{3}f and km. For floating, the direct variable transport cost varies between rivers and between different stretches of the same river, but is as a rough average ca 0.03 Skr/m^{3}f and km.

What goes for transport in northern Sweden for delivery to the coast may also be said to hold for delivery to industry in southern Sweden, with the difference that floating scarcely occurs in practice in southern Sweden.

In certain contexts it is desirable to differentiate the transport cost, for lorry transport, for instance, by assortment and road standard. This may be especially relevant for investigations closely associated with forestry enterprises.

Distance to settlement has been used in papers I—V as an expression for location relative to the dwellings of the labour force. The definition of the concept "settlement" (Swedish "bygd") is taken from the forestry wage agreement valid up to 1965, as being, besides built-up areas, villages and communities possessing regular communications, shops, post and telephone. The cost for the commuting of the labour force between dwelling and work-place in the forest has been added to the felling cost and the manual part of the extraction cost in the form of a percentage supplement, the magnitude of which is obtained from the wage agreement mentioned above (see III, p. 102). In the supplement is included also remuneration for the worker's walking from the motor road to his work-place. The supplement is, for instance, nine per cent for an off-road walking distance of 1—2 km and a motor road distance of 12—16 km to a settlement. The supplement changes by two or three percentage units per kilometre for changes in the walking distance and by 0.5—0.9 percentage units per kilometre for changes in the motor road distance. For a felling cost of 10—20

Skr/m^{3}f, a supplement of nine per cent means in absolute terms 0.9—1.8 Skr/m^{3}f. The corresponding supplement to the manual part of the tractor extraction costs for a distance of 1—2 km is 0.3 Skr/m^{3}f.

4.2 Stand and tree factors

The stand and tree characteristics which normally have the greatest influence on the exploitation costs are as follows:

a) density of cut,
b) tree species,
c) tree dimensions,
d) branchiness.

Density of cut is included in papers II—V as a cost-determining variable in the calculation of both the felling and the extraction costs. In project II a field determination was made of the density. The information about this is obtained in papers III—V from a simultaneously performed calculation of the potential cut, in which the outturn per hectare is varied according to the stand's cutting class and stocking density, on the basis of a "trial marking" in the field (*Nilsson* 1967; see also *Anon.* 1969 b, Appdx 5).

The range of variation for the influence of density of cut on the felling cost is ca 1 Skr/m^{3}f for small trees, D.B.H. 10—15 cm, but decreases with increasing diameter to ca 0.1 Skr/m^{3}f for large trees, D.B.H. over 40 cm.

For extraction, the density of cut is independent of the tree diameter and has a range of variation of 1.6 Skr/m^{3}f.

Tree species may, in addition to the effect of differences between different species in tree dimensions and branchiness, also influence the costs by other specific characteristics. For instance, birch cannot be loose floated. It must therefore be transported on land, which may, in areas where coniferous timber is floated, increase both the direct and the indirect costs.

Tree dimensions have, as a result of the relationship between the diameter and the volume of the tree, a large influence on the felling cost, with a sharply increasing unit cost for smaller trees. Since both the felling and the primary conversion of the tree is by motorsaw, as is assumed in papers III—V, the felling cost per unit volume merchantable timber is approximately twice as great for a tree in the class 10—15 cm D.B.H. than for one in the class 20—25 cm D.B.H.; this implies a cost difference which for different areas and species varies between ca 6 and 14 Skr/m^{3}f (cf. III, Tab. B.1). The influence of diameter decreases, however, for larger trees. Thus, for example, the corresponding cost difference between the small tree and that in the class 30—35 cm D.B.H. is 8 and 18 Skr/m^{3}f, respectively.

The tree dimensions, however, have no effect on the extraction cost, since timber is considered to be assembled after felling in stacks of a size suitable for loading (ca 0.3 m^{3}f per stack). No allowance is made in the calculations for the possibility that this may perhaps not be expected to be carried out according to instructions if the logs are very large or heavy.

The large variation in tree volume for trees of the same diameter should be noted. Thus, in the processing of the forest survey's sample tree material, differences of the order of 35 per cent or more in average tree volume within the same species have been demonstrated between different geographical areas and within a particular diameter and cutting class group. The differences seem to be caused primarily by dissimilarities in site conditions, tree age and tree class.

In papers III och IV, consideration is given to these volume differences by differentiating the tree volume in various diameter classes not only by regions and for three cutting class groups (as is done in the normal processing of the material), but also for three altitude classes in every region. For southern Sweden in paper V, there is a corresponding differentiation into three site quality classes. The average tree volume for trees of the same diameter in an outer class deviates in some cases by ± 15—20 per cent from the average for the central class (cf. the example in Fig. 3, where, however, the deviations are considerably smaller). It is probable that a satisfactory differentiation of tree volume could also be obtained with the help of the site quality class and tree age (*Arman & Jakobsons* 1967). This problem is at present on the department's research programme (*Anon.* 1969 c).

The differences in tree volume affect the felling cost almost directly. Thus for a unit cost of 10—15 Skr/m^{3}f, the cost is increased by 1—1.5 Skr/m^{3}f if the tree volume decreases by ten per cent.

The branchiness of the trees is described in papers III—V both by the de-branched merchantable length per tree and by the "difficulty of de-branching". The latter is to express the coarseness and toughness of the branches, as well as their frequency on the de-branched part of the crown.

The de-branched merchantable length has been obtained by a theoretical break-down of the sample trees into assortments and from a

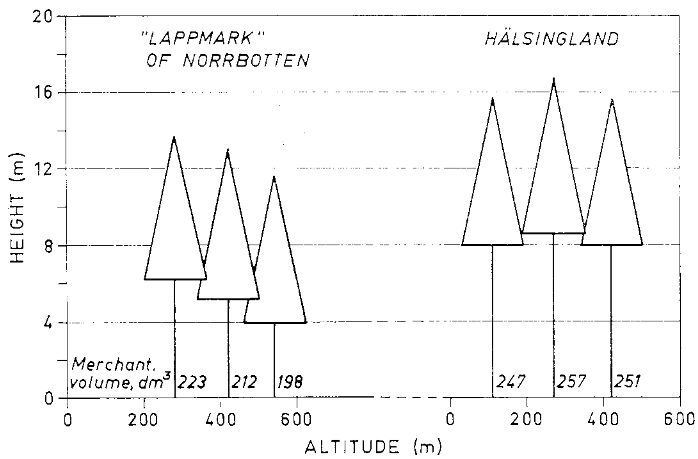

Fig. 3. Example of mean trees for various altitude classes; pine 20—25 cm D.B.H.

corresponding grouping of the material into three classes of altitude and site quality (the latter in southern Sweden only, in paper V), as was done for tree volume.

The difficulty of de-branching, in the absence of direct field observations at the time of the projects, has been differentiated, with the aid of the relative height, for a type tree in the various altitude classes. Earlier investigations demonstrated a strong relationship between the difficulty of de-branching and the length and form of the tree (*Mattsson Mårn* 1920; *Almqvist* 1945; *Samset* 1950; see also *Samset, Strømnes, Vik* 1969). Special measurements of branchiness were made in stands at the final felling stage by the forest survey in 1966 (*Bredberg & Herlitz sine anno*). Supporting studies have subsequently been made to elucidate the practical applicability of the results of these measurements. It has not been possible, however, to consider the results of these studies[1] in any of the papers discussed.

The range of deviation for the influence on the felling cost of the de-branched length and the difficulty of de-branching is for each factor fully 6 Skr/m³f for trees in the class 10—15 cm and ca 2 Skr/m³f in the class 30—35 cm D.B.H.

[1] To be published by Royal College of Forestry, Dept. of Operational Efficiency.

4.3 Factor analysis

With the intention of showing the relative weight of various cost factors, a factor analysis is given here for two cases having large differences as regards the factors. As was mentioned above, it may be shown with the help of the analysis how uncertainty in the estimation of the factors may influence the final results.

The one case concerns the exploitation of spruce in the classes 10—15 and 30—35 cm D.B.H. respectively, by light thinning in the "lappmark" of Norrbotten (area Nb 1 & 2, Appdx C), and the other concerns the final felling of a well-stocked pine stand in Hälsingland. The analysis is based on the assumption below, which for most of the factors illustrates the average relationships in each area (cf. IV, Tab. B.2, B.7 & B.8):

Factor	*"Lappmark" of Norrbotten*	*Hälsingland*
Species	Spruce	Pine
Tree diameter, B.H., cm	12.5 and 32.2	12.5 and 32.2
Density of cut, m^3sk/ha	28	200
Altitude class	Middle	Middle
Transport method[1]	2	3
Extraction distance, km	1.4	0.9
Terrain class	1.3	2.1
Distance to settlement, km	28	14
Lorry transport distance to floatway, km	24	—
Floating cost, Skr/m^3f	8.1	—
Lorry transport distance to coast, km	(192)	70

[1] Transport methods: (1) extraction to floatway and floating; (2) extraction to motor road, lorry transport to floatway and floating; (3) extraction to motor road and lorry transport to coast.

The costs are calculated according to the principles detailed in paper III. The initial cost situation for the analysis is shown in Tab. 1 and Fig. 4.

Tab. 1. Initial cost composition for the type-cases of the factor analysis.
Units of measurement: Skr/m^3f and per cent

Element	"Lappmark" of Norrbotten Spruce, D.B.H. cm 10—15		30—35		Hälsingland Pine, D.B.H. cm 10—15		30—35	
Felling and primary conversion	32.6	(56)	11.5	(31)	16.5	(48)	5.1	(22)
Extraction	10.6	(18)	10.6	(28)	6.8	(20)	6.8	(30)
Lorry transport	6.9	(26)	6.9	(41)	10.8	(32)	10.8	(48)
Floating	8.1		8.1		—		—	
Total	58.2	(100)	37.1	(100)	34.1	(100)	22.7	(100)

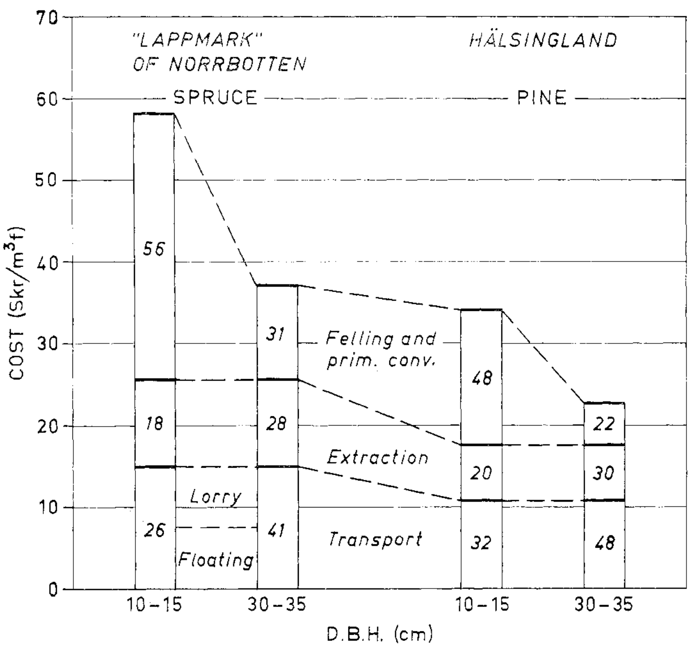

Fig. 4. Initial cost composition for the type-cases of the factor analysis.
The figures in the columns give the percentage distribution of costs for the various trees.

