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SHORT-TERM FORECASTING OF THE TOTAL DRAIN FROM FINLAND'S FORESTS

SUOMEN METSIEN KOKONAISPOISTUMAN LYHYTJAKSOINEN ENNUSTAMINEN

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Juhani Numminen

SHORT-TERM FORECASTING OF THE TOTAL DRAIN FROM FINLAND'S FORESTS

Suomen metsien kokonaispoistuman lyhytjaksoinen ennustaminen

Tiivistelmä sivulla 12

PREFACE

The present study has been prepared in the Department of Forest Economics of the Finnish Forest Research Institute. It has been developed from the material of a more comprehensive manuscript which was presented as a master's degree thesis to the forestry faculty of the University of Helsinki.

Prof. SEPPO ERVASTI supervised both the thesis and the project. TERHO HUTTUNEN, B,F., provided valuable advice and assistance in the course of the study. DAVID COPE, A.B., checked the manuscript and helped with preparing it for publication.

The author wishes to express his sincere appreciation to these three and to all others who have assisted him.

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1. INTRODUCTION

The Finnish forest industries greatly expanded their capacity in the early 1960s with the result that the 1960–64 allowable cut was exceeded by a substantial amount. The total drain (removals plus losses) reached its highest level, 54.6 million m^3 (solid measure), in 1961. Since then the drain has been reduced by 8 million m^3 in seven years. This has been done by reducing the export of roundwood and the consumption of fuelwood, increasing roundwood imports, and intensifying the use of wood residues. A number of forest-improvement plans were drawn up to increase the production of roundwood. Three MERA financing plans were prepared during the 1960s to secure the necessary funds for the realization of the silvicultural plans. This intensification of planning in the forestry and wood-economy sector requires reliable data on the consumption of roundwood, total drain and forest balance (allowable cut less total drain).

The consumption of wood has been the object of research since 1927. However, it was not until 1962 that the annual compilation of statistics was commenced in the Department of Economics of the Forest Research Institute. The statistics have been published from 1964 in *Folia Forestalia* (nos. 4, 15, 25, 35, 46, 67 and 90).

In addition to serving forest policy, the annual statistics on total drain and forest balance serve planning within the forest industry, at both the industry and enterprise level. The supply of wood raw material has become more and more frequently the bottleneck to expansion of the primary forest industries, notably the birch plywood and pulp industries. Therefore the supply of raw material must be determined accurately at an early stage in the planning of a new mill.

The consumption of wood by the forest industries is calculated from the annual reports submitted for the official Industrial Statistics by all industrial enterprises. This has caused a delay of almost two years in the publishing of the final statistics. A preliminary estimate of the total drain in the year immediately preceeding has been published at the same time. Thus, in the autumn of 1967 the final estimate for 1965 was published, together with a preliminary estimate for 1966. *The growing demand for up-to-date data has created a need to develop a method for short-term forecasting of the total drain to provide an estimate for total drain in the publishing year.* The method described in this study has been used three times, in 1968, 1969 and 1970 (*Folia Forestalia*, 46, 67 and 90).

The main emphasis in this study was placed on the forecasting of the consumption of wood raw material by the forest industries, discussed in Chapter 2. The method of estimating the total drain is discussed in Chapter 3.

2. FORECASTING THE CONSUMPTION OF WOOD RAW MATERIAL BY THE FOREST INDUSTRIES

21. Model for forecasting consumption

Forestry products include only negligible amounts of raw materials other than wood. It is obvious, therefore, that the relationship between the output and consumption of wood raw material is fairly constant. This relationship is described by the following correlation coefficients calculated from data for 1955–65 (sawmills, 1955–63):

		95 % confidence limits
Sawmills	0.974	0.878 – 0.995
Plywood & veneer	0.890	0.635 – 0.972
Fibreboard	0.880	0.558 – 0.967
Pulp	0.995	0.980 – 0.999

Due to the small number of observations, the confidence limits were calculated applying Fisher's transformation (SNEDECOR 1962, pp. 175–179). The correlation coefficient, *r*, is transformed into *z* by the following equation:

$$z = \frac{1}{2} [\log_e (1 + r) - \log_e (1 - r)].$$

The distribution of *z* is almost normal with variance:

$$\sigma_z^2 = \frac{1}{n-3}$$

Since *z* is independent of the number of observations the t-distribution can be applied to determine the confidence limits.

