THE DEVELOPMENT OF FINLAND'S FORESTS IN 1964—2000

MEMORANDUM TO THE ECONOMIC COUNCIL

FORECASTS OF THE DEVELOPMENT OF REMOVALS, GROWING STOCK AND THE GROWTH OF FINLAND'S FORESTS AND A PROPOSAL FOR A SILVICULTURAL PROGRAMME FOR A SUSTAINED SUPPLY OF INDUSTRIAL RAW WOOD

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Introduction

In a letter dated December 5, 1963, the Economic Council asked HEIKINHEIMO, HOLOPAINEN and KUUSELA to prepare a report on the development of Finland's forest resources up to the beginning of the next century, based on the assumptions that the production volume of the wood pulp industry would grow in accordance with a given timetable and that silviculture of at least the TEHO programme level would be pursued.

In negotiations with JUSSI LINNAMO, the liaison official of the Economic Council, the following details were agreed:

1. The Central Association of the Finnish Woodworking Industries will provide information on the probable development of the capacity of the pulp industry up to 1967. It is expected to grow by 2 per cent per annum in 1968—1975.
2 The degree of utilisation of the above capacity is expected to rise from 90 per cent in 1964 to 95 per cent by 1967 and to remain at this level thenceforth. The working team must, however, study whether the possibilities for this production exist with reference to the probable development of foreign demand and, if necessary, prepare an alternative parallel forecast.
3. The team was to work out from the above production forecast for the pulp industry a forecast of the wood raw material requirement of this branch of industry and, using the available data, forecasts of the roundwood requirement of the other wood utilisation branches; also, on their basis, a prediction of the removals of the forests for 1964—1975.
4. The above-mentioned forecasts were to disregard completely the effect on the supply and utilisation of wood produced by possible changes in the ratio between the roundwood requirements and the cutting possibilities.
5. With the removals predicted in the manner described above as the starting point — it was to be expected to rise again by 1/2 per cent per annum after 1975 — and making use of the most recent forest inventories, forecasts were to be prepared of the development of the growing stock and increment up to about the year 2050, as far as possible for alternative silvicultural programmes. Forest fertilisation was also to be considered in working out the programmes.

The working team, which ERVASTI and SIRÉN were invited to join when the work was in progress, wishes to stress specifically:

that its removal forecast is not a forecast of the in the long term possible allowable cut, but a forecast of the development of the logging quantities provided that the industry's wood requirement is satisfied up to the

amount that the Economic Council considers necessary for the growth of the national income and that forest owners are ready to meet this requirement on price etc. conditions determined by the cost and market situation at a given time. In fact, the predicted continuous growth of the roundwood requirement and the decrease in the growing stock which appears unavoidable in the near future will probably tighten the timber market, raise prices and thus limit the predicted growth of the industry.

As the realisation of the removal forecast prepared in this way together with the realisation of a silvicultural programme of the scope of the Teho programme, would lead to a very rapid reduction of the growing stock and growth of our forests and the industry's chances of obtaining raw material, the team has drawn up an estimate of the potential development of the growing stock and increment, based on the assumption that in addition to increased forest cultivation and forest drainage, large-scale forest fertilisation is also taken into consideration. On the other hand, there is as yet no fundamental material available for an accurate quantitative evaluation of the possibilities offered by forest tree breeding. This silvicultural programme, called an expanded Teho programme, is identical in its first part, i.e. until 1970, with the so-called MERA programme which was its parallel except for the scope of fertilisation.

The fuelwood utilisation and waste wood forecasts are based on the projections of partially obsolete statistical data. It is possible that the utilisation of fuelwood and the amount of waste wood could be reduced by a deliberate economic policy, and that the imports of round wood could perhaps be increased, thus increasing the quantity of industrial wood beyond that forecast. Nor do the calculations take into account the possibility of increased utilisation of stump wood and bark. As fuelwood is chiefly hardwood, the demand for chemical pulp and other products of hardwood limits the rapid expansion of industrial utilisation and reduction in the use of fuelwood. On the other hand, because all long-term forecasts of the demand for, and the production of, pulp have hitherto proved to be under-estimates, the team regards its development forecast of the removals as relatively probable.

In the following, the quantities of wood are always expressed as solid cu.m., excluding bark. The abbreviation cu.m. is used in the text.

Of the undersigned, HEIKINHEIMO, HOLOPAINEN and ERVASTI wrote Chapter 1, KUUSELA and SIRÉN Chapter 2, and Chapter 0 was written jointly by all the authors.

Helsinki, May 29, 1964

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0. Summary and proposals

The expansion of the forest industry considerably beyond the level foreseen in earlier forecasts, the continuously growing need for wood, and the decrease in forest resources suggested by the most recent information, together with the increase in poorly productive stands, has changed the situation essentially from what it was during the preparation of earlier programmes for the intensification of forestry and the estimates of the allowable cut associated with them. The large-scale removal and neglect of the basic improvements required have weakened the conditions for wood production to such an extent that much more extensive measures than those envisaged in the earlier estimates will be necessary to save the situation and ensure the continuity of the supply of wood. The results of the calculations made for this report, and the conclusions and proposals based on them, are presented in the following summary in the form of three separately analysed alternatives.

Alternative I: Realisation of the Teho programme and the removal corresponding to it. Predictions of the development of the growing stock show that even the immediate realisation of the Teho programme (for the time tables of the silvicultural programmes, see Table 7) would only permit a cut amounting to an annual drain of no more than c. 51 million cu.m. *up to the year 2000.* Only after this year will ig be possible gradually to increase the removal.

Limiting the drain to 51 million cu.m. means that, unless imports of industrial wood exceed the forecast (see Chapter 1) or the quantity of fuelwood and waste wood decreases considerably, it will not be possible to utilise fully the production capacity of the forest industry already in existence. Nor would Finland be able to benefit from the increased sale of forest industry products which, according to FAO forecasts, will occur in Europe after 1975.

A precondition for full utilisation of the still growing production capacity of the forest industry is to expand wood production, a feature which has long been grossly neglected. If the neglect continues, part of the funds invested in expansion of the forest industry will prove to have been a poor investment.

The realisation of the Teho programme as such in the conditions indicated by the most recent information on forest resources, means that the growth of national income cannot be based on forestry and wood economy. Moreover, the continued failure to realise this programme is creating a serious obstacle to endeavours even to maintain the national income unchanged.

Alternative II: The consequences of the predicted removal if the Teho programme is realised as such. The wood utilisation forecast based on the premisses given to the team show that the annual drain will grow in 1964—1975 from 52 million to 58 million cu.m., and thereafter by 0.5 per cent per annum. The calculations

show that the Teho programme as such does not permit a removal of such proportions. Because of earlier neglect and over-cutting, which steadily diminishes industrial wood resources, the consequence would be exhaustion of the present growing stock (stands now growing) by the turn of the century. After that, for at least some twenty years, large-sized timber could be cut only very sparingly, and then only from new plantations which would still be very young. Only a small part, perhaps 20 per cent at the most, of the need for other industrial wood could be met during the same period. If an annual total drain of c. 58 million cu.m. after 1975 is considered sufficient, exhaustion of the present growing stock would be postponed by 4—5 years only.

The utilisation of forest resources on the scale mentioned above, even if the Teho programme were carried out in full, would thus lead to a catastrophic weakening of the roundwood supply potential. In fact, the amount of cut would begin to diminish gradually before the turn of the century, because of the contraction in the supply of wood. This slowing-down process has in fact already started.

To conclude, the Teho programme as it stands, combined with the removal foreseen by the required growth of the national income — which has been set as the starting point for the calculations — would lead to exhaustion of the present growing stock by 2000 A.D., with all the resultant economic consequences.

Alternative III: Teho programme expanded in conformity with the removal forecast. As neither the original Teho programme nor the MERA programme seems to permit the predicted total removal, we felt it necessary to work out an alternative in ehich the targets of the Teho programme were increased considerably, and the potential growth obtainable by large-scale forest fertilisation was taken into consideration. With the exception of fertilisation, the programme keeps initially to the timetable drawn up by the Forestry Financing Committee (MERA).

Proposals: The following measures must be taken without delay, in order to retard the rapid decrease in felling possibilities, the consequences of which have already begun to be felt.

1. Large-scale *fertilisation* of fully-stocked firm forest land, which will increase the growth of present growing stocks most rapidly, must be instituted. This work should begin as soon as possible at the rate of about 100,000 hectares per annum, expanding to an annual maximum of c. 1 million hectares around 1975, whereafter it can be kept at the same level. The fertilisation area can be reduced considerably if there is a much more rapid conversion than predicted from fuelwood to industrial wood utilisation, and/or if wood imports grow above the estimated level. Fertilisation must begin in nearly mature forests with the best growing stock.

2. The annual area of *forest artificially regenerated* must be enlarged from the present rate (112,000 hectares, of which only 80,000 are successfully regenerated) to 300,000 hectares of efficiently regenerated area by 1970. It must remain at this level for at least ten years during which time the main part of the now poorly productive areas will be regenerated. After about the year 1980, the area so treated may be reduced to 250,000 hectares, of which a considerable proportion will then consist of drained peat-land. Artificial regeneration must be commenced on the more fertile land and in ruined stands.
3. *The supply of planting stock and seed* must be ensured for many years ahead. A national forest tree-seed store must be established. It should have a minimum of 100,000 kg of seeds for immediate forest sowing operations, and for the needs of seedling stands. To obtain sufficiently good seed, especially for the needs of the near future, additional selected seed-collection stands should be reserved, fertilised and maintained for seed production. The establishment of seed orchards must be continued up to c. 3,500 hectares for future needs.

   Seedling production must be raised to 400—450 million seedlings by 1970. To raise the standard of the regeneration material, forest-tree breeding must be given a central role in the production of seeds and seedlings. Forest-tree breeding must be intensified vigorously for the production of hybrids of rapid growth and high quality.
4. It is advisable to leave only the dry forest sites and exceptionally easily regenerated peat-land to the generally slow and random process of *natural regeneration*. However, use should be made of existing seedling stands and understoreys capable of development.
5. *Forest drainage* must be increased from the present figure of about 155,000 hectares per annum to about 250,000 hectares by 1970. When this target has been achieved, and when the forest growth capacity of peat-lands has been ensured, drainage should continue up to a total of 7 million hectares, i.e. until about the year 1990.

   The increase in the amount of cut that can be achieved through swamp drainage and fertilisation is so significant that, provided the drained areas are maintained, acceleration of this schedule for drainage work must also be considered.

   At least 30,000 km of ditches must be cleared annually.
6. *Clearing of logging areas and preparation of the ground* for artificial regeneration must total 250,000—300,000 hectares per annum.
7. The total of *seedling stand tending work* must be raised to c. 300,000 hectares by 1970. The aftercare of the cultivation areas must be performed in time; special attention must be paid to the weeding of seedling stands.