From the table and the figure can be seen how large a proportion of the total cost for the small trees is made up by the felling cost (50—60 per cent), while transport is the dominant cost item for the larger trees (40—50 per cent). The difference in felling cost between the trees of different dimensions is also pronounced. For each tree species the small trees are approximately three times more expensive in felling and primary conversion than the large, which gives a difference of 50—60 per cent in the total cost.

The factor analysis is performed in such a way that one factor is changed at a time by ± 20 per cent in relation to its initial value, while the other factors are held constant. The cost changes thereby caused are expressed as a percentage of the total cost for exploitation and transport to the coast.

As regards the factor tree diameter, consideration is given in the analysis not only to the change in breast-height diameter but also to the corresponding change in the volume of the tree and in the merchantable volume. The results of the analysis are shown in Tab. 2.

It should be noted that as regards tree diameter and density of cut, an increase in the value of the factor results in a lower unit cost and *vice versa,* while for other factors, an increase in the value gives a higher cost.

The results of the analysis show that the dominant factor as regards differences in the economic accessibility is tree diameter, or more correctly, the tree dimensions. After this come branchiness and transport. Between the two last-named tree factors there is strong co-variation. For increases in diameter there is, on the average, a consequent increase in the de-branched length, which reduces the pure dimension effect. Thus the de-branched length for the two type trees of spruce in the "lappmark" of Norrbotten changes by ± 34—37 and ± 7—9 per cent, respectively, for a ± 20 per cent change in diameter, while the corresponding figures for pine in Hälsingland are ± 16—19 and ± 12—13 per cent. It is noteworthy that with the highly mechanised exploitation systems at present under discussion, the influence of tree diameter may be expected to increase, with greatly increasing costs for smaller trees as a consequence, at the same time as the importance of branchiness is expected to decrease (see e. g. *Ager* 1969).

Co-variation also exists between other factors, but not, however, to the same marked extent as in the case of the tree factors. As will be evident from the example in Tab. 3 for the "lappmark" of Norrbotten, there is a positive relationship between, on the one hand, the distance to the coast and on the other, the extraction distance and the lorry transport distance to a floatway (cf. also IV, Tab. B.5).

Tab. 2. Results of the factor analysis.
Unit of measurement: per cent of initial total cost

Factor	"Lappmark" of Norrbotten Spruce, D.B.H. cm		Hälsingland Pine, D.B.H. cm	
	10—15	30—35	10—15	30—35
Tree diameter	−18 +36	−6 +10	−14 +28	−5 +8
Branchiness				
— length	± 5	± 3	± 4	± 2
— difficulty	± 5	± 3	± 4	± 2
Density of cut	∓ 1	∓ 3—4	∓ 0	∓ 0—1
Snow influence	± 2	± 1	± 1	± 0
Extraction distance	± 1	± 1	± 1	± 2
Distance to settlement	± 2	± 0	± 0—1	± 0—1
Lorry transport distance	± 1	± 1	± 2	± 3
Floating cost	± 3	± 4	—	—

Tab. 3. Extraction distance and lorry transport distance to floatway situated at various distances from the coast; "lappmark" of Norrbotten.

Lorry transport distance to coast, km	Area of forest land, %	Extraction distance, km	Lorry transport distance to floatway, km
50—(100)	1	0.8	27
100—(150)	27	1.0	21
150—(200)	28	1.2	19
200—(250)	28	1.5	24
250—(300)	13	1.7	34
300—(350)	3	3.5	46
Average	100	1.4	24

Furthermore, a relationship may, for instance, be found between site quality class and extraction distance. This situation is illustrated by the figures for the "lappmark" in Tab. 4, which gives the shortest distance from forest land to the nearest permanent road in Norrbotten. (The information is from an unpublished pilot investigation, based on the sample plots of the 1957 forest inventory.)

Tab. 4. Extraction distance in various site quality classes; Norrbotten.

Site quality class	Yield capacity m^3sk/annum/ha	Extraction distance, km[1] "Lappmark"	Coastal region
IV—V	4.5—3.4	1.7	1.6
VI	2.5	2.1	2.0
VII	1.8	3.3	1.8
VIII	1.2	3.7	2.1
Average	—	2.8	1.8

[1] Straight-line distance to nearest permanent road.

As may be seen from the table, no corresponding clear relationship can be discerned for the coastal region of Norrbotten. This probably depends on the fact that the road network is less developed from the forestry point of view in the coastal region than it is in the interior (cf. also I, Tab. 5).

5. Problems Considered

5.1 General description of accessibility

For the purposes of describing generally the accessibility of a given area, e. g. Jämtland in paper I, information for both location and cost has been used.

The description of location is elucidated here mainly on the basis of paper I. In that paper the county of Jämtland (2.5 million ha of forest land) was divided both into three main regions and into 32 "small regions" (*Nilsson* 1961).

For the three main regions, the distribution of forest land and growing stock by classes of distance to floatway and permanent road is shown in tabular form separately for two alternative methods of delivery, namely delivery free after sorting and delivery free at roadside. All information is given for two degrees of development of the road network.

In the case of delivery free after sorting, distributions by classes of distance to floatway and to permanent road are also given in the form of a two-way table, for that part of a main region from which extraction to floatway and floating was found to be cheapest. For the remainder of the area, from which extraction to permanent road, lorry transport to floatway and floating was found to be cheapest, distributions by distance to permanent road and the distance for lorry transport, are given in the same form.

In the case of delivery free at roadside, is shown the distribution by classes of distance to permanent road for various ownership groups and site quality classes.

The distribution of the regions by classes of distance, both off-road walking distance and road distance, to a settlement is also given, in the form of contingency tables.

For each of the 32 small regions, in addition to the area of forest land, the growing stock and the attainable yield capacity, is given the average area-weighted distance to floatway, permanent road and settlement. It is, however, emphasised that the information for individual small regions is burdened with relatively large standard errors. Therefore the small regions must usually be formed into groups of four or five at least. If, however, only the tendencies within a certain area are to be studied, then the individual small regions within it may be considered.

As an example of this type of analysis, a calculation is shown for

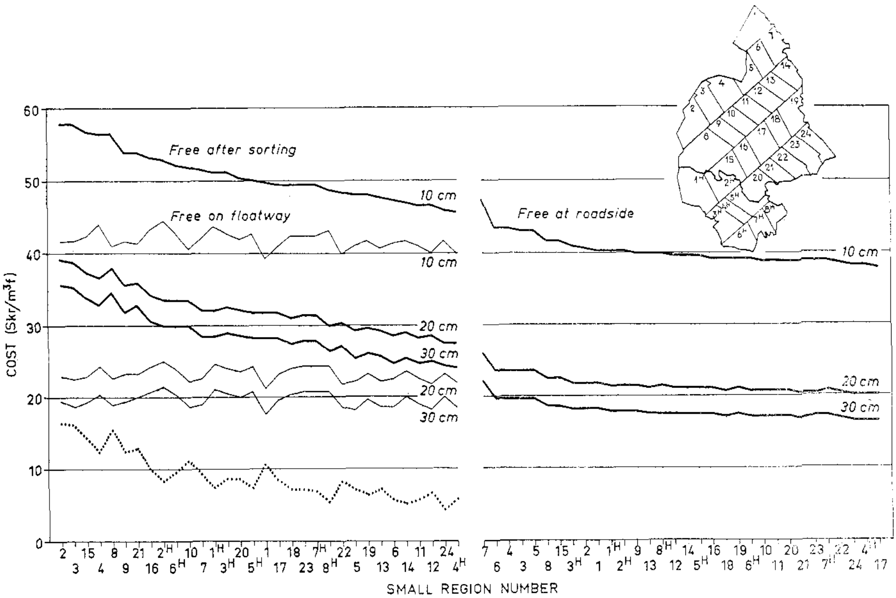

Fig. 5. Costs for type trees of pine in various small regions for delivery free after sorting, free on floatway and free at roadside; Jämtland (paper I).
The small regions are ranked according to the costs for the 10 cm tree. The dotted line represents the floating cost. See note to Tab. 5.

the exploitation and transport costs for certain "type trees" in individual small regions. This is also intended to illustrate how the tabular material presented may be used for calculations of operational economic nature. In each small region costs were calculated for 10, 20, and 30 cm trees of pine, spruce and hardwood for the methods of delivery free after sorting, free on floatway and free at roadside. The type trees are identical in all of the regions. Thus the variation which occurs between different regions is not considered.

The result of the calculations is presented both graphically (e. g. Fig. 5) and in tabular form. As an example of the latter is shown for type trees of pine in Tab. 5, a compilation of the average costs for various methods of delivery, as well as the corresponding cost difference between the most expensive and the least expensive small region.

In view of the fact that the difference in average cost between the 10 cm tree and the 20 cm tree is 18—19 Skr/m³f, while the cost difference between the most expensive and the least expensive region is at most 12 Skr/m³f, the conclusion was drawn that it is more the

Tab. 5. Costs for the small regions for various methods of delivery; Jämtland (paper I).
Unit of measurement: Skr/m³f

Pine	Average cost			Cost difference between most expensive and least expensive region		
	Free after sorting	Free on floatway	Free at roadside	Free after sorting	Free on floatway	Free at roadside
10 cm	51	42	40	12	9	10
20 cm	32	23	22	12	4	6
30 cm	29	20	18	12	4	6

Note: The cost has been converted from öre/f³ to Skr/m³f.

fact that the trees are small than the accessibility (*scil.* location) that determines the high cost for smaller trees (cf. *Sundberg* 1954).

A weakness of this cost calculation is that it concerns average conditions in the various regions, for which reason the actual variation between good and bad conditions of accessibility is not expressed directly. The situation can be elucidated by means of information from a corresponding cost calculation for type trees, made in paper IV (p. 280). In this was calculated primarily the cost for the type trees on each sample plot, from which an average cost was obtained for each inventory tract. In contrast to what was done in paper I, in paper IV regional differences between the type trees as regards volume, degree of branchiness, etc., are taken into account (see section 4.2).

For the small regions which in paper I have the highest and the lowest costs, respectively, for delivery free after sorting (regions 2 and H:4, according to Fig. 5) is given in Tab. 6 the average cost weighted with the forest land area as in papers I and IV. The corresponding cost difference, both between the regions, and—as in paper IV—between the most expensive and the least expensive inventory tract ("within regions") is also given.