As the correlation coefficients lie above the one per cent significance level (9 degrees of freedom, r = 0.735 and 7 d.o.f., r = 0.798) they are considered to deviate significantly from zero. Accordingly, it can be said that the output of an industry explains sufficiently the variation of its consumption of wood raw material.

Due to the technical relation between the two variables the regression model is a linear one:

$$Z_i = a + b\,Y_i + u\,; \qquad (1)$$

Z_i = wood raw material consumption of industry i;
Y_i = output of industry i;
u = random variable;
a,b= parameters

SNEDECOR (1962), among others, has dealt with the estimation of parameters.

The above model can be applied only to industries providing data on their output. No regularly collected data is available for the output of some 11 000 small sawmills (VECKMAN 1968, p. 9). Three sample surveys have investigated the raw material consumption of these small sawmills in 1965, 1967 and 1969, producing the following results: 2.443, 1.931 and 1.713 million solid m^3 excluding bark, respectively.

It would seem natural to expect a marked correlation between the above figures and the output of the larger sawmills. However, this is not the case since the outputs were 1.185, 1.015, and 1.185 million std. in the respective years. While the latter figures show a clear cyclical variation, the consumption figures of the small sawmills show a steady decline. The decline can be attributed to the structural change of society – the agglomeration of population and economic activity in urban areas. This happens at the expense of the rural areas where the small sawmills traditionally operate. It is very difficult to forecast the pace of such development; hence, the most feasible means of forecasting the raw-material consumption of the small sawmills would be to use the latest available estimate as a forecast.

The category "other industries" includes a number of special woodworking industries which have consumed wood raw material as follows:

1961	350 000 m^3
1962	340 000 "
1963	396 000 "
1964	220 000 "
1965	181 000 "
1966	198 000 "
1967	181 000 "
1968	147 000 "

This category is a small one and shows a falling trend; however, the decline seems to be levelling off. Therefore, the latest available observation would be a sufficient prediction, i.e.:

$$Z_{10t} = Z_{10\,(t-2)} \qquad (2)$$

The model for the consumption of wood raw material (Z) by the forest industries is formed by the previous results, (1) and (2);

$$Z = \sum_{i=1}^{10} Z_i\,; \qquad (3)$$

$Z_i = a + b\,Y_i$, when i = 1, 3, 4, . . . , 9;
Z_2 = the latest available Z_2;
$Z_{10t} = Z_{10(t-2)}$.

This model (3) produced the following forecasts for the consumption of wood raw material by the forest industries in 1962–1968:

	Forecast mill. m^3	Observation mill. m^3	Deviation %
1962	32.643	30.735	+6.21
1963	33.688	32.204	+4.61
1964	36.445	36.957	–1.38
1965	37.756	37.710	+0.01
1966	35.550	36.174	–1.72
1967	35.945	36.177	–0.64
1968	37.069	37.280	–0.57

The model has predicted correctly the direction of the change in 1963–1966 and 1968. All the forecasts are better than those produced by the model, $Z_t = Z_{t-2}$. The deviations have been quite reasonable except in 1962–1963. *Thus the model for estimating the consumption of wood raw material fulfills the requirement of accuracy.*

22. Forecasting output

221. Seasonal variations in output

In addition to cyclical and random variations, time series consisting of monthly data often show considerable seasonal variations which are described by seasonal indices. The significance of the seasonal variation can be verified by testing the recurrence of the rank of the twelve-month seasonal indices. The chi-square ranking test can be applied (DAVIES & YODER 1948, pp. 478–480):

$$\chi_r^2 = \frac{6 \sum_{k=1}^{12} (x_k - \bar{x}_k)^2}{\sum_{k=1}^{12} x_k}$$

x_k = sum of the rankings assigned to the k:th month;
$\bar{x}_k$ = average of x_k.