8. The use of shelterwood cut and the traditional seed-tree method, aimed at natural regeneration but greatly reducing total growth must be stopped. Stands must be thinned in such a way that yield is not reduced, until the final cutting takes place. The methods of regeneration mentioned above can only be considered on areas which rapidly regenerate naturally.
9. *Fuelwood* must be replaced by other fuels as quickly as possible, and this change must be furthered by administrative means, and price and tariff policy industrial use of deciduous wood and thin pulpwood is to increase.
10. A start must be made with increasing *wood imports.*
11. *New forest motor roads* must be built under the MERA programme.
12. The legislative, economic and political action required for the realisation of the above measures, and the measures foreseen in the report, must be clarified urgently.
13. The quantity of semi-abandoned arable land which is not needed for farming must be found out, and the measures required for the afforestation of these areas must be worked out.
14. The work detailed above will make such great demands on the organisation in the forestry, and will require such extensive activity, guidance and co-ordination that their re-organisation must be considered, or the establishment of a new organ for the work and for a national forest policy. Special attention must be paid to the flexible and efficient operation of the field organisations.
15. A sufficiently large corps of skilled personnel must be trained for the realisation of the above programmes.
16. The most economic expansion of forest production possible also presupposes that the present *inadequate scale of forest research* must be corrected without delay. This applies above all to artificial regeneration, forest fertilisation, forest tree breeding, damage to forests and the pertinent economic calculations. An increase in research grants must begin immediately, so that a lasting foundation can be established for basic improvements, and great losses resulting from the lack of information and experience can be prevented.
17. The aspects of commercial policy etc. which affect the *raising of the degree of processing* and, thus increase the growth rate of the national income without increasing the utilisation of roundwood, must be clarified.

1. Development of the romovals in 1955—1963 and the forecast for 1964—1975

11. Development of the capacity of the pulp industry

The growth of Finland's forest industry has been concentrated of late, and obviously will be in the future, in the wood-pulp and paper branches. These are therefore of primary importance for the future roundwood requirements of the forest industry. It may suffice here to consider only the level of production which utilises roundwood, i.e. the pulp industry.

The Central Association of Finnish Woodworking Industries, at the request of the team, supplied a calculation of the development of Finnish pulp industry capacity by the main production branches up to 1967. The calculation is based on plans — already being put into effect to a considerable extent — for building new mills and enlarging existing plants. The results are given in Table 1, which includes data on the capacity in 1955 and the early 1960s to illustrate the trend.

The total capacity figures for the different years are not fully comparable as regards e.g. economic growth potential, investment needed for building, and the raw wood requirements for production. Considerable changes have occurred, during the period under examination, in the ratios of the various products. Therefore, the raw timber calculations which follow were made by product groups.

To summarize, concerning the figures in Table 1 it may be said that the increase in capacity in the 12-year period 1955—1967 appears as follows:

in the mechanical pulp industry	86 %
» » sulphite industry	60 %
» » sulphate industry	237 %
» » pulp industry as a whole	128 %

It is assumed that the capacity of the pulp industry will grow by a further 2 per cent per annum in 1968—1975. The assumed 2 per cent rate of growth in 1968—1975 will mean a markedly decelerating capacity growth rate towards the end of the 20-year period 1955—1975. Total capacity will increase in 1955—1965 by 106.8, and in 1965—1975, by 29.9 per cent.

In the following calculations it is assumed that the production capacity of the pulp industry will grow at the same rate in all product groups in 1968—

Table 1. Calculation of the development of the capacity of the wood-pulp industry, 1955—67. 1 000 tons

Year	Mechanical wood-pulp industry	Sulphite industry				Semi-chemical wood-pulp industry	Grand total
		Dissolving	Bleached	Unbleached	Total		
1	2	3	4	5	6	10	11
1955	1 050				858	15	2 970
1960	1 250	190	440	730	1 360	50	3 875
61	1 300	225	515	780	1 520	130	4 485
62	1 450	260	515	785	1 560	160	5 045
63	1 530	285	535	760	1 580	165	5 405
64	1 600	290	515	775	1 580	180	5 670
65	1 760	290	530	785	1 605	220	6 100
66	1 870	290	555	800	1 645	220	6 385
67	1 950	290	595	810	1 695	232	6 767

Source: 1955 Holopainen (capacity study)
1960—67 SPKL (Toppari) 13. 3. 1964.

1975. Such uniform development is highly improbable, but changes in the product group distribution have a relatively small effect on the total forecast for wood utilisation by this industry.

The wood requirement of the wood-pulp industry depends not only on the production capacity but also on the utilisation of that capacity. Among the factors limiting the employment of capacity, one of special importance — in addition to the supply of wood — is the market situation. This many-faceted question can only be considered briefly here.

The FAO has made several forecasts of the demand (more correctly: need) for the end products of the pulp and paper industry. Attached to them is a calculation of the amount of pulp (mechanical, semichemical and chemical pulp) needed for the end products. A comprehensive study[1]), completed at the end of 1963, is available of the development of the need for paper and board in Western Europe (EEC and Finefta, Spain, Ireland, Iceland and Greece). It forecasts the requirement of pulp and paper products up to 1975, based chiefly on the growth of the population, and the GNP per capita.

There is also a forecast[2] of the paper and board need of the whole world up to 1975, and of the pulp requirements based on it, prepared on the same basis.

Finland's marketing possibilities are influenced most by the development of Western Europe's use of forest products. In 1960—1962 the share of this area in Finnish exports was as follows for the different product groups:

sawnwood	93 %
plywood	76 %
pulp	71 %
paper	59 %

The trend of the long-term demand for the products of the pulp and paper industry calculated in this way (fluctuations due to business cycles were disregarded in making the calculation) can be seen in Table 2.

Table 2. Production possibilities (in terms of pulp) for the products of Finland's pulp and paper industry in the years 1965, 1967, 1970 and 1975 on the basis of world and West European demand.

Year	Predicted demand, mill. tons		Finland's output, mill. tons	
	World	West Europe	According to world demand	According to West European demand
1965	74.4	17.3	4.6	4.3
1967	82.0	20.0	5.1	4.9
1970	94.0	22.5	5.8	5.6
1975	117.1	26.6	7.3	6.6

[1] Pulp and paper prospects in Western Europe. A study by FAO secretariat under the direction of Arne Sundelin. Munich 1963.

[2] World demand for paper to 1975. A study of regional trends. Rome 1960.

Slightly different grounds were used in calculating the trend of demand for wood-pulp in Western Europe and in the world. Hence the comparison must be regarded as a fairly rough one only. However, both calculations seem to give a fairly similar result. The only essential difference is for the year 1975.

Departing from the rate of growth of pulp utilisation (correctly: need) in Europe, we obtain the following production of pulp by Finland up to 1975:

1962 (production according to the statistics)	4.1 million tons
1965	4.3 » »
1967	4.9 » »
1970	5.6 » »
1975	6.6 » »

The predicted increase in production in 1962—1965, according to the premisses used here, is very modest, only 0.2 million tons. On the other hand, it will be considerable by 1970, c. 1.4 million tons, and sizeable already by 1967 (0.8 million tons).

There are, however, grounds for assuming that Finland might be able, in the future, to increase its share in the Western European market for products of the pulp and paper industry. Some of the factors influencing the situation in this way are:

1. Through its pulpwood exports, which continue to be fairly large, Finland has, up to the present time, supported the pulp and paper production of certain West European countries. It is to be expected that a contraction of these exports by Finland will open up increasing opportunities for our exports of pulp and products thereof. Round wood exports, 6.0 million cu.m. in 1961, have contracted sharply; probably no more than 1.2 million cu.m. will be exported in 1964.[1]
2. Hard evidence of the chances of increasing our proportion is the fact that Finland's pulp production rose in 1963 to 4.4 million tons — without building up inventories — a slightly higher figure than the level foreseen for 1965 in the forecasts mentioned above.

Although there is also a number of factors working in the opposite direction, especially the increasing exports to Western Europe, by the USA and Canada, of the products of the pulp and paper industry, it would seem justifiable in the following calculations of wood requirements (Table 3) to assume as one alternative (utilisation of capacity »A») that the demand for our pulp and paper industry products would grow slightly faster than the need for these products in Western Europe in the period 1959/1961—1975, and that sales in our other markets would increase in nearly the same ratio. The other wood requirement calculation (utilisation of capacity »B») is based — in accordance with the terms

[1] The figure was 1.4 mill. cu.m.

Table 3. Utilisation of raw material corresponding to total capacity and utilisation of raw material according to the alternative capacity utilisation levels in 1960—75.

Year	Mechanical wood pulp industry	Sulphite industry				Sulphate industry				Semi-chemical wood pulp industry	Total	Utilisation of capacity »A»		Utilisation of capacity »B»	
		Dissolving	Bleached	Unbleached	Total	Bleached	Unbleached	Total				%	Mill. sol. cu.m.	%	Mill. sol. cu.m.
	Thousands solid cu.m. unseasoned wood (excl. bark) at 100 % utilisation of capacity														
1960	3 125	1 064	2 112	3 212	6 388	1 034	4 428	5 462	11 850	120	15 095	94.0	14.2	94.0	14.2
61	3 250	1 260	2 472	3 432	7 164	1 669	5 251	6 920	14 084	312	17 646	92.5	16.3	92.5	16.3
62	3 625	1 456	2 472	3 454	7 382	2 350	6 119	8 469	15 851	384	19 860	84.2	16.7	84.2	16.7
63	3 825	1 596	2 568	3 344	7 508	2 632	6 986	9 618	17 126	396	21 347	84.6	18.1	84.6	18.1
64	4 000	1 624	2 472	4 410	7 506	3 431	7 031	10 462	17 968	432	22 400	85.0	19.0	90.0	20.2
65	4 400	1 624	2 544	3 454	7 622	4 371	7 053	11 424	19 046	528	23 974	85.0	20.4	91.5	21.9
66	4 675	1 624	2 664	3 520	7 808	5 288	6 786	12 074	19 882	528	25 085	85.0	21.3	93.1	23.4
67	4 875	1 624	2 856	3 564	8 044	6 274	6 920	13 194	21 238	557	26 670	85.0	22.7	95.0	25.3
68	4 972	1 658	2 914	3 634	8 206	6 401	7 058	13 459	21 665	569	27 206	85.0	23.1	95.0	25.8
69	5 072	1 691	2 971	3 705	8 367	6 528	7 200	13 728	22 095	581	27 748	85.0	23.6	95.0	26.4
1970	5 172	1 725	3 029	3 780	8 534	6 660	7 342	14 002	22 536	593	28 301	85.5	24.2	95.0	26.9
71	5 275	1 758	3 091	3 854	8 703	6 791	7 489	14 280	22 983	605	28 863	87.4	25.2	95.0	27.4
72	5 380	1 792	3 154	3 929	8 875	6 928	7 641	14 569	23 444	617	29 441	89.2	26.3	95.0	28.0
73	5 487	1 826	3 216	4 008	9 050	7 064	7 792	14 856	23 906	629	30 022	90.9	27.3	95.0	28.5
74	5 597	1 865	3 278	4 087	9 230	7 205	7 948	15 153	24 383	641	30 621	92.5	28.3	95.0	29.1
75	5 710	1 904	3 346	4 171	9 421	7 351	8 108	15 459	24 880	653	31 243	94.0	29.4	95.0	29.7

Demand for raw material:

Mechanical wood-pulp	2.50 solid cu.m. excl. bark per ton	(4.52) solid su.m. excl. bark per ton		
Sulphite	(4.77)	4.70	—»—	
bleached	4.80	4.45	—»—	
unbleached	4.40	2.40	—»—	
dissolving	5.60			

of reference of the Research Department of the Economic Council — on the assumption that the utilisation of capacity in the pulp industry is 90 per cent in 1964, rises to 95 per cent by 1967, and then remains steady at that level to the end of the period.