Tab. 6. Costs for the most expensive and the least expensive small regions for delivery free after sorting; Jämtland (papers I and IV).
Unit of measurement: Skr/m³f

Pine	Average cost				Cost difference			
	Region 2		Region H:4		Between regions		Within regions	
	I[1]	IV[2]	I	IV	I	IV	Reg. 2	Reg. H:4
10 cm	58	60	46	47	12	13	13	19
20 cm	39	41	28	31	12	10	9	12
30 cm	36	37	24	28	12	9	8	11

[1] Paper I. [2] Paper IV.

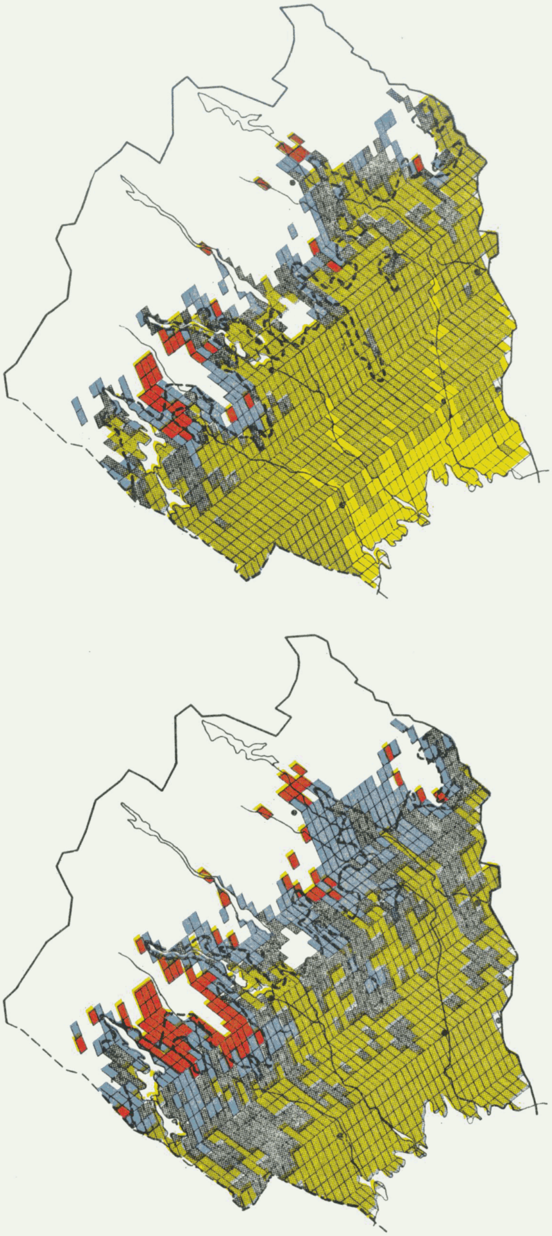

Fig. 6. Costs for type trees of pine (above) and spruce (below) for delivery free at coast, for lorry transport and floating; Norrbotten (paper IV).

Yellow	10 cm tree	$\leq$	42 Skr/m³f						
Green	15 »	$\leq$	»	and	10 cm tree	$>$	42 Skr/m³f		
Grey	20 »	$\leq$	»	»	15 »	$>$	»		
Blue	30 »	$\leq$	»	»	20 »	$>$	»		
Red	30 »	$>$	»						

As may be seen, the cost level is approximately the same in both papers—in spite of large dissimilarities both in the assumptions for the cost calculation and in its execution. The table shows that the cost difference within the small regions may be of the same order of magnitude as the difference in the average cost between the most expensive and the least expensive region in the entire county.

The result of the cost calculation for type trees in paper IV is shown in the form of a map, on which for every inventory tract is marked the cost of type trees in relation to a cost limit of 42 Skr/m³f. This representation model is exemplified in Fig. 6, which comprises only Norrbotten (for other parts of Norrland, see IV, Fig. B.12). Detailed tables of results, giving the total cost and the cost items for felling and extraction, respectively, for every type tree, are available at the Department of Forest Survey, where they may be used for elucidating particular problems (e. g. *von Segebaden* 1968 and *Streyffert* 1969).

5.2 Accessibility of potential and actual cut

The concept of "potential cut" used in this report can be described as follows: "The volume estimated to be available for felling, based on the species, development classes, age classes and growth rates found in the forests and assuming a pattern of prudent and realistic forest management and exploitation; at the same time taking into account policies concerning the protective, recreational and other functions of the forest. The potential cut is estimated for a 10—20-year period, but the estimate should normally be revised after five years to take into account changes in the forests or in the circumstances governing their management and exploitation" (*Anon.* 1969 a, Vol. 2).

The potential cut is, as a rule, a gross quantity, to be reduced in respect, for instance, of wood which from the economic point of view may be considered inaccessible because the exploitation and transport costs are so high that no positive stumpage value would remain. Usually an empirical reduction figure is applied (e.g. *Anon.* 1933, 1935, 1948, 1956 b & 1959 b).

In paper II, which according to the terms of reference, should consider "the resources of wood suitable for and accessible to exploitation for a planned hardwood pulp mill at Storuman", the cost calculation for type trees used in paper I was further developed to refer to the gross potential cut on every sample plot. From this the quantities may be estimated which under the assumed silvicultural programme it would be possible to exploit and transport to Storuman,

Tab. 7. Available proportion of the potential cut; Storuman region (paper II).
Unit of measurement: per cent

Delivery	Maximum cost limit, Skr/m³f 18	21	24	27	30	33	36	42	48
Free at Storuman			4	13	32	48	62	76	81
Free at roadside	16	40	56	66	74	78	81	83	83

or to a permanent road, at a cost which for no part of the quantity would exceed given cost limits. The result of the cost calculation is given both in tabular form, with a cost interval of 3 or 6 Skr/m³f, and in diagrams which permit of interpolation between the cost limits given in the tables. In Tab. 7 an extract from the tables is given, showing the percentage proportion of the gross cut which for a given maximum cost limit is economically available. The extract refers to the "present road network".

From this table it may, for instance, be seen that approximately half the gross quantity is "available" at a cost limit of 33 Skr/m³f free at Storuman and at 23 Skr/m³f free at roadside. The average cost for this quantity is ca 29 and 19 Skr/m³f, respectively (after II, pp. 58—59).

In paper II directions are given for making allowance for changes in certain cost assumptions. However, no mention is made of any cost limit which it would be reasonable to assume for the purposes of obtaining the available quantity of pulpwood. In the case in question, the level of the cost limit, in relation to the value of the timber, must be considered purely a matter for negotiation between buyer and seller.

The accessibility of the potential cut is also considered in papers III—V. In these papers, however, the cost calculation is still more closely bound up with the calculation of the cut than is the case in paper II. Papers III and IV were prepared in connection with regional timber balances, in which the credit side was to be reduced, for instance, in respect of such timber as was probably non-available. (This timber was referred to in paper IV as a "doubtful resource".) The aim of the cost calculation in paper V is to compare the cost levels in northern and southern Sweden (see section 5.3).

The result of the calculations in these latter papers is summarised by way of tables and diagrams corresponding to those of paper II. The size of the non-available quantities is there given on the basis of a cost limit of 42 Skr/m³f for delivery free at coast (or free to industry in southern Sweden, in paper V). Concerning this cost limit the following remarks are made in paper IV: "There are many opinions on the question of what maximum cost limit shall be chosen when it is a matter of determining the economically inaccessible part of the potential cut, in the "zero areas". Amongst other things, the stumpage value, the indirect exploitation costs and the regeneration costs must be considered. From some aspects the quantity immediately below the cost limit should be considered as a marginal quantity, for which a price must be set and a cost calculated appropriately. Because of the varying conditions which obtain regarding such costs and the timber value, no generally applicable cost limit exists. The cost limit must therefore be calculated from case to case. If, however, it is only a matter of determining the order of magnitude of what from the economic point of view, must be regarded as the doubtful cut, it should be possible to do this from a single—suitably selected—cost limit. With the intention of elucidating the situation in 1964 in this way, the cost limit of 42 Skr/m^{3}f is used for softwood. This cost limit is based on the following assumptions: A timber value free at coast of 54 Skr/m^{3}f and indirect exploitation costs and regeneration costs of 7 and 5 Skr/m^{3}f, respectively."

For the entire area investigated in paper IV, which consists of almost all Norrland (and which comprises 56 per cent of the area of forest land and ca 40 per cent of the potential cut for the whole country), the "doubtful" proportion of the potential cut was found, for softwood, to be ten per cent, for the method of delivery most closely equivalent to that in actual use, namely, delivery free at coast, with both lorry transport and floating. In these areas, where access to softwood resources is expensive (18 per cent of the area "treated" during a 20-year period, according to the calculation of potential cut), 24 per cent of the potential hardwood cut is to be found (see Fig. 7).

Between various sub-regions, however, very large differences are evident as regards the "doubtful" cut—from 57 per cent for softwood in the "lappmark" of Norrbotten above the investment limit, to one per cent in Hälsingland (denoted Nb 1 and Gvl 1 in Fig. 8). The corresponding proportion for Älvsborg in paper V is one per cent.

The cost calculation for the potential cut is complemented in papers IV and V by an analogous calculation for the actual cut, according to the stump inventories of the National Forest Survey. The material is derived from ten years' inventories, namely the felling seasons 1952/53—1961/62 (for some areas the period 1954/55—1963/64). The costs for the actual cut are given for the output, cost and price levels

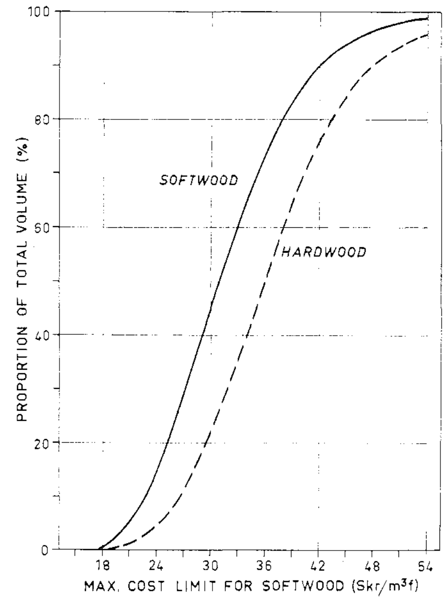

Fig. 7. Potential cut distributed by cost classes for delivery free at coast, for lorry transport and floating. Existing road network; Norrland (paper IV).