Table 1 reveals that the seasonal variation of output has been very significant in two industries and significant in three industries. Thus, the pattern of the seasonal variation in output has remained more or less unchanged during the first half of the 1960s.

A simple method of forecasting the output of the forest industries can be based on this regularity.

Table 1. Seasonal indices of forest-industry output
Taulukko 1. Metsäteollisuuden tuotoksien kausivaihtelun indeksejä

	Sawmills[1] Teollisuustilaston sahat	*Plywood & veneer industry* Vaneriteollisuus	*Sulphite pulp industry* Sulfiittiselluloosateollisuus	*Sulphate pulp industry* Sulfaattiselluloosateollisuus	*Fibreboard industry* Kuitulevyteollisuus
	1960–66[2]	1961–66[2]	1961–66[2]	1961–66[2]	1962–66[2]
January – Tammikuu	89	110	104	95	106
February – Helmikuu	109	116	109	108	111
March – Maaliskuu	113	109	106	107	105
April – Huhtikuu	116	104	97	98	99
May – Toukokuu	109	102	100	105	106
June – Kesäkuu	114	86	81	82	82
July – Heinäkuu	107	59	93	95	73
August – Elokuu	90	82	99	98	91
September – Syyskuu	92	109	105	107	109
October – Lokakuu	89	111	109	110	112
November – Marraskuu	89	111	107	109	112
December – Joulukuu	83	101	90	86	94
χ_r^2	55.94xxx	30.92xx	29.86xx	37.96xxx	30.69xx

1. *Those covered by the Industrial Statistics*
2. *Period of estimation* – Estimointijakso

χ_r^2 = *Significance of seasonal variation* – Kausivaihtelun merkitys

$\chi_{0.001}^2$ = 31.26 = xxx = *very significant* – erittäin merkitsevä

$\chi_{0.01}^2$ = 24.73 = xx = *significant* – merkitsevä

For example, when output during the first six months of a year is known, the output for the twelve months can be predicted assuming that the pattern of seasonal variation does not change considerably.

222. Choice of forecasting method

Two models based on the above assumption were chosen for further experiments;

the seasonal index method:

$$Y_i = a_k Y_{i_k} \quad ; \qquad (4)$$

$$a_k = \frac{\sum_{k=1}^{12} b_k}{\sum_{k=1}^{k} b_k} \quad ;$$

b_k = seasonal index of the k:th month.

the regression method:

$$Y_i = a + b\, Y_{i_k}. \qquad (5)$$

The goodness of fit of the two models was described by the relative deviation of the predicted value from the observed value:

$$D_i = \frac{\hat{Y}_i - Y_i}{Y_i} \cdot 100 \quad ;$$

Y_i = output of industry i

$\hat{Y}_i$ = predicted value of Y_i

The arithmetic mean of the relative deviations (disregarding the sign) was calculated to serve as a basis for comparisons:

$$M_i = \frac{1}{n} \sum_{t=1}^{n} |D_i|$$

The arithmetic mean of the squares of the deviations was calculated as well:

$$S_i = \frac{1}{n} \sum_{t=1}^{n} D_i^2$$

This mean describes the dispersion of the deviations.

Table 2 presents a comparison of the two forecasting methods based on data from 1961–66. This shows that the regression method produces more accurate predictions than the seasonal-index method. This is more clearly seen from the weighted means of parameters *M* and *S*. The consumption of wood raw material in 1966 by the respective branches of industry was used as the weight:

	Seasonal-index method		Regression method	
	M	S	M	S
May	3.38	16.37	2.18	7.68
June	2.83	11.54	1.71	5.00
July	2.13	7.02	1.42	3.84
August	1.79	4.61	1.50	3.48
September	1.52	3.39	1.26	2.35

This comparison shows that the output for the first seven months gives, on average, satisfactory results. Also, the end of August, when the data for July is available, is suitable for the publication of a forecast.