It should be emphasised that the market estimate, although based on the development of the pulp requirement (which uses primarily wood), does not presuppose that the output is also marketed as chemical or mechanical pulp. Already, over half of our pulp production is used for the manufacture of paper and board, and the emphasis in exports has been placed increasingly on these products which represent a higher degree of processing. The production capacity and the assortment must adjust flexibly to the market, and the degree of processing should be raised within the limits dictated by the market. The country's economic growth can be maintained also through the raising of the degree of processing. This happened in the 1950s in the exports of the products of Finland's pulp and paper industry to Western Europe. The Finnish share of West European pulp imports fell, between 1950/1951 and 1960/1961, to 20 per cent, while the proportion of paper and board exports sold to Western Europe increased from 19 to 25 per cent.

It must also be stressed that the market forecast is based only on factors which are in play on the *demand side* for pulp and paper industry products, i.e. the growth of the population and the national income. This applies to the FAO forecasts which constitute the starting point, and assume that the prices of these forest products, in relation to other prices, will remain constant (the ratio in 1957—1959). The need for forest products in Western Europe, calculated on these premisses, will grow to such an extent that it will exceed considerably the long-term logging that can be pursued in this area. As it is improbable that, at the assumed prices, imports from elsewhere can make good the deficit, the balance between supply and demand will probably mean a higher price level and, at the same time, not so sharp an increase in utilisation as is given in the forecasts based on demand factors. This will be valid if the population and the national income do not grow more rapidly than predicted.

It is also assumed in the market analysis that the competitive position of the pulp and paper companies in our country will not deteriorate essentially from the present level. As will be seen from the calculations presented later, the predicted development of sales — together with the increase in the forest industry's round wood requirement — will lead to such a great increase in the round wood requirement, that it will essentially change, for example, the conditions governing the formation of round wood prices. Rationalisation of the industry and of logging will hardly be able to absorb completely the cost increase to be expected from this development.

In any case, a bigger market (utilisation of capacity »B») can hardly be regarded as realistic in the light of these factors.

12. Development of other forest industry

It has been estimated that the production trend of the sawmill industry in 1964—1975 will be a very slow increase based on hardwood, considerably slower than the sawnwood demand in Europe predicted by FAO. The growing competition between the pulp industry and sawmills for round wood will probably keep the average sawmill production in 1964—1975 below that of the early 1960s. The main reason is the slow growth of the productivity of sawmills.

It has been assumed that the plywood industry, and also the board industries of more recent date, will continue to raise their output in the manner of the last few years.

13. The wood raw material requirement of the forest industry as a whole

Table 3 shows the wood quantities needed for 100 per cent utilisation of capacity, calculated from the production series in Table 1, which indicate the total capacity of the pulp industry. Conversion factors based on the experience gained in the last few years, were used for the calculation. Two forecasts were made for the utilisation of wood in Table 3, applying the above- mentioned probable forecast »A» for the development of utilisation of capacity, and forecast »B», which is less probable in our opinion, but which was given in the terms of reference. The forecasts take into account the raw material obtained from industrial waste, and the wood which might be imported.

In Table 4 is entered the round wood utilisation by Finland's forest industry as a whole in 1955—1963, and the utilisation forecast for 1964—1975. For the calculations of the development of the growing stock, coniferous and deciduous wood were taken separately.

In 1960, Professor Saari predicted for the Economic Programme Committee the wood utilisation[1] in 1970. Basing his calculations on the forest industry's expansion plans at that time, he arrived at the following figures: 10.0 million (here 11.7 million) cu.m. for the sawmill industry, 18.0 million (here 24.2 million in alternative »A», and 26.9 million in alternative »B») cu.m. for the wood-pulp industry, and 1.9 million (here 2.9 million) cu.m. for other industry. The total wood utilisation of the forest industry in 1970 would thus be 38.8 or 41.5 million cu.m. according to the present calculations, and 29.9 million cu.m. according to Saari. Even if 2.7 million cu.m. of industrial waste, which is not included in Saari's figure, is deducted from the present total, the comparison shows the great change that has taken place in the production and sales prospects of the forest industry.

[1] Here and later, cu.m. = solid cu.m. green timber excl. bark.

Table 4. Utilisation of unprocessed wood[1] by forest industry in 1955—63 and forecast for 1964—75.

Mill. solid cu.m. unseasoned wood (excl. bark)

Year	Saw mill industry			Plywood industry			Wood pulp industry						Fibreboard industry			Particle board industry			Other forest industry			Domestic and foreign industrial wood and industrial chips together					
							Coniferous		Deciduous		Total											Util. of capacity »A»		Util. of capacity »B»		Total	
	Conif.	Decid.	Total	Conif.	Decid.	Total	A	B	A	B	A	B	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Conif.	Decid.	»A»	»B»
1955	10.7	0.1	10.8	0.0	1.3	1.3	10.7		0.1		10.8		0.4	0.1	0.5	—	—	—	0.2	0.2	0.4	21.8	1.8			23.6	
56	8.3	0.2	8.5	0.0	0.9	0.9	11.0		0.2		11.2		0.3	0.1	0.4	—	—	—	0.2	0.2	0.4	19.7	1.6			21.3	
57	8.5	0.2	8.7	0.0	0.9	0.9	11.9		0.2		12.1		0.4	0.1	0.5	—	—	—	0.2	0.2	0.4	20.9	1.6			22.5	
58	9.9	0.2	10.1	0.0	0.8	0.8	11.8		0.3		12.1		0.4	0.1	0.5	0.0	0.1	0.1	0.1	0.1	0.2	22.2	1.5			23.7	
59	10.7	0.1	10.8	0.0	0.9	0.9	12.1		0.4		12.5		0.3	0.2	0.5	0.0	0.1	0.1	0.1	0.1	0.2	23.3	1.8	Same as		25.1	
1960	13.8	0.1	13.9	0.0	1.0	1.0	13.7		0.5		14.2		0.4	0.2	0.6	0.1	0.1	0.2	0.2	0.2	0.4	28.1	2.1	»A»		30.2	
61	13.3	0.2	13.5	0.0	1.0	1.0	15.5		0.8		16.3		0.4	0.2	0.6	0.1	0.1	0.2	0.2	0.2	0.4	29.6	2.4			32.0	
62	11.6	0.1	11.7	0.1	1.0	1.1	15.7		1.0		16.7		0.3	0.3	0.6	0.1	0.1	0.2	0.2	0.1	0.3	28.0	2.7			30.7	
63	11.7	0.1	11.8	0.1	1.1	1.2	16.9		1.2		18.1		0.4	0.3	0.7	0.1	0.1	0.2	0.2	0.1	0.3	29.4	2.9			32.3	
64	11.5	0.1	11.6	0.1	1.1	1.2	17.5	18.6	1.5	1.6	19.0	20.2	0.4	0.3	0.7	0.1	0.1	0.2	0.2	0.1	0.3	29.8	3.2	30.9	3.3	33.0	34.2
65	11.5	0.1	11.6	0.1	1.1	1.2	18.5	19.9	1.9	2.0	20.4	21.9	0.3	0.4	0.7	0.1	0.1	0.2	0.2	0.1	0.3	30.7	3.7	32.1	3.8	34.4	35.9
66	11.5	0.1	11.6	0.1	1.2	1.3	18.9	20.8	2.4	2.6	21.3	23.4	0.4	0.4	0.8	0.1	0.2	0.3	0.2	0.1	0.3	31.2	4.4	33.1	4.6	35.6	37.7
67	11.5	0.1	11.6	0.1	1.2	1.3	20.1	22.4	2.6	2.9	22.7	25.3	0.4	0.4	0.8	0.1	0.2	0.3	0.2	0.1	0.3	32.4	4.6	34.7	4.9	37.0	39.6
68	11.5	0.1	11.6	0.1	1.2	1.3	20.3	22.7	2.8	3.1	23.1	25.8	0.3	0.5	0.8	0.1	0.2	0.3	0.2	0.1	0.3	32.5	4.9	34.9	5.2	37.4	40.1
69	11.5	0.1	11.6	0.1	1.2	1.3	20.6	23.0	3.0	3.4	23.6	26.4	0.4	0.5	0.9	0.1	0.2	0.3	0.2	0.1	0.3	32.9	5.1	35.3	5.5	38.0	40.8
1970	11.5	0.2	11.7	0.2	1.2	1.4	21.0	23.3	3.2	3.6	24.2	26.9	0.4	0.5	0.9	0.1	0.2	0.3	0.2	0.1	0.3	33.4	5.8	35.7	5.8	38.8	41.5
71	11.5	0.2	11.7	0.2	1.2	1.4	21.7	23.6	3.5	3.8	25.2	27.4	0.4	0.5	0.9	0.1	0.3	0.4	0.2	0.1	0.3	34.1	5.8	36.0	6.1	39.9	42.1
72	11.5	0.2	11.7	0.2	1.2	1.4	22.5	24.0	3.8	4.0	26.3	28.0	0.3	0.6	0.9	0.1	0.3	0.4	0.2	0.1	0.3	34.8	6.2	36.3	6.4	41.0	42.7
73	11.5	0.2	11.7	0.2	1.2	1.4	23.3	24.3	4.0	4.2	27.3	28.5	0.4	0.6	1.0	0.1	0.3	0.4	0.2	0.1	0.3	35.7	6.4	36.7	6.6	42.1	43.3
74	11.5	0.2	11.7	0.2	1.2	1.4	24.1	24.7	4.2	4.4	28.3	29.1	0.4	0.6	1.0	0.1	0.3	0.4	0.2	0.1	0.3	36.5	6.6	37.1	6.8	43.1	43.9
75	11.5	0.2	11.7	0.2	1.2	1.4	24.9	25.2	4.5	4.5	29.4	29.7	0.4	0.7	1.1	0.1	0.3	0.4	0.2	0.1	0.3	37.3	7.0	37.6	7.0	44.3	44.6

[1] Includes domestic and foreign roundwood and industrial waste.