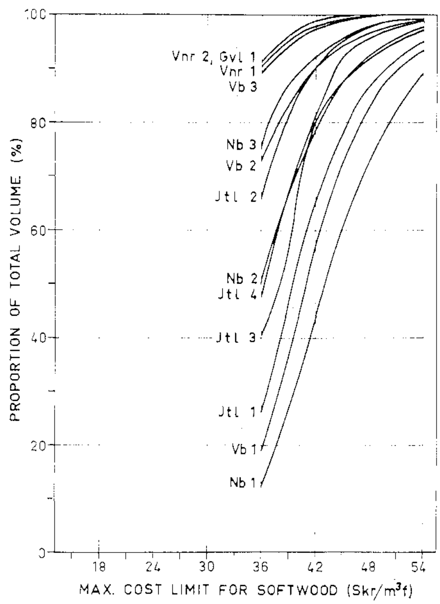

Fig. 8. Potential softwood cut distributed by cost classes for delivery free at coast, for lorry transport and floating. Existing road network; subregions in Norrland (paper IV). For symbols, see Appdx C.

current in 1964 and are based on the same assumptions as to roads, floatways, etc., as those for the potential cut.

Comparisons between the two calculations show that as regards softwood, the average cost for the potential cut and for the actual cut is as nearly as possible identical in the coastal districts of Norrland (Fig. 9). For hardwood in these regions the average cost of the actual cut is 1—2 Skr/m^{3}f lower than that for the potential cut. The average costs are considerably higher in the interior than in the coastal districts, and the average cost for the actual cut is throughout lower than that for the potential cut. In the areas above the investment limit, near the mountains, the difference reaches 2—6 Skr/m^{3}f, or 4—12 per cent. These differences in the average cost show that in practice there has not been exploitation to the extent envisaged in the calculation of potential cut. This situation is the more clearly expressed when the actual cut for softwood is expressed as a percentage of the potential within each cost class (Tab. 8).

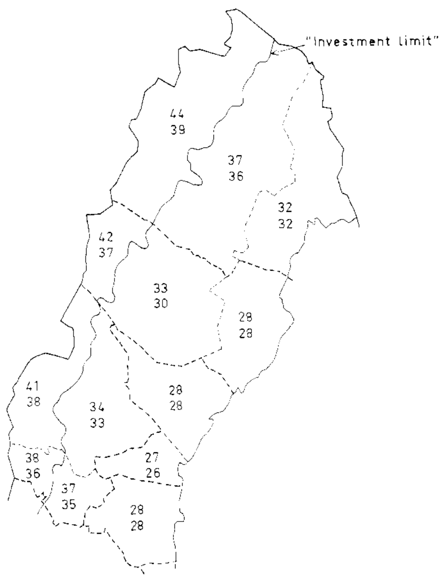

Fig. 9. Average cost for softwood free at coast, for lorry transport and floating, potential cut (above) and actual cut (below); Norrland (paper IV).
Unit of measurement: Skr/m³f

An attempt to calculate the cost limit for the actual cut is made in paper IV. The calculation is based on the percentage figures in Tab. 8 and on the distribution by cost classes of the actual and the potential cut. The following argument is put forward:

Up to a limit of 36 Skr/m³f the actual cut is at approximately the same level in all cost classes, on the average 87 per cent of the potential cut, but thereafter decreases progressively. Since there is no decreasing trend in the figures for the percentage cut in the classes up to and including 36 Skr/m³f, then in this cost interval no stands should have been adjudged too expensive to exploit—and the frequency curve for the actual cut should mainly follow the curve for the potential cut. On this assumption the frequency curve for the actual cut has been transformed to the level of the potential cut (Fig. 10).

Tab. 8. Actual cut as a percentage of the potential cut by different cost classes, for softwood; Norrland (paper IV).

Cost class, Skr/m³f	—18	—21	—24	—27	—30	—33	—36	—39	—42	—45	—48	—51	—54	54+	All
Actual cut, %	56	70	90	83	93	89	84	71	63	41	37	31	14	11	78

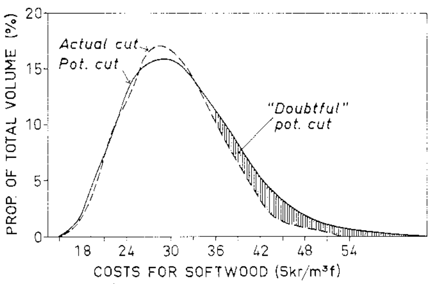

Fig. 10. "Doubtful" potential cut of softwood; a comparison of the actual with the potential cut; Norrland (paper IV).

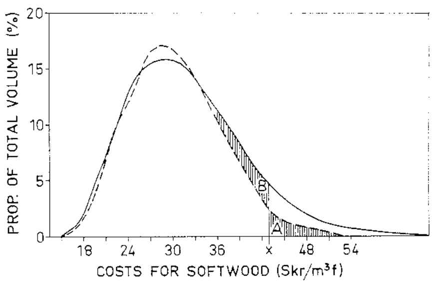

Fig. 11. Schematic representation of the "actual" cost limit for softwood; Norrland (paper IV).

The plus and minus areas between the curves to the left of 36 Skr/m³f in Fig. 10 arise because the percentage cut in the various cost classes oscillates about the mean, 87 per cent.

The area between the curves to the right of 36 Skr/m³f shows to what extent exploitation in the more expensive cost situations has been avoided. This area, in other words, is a measure of the practical assessment of the "doubtful" part of the potential cut. This arises, as may be seen, not suddenly at a given cost limit, but progressively.

One reason for the existence within so large a cost interval of the "doubtful" cut, is that state, industrial and production forestry enterprises have cause to employ different cost limits (*Streyffert* 1957 & 1965, pp. 49—58; *Streyffert & von Malortie* 1963, Cap. 6; *von Heideken* 1969). There are, of course, other reasons too. It is necessary only to think of the number of persons concerned in the decision "To fell—or not to fell?"—persons, moreover, having different degrees of cost-consciousness as well as different degrees of optimism or pessimism in their assessments.

The "actual" cost limit which corresponds with the "doubtful" cut is calculated in Fig. 10 by seeking that cost at which the volume exploited at a higher cost is equal to the volume which was not exploited, even at a cost lower than the required cost—or, as expressed by the symbols in Fig. 11—that cost x is to be sought for which area A is equal to area B.

In this case the required cost x is found to be 42.5 Skr/m³f. From a corresponding calculation for the cut during the last five years of the ten-year range of material, this cost is 41 Skr/m³f.

Agreement, therefore, is good between the cost limit of 42 Skr/m^{3}f used for the gross cut and that calculated in this way for the actual cut. More definite conclusions may, however, not be drawn on the basis of this result, since it is not known whether the stand treatment has in practice been identical with that assumed in the calculation—with which some parts of the cost calculation are bound up. Nevertheless, there has so far been no indication that any large differences exist.

5.3 A comparison between accessibility in northern and southern Sweden

Comparisons have been made in various contexts between the economic conditions for forestry in the northern and southern parts of Sweden. This was done most recently in paper V, prepared in connection with a state commission of enquiry into the developmental trends in and pre-requisites for the establishment of forest industries in southern Sweden (*Anon.* 1969 d).

The comparisons in paper V are made both on the basis of the average extraction distance to permanent road in various counties and on the basis of the average cost for the potential cut.

The information about extraction distance, obtained from the account of a road inventory prepared by the National Forest Survey in 1957—1963 (*von Segebaden* 1965), shows a marked decrease from north to south—from 2.4 km in the northernmost county to 0.2 km in the southernmost. Experience from project IV suggests that the difference is still greater. On the other hand, as was mentioned above, the permanent road network in northern Sweden is supplemented by winter haulage roads, which tends to even out the difference. To this it must be added that the average standard of the roads is higher in the northern than in the southern parts of the country.

For the purpose of elucidating the cost level in southern Sweden, Älvsborg was chosen as a type area. In this area it appears that the average exploitation and transport costs for the potential cut are at the same level as, or somewhat lower, than those in the parts of Norrland which from the cost point of view are better (see V, Tab. A.1). A summary of the comparison is given in Tab. 9, where the northern sub-regions are grouped into three zones.

Tab. 9. Cost comparison between northern and southern Sweden; average exploitation and transport costs for the potential cut (paper V).
Unit of measurement: Skr/m³f

Zone	Free to permanent road		Free at coast/to industry			
			Lorry transport alone		Lorry transport and floating	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
Norrland						
Interior "os"[1]	27	33	49	56	42	56
Interior "ns"[2]	23	27	41	47	35	47
Coastal[3]	19	24	30	35	29	35
S. Sweden	16	21	27	31	—	—

[1] Sub-region Nb 1, Vb 1, Jtl 1 & 3.
[2] Nb 2, Vb 2, Jtl 2 & 4.
[3] Nb 3, Vb 3, Vnr & Gvl 1.

For Älvsborg the lorry transport distance to industry was not measured in connection with the classification of the inventory tracts, but the cost was calculated on the basis of an estimated average distance of 70 km. In this part of the country, however, much of the potential cut may be delivered as saw timber to local saw mills, for which reason the average distance chosen may be too great. A reduction of this from 70 to e. g. 50 km would decrease the cost free to industry by ca 1.5 Skr/m³f.

The importance of the differences in cost levels between northern and southern Sweden is illustrated in paper V by a worked example, in which the costs for timber from the interior of Norrland are placed in relation to the costs for timber brought from southern Sweden. On various occasions the idea has been put forward that the present surplus of timber in southern Sweden should be transported by rail to the forest industries in northern Sweden, where the timber supply situation is harder pressed, and that the most expensive timber in the interior should not be exploited.

The average exploitation cost for softwood from the areas above the investment limit in the interior of Norrland has been calculated (free at coast) as 42 Skr/m³f for lorry transport and floating and as 49 Skr/m³f for lorry transport alone (see Tab. 9). In southern Sweden the cost free to permanent road is given as 16 Skr/m³f. To the cost free at roadside should be added the forwarding cost to a railway and the terminal costs for rail transport, which are considered to be 6.80 and 1.50 Skr/m³f, respectively. The various cost items are summarised in the scheme below.

	Skr/m^3f		
Norrland. Exploitation and transport cost free at coast for timber from the areas above the investment limit, for lorry transport and floating and lorry transport alone	42	and	49
S. Sweden. Exploitation cost free to permanent road		16	
Forwarding to railway, 30 km		6.8	
Terminal costs		1.5	
Total		24.3	
Balance for rail transport	17.7		24.7
Total	42		49

The softwood from southern Sweden could bear, therefore, as is evident from the above scheme, a direct variable rail-transport cost of ca 18 or 25 Skr/m^3f, respectively, before the total cost became equal to that for the timber from the interior of Norrland. This corresponds to a transport distance of 420 or 590 km at the freight charge of 0.042 Skr/m^3f and km (0.045 Skr/tonkm) considered to apply to rail transport.