Data on the output of the semi-chemical pulp and particle board industries is collected only twice a year. Therefore the forecasts of the output of these two branches of industry must be based on the output of the first six months of the year. The output forecast for the mechanical pulp industry must be subjective, since no data is collected for periods shorter than a year.

223. Effect of cyclical variations on output forecasts

The regression method was used to forecast the 1967 output of the seven branches of industry. Table 3 presents the results as well as the multiple correlation coefficients (R^2) of the models.

Due to the small number of observations no definite conclusion can be drawn from the randomness of the model residuals. A graphic examination reveals, however, a cycle in the residuals. The cycle is more or less similar in each model. This suggests that the residuals include variations which could be eliminated by another explanatory variable. The graphic examination revealed that the models produced forecasts which were too low during a boom and too high during a recession. To eliminate this defect, the variable

$$B_{it} = \frac{Y_{i_{kt}}}{Y_{i_{k(t-1)}}} \cdot 100$$

Table 2. Comparison of the forecasting methods in 1961–1966
Taulukko 2. Ennustemenetelmien vertailu vuosina 1961–1966

Base month Peruskuukausi	*Sawmills*[1] Teollisuustilaston sahat		*Plywood & veneer industry* Vaneriteollisuus		*Sulphite pulp industry* Sulfiittiselluloosa-teollisuus		*Sulphate pulp industry* Sulfaattiselluloosa-teollisuus		*Fibreboard industry* Kuitulevyteollisuus	
	M_1	S_1	M_3	S_3	M_7	S_7	M_8	S_8	M_9	M_9
Seasonal-index method – Kausi-indeksimenetelmä										
May – Toukokuu	1.44	2.68	3.46	16.45	2.83	9.10	5.86	34.75	1.31	2.24
June – Kesäkuu	1.15	2.40	3.35	12.49	2.22	5.32	4.83	24.57	1.20	2.17
July – Heinäkuu	0.66	0.68	2.50	8.71	1.56	3.29	3.91	15.52	1.03	1.35
August – Elokuu	1.07	1.64	2.34	6.70	1.30	3.22	2.70	8.12	1.45	3.16
September – Syyskuu	1.00	1.64	1.79	4.42	0.99	2.04	2.33	5.87	1.21	2.02
Regression method – Regressiomenetelmä										
May – Toukokuu	1.38	2.62	2.97	12.90	2.16	6.59	2.90	12.79	0.91	1.70
June – Kesäkuu	1.16	2.45	2.10	5.78	1.49	3.70	2.34	8.33	1.18	1.63
July – Heinäkuu	0.75	0.70	2.20	5.88	1.19	2.66	2.13	7.43	0.99	1.27
August – Elokuu	0.96	1.29	2.41	6.17	1.33	2.72	2.01	5.75	1.21	2.28
September – Syyskuu	1.02	1.46	1.77	3.23	0.88	1.20	1.68	3.87	1.01	1.19

1. *Those covered by the Industrial Statistics.*

Table 3. Forecasting forest-industry output in 1967
Taulukko 3. Metsäteollisuuden tuotoksien ennustaminen vuonna 1967

Branch of industry Teollisuuslaji	*Simple models* Yksinkertaiset mallit		*Models with* B_i Suhdannemallit	
	Deviation Poikkeama %	R^2 %	*Deviation* Poikkeama %	R^2 %
Sawmills[1] – Teollisuustilaston sahat	–1.69	99.08	–0.60	99.46
Plywood & veneer – Vaneri	–3.49	95.77	–12.31	97.90
Particle board – Lastulevy	–8.22	99.08	–9.52	99.65
Semi-chemical pulp – Puoliselluloosa	+4.90	99.62	+11.27	97.65
Sulphite pulp – Sulfiittiselluloosa	+5.24	92.85	+5.24	92.99
Sulphate pulp – Sulfaattiselluloosa	+1.94	96.45	+1.98	98.00
Fibreboard – Kuitulevy	+0.97	95.63	–2.50	94.40

1. *Those covered by the Industrial Statistics*

was inserted in the models to describe the direction of the cyclical movement. If $B_{it} > 100$, then the trend is rising, but if $B_{it} < 100$ the trend is falling. Table 3 also presents the results of this experiment.