Table 5. Utilisation of roundwood[1] in 1955—63 and forecast of utilisation in 1964—75

Mill. solid cu.m. unseasoned wood (excl. bark)

Year	Unprocessed wood for forest industry						Non-industrial wood			Roundwood export less import			Raw material in form of wastewood			Total utilisation						Losses		
	Utilisation of capacity »A»			Utilisation of capacity »B»												Utilisation of capacity »A»			Utilisation of capacity »B»					
	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total	Conif.	Decid.	Total
1955	21.8	1.8	23.6				6.5	9.5	16.0	5.0	0.1	5.1	−1.3	−0.1	−1.4	31.9	11.4	43.3				3.2	1.4	4.6
1956	19.7	1.6	21.3				6.4	9.5	15.9	4.1	0.1	4.2	−1.3	−0.1	−1.4	29.0	11.0	40.0				3.1	1.5	4.6
1957	20.9	1.6	22.5				6.3	9.3	15.6	3.8	0.1	3.9	−1.5	−0.1	−1.6	29.5	10.9	40.4				3.2	1.5	4.7
1958	22.2	1.5	23.7				6.3	9.4	15.7	3.7	0.0	3.7	−1.7	−0.1	−1.8	30.5	10.8	41.3				3.2	1.4	4.6
1959	23.3	1.8	25.1	Same as »A»			6.3	9.4	15.7	3.5	0.1	3.6	−2.0	−0.1	−2.1	31.2	11.1	42.3	Same as »A»			3.2	1.4	4.6
1960	28.1	2.1	30.2				6.3	9.4	15.7	4.5	0.0	4.5	−2.2	−0.1	−2.3	36.7	11.4	48.1				3.7	1.4	5.1
1961	29.6	2.4	32.0				6.3	9.2	15.5	5.4	0.2	5.6	−2.3	−0.1	−2.4	39.0	11.7	50.7				3.7	1.5	5.2
1962	28.0	2.7	30.7				6.2	9.1	15.3	3.0	0.2	3.2	−2.1	−0.1	−2.2	35.2	11.9	47.1				3.5	1.5	5.0
1963	29.4	2.9	32.3				6.2	9.0	15.2	0.9	0.1	1.0	−2.1	−0.1	−2.2	34.4	11.9	46.3				3.5	1.5	5.0
1964	29.8	3.2	33.0	30.9	3.3	34.2	6.1	8.9	15.0	1.2	0.0	1.2	−2.2	−0.1	−2.3	34.9	12.0	46.9	36.0	12.1	48.1	3.4	1.4	4.8
1965	30.7	3.7	34.4	32.1	3.8	35.9	6.0	8.7	14.7	1.2	0.0	1.2	−2.3	−0.1	−2.4	35.6	12.3	47.9	37.0	12.4	49.4	3.3	1.3	4.6
1966	31.2	4.4	35.6	33.1	4.6	37.7	5.8	8.6	14.4	1.2	0.0	1.2	−2.4	−0.1	−2.5	35.8	12.9	48.7	37.7	13.1	50.8	3.2	1.3	4.5
1967	32.4	4.6	37.0	34.7	4.9	39.6	5.6	8.4	14.0	1.2	0.0	1.2	−2.4	−0.2	−2.6	36.8	12.8	49.6	39.1	13.1	52.2	3.1	1.3	4.4
1968	32.5	4.9	37.4	34.9	5.2	40.1	5.5	8.2	13.7	1.2	0.0	1.2	−2.4	−0.2	−2.6	36.8	12.9	49.7	39.2	13.2	52.4	3.0	1.3	4.3
1969	32.9	5.1	38.0	35.3	5.5	40.8	5.3	8.1	13.4	1.2	0.0	1.2	−2.4	−0.2	−2.6	37.0	13.0	50.0	39.4	13.4	52.8	2.9	1.2	4.1
1970	33.4	5.4	38.8	35.7	5.8	41.5	5.2	8.0	13.2	1.2	0.0	1.2	−2.5	−0.2	−2.7	37.3	13.2	50.5	39.6	13.6	53.2	2.8	1.1	3.9
1971	34.1	5.8	39.9	36.0	6.1	42.1	5.0	7.8	12.8	1.2	0.0	1.2	−2.5	−0.2	−2.7	37.8	13.4	51.2	39.7	13.7	53.4	2.7	1.1	3.8
1972	34.8	6.2	41.0	36.3	6.4	42.7	4.7	7.7	12.4	1.2	0.0	1.2	−2.5	−0.3	−2.8	38.2	13.6	51.8	39.7	13.8	53.5	2.6	1.1	3.7
1973	35.7	6.4	42.1	36.7	6.6	43.3	4,6	7.6	12.2	1.1	0.0	1.1	−2.5	−0.3	−2.8	38.9	13.7	52.6	39.9	13.9	53.8	2.5	1.1	3.6
1974	36.5	6.6	43.1	37.1	6.8	43.9	4.5	7.5	12.0	1.1	0.0	1.1	−2.6	−0.3	−2.9	39.5	13.8	53.3	40.1	14.0	54.1	2.5	1.1	3.6
1975	37.3	7.0	44.3	37.6	7.0	44.6	4.4	7.3	11.7	1.1	0.0	1.1	−2.6	−0.3	−2.9	40.2	14.0	54.2	40.5	14.0	54.5	2.5	1.0	3.5

[1] Also included in the utilisation figures are foreign wood and industrial wastewood used as raw material. In calculating the total utilisation, however, they have been omitted, so that the item includes only the utilisation (primary utilisation of stemwood) of domestic roundwood.

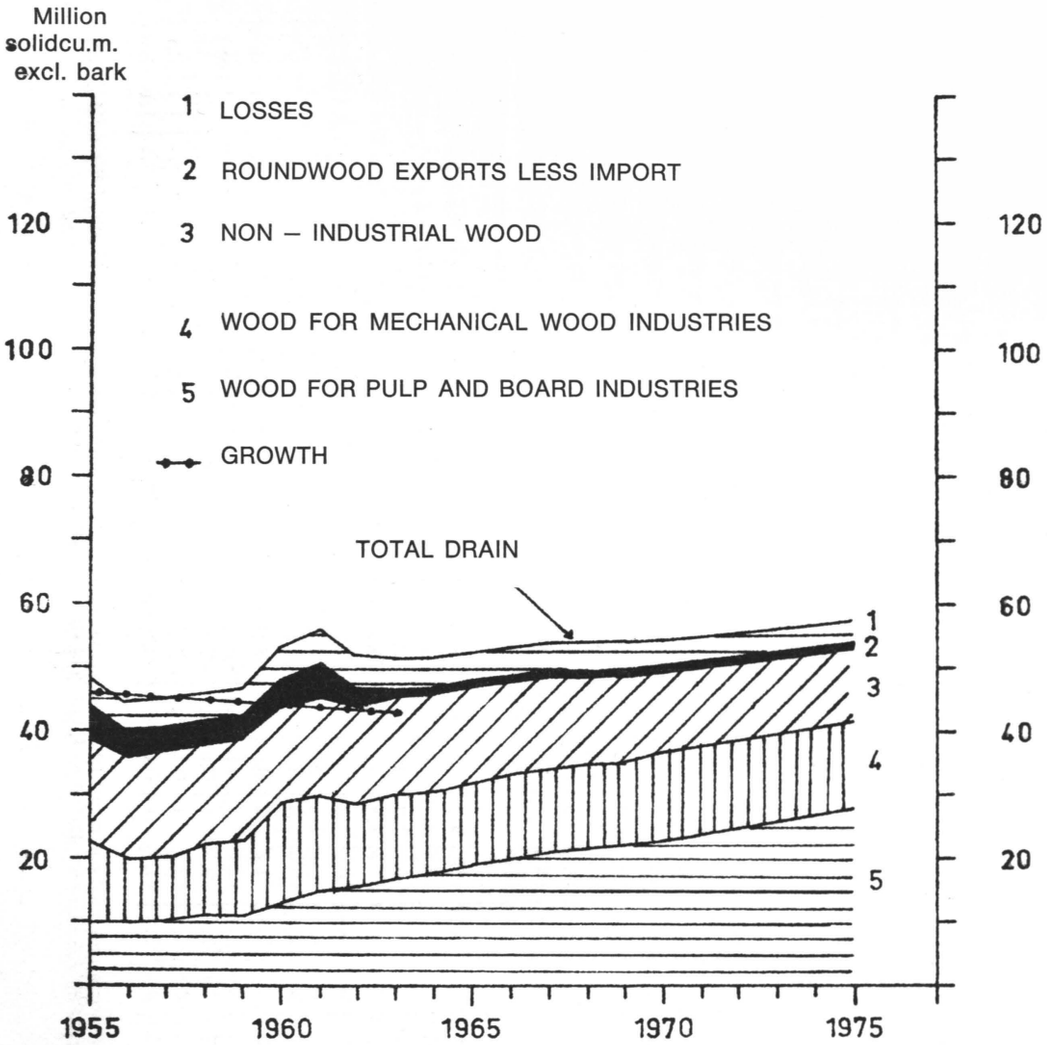

Figure 1. Drain (including fellings and mortality) and growth in 1955—63 and removal forecast according to activity level »A» for 1964—75. Source: Tables 4 and 5.

14. Forest removal

In addition to industrial raw material and round wood exports, considerable quantities of stem fuelwood (13.6 million cu.m. in 1955) and round wood for building, poles, railway sleepers, etc. (2.4 million cu.m. in all in 1955) are used in our country. All these uses together (16.0 million cu.m.) have shown a slowly

decreasing trend. The quantity of fuelwood utilisation, however, seems to have remained unchanged in the period 1927—1955 as the increase in the number of dwelling units has counterbalanced the decrease in the fuelwood used per unit. SAARI, for the Economic Programme Committee, forecast, for instance that this wood utilisation would remain unchanged in the 1960s. The present team unfortunately had access to no newer figures for the main items of this utilisation group than those for 1955. Taking into account the change in recent years from wood-burning to electric, gas or oil-fuelled heating and cooking apparatus even in rural districts, the team estimated that the wood utilisation in question here may be reduced by 1975, by economic policy measures, to 11.7 million cu.m., i.e. by 27 per cent of the quantity in 1955 (16.0 million cu.m.). The predicted rate of decrease in the use of stem fuelwood is approximately the same as that calculated by the Fuel Department of the Industrial Negotiating Body. A condition for its validity is that industry can increase in a corresponding degree the demand for thin softwood and hardwood pulpwood.

The difference (export surplus) between round wood exports and imports, narrowed in 1963 to c. 1 million cu.m. It is estimated that round wood exports and imports will more or less balance in 1964.

From the total wood raw material utilisation must be deducted the waste wood of the sawmills and plywood mills, etc. which is consumed by the pulp and board industries. Otherwise it will be calculated twice. The recovery of waste wood as raw material for the pulp and particle board industry has been intensified in the last few years. It is assumed that it will be made still more efficient, but it seems to be approaching the limit of possibility.

Industrial waste suitable for industrial use, and not utilised by the pulp and board industry at the beginning of the 1960s, totalled c. 1 million cu.m. As the combined output of the sawmill and plywood industry will obviously be somewhat smaller in the future than it was in the early 1960s, the quantity of waste will decrease slightly. It has been estimated that an additional 0.7 million cu.m. of the total 1 million cu.m. of waste will be utilised by 1975.

When the total wood utilisation is compared with the cutting possibilities offered by the volume of growing stock and its growth, we must add to the useful wood the logging waste in the forests, floating losses in the waterways, and the unused wood rotting in the forests. These items are difficult to estimate, but the quantity is one the whole a dimishing one, in relation to the total felling quantity. However, there is very little likelihood that these items would amount to less than the predicted figure of about 6 per cent of the total removal by 1975.

The two alternative forecasts for total drain in 1963—1975 are shown in Table 6.

Very radical rationing, and other measures necessitated by the shortage of wood may, of course, affect the trends outlined above, especially for fuelwood.

However, the development indicated here is sufficient to require extension work and an active economic policy if the utilisation of wood is to be directed along the desired lines.

Table 6. Drain (including fellings and mortality) (based on wood utilisation) in 1955—63 and forecast for 1964—75.