5.4 Accessibility and the extension of the road network

The expansion of forest roads is an important item in the rationalisation programme for forestry. There was great interest in this in Sweden during the 1950s and the first half of the 1960s. Road problems were investigated by state commissions (*Anon.* 1956 a, 1958 b & 1963 c), road and transport conditions were surveyed (*Fredén* 1957; *Anon.* 1960 b & 1965 a; *Kritz* 1960; *von Segebaden* 1965) and norms were drawn up for various road types (*Anon.* 1968 b). Problems concerning the optimal road density, the co-ordination of transport and associated problems were studied at both research and other departments (*Sundberg* 1952/53; *Larsson* 1956; *Andersson* 1960; *Anon.* 1961 & 1963 a; *Larsson & Rydstern* 1961; *Hultin* 1964; *von Segebaden* 1964 b). Regional plans were prepared for the road network (*Anon.* 1963 c, Cap. 6) and road building was intensified. During the period 1960—1967, between 3,300 and 4,000 km of permanent forest roads were completed annually (*Anon.* 1969 e).

Since the collection of operational data by the National Forest Survey through the road inventory had shown itself satisfactory, it

Tab. 10. Average extraction distance to permanent road for two degrees of extension of the road network; Jämtland (paper I).
Unit of measurement: km

Region[1]	Network	Forest land	Growing stock		
			Softwood	Softwood $\geq$25 cm D.B.H.	Hardwood
A	Existing	3.9	3.7	4.1	4.8
	Planned	2.9	2.8	3.3	3.6
B	Existing	2.0	1.9	1.8	2.2
	Planned	1.5	1.5	1.5	1.6
C	Existing	2.2	2.0	2.2	2.5
	Planned	1.7	1.6	1.7	1.9
A—C	Existing	2.6	2.4	2.7	3.2
	Planned	1.9	1.9	2.1	2.4

[1] A=sub-region Jtl 1 and a western zone of Jtl 2; B=remainder of Jtl 2; C=Jtl 3 & 4.

seemed appropriate also to try to collect information for assessing the benefit to be obtained from the suggested road building schemes. On the basis of the improvement of accessibility resulting from the roads, the advantage accruing from the planned construction might be determined. This was also the motive underlying project I.

Situation data are given in paper I both for the existing network of ca 9,000 km of arterial forest roads, and for the proposed extension of this by 2,100 km over a period of ten years. With the study area Jämtland divided into three main regions, the distribution of the area of forest land and of the growing stock by classes of distance to a permanent road is shown for the two road networks. A summary of this is given in Tab. 10.

As may be seen from the table, the average distance to a permanent road is reduced as a result of the planned extension by ca 1 km in area A, consisting of "mountain communes", while the decrease in areas B and C is approximately half as great. The prominent difference in situation for conifer forest, large-dimension conifer forest and hardwood forest, respectively, should be noted.

The situation relative to a permanent road is also given in paper I for the 32 small regions. In the most expensive small region, for delivery free after sorting (region 2—see section 5.1) the average distance to permanent road is thus 3.1 km for the existing road network and 1.9 km for the proposed network. The corresponding figures for the least expensive region (region H:4) are 1.5 and 1.2 km, respectively.

In section 5.1 above, the calculation of the exploitation and transport costs for certain type trees, carried out in the various small regions, was discussed. After the amalgamation of the small regions into groups of two or three, a corresponding calculation was made, for the two alternative road networks, for the area affected by the extension of the road network. For the entire county, 822,000 ha of a total of 2,491,000 ha, i. e. 33 per cent, are affected by the extension.

On the basis of both the decrease in cost for the type trees, which arises from the extension of the road network, and the calculated annual cut for the various small regional groups (after *Nilsson* 1961), the total cost decrease is estimated as ca three million Skr annually, for the delivery method free at roadside and as ca one million Skr annually, for the method free after sorting (see I, Tab. 19). On the assumption that this annual cost decrease remains unchanged in future, its capital value, the advantage, is ca 76 or 26 million Skr at 4 per cent interest. For a road construction cost of 30 Skr per metre, this would pay for the building of either 2,500 or 850 km of road. As was mentioned above, the proposed extension is 2,100 km. In paper I it is stated that the calculated advantage is, however, less than the actual, depending primarily on the fact that no consideration is given in the calculation either to the further extension of the road network with simpler types of road which is made possible by the planned network, or to the increased "general benefit" from the extension.

In papers II—IV also, the accessibility for various degrees of extension of the permanent road network is described. The decrease brought about in the average extraction distance by the road extension is in these papers of the same order of magnitude as that in paper I (see Tab. 10). The effect of the road extension on diminishing the cost level is, however, relatively small. For instance, in Norrbotten it is on the average 1 Skr/m^{3}f for the potential cut, for the delivery method free at roadside, and less than 0.5 Skr/m^{3}f for delivery free at coast (see III, pp. 76—80). In the same way, the extension has a rather slight influence on the distribution of the potential cut into cost classes and on the "available" and "doubtful" proportions of this. In Norrbotten the proportion of "doubtful" softwood for the delivery method free at coast, with lorry transport and floating, is 20 per cent for the existing road network and 19 per cent for the planned network (see III, Tab. 36). For all Norrland in paper IV, the corresponding figures are 10 and 9 per cent, respectively.

The fact that the differences between the existing and the planned road network are so small as regards costs may be explained by that the planned extension often means that winter haulage roads are replaced by permanent roads. The alignment of both types of road is thus largely identical, and the extraction distance is only inconsiderably affected. This situation is illustrated by, for instance, the fact that in Norrbotten the average distance to an existing permanent road is 3.3 km and to a planned road 2.7 km, while the average distance to a transport route (i. e. floatway, winter haulage road or permanent road) is 1.3 or 1.2 km, respectively (cf. IV, Tab. B.4 and B.9).

The extension of the permanent road network carries with it, however, advantages other than the decrease in the direct exploitation and transport costs. Thus the possibilities for carrying out exploitation also during the snow-free period, and for mechanising both this and silvicultural work, are increased. Furthermore, the possibilities for the continuous delivery of timber to industry are improved. To this must be added advantages such as decreased commuting costs[1], improved supervision and increased fire protection, as well as an increase in the value of the forest for multiple-use. Otherwise expressed, the extension of the road network will permit a more intensive management of the forests (see e.g. *Anon.* 1965 b, pp. 110—137 and *Samset* 1967). These advantages of "other type" are difficult to quantify, but their value is often considered greatly to exceed the effect of road extension on decreasing the direct exploitation and transport costs (*Streyffert* 1965, pp. 178—179).

5.5 Optimalisation of the transport costs

Forestry is characterised by having its raw material production widely dispersed. The raw material produced, the timber, must be transported to industry for processing, and the cost for this transport depends, amongst other things, on the size and location of the industrial units. This situation, in which there is an increase in the transport cost for timber when the requirement for timber increases, is especially notable in the pulp industry, where development is proceeding rapidly towards a few very large units and where the expansion of the individual units involves ever larger increases in production. The advantages of economies of scale on the processing side are counterbalanced, to some extent, by increasing acquisition costs for the timber.

The developmental trends in, and pre-requisites for the localisation

[1] In addition to that expressed by a decrease in the travel allowance for commuting associated with exploitation.

of forest industries in southern Sweden have recently been studied by a state commission (*Anon.* 1969 d). In this study an attempt was made to elucidate how the transport costs are affected by the re-structuring of the pulp and board industry in southern Sweden which is assumed to take place during the period 1970—1980. The analysis, which is discussed in paper V, is based upon an optimalisation of the transport costs, whereby pulpwood is supplied to the various industrial units according to their requirements and is so distributed that the total transport cost is minimised.

In the analysis the available quantity of pulpwood is calculated as being the difference between the potential cut and the expected utilisation of assortments other than pulpwood. This calculation is made for individual counties. In the counties, the pulpwood resources are then divided into "small regions", 263 in all, in proportion to their forest land area and attainable yield capacity (according to *Nilsson* 1961), and then within each small region into 3—4 "sources" with equally large quantities in each source. The number of sources is 896 in all.

The location of the sources is referred to the central point of certain of the forest survey's inventory tracts, mutually spaced at ca 12 km intervals (see section 3.2). The location of these is described by co-ordinates, as is also that of the industrial units, the "destinations". From the co-ordinates is computed the straight-line distance from each source to each destination. In addition, for ca 80 of these sources, the distance by motor road is measured to 12 different destinations scattered throughout the area investigated. The ratio between the road distance and the straight-line distance is used in the form of an allowance for winding, to transform the closest situated survey tracts' straight-line distance to a given destination into a road distance.

As regards the location and pulpwood requirements of the various industrial units, the analysis is based on the information given by the various companies for the year 1970, and on the commission's own assessment for the year 1980. The transport of timber from source to destination is assumed to be by lorry. The cost level has been adjusted to that for southern Sweden in 1968 (see V, p. 106).

For technical reasons of computation it is necessary in this case to limit the number of destinations in the optimalisation programme to at most 19, for which reason two or more adjacent industrial units must be considered as a single destination. This generalisation should, however, affect the result inconsiderably. (For the optimalisation programme, see *Anon. sine anno.*)

Tab. 11. Number of production units, theoretical capacity and equivalent roundwood requirement of the industrial groups; S. Sweden (paper V).

Industry group[1]	Year	No. units[2]	Capacity, million tons	Pulpwood requirement,[3] million m³f Softwood	Hardwood	Total
NV	1970	13	1.2	3.4	0.5	3.9
	1980	8	1.6	3.7	1.1	4.8
NO	1970	9	0.7	1.7	0.2	1.9
	1980	5	0.8	2.3	0.3	2.6
GÄ+SV	1970	13	0.5	1.1	0.1	1.2
	1980	8	0.7	1.3	0.3	1.6
SO	1970	14	0.7	1.3	0.7	2.0
	1980	7	1.1	1.6	1.4	3.0
Total	1970	49	3.1	7.5	1.5	9.0
	1980	28	4.2	8.9	3.1	12.0

[1] The symbols refer to units in the north-west (NV), north-east (NO), south-west (SV) and south-east (SO) parts of the study area and to the units around the Göta River (GÄ). See also Appdx C.

[2] A "unit" may comprise several lines of production or several adjacent factories belonging to the same company.

[3] Excepting saw mill chips, in total 2.7 million m³f in 1970 and 3.5 million in 1980.

From the calculation, information is obtained for every destination about the quantity received and the transport cost from various sources, according to the required optimal solution. On the basis of this information the "optimal supply area" may be located. However, for confidential reasons, the various industrial units or destinations cannot be shown individually, hence, as regards geographical location, they are grouped into five groups of industries. The number of units, the production capacity and the pulpwood requirements are given for the various groups in Tab. 11.

An example of the description of the optimal supply areas is outlined in Fig. 12, which refers to conifer pulpwood. (For hardwood pulpwood, see V, Fig. A.3.) On the figure, some areas are distinguished as "surplus areas". This may, however, not be construed as meaning that the pulpwood in these areas lacks a market. Where the timber supply to industry is concerned, consideration must also be given to factors other than transport economics, and several of these tend to cause the supply areas to have a greater extent and a lower cut per unit area than is optimal from the point of view of transport economics alone. The concepts "optimal supply area" and "surplus area" are used here only to illustrate the position of the raw material as a localisation factor in the expansion of the pulp and board industry.