Table 3 clearly shows that the introduction of variable B_i as constructed above did not improve the models as expected. Although the coefficients of multiple correlation in some cases were somewhat higher than those of the simple models, the 1967 output forecasts produced by the cyclic models deviated considerable more from the actual output than those produced by simple method.

224. Reliability of output forecasts

In the previous sections the accuracy of the forecasts was measured only by the proportional deviations. The inequality coefficient, *U*, can also be applied (see THEIL 1958, pp. 32–48):

$$U = \frac{\sqrt{\frac{1}{n}\sum^{t}(\hat{Y}_t - Y_t)^2}}{\sqrt{\frac{1}{n}\sum^{t}\hat{Y}_t^2} + \sqrt{\frac{1}{n}\sum^{t}Y_t^2}}$$

Y_t = output in year t;
$\hat{Y}_t$ = forecast of Y_t;
t = 1. . . n = years.

The numerical value of the inequality coefficient ranges from zero to one, zero denoting perfect forecasting and one the worst possible forecasting. U-values were calculated for the output forecasts produced by the regression method:

	U_i	Proportional deviations M_i	S_i
Sawmills	0.004	0.75	0.70
Plywood & veneer	0.019	2.20	5.88
Sulphite pulp	0.008	1.19	2.66
Sulphate pulp	0.015	2.13	7.43
Fibreboard	0.006	0.99	1.27

This comparison shows that the two methods of measuring accuracy place the industries in the same rank. The significance of the U-values can be tested with the t-test, but in this case the U-values deviate so little from zero that the test is not necessary.

The inequality coefficient can be applied to determine the causes of the deviations. The deviations can be divided into three components which reveal the effect of unequal mean, unequal variance and incomplete correlation:

	Unequal mean, %	Unequal variance, %	Incomplete correlation, %
Sawmills	0.08	0.19	99.73
Plywood & veneer	0.01	1.32	98.67
Sulphite pulp	0.22	0.42	99.36
Sulphate pulp	0.03	1.30	98.67
Fibreboard	0.15	1.49	98.36

Deviations caused by the unequal means and variances are not desirable since they indicate that the forecasts include systematic errors. The incomplete correlation is a source of error that cannot be controlled.

The above comparison shows that the systematic errors in the forecasts are insignificant. Due to the small number of observations the outcome of the analysis is not very reliable, however. On the other hand the simultaneous examination (p. 6) of the residuals suggested that they include cyclical variation.

3. FORECAST OF THE TOTAL DRAIN IN 1970

31. Industrial wood consumed by the forest industries

Table 4 presents the forecasts of forest-industry output as well as forecasts of the consumption of wood raw material by the respective industrial branches in 1970.

The models for the sulphate pulp industry are taken as an example:

Output: $Y = 196 + 1.611\, Y_7$

Consumption: $Z = 67 + 4.551\, Y$

Wood raw material includes several consumption categories which must be deducted to arrive at *domestic roundwood*[1] *consumed by the forest industry*. The forecasting of these items is discussed in the following.

Logging residues from previous years have been collected in northern Finland for industrial processing since 1964 (HUTTUNEN 1970, p. 9).

1. Roundwood is timber from forests, felled green, and prior to any primary use.

Table 4. Forecasts of forest-industry output and wood raw material consumption in 1970
Taulukko 4. Teollisuuden tuotoksen ja puuraaka-aineen käytön ennusteet v. 1970

Branch of industry Teollisuuslaji	*Forecast* — Ennustettu		
	Output Tuotos 1000		*Consumption of WRM*[1] Puuraaka-aineen kulutus *1000 m*^{3} — k-m^3
Sawmills[2] — Teollisuustilaston sahat	1264	std.	11 775
Other sawmills — Muut sahat	. .		1 700
Plywood & veneer — Vaneri	707	m^3	1 721
Particle board — Lastulevy	373	”	528
Mechanical pulp — Hioke	1695	tons — tn	4 147
Semi-chemical pulp — Puoliselluloosa	331	”	679
Sulphite pulp — Sulfiittiselluloosa	1476	”	7 069
Sulphate pulp — Sulfaattiselluloosa	2717	”	12 432
Fibreboard — Kuitulevy	236	”	664
Other — Muu	. .		147
Total — Yhteensä	.		40 862

1. *WRM — wood raw material*
2. *Those covered by the Industrial Statistics*

Forecasting of logging residues is not necessary, since the quantity collected in one year is regarded as consumed by industry in the following year. Thus the quantity for 1970 has already been determined from the logging residues collected in 1969.