Mill. solid cu.m. unseasoned wood (excl. bark)

Year	Utilisation of capacity »A»				Utilisation of capacity »B»			
	Conifer.	Deciduous	%	Total	Conifer.	Deciduous	%	Total
1955	35.1	12.8	26.7	47.9				
56	32.1	12.5	28.0	44.6				
57	32.7	12.4	27.5	45.1				
58	33.7	12.2	26.7	45.9				
59	34.5	12.4	26.5	46.9				
1960	40.3	12.9	24.2	53.2	Same as »A»			
61	42.7	13.2	23.5	55.9				
62	38.7	13.4	25.6	52.1				
63	38.0	13.4	26.1	51.4				
64	38.3	13.4	25.9	51.7	39.4	13.5	25.5	52.9
65	38.9	13.6	25.9	52.5	40.3	13.7	25.4	54.0
66	39.0	14.2	27.0	53.2	40.9	14.4	26.0	55.3
67	39.9	14.1	26.1	54.0	42.2	14.4	25.4	56.6
68	39.8	14.2	26.3	54.0	42.2	14.5	25.6	56.7
69	39.9	14.2	26.2	54.1	42.3	14.6	25.7	56.9
1970	40.1	14.3	26.3	54.4	42.4	14.7	25.7	57.1
71	40.5	14.5	26.4	55.0	42.4	14.8	25.9	57.2
72	40.8	14.7	26.5	55.5	42.3	14.9	26.0	57.2
73	41.4	14.8	26.3	56.2	42.4	15.0	26.1	57.4
74	42.0	14.9	26.2	56.9	42.6	15.1	26.2	57.7
75	42.7	15.0	26.0	57.7	43.0	15.0	25.9	58.0

2. The development of the growing stock with alternative silvicultural programmes

21. Present forest resources and definition of the task

The increasing use of wood and processed wood goods and the vigorous expansion of Finland's forest industry, which have exceeded considerably the earlier forecasts, have led to a situation in which the allowable cut estimates for the long term in relation to the production of wood so far, have clearly been exceeded. The situation has weakened mainly because forest resources have been reduced through logging in excess of both increment and allowable cut, and because the area of poorly productive forests has increased considerably during the same time, through failure to realise silvicultural programmes.

The country's forest resources are 1,410 million cu.m. incl. bark according to the preliminary results of National Forest Inventory IV. A decrease of 83 million cu.m. has occurred from the volume of the growing stock according to Inventory III, 1951—1953. The growth estimate in Inventory IV was 42.8 million cu.m. of barkless wood. (The calculation for the present study was based on slightly different growing stock and growth estimates as the final results of Inventory IV had not been completed when the calculations were commenced.) The drain of wood, according to the utilisation studies, has been 51—55 million cu.m. in the last few years and has thus reached a distinctly higher level than increment. The area of poorly productive forests is c. 3.2 million hectares, i.e. about 15 per cent of the forest land, according to Inventory IV.

As it is no longer possible to obtain sufficient timber from old and sparse growing stocks by thinning, and as there is no inducement to perform new final cutting in the poorly productive area because of the scarcity of regeneration material, fulfilling the wood requirement is difficult, and the problem will proba-

Table 7. Management programme schedules compared with actual work accomplished in 1963—64.

1 000 ha

Year	Forest cultivation			New drainage			Fertilisation	
1963	112			149			,. 4.0	
1964	125			155			c. 7.0	
	Teho programme[1]	MERA plan[2]	Expanded Teho programme[1]	Teho-[1]	MERA plan[2]	Expanded Teho programme	MERA plan[2]	Expanded Teho programme
1965	At continuous	138	138	At continuous	179	179	20	By 1967
66	average rate	165	165	average rate	184	184	25	total 100
67	of 201 per	190	190	of 194 per	189	189	30	200
68	year	235	235	year until	197	197	30	300
69		165	265	about 1990,	220	220	30	400
1970		295	295	after which	247	247	30	500
71			300	0 per year		250*		600
72			300			250		700
73			300			250		800
74			300 per year			250 per year		900
75			until about			until about		1 000
76			1980, after			1990, after		1 000
77			which 250			which 0 per		1 000
78			per year			year		Continuously
79								at 1 000
1980								
81								

* Proportion of open peat-land increases thenceforth.

[1] Maatalouskomitean mietintö 1962. Liite VII. — Available as a reprint: Heikinheimo etc. 1963. Metsätalouden parannusten työllisyys- ja tulovaikutukset. Silva Fennica 114.

[2] MERA metsätalouden rahoitusohjelma 22. 5. 1964. Published by: Metsätiedotustoimisto.

bly only be aggravated in the next few years. If the present excessive cutting is continued without paying heed to the silvicultural programmes, a drastic curtailment of the production of the entire forestry and wood economy sector will sooner or later prove inevitable.

As the targets set by the Economic Council for the growth of national income presuppose that the entire production capacity of the woodworking industry is utilised, and that it should be possible to increase this production capacity to some extent, this part of the report estimates how the growing stock and increment will develop if the wood is cut in conformity with the given forecast of national income growth requirements, and with the silvicultural measures required to increase raw wood production.

The development of the growing stock was studied with reference to the three alternatives described below. The timetables of the silvicultural programmes are given in Table 7.

22. The alternatives for the development of the growing stock

Alternative I: The Teho programme will be carried out as such, and the long-term removals foreseen in that plan will be realized, i.e. an average of 51 million cu.m. per annum. Basic improvements were estimated quantitatively and qualitatively, as given in the Agricultural Committee report of 1962. A point to be stressed especially is that the original Teho programme was based on the forest resources given in National Forest Inventory III. According to Inventory IV, this basis has weakened essentially because of arrears of work which have accumulated in the last few years, which means that the work targets of the Teho programme must be increased considerably. The development of the growing stock in accordance with this alternative is shown in Fig. 2. The development of the growing stock has been followed in this and the following alternatives, by dividing it into present-day growing stocks, and new stands to be established after 1963. The results of the calculation differ somewhat from those in the Teho programme, because the productive condition of the growing stock has weakened in the past ten years. It has therefore been necessary to keep the long-term total drain at 51 million cu.m. up to the year 2000.

Table 8. An example of the method of calculating the development of the growing stock. Alternative III (Fig. 4). In the calculation the observed and forecast development of the stands existing in 1962, stands started or to be started after 1962, and the observed and forecast drain are considered separately. The forecast is based on the preliminary results of the Fourth National Forest Inventory.

Year	Development of present stands							Development of new stands				Total growing stock		Development of removals						
	Cubic content	Growth		Growth increase			Total growth	Plantations		Natural stands				Corresponding to growth of old stands	Drain increase		From new plantations	From new natural stands	Decrease in old stands	Drain
				Due to fertilising		Due to draining		Cubic content	Growth	Cubic content	Growth	Cubic content	Growth		Due to fertilising	Due to draining				
				k*	s**															
	mill. cu.m.	%	mill.cu.m. (excl. bark.)																	
1962	1 124	3.75	42.2	—	—	—	42.2	△	△	△	△	1 124	42.2	42.2	—	—	—	—	8.8	51
63	1 115	3.7	41.3	—	—	0.2	41.5	0.2	△	△	△	1 115	41.5	41.3	—	0.7	—	—	9.1	51
64	1 106	3.7	40.9	—	—	0.4	41.3	0.4	△	△	△	1 106	41.3	40.9	—	0.8	—	—	10.3	52
65	1 096	3.7	40.6	—	—	0.6	41.2	0.8	0.1	△	△	1 097	41.3	40.6	—	0.9	—	—	11.5	53
66	1 084	3.7	40.1	0.5	0.3	0.8	41.7	1.3	0.3	0.2	△	1 086	42.0	40.1	0.8	0.9	—	—	12.2	54
67	1 072	3.6	38.6	1.0	0.5	1.0	41.1	1.8	0.5	0.4	0.1	1 074	41.7	38.6	1.5	0.9	—	—	13.0	54
68	1 059	3.6	38.1	1.5	0.8	1.1	41.4	2.4	0.7	0.7	0.1	1 062	42.2	38.1	2.3	1.0	—	—	12.6	54
69	1 046	3.6	37.7	2.0	1.0	1.3	42.0	3.2	0.9	1.0	0.2	1 050	43.1	37.7	3.0	1.0	—	—	12.3	54
70	1 034	3.6	37.2	2.5	1.3	1.5	42.5	4.6	1.1	1.5	0.2	1 040	43.8	37.2	3.8	1.1	—	—	11.9	54
71	1 022	3.5	35.8	3.0	1.5	1.7	42.0	5.7	1.5	2.0	0.3	1 030	43.8	35.8	4.5	1.1	—	—	13.6	55
72	1 008	3.5	35.3	3.5	1.8	1.9	42.7	7.9	2.0	2.5	0.3	1 018	45.0	35.3	5.3	1.2	—	—	13.2	55
73	995	3.5	34.8	4.0	2.0	2.1	42.9	11.0	2.6	3.0	0.4	1 009	45.9	34.8	6.0	1.2	—	—	14.0	56
74	981	3.5	34.3	4.5	2.3	2.3	43.4	13.5	3.2	3.5	0.5	998	47.1	34.3	6.8	1.3	—	—	14.6	57
75	966	3.4	32.8	5.0	2.5	2.5	42.8	17.7	3.9	4.0	0.6	988	47.3	32.8	7.5	1.4	—	—	16.3	58
76	950	3.4	32.3	5.5	2.8	2.7	43.3	23.0	5.0	4.8	0.7	978	49.0	32.3	8.3	1.5	—	—	15.9	58
77	934	3.4	31.8	6.0	3.0	3.0	43.8	30	6.1	5.8	0.8	970	50.7	31.8	9.0	1.6	—	—	16.6	59
78	917	3.3	30.3	6.5	3.3	3.3	43.4	39	7.2	6.8	0.9	963	51.5	30.3	9.8	1.7	—	—	17.2	59
79	900	3.3	29.7	7.0	3.5	3.6	43.8	47	8.3	7.8	1.0	955	53.1	29.7	10.5	1.8	—	—	17.0	59
80	883	3.3	29.1	7.5	3.8	3.9	44.3	56	9.5	9.0	1.2	948	55.0	29.1	11.3	1.9	—	—	16.7	59
81	866	3.2	27.7	8.0	4.0	4.2	43.9	68	11.1	10.5	1.3	945	56.3	27.7	12.0	2.0	—	—	18.3	60
82	848	3.2	27.1			4.5	43.6	78	12.7	12.0	1.5	938	57.8	27.1	12.0	2.2	—	—	18.7	60
83	829	3.2	26.5	etc.	etc.	4.7	43.2	90	14.4	13.5	1.6	933	59.2	26.5	etc.	2.4	—	—	19.1	60
84	810	3.1	25.1	constant	constant	5.0	42.1	105	16.2	15.2	1.8	930	60.1	25.1	constant	2.6	—	—	21.3	61
85	789	3.1	24.5			5.3	41.8	121	18.0	17.0	2.0	927	61.8	24.5		2.8	—	—	21.7	61
86	767	3.1	23.8			5.7	41.5	143	20.2	19.0	2.1	929	63.8	23.8		3.0	—	—	22.2	61
87	745	3.0	22.4			6.0	40.4	162	22.4	21.0	2.3	928	65.1	22.4		3.1	—	—	24.5	62
88	721	3.0	21.6			6.1	39.7	182	24.6	24.0	2.5	927	66.8	21.6		3.2	—	—	25.2	62
89	696	3.0	20.9			6.2	39.1	205	26.8	27	2.7	928	68.6	20.9		3.4	0.5	△	25.2	62
90	671	3.0	20.1			6.4	38.5	232	29.0	30	2.8	933	70.3	20.1		3.6	1.0	△	26.3	63
91	645	2.9	18.7			6.6	37.3	257	31.6	33	3.0	935	71.9	18.7		3.8	1.6	△	26.9	63
92	618	2.9	17.9			6.8	36.7	285	34.2	36	3.1	939	74.0	17.9		4.0	2.2	△	26.9	63
93	591	2.9	17.1			7.0	36.1	315	36.8	39	3.3	945	76.2	17.1		4.2	2.9	△	26.8	63
94	564	2.8	15.8			7.0	34.8	350	39.4	43	3.5	957	77.7	15.8		4.4	3.6	△	28.2	64
95	536	2.8	15.0			7.1	34.1	395	42.0	47	3.7	978	79.8	15.0		4.6	4.4	△	28.0	64
96	508	2.8	14.2			7.2	33.4	434	44.6	51	3.9	993	81.9	14.2		4.8	5.5	△	27.5	64
97	480	2.7	13.0			7.3	32.3	470	47.2	55	4.0	1 005	83.5	13.0		5.0	6.6	△	28.4	65
98	452	2.8	12.7			7.4	32.1	510	49.8	59	4.2	1 021	86.1	12.7		5.2	7.7	△	27.4	65
99	425	2.9	12.3			7.5	31.8	575	52.4	64	4.4	1 064	88.6	12.3		5.4	8.8	△	26.5	55
2000	398	3.0	11.9			7.6	31.5	593	55.0	69	4.6	1 060	91.1	11.9		5.6	10.0	0.5	26.0	66
01	372	3.1	11.5			7.7	31.2	640	57.6	74	4.7	1 086	93.5	11.5		5.9	11.4	1.0	24.2	66
02	348	3.2	11.1			7.8	30.9	680	60.2	80	4.8	1 108	95.9	11.1		6.1	12.8	1.0	23.0	66
03	325	3.3	10.7			7.9	30.6	725	62.8	85	4.9	1 135	98.3	10.7		6.4	14.2	1.0	22.7	67
04	302	3.4	10.3			8.0	30.3	770	65.4	90	5.0	1 162	100.7	10.3		6.6	15.6	1.0	21.5	67
05	280	3.5	9.8			8.0	29.8	826	68.0	95	5.1	1 201	102.9	9.8		6.8	17.0	1.0	20.4	67
06	260	3.6	9.4			8.0	29.4	875	70.6	100	5.2	1 235	105.2	9.4		7.0	18.6	2.0	19.0	68
07	241	3.7	8.9			8.0	28.9	924	73.2	105	5.3	1 270	107.4	8.9		7.3	20.2	2.0	17.6	68
08	223	3.8	8.5			8.0	28.5	980	75.8	110	5.4	1 313	109.7	8.5		7.5	21.8	2.0	16.2	68
09	207	3.9	8.1			7.5	27.6	1 030	78.4	116	5.5	1 353	111.5	8.1		7,8	23.4	2.0	15.7	69
10	191	4.0	7.6			7.5	27.1	1 085	81.0	122	5.6	1 398	113.7	7.6		8.0	25.0	3.0	13.4	69
11	178	4.0	7.1			7.5	26.6	1 137	83.4	128	5.7	1 443	115.7	7.1		8.2	27.2	3.0	11.5	69
12	166	4.0	6.6			7.5	26.1	1 195	85.8	134	5.8	1 495	117.7	6.6		8.5	29.4	3.0	10.5	70
13	155	4.0	6.2			7.5	25.7	1 245	88.2	140	5.9	1 540	119.8	6.2		8.7	31.6	3.0	8.5	70
14	146	4.0	5.8			7.5	25.3	1 305	90.6	145	6.0	1 596	121.9	5.8		8.9	33.8	3.0	6.5	70
15	139	4.0	5.6			7.0	24.6	1 357	93.0	150	6.1	1 646	123.7	5.6		9.0	36.0	4.0	4.4	71