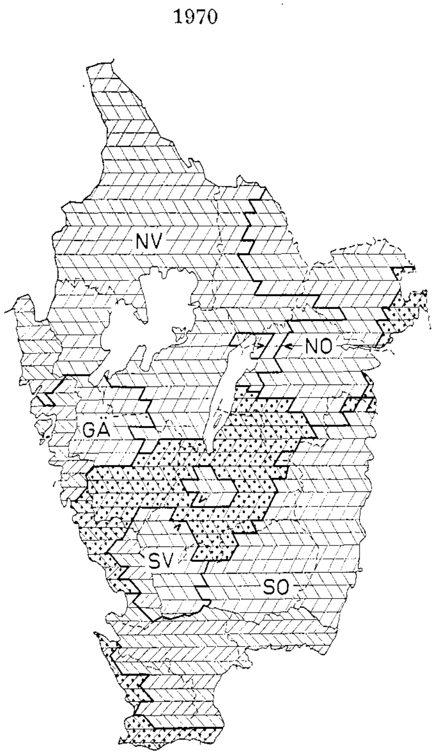

Fig. 12. Optimal supply areas for conifer pulpwood in the years 1970 and 1980; S. Sweden (paper V). — Dotted areas mark "surplus areas".

The minimised total transport cost is 91 million Skr for 1970 and 135 million Skr for 1980. Of this, 78 and 101 million Skr, respectively, are for conifer pulpwood.

The average transport cost for pulpwood will increase from 10.1 Skr/m^{3}f in 1970 to 11.2 Skr/m^{3}f in 1980. The corresponding average costs for the various industrial groups are shown in Fig. 13 and Tab. 12, which also shows coniferous and hardwood pulpwood separately.

In Fig. 13, in which the average cost is set against the timber requirement, the well known fact, namely that an increased raw material requirement, which must be satisfied from more distant resources, also results in a higher transport cost, is evident (cf. *Lindberg* 1951). The industries on the Göta River (GÄ) stand on too high a cost level relative to the other industrial groups, which is explained by the fact that this group's raw material requirement is limited to softwood.

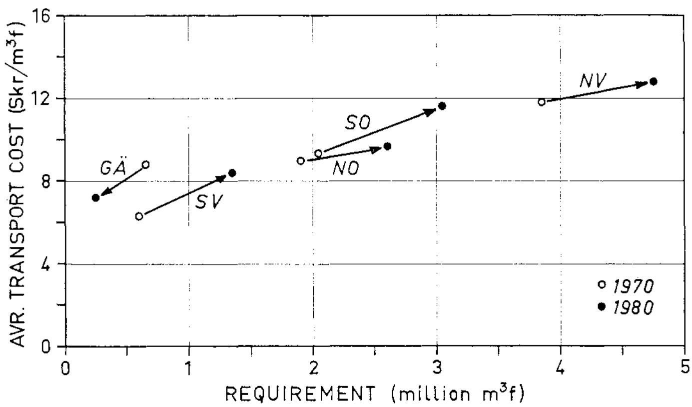

Fig. 13. Average transport cost for pulpwood in the industrial groups; S. Sweden (paper V).

The size of the increase in the transport cost for an increased raw material requirement depends not only on the wood resources per unit area, but also on the form of the supply area in respect of the geographical location and the neighbouring industries' supply areas. As an example of this, it may be mentioned that for three destinations, each of which has in 1980 a requirement for conifer pulpwood of ca 1.5 million m^3f, the average transport cost varies between 10 and 15 Skr/m^3f.

More illustrative of the cost situation of the various industrial groups than the average cost for the total quantities, is the average

Tab. 12. Average transport cost for pulpwood in the industrial groups; S. Sweden (paper V). Unit of measurement: Skr/m^3f

Industry group	Year	Softwood	Hardwood	Softwood + hardwood
NV	1970	12.2	8.9	11.8
	1980	13.3	11.0	12.8
NO	1970	9.1	7.6	9.0
	1980	9.9	8.4	9.7
GÄ	1970	8.8	—	8.8
	1980	7.2[1]	—	7.2[1]
SV	1970	6.4	5.6	6.3
	1980	8.2	9.1	8.4
SO	1970	9.8	8.5	9.3
	1980	11.7	11.6	11.6
Total	1970	10.4	8.4	10.1
	1980	11.4	10.8	11.2

[1] A lower pulpwood requirement in 1980 than in 1970, e.g. in consequence of the increased use of saw mill chips.

Tab. 13. Average transport cost for the "increased requirement" of pulpwood between 1970 and 1980 in the industrial groups; S. Sweden (paper V).
Unit of measurement: Skr/m³f

Industry group	Softwood	Hardwood	Softwood + hardwood
NV	24.1	12.8	16.8
NO	11.9	10.8	11.8
GÄ	10.1[1]	—	10.1[1]
SV	10.3	9.6	10.0
SO	18.5	15.0	16.3
Total	16.4	13.0	14.6

[1] See note to Tab. 12.

cost for only the change in requirements between 1970 and 1980. This information is presented in Tab. 13. As may be seen from the table, there are notable differences between the industrial groups in the cost of transport for this additional quantity. For conifer pulpwood, the average cost is remarkably high in the north-western (NV) and south-eastern (SO) groups, namely 24.1 and 18.5 Skr/m³f, respectively. For hardwood pulpwood, too, the cost level is high in these regions, being 12.8 and 15.0 Skr/m³f, respectively.

If the optimalisation were based on a lower potential cut than that assumed and if the requirements for assortments other than pulpwood remained unchanged, the supply areas shown in Fig. 12 would increase and the surplus areas decrease. At the same time, of course, the transport cost would increase. The reverse situation would obtain if a higher cutting alternative were chosen. New surplus areas would then also arise.

The same effect would be obtained if for unchanged potential resources the requirement for assortments other than pulpwood, primarily saw timber, were generally, or in some counties, higher or lower than that assumed.

Conifer and hardwood pulpwood have been separately treated in the calculation. However, no difference is made between pulpwood of pine and spruce, since these species are to a large extent mutually interchangable in pulp and board manufacture. In cases in which an industry is based on spruce pulpwood alone, such as in the manufacture of mechanical pulp, the supply area must become larger and the transport cost higher than that given in the optimalisation. Possibly a cost decrease might also be obtained if the pine pulpwood in that supply area were suitably situated, from the point of view of transport, for an industry using pine wood.

The transport cost optimalisation is based on the assumption that all transport of pulpwood is by lorry. In reality, some is at present floated and some carried by rail in the area investigated. Floating, however, is constantly decreasing in importance, while in contrast, the transport of pulpwood by rail has increased in extent in recent years, and there is reason to believe that this development will continue.

In principle, there is no difficulty in performing a calculation for other methods of transport. Thus the original intention was to perform in project V also a calculation for lorry and rail transport combined. The optimalisation for each source would then be based on that transport method—lorry alone or lorry and rail or rail alone—which gave the lowest cost to the various destinations. Subsequently, however, the calculation for lorry transport alone was considered adequate for the purposes of the study. As was mentioned above, it should be noted that rail transport cannot be treated in the same general form as lorry transport. Amongst other things, consideration must be given to the feasibility of the various factories' receiving wood transported by rail.

6. Concluding Remarks

A classification of the accessibility of the forest and forest land according to the method discussed here seems to be a valuable addition to the material normally collected in field inventories. In this way good opportunities may be obtained of elucidating more precisely problems concerning the localisation and accessibility of the timber resources in respect of the technical problems of exploitation and various transport and delivery forms. In a particular case it may be desirable to collect data other than that collected here. Especially in the inventories carried out in close association with forestry enterprises, advantage should be taken of these opportunities.

In this account several examples of operational economic calculations concerning the accessibility are given. It should be emphasised that the value of such calculations may be relatively short-term as a result of the development of exploitation and transport methods. To this must be added the changes which may be caused by improvements to the methods of calculation. The calculations should therefore be made using alternative assumptions and renewed not too infrequently.

Acknowledgements

Behind all papers based on the material collected by the National Forest Survey lie the efforts of a large number of persons who have been engaged in the collection, checking and processing of the field material. In the present case, officials of the various forestry authorities, companies and organisations have co-operated in the projects discussed here. Thus it has been possible to base, to a large extent, this work on factual conditions. I should like to express, on behalf of the Department and personally, grateful thanks for the assistance given in so many ways.

I am especially indebted to those of my colleagues and collaborators at the Royal College of Forestry who have initiated, stimulated and otherwise helped me in my work. In particular must be mentioned *Professor Ulf Sundberg* and *Professor Nils-Erik Nilsson*. When the first investigations concerning accessibility were carried out by Nils-Erik Nilsson and myself, as a joint study by the Department of Forest Survey and the Department of Operational Efficiency, Ulf Sundberg was my head of department—and he has since followed the various projects with great interest. The co-operation between the two departments resulted, in 1962, in my migrating to the Department of Forest Survey, where in recent years I have had the advantage of working directly under Nils-Erik Nilsson. To both of these my friends I should like to express my sincere thanks.

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SDA — Föreningen Skogsarbetens och Kungl. Domänstyrelsens Arbetsstudieavdelning, and Forskningsstiftelsen SDA; organizations previous to Forskningsstiftelsen Skogsarbeten (Logging Research Foundation), Stockholm.

SOU — The series "Statens offentliga utredningar" (the Swedish Government Official Reports).

Sammanfattning

Studier över skogens och skogsmarkens avsättningslägen

I detta arbete sammanfattas de studier rörande skogens och skogsmarkens avsättningslägen som utförts vid skogshögskolan i samband med olika utredningsuppdrag (arbete I—V, se s. 5). Resultatet av dessa studier har, med undantag för korta sammanfattningar på engelska i de två första arbetena, tidigare endast varit tillgängligt på svenska.

Den i studierna använda undersökningsmetoden innebär att riksskogstaxeringens ordinarie taxeringsmaterial kompletteras med data om provytornas belägenhet i olika avseenden. Denna komplettering sker på rummet med hjälp av kartor. Beskrivningen av provytornas belägenhet omfattar bland annat köravstånd i terräng till bilväg och flottled samt biltransportavstånd till visst leveransställe samt till bygd. Uppgifterna kan avse skilda transport- och leveransformer samt olika utbyggnadsgrader av det permanenta vägnätet.

Med utgångspunkt från det erhållna datamaterialet, som för varje provyta innehåller såväl skogliga uppgifter som belägenhetsuppgifter, är det möjligt att beskriva skogens och skogsmarkens avsättningsförhållanden på en mängd olika sätt. De beskrivningar som lämnas i arbetena I—V avser i första hand dels skogsmarkens och virkesförrådets belägenhet i förhållande till bilväg, flottled etc., dels avverknings- och transportkostnaderna för det potentiella uttaget enligt avverkningsberäkning och det faktiska uttaget enligt riksskogstaxeringens stubbinventering. Syftet med dessa beskrivningar är både att ge en allmän bild av avsättningsläget och att de skall kunna tjäna som underlag för vidare beräkningar.