Dead trees on the stump have been previously included in natural losses and therefore must be excluded from roundwood. It has been estimated at 0.2 million m^3 yearly since 1955. The same quantity also serves as a forecast.

Wood residues from industry includes all wood (strips, sawdust, etc.) coming from the primary-processing industries, mainly the sawmilling and plywood industries. The main uses of such wood residues are in the particle board and pulp industries. The forecasting of this item has been quite difficult since the exploitation of this raw-material source has been continuously intensified during the 1960s. Later, when the development has levelled off, forecasts can be based on the output of the sawmilling and plywood industries. In the meantime forecasts must be based on the latest observations adjusted to the change in output of the respective industries.

The quantities of *imported roundwood and residues* can be predicted on the basis of the information collected from the few importing companies.

The estimates for 1970 of the deductions are as follows:

Logging residues from previous years	60 000 m^3
Dead trees on the stump	200 000 "
Wood residues from industry	3 800 000 "
Imported roundwood	2 200 000 "
Imported wood residues	137 000 "
Total	6 397 000 m^3

The estimate of domestic industrial wood consumed by the forest industries in 1970 is as follows:

Total wood raw material	40 862 000 m^3
Deductions	6 397 000 "
Domestic industrial roundwood	34 465 000 m^3

32. Fuelwood for industry

The fuelwood (roundwood) consumed by industry has shown a falling trend; in 1959 it was 1.22 million m^2, and in 1968 a mere 0.15 million m^3. The simplest way of forecasting this category is by extrapolating the trend. Later, when the decline levels off, the latest available figure can serve as a forecast. The forecast for 1970 is 0.08 million m^3.

33. Roundwood consumed on farms and in buildings

This category (formerly called "wood for real estates") comprises the consumption of roundwood on farms and in buildings, which is not covered by the Industrial Statistics. The main constituent is fuelwood.

Two surveys (1955 and 1965) have been undertaken to investigate the roundwood consumption on farms and in buildings. The 1965 investigation (ERVASTI, SALO & TIILILÄ 1967) was a sample survey of nearly five thousand buildings and farms drawn from the Census of Buildings.

Since 1965 the estimates have been based on a linear extrapolation of the trend as derived from the 1955 and 1965 figures. This extrapolation is inaccurate since it is based on only two points which are ten years apart. It does not take into account the rapid urbanization of society and changes in heating methods. A new survey is being undertaken for 1970. As soon as the new data is available the forecasting method must be reconsidered.

The forecast for 1970 is 8.58 million m^3.

34. Roundwood exports

Finland's formerly large export of roundwood has been transformed into a net import in recent years, the balance showing a net import since 1964. Roundwood exports fell to 0.57 million m^3 in 1968 from their peak of 5.91 million m^3 in 1961.

Since 1968 foreign buyers of roundwood have been able to pay substantially higher prices than those paid by Finnish industry. As a result, exports increased to 0.83 million m^3 in 1969. The estimate for 1970 is 1.1 million m^3. This forecast is based on the quantities licensed for export up to the end of August.

35. Other roundwood consumption

This category covers all roundwood consumption not included in Sections 31 to 34.

The main constituents are telephone poles, timber for civil engineering and fuelwood for various purposes (railways, defence forces, etc.).

Roundwood consumption in this category was first determined in 1964, when it was 0.43 million m^3. In 1968 it had fallen to 0.24 million m^3. The steadily falling trend may be expected to continue. The forecast for 1970 is 0.2 million m^3.