* on firm lands * on swamps

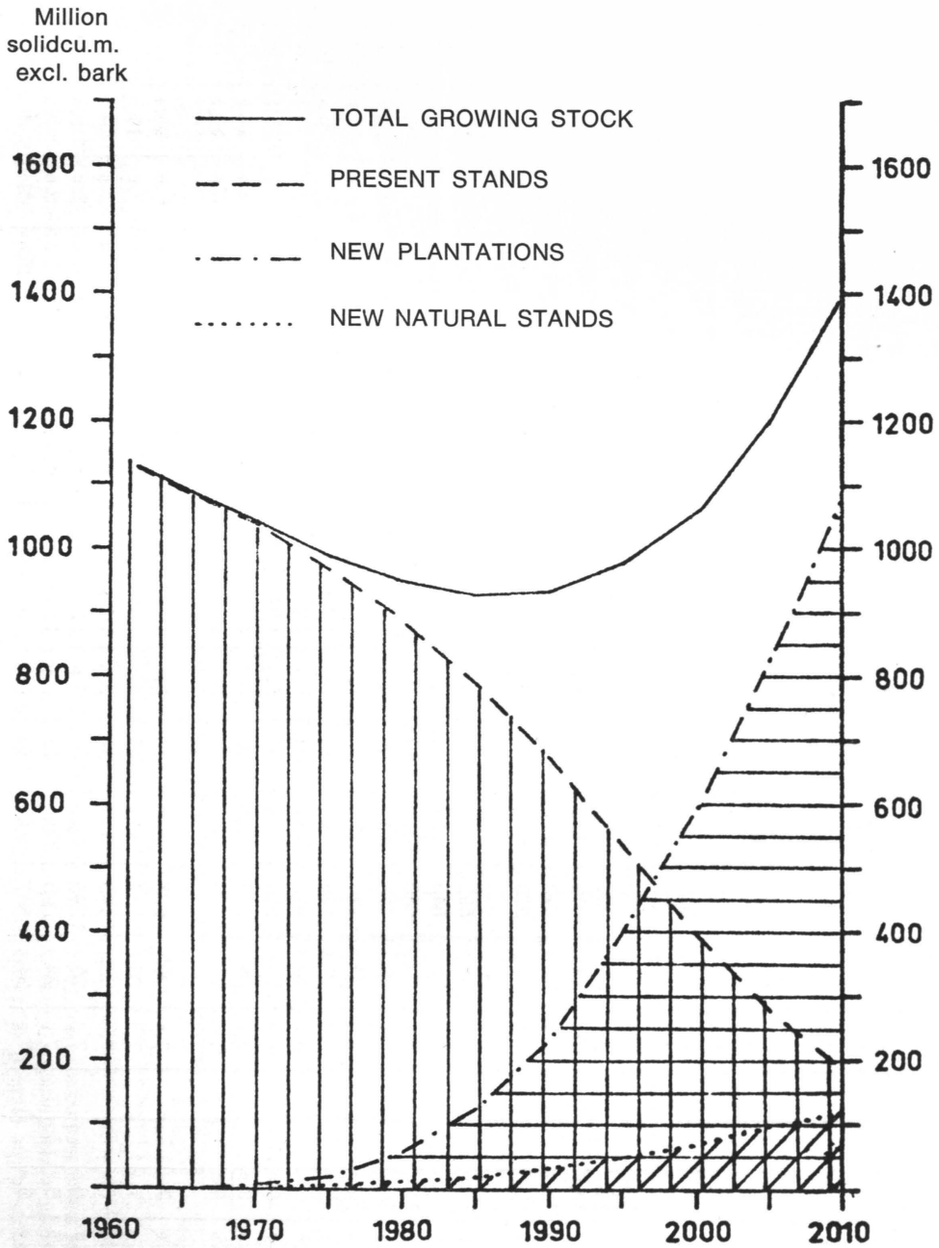

Figure 2. Development of forest resources in 1962—2010. Alternative I.

Prerequisites of alternative I:

Drain remains at 51 million cu.m. per year from 1964.

The management programme is realised in accordance with the, Teho programme: forest cultivation continuously, an average of 201,000 hectares/annum; new drainage continuously, an average of 194,000 hectares/annum up to 1990, no fertilisation.

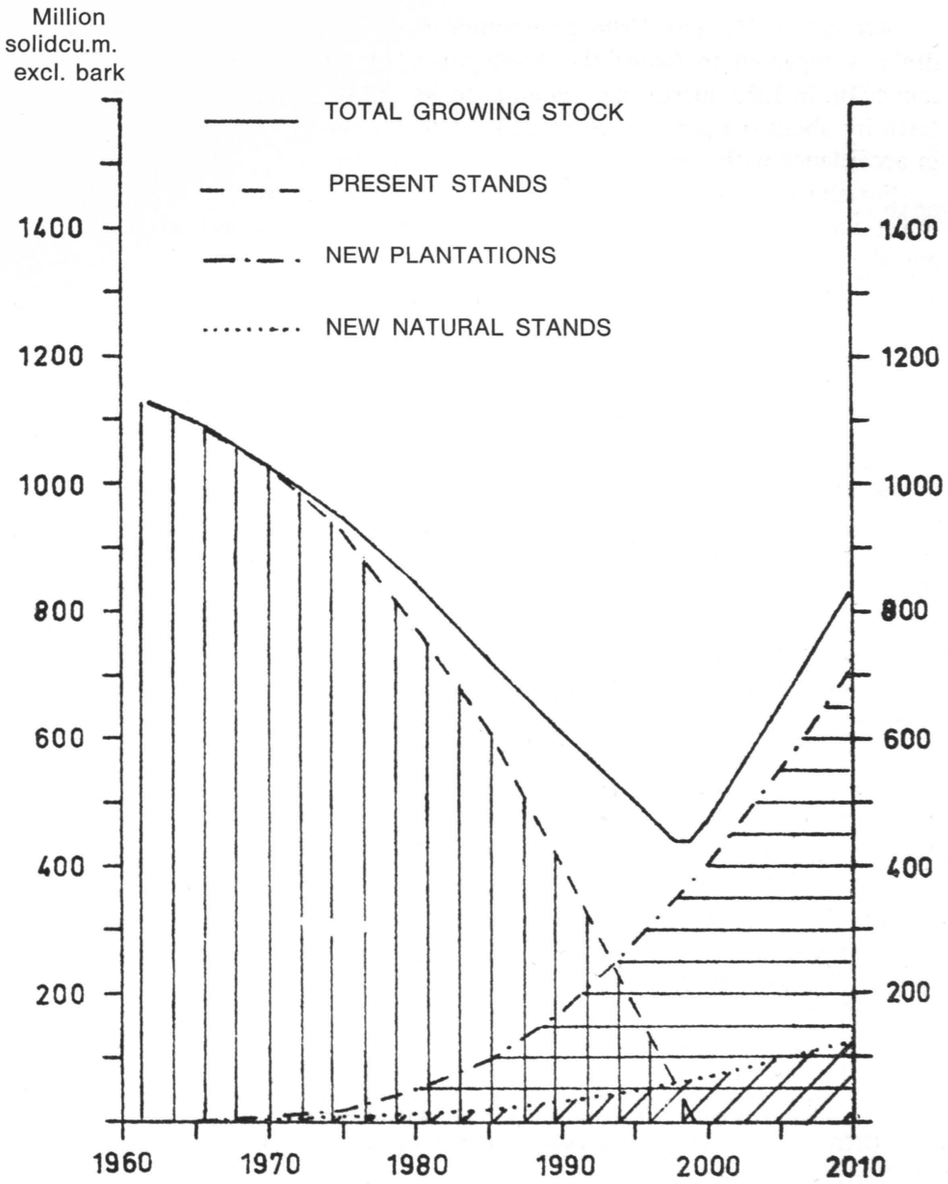

Figure 3. Development of the growing stock in 1962—2010. Alternative II.