Exempel på beskrivningar och sådana frågeställningar som har belysts med hjälp av driftsekonomiska kalkyler, baserade på materialet, ges i kapitel 5. Det poängteras att värdet av dylika kalkyler kan vara relativt kortvarigt på grund av avverknings- och transportmetodernas utveckling. Därtill kommer de förändringar som kan orsakas av en förfinad kalkylteknik, bl. a. bättre kännedom om olika kostnadssamband. Kalkylerna bör därför utföras med alternativa förutsättningar och förnyas med ej alltför långa tidsmellanrum.

Appendix A

INSTRUCTIONS FOR CLASSIFYING THE FOREST INVENTORY TRACTS IN RESPECT OF ACCESSIBILITY[1]

Classification is carried out on maps (scale 1: 100,000) on which have been drawn in roads and the forest inventory tracts. Recording is done on a special form (see below), and the directions here follow the layout of that form. The completed form *(clear figures!)* is dated and signed by the observer.

County — Use county letter.

Col. 1 — The tract number is given with both the number of the line and the number marked under each tract on the map. E.g. 400—14—8.

Col. 2 — The tract corners are numbered clockwise from 1—4, beginning in the north corner. All classification refers to the "accessibility" of the various corner points.

Col. 3 — Classification is based on the existing road network and on the network delineated or sketched on the outline of forest road planning (regional plan).
For "existing road network" entries are to be made in all col-

[1] Reproduces, in slightly edited form, the instructions used in papers III and IV. Some sub-appendices are omitted.

Royal College of Forestry: Form "Accessibility study"

Tract No.	Corner No.	Road net-work	Extraction dist.						Lorry tspt dist.				Del'y site acc. to col. 12, 13
			straight-line			actual			straight-line		actual		
			to						to delivery site at coast from				
			perm. rd	wint. rd	f'way	perm. rd	wint. rd	f'way	perm. rd	wint. rd	perm. rd	wint. rd	
			tenths of km						km				
1	2	3	4	5	6	7	8	9	10	11	12	13	14
E.g. 1	1	Ex.	2.9	—	3.5	3.1	—	4.0	145	—	182	—	4
		Pl.	0.8			2.4			142		187		
E.g. 2	2	Ex.	0.8	0.5	3.2	0.9	0.6	3.8	145	145	182	183	4
		Pl.	0.5	—		0.6	—			—	183	—	
E.g. 3	3	Ex.	3.7	0.8	17.3	6.1	0.9	22.9	76	81	82	127	3
		Pl.	3.4			3.7			78		87	89	
[1]	4	Ex.	3	2	3	3	2	3	3	3	3	3	2
[2]		Pl.	999	99		999	99			999		999	

[1] Max. no. figures in col. [2] Punching for "No information".

umns 4—31. In the line for "planned network", *only* information is to be entered which differs from that for the "existing network".

Only the following columns may be left uncompleted:

Col. 4 and 7 for roadless island tracts;

Col. 5, 8, 11, 13, 17, 19 when no winter lorry haulage road is in question;

Col. 16—19 for transport methods (1) and (3), and Col. 16 and 18 when the classification concerns "winter haulage road, transport method (2)" and when "permanent road" simultaneously gives transport method (1);

Col. 20—22 for transport method (3).

"No information" is denoted by a dash (—). In punching, "No information" is codified with figures consisting solely of nines (e.g. in Col. 11, "999"). Actual values may not therefore come up to the number of nines which is given in the example.

Col. 4—6 Measure with dividers the shortest straight-line distance from every tract corner (in tenths of km in reduced measure) to the nearest

— permanent road (Col. 4);

— existing or presumptive winter haulage road, if closer than the permanent road (Col. 5);

— substantive floatway (sub-appdx A.1) (Col. 6).

Measure irrespective of the land category the corner is on (forest land, cultivated land, water, etc.).

For *coastal and island tracts* additional instructions are given in the special section below.

County Nb

Tspt meth. for s'wood	Lorry tspt dist.				Floating		Del'y site acc. to col. 20, 21	Dist. to settlemt	Trav. allow.	B-up area				Zone	Commune	Ex. ≡ Pl. network
	straight-line		actual							Type C+O		Type C				
	to f'way from															
	perm. rd	wint. rd	perm. rd	wint. rd	District	Cost				Dist.	No.	Dist.	No.			
	km					ö/f³		km	%	km		km				
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	—	—	—	—	L 8	28	4	7 12	10 11	7 12	3	7 12	3	1	10	1
2	2 3	3 —	3 4	4 —	L 7	30	4	8	5	8	3	8	3	1	10	1
3	—	—	—	—	—	—	—	39 21	20 11	45 50	25 38	95 76	8 12	1	23	1
1	2 99	2 99	2 99	2 99		2 99	2 99	2	2	3	3	3	3	1	2	1

Date 25.2.1965 Name N.N.

Col. 7—9 From every tract corner is measured by map-measurer (in tenths of km in reduced measure) the estimated off-road route to landing beside or access to

— permanent road (Col. 7);
— existing or presumptive winter haulage road if this route is shorter than to the permanent road (Col. 8);
— substantive floatway (Col. 9).

Measure irrespective of what land category the corner is on. If the route according to Col. 7, possibly Col. 8 or one of them, does not predominantly coincide with the route to floatway (Col. 9), mark this by ringing the figure in question (Col. 7—8).

Note that Col. 7 is to be completed for all methods of transport (see Col. 15 below).

Col. 10—13 Measure from estimated landing by roadside or possibly winter haulage road (in whole km in reduced measure) both the straight-line distance and the lorry transport distance to the nearest delivery site (even outside the county) at the coast (sub-appdx A.2).

Col. 14 Delivery site to which the lorry transport distance in Col. 12—13 is measured is given by a number according to sub-appdx A.2.

Col. 15 Transport method for softwood to delivery site at coast is given as the cheapest of the following three choices:

(1) extraction to floatway and floating;
(2) extraction to road, lorry transport to floatway and floating;
(3) extraction to road and lorry transport to coast.

Above the "direct haulage limit" (D-limit) (sub-appdx A.2) it is assumed that neither transport method (3) nor lorry transport along a floatway or to another district by method (2) occurs, other than when the cost is clearly lower (at least 3 öre/f^3). The choice between methods (1) and (2) is made schematically by the aid of sub-appdx A.3.

Below the "direct haulage limit" method (2) is not considered. The choice between method (1) and (3) is made schematically with the aid of sub-appdx A.3.

Within the direct haulage area the code number for the transport method is ringed.

Col. 16—19 *Transport method (2):* From estimated landing for softwood at roadside or possibly winter haulage road is given (in whole km in reduced measure) both the straight-line distance and the lorry transport distance to the nearest substantive floatway or nearest landing at or near a substantive floatway. For haulage along a floatway, see Col. 15 above.

Transport methods (1) and (3): Mark with dash in Col. 16—19.

Col. 20—21 *Transport methods (1) and (2):* Allocate driving district number and cost according to sub-appdx A.1.

Transport method (3): Mark with dash in Col. 20—21.

Col. 22 *Transport methods (1) and (2):* Allocate number for delivery site at coast (even outside own county) according to Col. 20—21.

Transport method (3): Mark with dash in Col. 22.

Col. 23 Give distance by road (in whole km in reduced measure) to the nearest settlement according to the forestry wage agreement ("besides built-up areas, villages and communities possessing regular communications, shops, post and telephone"). The off-road distance to road is assumed to agree with the estimated route in Col. 7 or possibly 8.

Col. 24 Travel allowance for commuting is given according to sub-appdx A.4. The "ceiling" for the allowance is 40 %.

Col. 25—28 Distance on road (in whole km in reduced measure) is given to the nearest built-up area (even outside own county) of the type C+O and type C[1], and the number for this, according to sub-appdx A.5.

As regards the off-road distance to road, see Col. 23 above.

Col. 29 Price zone according to the forestry wage agreement (1 or 2).

Col. 30 Allocate commune number according to sub-appdx A.6.

Col. 31 Comparison between the information for "existing network" and "planned network":

— information identical denoted by 0 on line for "exist. network";

— information not identical denoted by 1 on the line for "exist. network".

Classification of coastal and island tracts

Coastal tracts are classified according to the least expensive method of "normal classification" and "classification as island tract". In both cases the distance to shore is given in Col. 6 and 9.

Island tracts are classified as follows: — — —

Sub-appdx A.1. **Floating costs**

— — —

Sub-appdx A.2. **Delivery sites at coast and D-limit**

— — —

Sub-appdx A.3. **Model for selecting the least expensive transport method for softwood for delivery to site at coast**

Above the D-limit

Lorry transport to floatway is estimated to take place when the costs for transport method (2):

extraction to road (Tb),
lorry transport to floatway (B) and
floating (Fb)

are equal to or less than the costs for transport method (1):

[1] Type C = chief places in the municipality blocks;
» O = other built-up areas of major importance to forestry.

extraction to floatway (Tf) and
floating (Ff);

$Tb + B + Fb \leq Tf + Ff$

which can be restated

$Tb - Tf + B \leq Ff - Fb.$

The expression (Tb—Tf+B) has been tabulated in the schedules 1—12[1]. (Negative values are inserted into the schedules as required. The calculation may be performed "by hand" without recourse to the schedules.) The number of the schedule gives in öre/f³km the ratio between the cost difference (Tb—Tf) and the difference in the off-road distance in the case in question. This ratio has been calculated for various distances to road and floatway and is given in Tab. A.1. The table thus gives the schedule which is to be used in any case. The information for floating costs Fb and Ff is obtained from sub-appdx A.1.

Example:

Off-road distance to floatway 4.5 km
Off-road distance to road 1.5 km
Lorry transport distance to floatway 15 km.

Entry into Tab. A.1 indicates that schedule 4 is to be used. In schedule 4 the value $1-(-3)=4$ öre/f³ is obtained.

The floating cost for lorry transport (Fb) must, therefore, be 4 öre less than the floating cost for direct extraction to floatway (Tf) for transport method (2) to be selected. "Indirect floating costs" need not be considered, since these are included in both transport methods.

Below the D-limit

Lorry transport direct to the coast is estimated to take place when the costs for transport method (3):

extraction to road (Tb) and
lorry transport to coast (B)

are equal to or less than the costs for transport method (1):

extraction to floatway (Tf),
indirect floating costs (4 öre/f³) and
floating (Ff);

$Tb - Tf + B \leq Ff + 4.$

Entry into Tab. A.1 and the schedule there referred to is as above. The floating cost given in sub-appdx A.1 should, however, be increased by 4 öre/f³ for indirect floating costs.