Prerequisites of alternative II:

Drain in accordance with the forecast (Fig. 1), rises to 58 million cu.m. per annum by 1975, then increases by 0.5 per cent annually.

The management programme is realised in accordance with the Teho programme as in alternative I (Fig. 2).

Alternative II: The Teho programme will be realised as above, but the drain is expected to follow the development predicted in Chapter 1: 52 million cu.m. in 1962, increasing gradually to 58 million cu.m. by 1975 and thenceforth by about 0.5 per cent per annum. The development of the growing stock in accordance with this alternative is shown in Fig. 3.

For the growing stock development calculation, it was also assumed that forest cultivation and drainage would, until 1970, accord with the MERA plan, and thereafter with the expanded Teho programme (without fertilisation) shown in Table 7. The result did not differ essentially from the result of the principal alternative, shown in Fig. 3; the present-day growing stock will even then be exhausted in the course of the present century.

Alternative III: As all the above calculations give a total removal that is smaller than that required, or too rapid a reduction of existing growing stocks, alternative III (expanded Teho programme) takes into consideration the effect of very intensive measures in both present-day forests and new plantations. The procedure is shown in the calculation model (Table 8) and the results in Fig. 4. The basic improvements and silviculture required for wood production will be intensified practically to the limit, by increasing the work targets of the Teho programme sufficiently, with special attention to the possibilities offered by forest fertilisation to prevent the premature depletion of the present growing stock. The aim is to restore the total growing stock to its present level by the turn of the century, and to prevent the significant weakening in the immediate future of industry's possibility of obtaining round wood, which is predicted in alternative II. The removal forecast is the same in alternative II as above. Until 1970, the silvicultural programme follows the MERA time table; thenceforth, the yearly target for silviculture will be maintained at its maximum for about ten, and the yearly drainage target for about twenty years. Forest fertilisation will follow a separate time table (Table 7).

23. Growing stock development calculation in agreement with the expanded Teho programme

231. General and production-technical bases

The *forest area* is estimated at 21.5 million hectares in the calculation: 14.5 million hectares of firm forest land and 7 million hectares of peat land which has been drained, or which is to be drained by 1990. Two million hectares of swamp will be left for uses other than the growing of wood, such as farming,

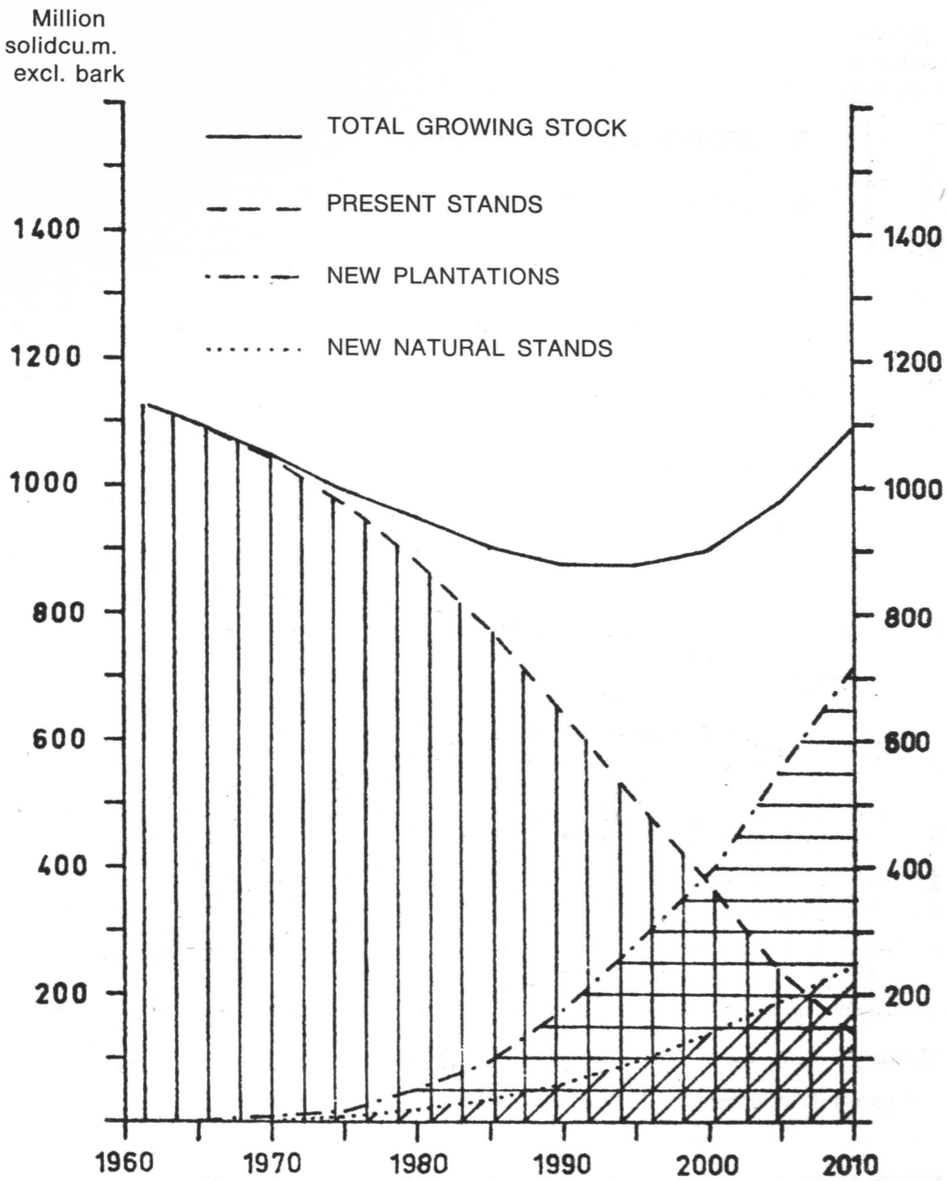

Figure 4. Development of the growning stock in 1962—2010. Alternative III.

Prerequisites of alternative III.

Drain in accordance with the forecast (Fig. 1), as in alternative II (Fig. 3).

The management programme is realised in accordance with the expanded Teho programme (see Table 7): Fully stocked, nearly mature forests are fertilised increasingly, from 1975 nearly 1 million hectares. Forest cultivation is expanded, amounting in the 1970s and 1980s to 300,000 effective hectares per year, then 250,000 hectares per year. New drainage will expanded in the 1960s to 250,000 hectares, remain there to the end of the 1980s, whereupon it will be discontinued.

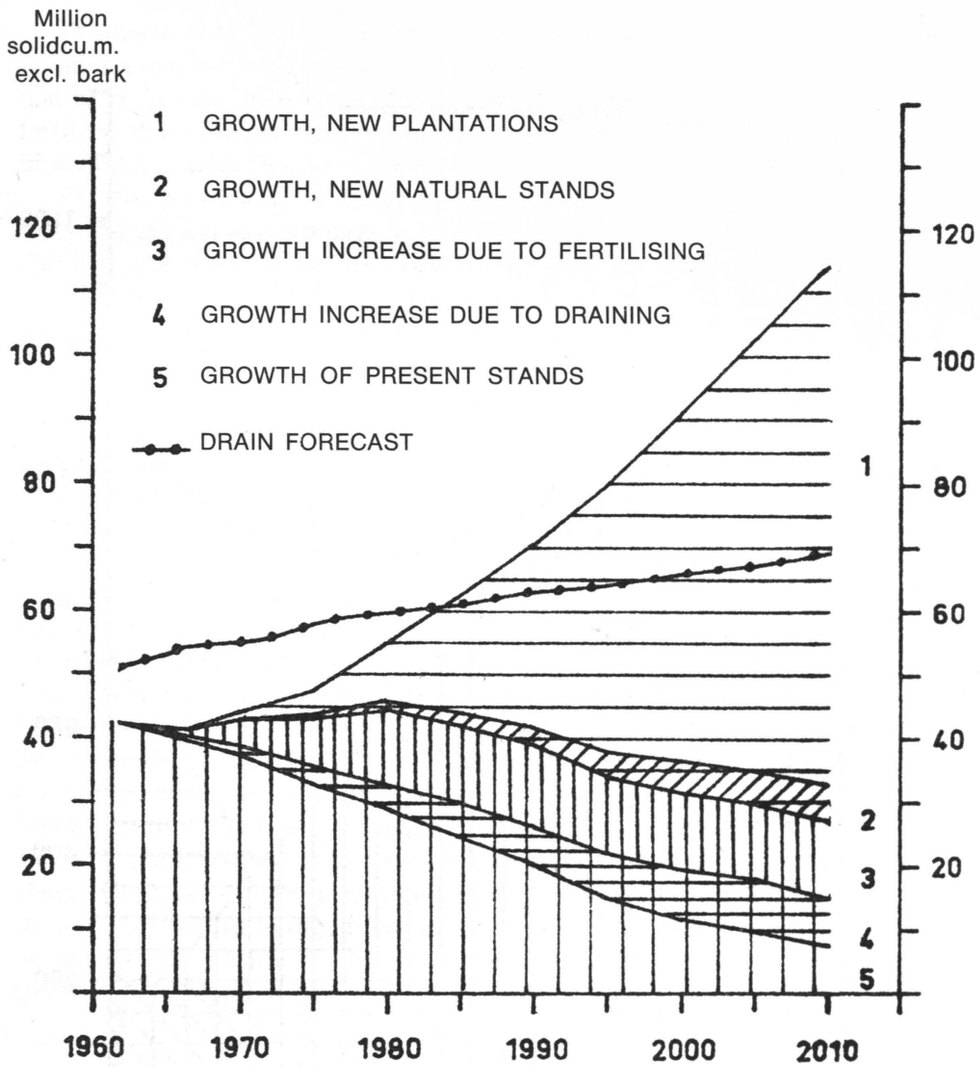

Figure 5. Development of drain and growth in 1962—2010. Alternative III (see Fig. 4).

nature reserves, peat industry and waste land. It is assumed that the area of field and pasture that will be afforested will be the same as the area of forest land which is converted to other uses.

The natural nutrient content of our forest land is fairly low. Therefore, a considerable increase in the growth of wood on a good proportion of moist forest land and better forest land, can be achieved by fertilisation. Fertilisation can also be considered for a part of the fairly dry, firm forest land if it has a sufficiently dense growing stock of valuable quality. Fertilisation can produce extremely good results, above all on peatlands.