The schedules may if required easily be expanded for lorry transport distances longer than 100 km: — — —

Sub-appdx A.4. **Travel allowance for commuting**

— — —

Sub-appdx A.5. **List of "built-up areas"**

— — —

Sub-appdx A.6. **List of communes**

— — —

[1] Only schedules 4—6 are given here.

Tab. A.1. In the table is given the number for the schedule (1—12) according to which the profitability of any lorry transport may be estimated for various extraction distances to road and floatway.

Off-road distance to road, km	Off-road distance to floatway, km 0—0,5	0,5—1	1—2	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10	10—12
0 — 0,5	12	10	8	8	6	6	5	5	4	4	4	3
0,5— 1	10	10	8	6	5	5	4	4	4	4	4	3
1 — 2	8	8	6	5	5	4	4	4	3	3	3	3
2 — 3	8	6	5	4	4	4	3	3	3	3	3	3
3 — 4	6	5	5	4	4	3	3	3	3	3	3	2
4 — 5	6	5	4	4	3	3	3	3	3	3	3	2
5 — 6	5	4	4	3	3	3	3	3	3	3	2	2
6 — 7	5	4	4	3	3	3	3	3	3	2	2	2
7 — 8	4	4	3	3	3	3	3	3	2	2	2	2
8 — 9	4	4	3	3	3	3	3	2	2	2	2	1
9 —10	4	4	3	3	3	3	2	2	2	2	2	1
10 —12	3	3	3	3	2	2	2	2	2	1	1	1

Schedule Nos 4, 5 and 6 *Expression $(Tb - Tf + B)$ in öre/f³*

	Difference between dist. to road and dist. to floatway, km	Schedule No. 4 6 — Decr. Incr. of value in Sch. 5, öre/f³	Schedule No. 5 — Lorry transport distance, km 10	15	20	25	30	35	40	45	50	55	60	70	80	90	100
Dist. to road > to floatway	8	8	54	56	57	59	60	62	63	64	66	67	68	70	73	75	77
	7	7	49	51	52	54	55	57	58	59	61	62	63	65	68	70	72
	6	6	44	46	47	49	50	52	53	54	56	57	58	60	63	65	67
	5	5	39	41	42	44	45	47	48	49	51	52	53	55	58	60	62
	4	4	34	36	37	39	40	42	43	44	46	47	48	50	53	55	57
	3	3	29	31	32	34	35	37	38	39	41	42	43	45	48	50	52
	2	2	24	26	27	29	30	32	33	34	36	37	38	40	43	45	47
	1	1	19	21	22	24	25	27	28	29	31	32	33	35	38	40	42
	0	0	14	16	17	19	20	22	23	24	26	27	28	30	33	35	37
Dist. to road < to floatway	—1	—1	9	11	12	14	15	17	18	19	21	22	23	25	28	30	32
	—2	—2	4	6	7	9	10	12	13	14	16	17	18	20	23	25	27
	—3	—3		1	2	4	5	7	8	9	11	12	13	15	18	20	22
	—4	—4					0	2	3	4	6	7	8	10	13	15	17
	—5	—5									1	2	3	5	8	10	12
	—6	—6													3	5	7
	—7	—7														0	2
	—8	—8															

Appendix B

PRECISION IN ESTIMATES OF THE AVERAGE DISTANCE TO ROAD

In the paper "Studies of cross-country transport distances and road net extension' (*von Segebaden* 1964 b), an empirical formula (5) is given for calculating the standard error (ε) in the estimate of the average (straight-line) distance to a road on an area, for various values of the superficial area (A), the average distance (Mg) and the number of measurement points (n) regularly spaced. The formula is as follows:

$$(5) \quad {}^{10}\log \sigma = 1.42+0.30\ x \cdot \frac{20}{20+x^2}$$

where $x = {}^{10}\log \left(\frac{A}{n \, . \, Mg^2}\right)$ and from which the relative standard error ε (in per cent) of the average distance is obtained from the equation

$$\varepsilon = \frac{\sigma}{\sqrt{n}}$$

The formula is less accurate for negative values of x. For values of x exceeding 4.5, the value 4.5 should be substituted in the formula.

In Tab. B.1, the required number of regularly spaced points, calculated from formula (5) is given for areas of between 25 and 20,000 km² for the average distances 0.5—2.5 km.

Tab. B.1. The required number of points regularly spaced on a square lattice, for given standard errors in determination of the average distance (straight-line) to road, for various areas and average distances.

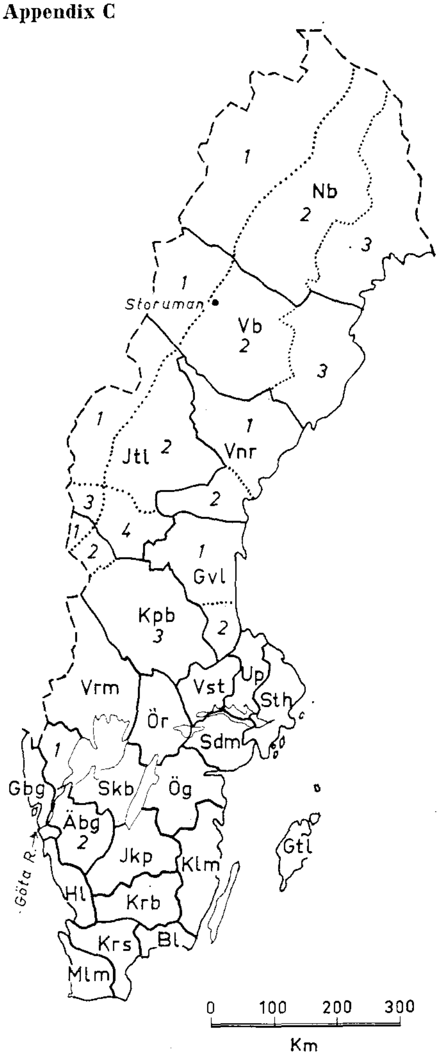
Area km²	Standard error, per cent														
	2.5					5					10				
	Average distance to road, km														
	0.5	1.0	1.5	2.0	2.5	0.5	1.0	1.5	2.0	2.5	0.5	1.0	1.5	2.0	2.5
25	110	(65)	(50)	(40)	(30)	45	(25)	(20)	(15)	(15)	20	(10)	(10)	(5)	(5)
50	140	80	(60)	(50)	(40)	60	35	(25)	(20)	(15)	25	15	(10)	(10)	(10)
75	160	95	(70)	(60)	(50)	70	40	(30)	(25)	(20)	30	15	(10)	(10)	(10)
100	180	110	80	(65)	(55)	75	45	35	(25)	(20)	30	20	15	(10)	(10)
150	210	120	90	75	(60)	85	50	40	30	(25)	35	20	15	15	(10)
200	230	140	100	80	(70)	95	60	45	35	(30)	40	25	20	15	(15)
250	250	150	110	90	75	100	65	45	35	30	40	25	20	15	15
300	270	160	120	95	80	110	65	50	40	35	40	30	20	15	15
400	300	180	130	110	90	120	75	55	45	40	45	30	25	20	15
500	320	190	140	120	100	130	80	60	50	40	50	35	25	20	15
750	370	230	170	130	110	150	95	70	55	50	55	35	30	25	20
1 000	410	250	190	150	130	160	100	75	60	55	60	40	30	25	20
1 250	440	270	200	160	140	170	110	85	70	60	65	40	35	30	25
1 500	470	290	220	170	150	180	120	90	75	60	65	45	35	30	25
2 500	550	350	260	210	180	210	140	110	90	75	75	50	40	35	30
5 000	680	440	330	270	230	250	170	130	110	95	90	65	50	40	35
10 000	820	540	430	350	300	300	210	160	140	120	100	75	60	50	45
20 000	1 000	680	520	440	380	350	250	200	170	150	110	90	75	65	55

Note: In the table, parentheses mark cases in which the "average mesh of the road network" (36 Mg²) is greater than the area of the region in question.

Formula (5) and Tab. B.1 may, in spite of the stated limitation to regularly spaced measurement points, be employed also for calculating the precision of the estimate of average distance based on determinations from the four corners of the inventory tracts. By selecting the number of points (n), either as equal to the number of tracts or as equal to the number of determinations for the tract corners, limits may be obtained within which the standard error should lie. The standard error, however, probably lies closer to the upper than to the lower limit. For a longer average distance—a sparser road network—the distance between the corner points of the various tracts is relatively less in relation to the "average mesh of the road network" than when the network is tighter; thus the individual determinations for the tract are not then independent, but are the more strongly correlated with one another. The closer the spacing of the road network, the greater is the degree of precision attained with four determinations per tract. The "clustered" grouping of the corner points always gives, however, a lower precision than that obtained when the same number of points is evenly distributed.

Appendix C

AREA DIVISIONS



Counties and their subdivisions

Nb	*Norrbottens län*
1,2	"Lappmark" above (os) and below (ns) the "investment limit"[1]
3	Coastal region
Vb	*Västerbottens län*
1,2	"Lappmark" os and ns
3	Coastal region
Jtl	*Jämtlands län*
1,2	Province of Jämtland os and ns
3,4	Härjedalen os and ns
Vnr	*Västernorrlands län*
1	Ångermanland
2	Medelpad
Gvl	*Gävleborgs län*
1	Hälsingland
2	Gästrikland
Kpb	*Kopparbergs län*
1,2	Särna-Idre communes os and ns
3	Remainder of the county
Vrm	*Värmlands län*
Ör	*Örebro län*
Vst	*Västmanlands län*
Up	*Uppsala län*
Sth	*Stockholms län*
Sdm	*Södermanlands län*
Ög	*Östergötlands län*
Skb	*Skaraborgs län*
Äbg	*Älvsborgs län*
1	Dalsland
2	Västergötland
Jkp	*Jönköpings län*
Krb	*Kronobergs län*
Klm	*Kalmar län*
Gtl	*Gotlands län*
Gbg	*Göteborgs och Bohus län*
Hl	*Hallands län*
Bl	*Blekinge län*
Krs	*Kristianstads län*
Mlm	*Malmöhus län*

Special regional terms

Storuman region (paper II): The area within a circle of radius 120 km from Storuman in Vb 2.

Norrland: Nb, Vb, Jtl, Vnr and Gvl (excl. Gvl 2 in papers IV and V).

N. Sweden (paper V): Nb . . . Kpb, Vst, Up and Sth.
S. Sweden (paper V): Vrm, Ör, Sdm . . . Mlm.

Industry groups (paper V):

North-western	(NV)	— units in Vrm, Skb and Äbg 1.
North-eastern	(NO)	— ,, in Ör, Sdm and Ög.
Göta River	(GÄ)	— ,, around Göta River.
South-western	(SV)	— ,, in Hl and the western parts of Jkp and Krb.
South-eastern	(SO)	— ,, in the eastern parts of Jkp and Krb and in Klm, Bl and Krs.

[1] Limit, above which regeneration measures are not generally taken due to low profitability.