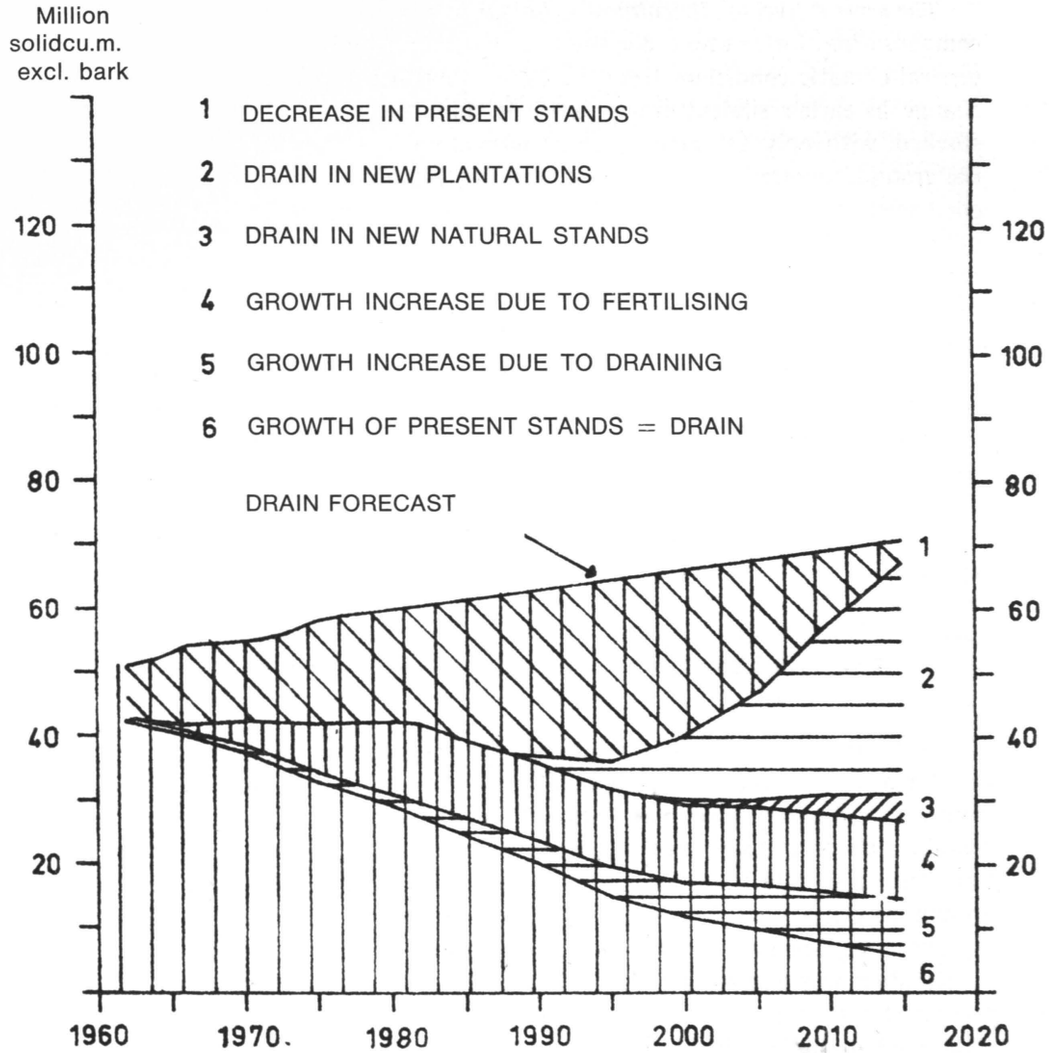

Figure 6. Development of structure of drain in 1962—2015. Alternative III (see Fig. 4).

General climatic conditions, it has been assumed, will remain similar to those of the past 50 years, although there are signs suggesting that a slight deterioration of climate is to be expected. The favourable climatic period 1920—1960 may have made the mean growth figures for these years too high for a long-term forecast.

The general level of silvicultural technique will improve steadily, it is assumed, compensating, for example, for the loss that may result from any worsening of general climatic conditions from the 1920—1960 situation. The most important change in earlier silvicultural practice is that the stands will be grown fully stocked, with only thinning to be performed until the final cutting to prepare the ground, followed by seeding and planting. However, especially in years after good seed crops, an exception will be where new seedling stands have appeared naturally under the old forest. The most barren hard forest soils and the easily regenerable swamps will probably only be worth regenerating naturally in the future as well. This has been allowed for in the present calculations. The calculations of the development of the growing stock of cultivated stands did not take into account in this phase the improvement that forest tree breeding can produce in the yield of our forests. In this respect, the calculations must be regarded as conservative.

232. Technical bases of the calculation

2321. Existing growing stocks

Owing to the short time available, the calculations were made for the country as a single unit. The volume of present-day growing stock was obtained from the preliminary results of National Forest Inventory IV. The growth percentage series were based on the same inventory results. As large-scale regeneration, after a certain time, lowers the mean age of existing growing stocks, the growth percentage used was at first a slowly falling, and then a relatively rapidly rising one towards the end (cf. calculation model, Table 8).

Rotation was allowed for by preserving the growing stock in a part of the present stands as far into the future as possible in order to ensure the supply of large-sized timber. Existing young stands (0—20 years) will be finally cut at the age of 65—75, depending on how rapidly logging moves to new plantations.

The increase in growth produced by fertilisation has been estimated at 25—90 per cent on the basis of experience gained so far. Five years was chosen as the duration of effect of fertilisation. After this, growth returns to its former level in the course of 2 years. The average growth increase in the calculations during the actual period of effect is 2 cu.m./ha/year, and in the after-effect years 1 cu.m./ha/year. Stands of at least saw log size, or consisting of other valuable industrial assortments on good sites and fully stocked, were taken as

fertilisation targets. It is assumed that fertilisation will begin during 1964—1966 on a total area of 100,000 hectares, increasing yearly by 100,000 hectares until the annual area is 1.0 million hectares in 1975, and will then remain at this level. It is assumed that fertilisation will affect the volume growth of the growing stock in the following year. When the present-day growing stocks diminish, fertilisation will be carried out on suitable planted stocks. The greatest part (about 5 million hectares) of the forest area (7—8 million hectares) suitable to be fertilised, of which at first at least a third will be peatland, will be treated simultaneously. After the growing stocks on peatland reach industrial wood size to a wider extent than they have today, fertilisation can be concentrated primarily on them, because of their particular suitablity for this treatment.

The effect of fertilisation on the growth of swamp forests on peatland is calculated to be the same as above, in spite of HUIKARI's conclusion that the effect of full fertilisation on peatland is maintained for about 20 years at an average of 3 cu.m./ha/year.

Drainage will initially accord with the MERA plan. The immediate consequence has been taken from HEIKURAINEN's[1] estimate (accelerated alternative) of the effect of drainage on growth.[2] The even faster drainage programme suggested by HUIKARI[3] is also possible, but the additional benefit to the amount of cut appears only after several decades. For this reason, forest fertilisation was given priority here over the acceleration of drainage activity proposed by HUIKARI. Drainage is assumed to continue until the drained area totals c. 7 million hectares. This target will be reached in about 30 years (by 1990).

2322. New plantations

Forest regeneration will occur, it is assumed, through the planting or seeding of fairly dry, firm forest land, forest land superior to this, and on all open peatland. It is assumed that c. 40,000—50,000 hectares/year of barren, firm forest land and peatland which is easily stocked with seedlings, will be left for natura regeneration. The present extent of poorly productive areas requires an in-

[1] HEIKURAINEN, L. 1961. Metsäojituksen vaikutuksesta puuston kasvuun ja poistumaan. Acta Forestalia Fennica 71.

[2] The drainage area in 1970—1990 has been assumed to be 250,000 hectares, of which an increasing proportion will be open swamp.

[3] HUIKARI et al. 1963. Ojitusopas.

crease in artificial forest regeneration from the 1963 figure of 112,000 hectares/year, corresponding to about 80,000 hectares/year of new seedling stands capable of development, to a productive area of 300,000 hectares per annum by 1970, in accordance with the MERA plan. After 1980, when arrears of work are assumed to have been made up, the regeneration area can be cut to 250,000 hectares per annum. It is expected that c. 4.5 million hectares of seedling stands will be planted in 1962—1980.

The development of new growing stock is based on the development series of the target stock of plantations, and on the target series of natural stands. For pine plantations in southern Finland, the target stock was based chiefly on KALLIO's[1] study, and for spruce plantations on KALELA's[2] study. As the results of KALELA's study apply to richer forest lands, the target stock mean value was obtained by correcting the former by the results of VUOKILA's[3] study. The increment of the target growing stock of spruce is slightly greater than that of the bilberry-type plantations reported by KALLIO.

The target stock of the plantations on north Finnish hard forest land is based on SIRÉN's[4] studies.

For the country as a whole, the target growing stock of plantations is assumed to exceed the mean growth reported by KALLIO for fairly dry, firm forest land, i.e. to be 5.4 cu.m./hectare per annum. The total mean is influenced above all by the rather low production figures from the dry firm forest land of north Finland which are to be regenerated artificially. For the whole country, an average rotation of 70 years was used in the calculation of the average growing stock of the plantations.

The target growing stock of natural stands is taken to be about half-way between that for the cowberry and the bilberrytype given in the HKLN[5] programme. It must be remembered that natural forests include a great many relatively fertile peatlands.

The productive capacity of peatland to be regenerated has been taken to be the same as that of moist, firm forest land.

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[1] KALLIO, K. 1960. Etelä-Suomen kylvömänniköiden rakenteesta ja kehityksestä. Acta Forestalia Fennica 71.

[2] KALELA (CAJANDER), E. K. 1923. Tutkimuksia Etelä-Suomen viljelykuusikoiden kehityksestä. Metsätieteellisen tutkimuslaitoksen julkaisuja 19.

[3] VUOKILA, Y. 1956. Etelä-Suomen hoidettujen kuusikoiden kehityksestä. Metsäntutkimuslaitoksen julkaisuja 48.

[4] SIREN, G. 1964. Pohjois-Suomen kylvömänniköiden kehitys ja käsittely. Unpublished manuscript.

[5] HEIKURAINEN et al. 1961. Metsätalouden suunnittelukomitean mietintö. Liite 1. Metsiemme hakkuumahdollisuudet. Pitkän ajan tarkastelua. Silva Fennica 110.

2323. Growth and removals

The total growth of forest is composed of the growth of present stands, the growth increase due to fertilisation, the growth increase due to drainage alone, and the growth of new stands (cf. calculation model, Table 8). Since fertilisation, and, in the case of peatlands which carry forest, drainage as well, are presupposed for stands capable of recovery and for stands with at least some industrial wood, the increment caused by fertilisation and drainage will go to augment the amount of cut in the immediate future.

As regards the timber *drain*, the plantations established in 1962—1966 will give about 1 million cu.m./year through thinning in 1990. From then onward, this drain will increase by c. 1 million cu.m. per annum, up to 2010 A.D. Natural stands will not give any thinning yield for industrial use until after the year 2000.

Conventional thinning and final cutting do not yield a sufficiently large amount of wood from old growing stock and new stands, when the removal forecast of this study is used in the calculations. The difference will have to be made good by decreasing the old stands through final cutting in excess over the normal quantity.

Although the development of plantations is relatively rapid, it will nevertheless be a couple of decades before they yield significant amounts of industrial wood. It must also be remembered that industrial wood cannot consist solely of small-diameter timber. But the rapid growth of the plantations will probably permit the depletion of present-day stands by 2020 A.D., without endangering the raw wood supply of the sawmill industry.

It may be mentioned for the sake of comparison, that while it appears possible to achieve a growing stock of 1,000 million cu.m. by 2000 A.D., the omission of fertilisation from the programme for increasing wood production in our forests, will mean a decrease to about 600 million cu.m. of young forests.