36. Total drain based on consumption

A forecast of the total consumption of domestic roundwood in 1970 is as follows:

Industrial wood for industry	34 465 000 m^3
Fuelwood for industry	80 000 "
Roundwood for farms & buildings	8 584 000 "
Roundwood exports	1 100 000 "
Other consumption	200 000 "
Total consumption of roundwood	44 429 000 m^3

An estimate of the total drain is arrived at when logging and silvicultural waste, plus floating and natural losses, are added to the total consumption. It is estimated that the proportion of logging and silvicultural waste will remain unchanged from the previous year. Only a small decrease from previous years is expected in floating losses. Natural losses have been estimated at 1 million m^3 annually since 1955.

Total consumption of roundwood	44 429 000 m^3
Logging & silvicultural waste	5 075 000 "
Floating losses	50 000 "
Natural losses	1 000 000 "
Total drain	50 554 000 m^3

The forecast shows a rise of 1.531 million m^3 from the preliminary estimate for 1969 which was 49.023 million m^3. The most recent final estimate, 46.558 million m^3, is for 1968.

4. CONCLUSIONS

In this study the main emphasis has been placed on forecasting the total consumption of wood raw material by the forest industries. The methods outlined can be further developed by introducing a new type of cyclical variable in the output models. Such a variable could be based on export data from the various branches of industry.

A new method can be developed for forecasting the roundwood consumed on farms and in buildings once the results of the new survey are available.

A forecast of the total drain for the country as a whole is not sufficient to satisfy the needs of intensified planning. Possibilities should also be explored of forecasting the drain by areas and by species.

TIIVISTELMÄ

Metsä- ja puutalouden kaikilla tasoilla tapahtunut suunnittelun tehostaminen ja sen aiheuttama kasvanut informaation kysyntä ovat synnyttäneet tarpeen ennakoida metsien kokonaispoistuma lyhytjaksoisesti. Tässä tutkimuksessa on kehitetty eräs menetelmä tähän tarkoitukseen.

Poistumaennusteen kannalta tärkein erä on teollisuuden ainespuu, joka on teollisuuden puuraaka-aineen käytön ja jätepuun sekä ulkomaisen puun erotus. Tästä syystä tutkimuksessa keskityttiin juuri puuraaka-aineen käytön ennustamiseen. Metsäteollisuuden puunkäyttöä selittäväksi muuttujaksi valittiin ao. teollisuuslajin tuotos. Metsäteollisuuden puuraaka-aineen käytölle, Z, muodostettiin malli:

$$Z = \sum_{i=1}^{10} Z_i \;;$$

$Z_i = a + b\,Y_i$, kun $i = 1, 3, 4, \ldots, 9$;
Z_2 = viimeisin tutkittu Z_2;
$Z_{10t} = Z_{10(t-2)}$;
Y_i = teollisuuslaji i:n tuotos.

Todettiin, että malli täytti hyvin sille asetetut tarkkuusvaatimukset.

Ennustamista varten tarvittiin tuotoksien ennakoidut arvot. Tutkittaessa metsäteollisuuslajien kausivaihtelua havaittiin sen pysyneen pääpiirteissään saman muotoisena 1960-luvulla. Tuotoksien ennustamisen menetelmä perustettiin tähän säännönmukaisuuteen, oletettiin, että kausivaihtelun muoto ei muutu ennustejakson kuluessa. Ennustamisessa kokeiltiin kahta menetelmää, jotka perustuvat em. oletukseen. Regressiomenetelmä osoittautui paremmaksi kuin kausi-indekseihin perustuva. Regressiomallien selittäväksi muuttujaksi valittiin ao. teollisuuslajin heinäkuun tuotoskertymä, mikä todettiin edulliseksi julkaisuajankohdan kannalta. Mallit olivat muotoa:

$Y_i = a + b\,Y_{i_k}$;
Y_{i_k} = teollisuuslaji i:n tuotos k:nnen kuukauden loppuun mennessä

Jäännöstermien simultaanisen tarkastelun perusteella tultiin siihen tulokseen, että suhdannetilanne vaikuttaa ennusteisiin. Tämän vuoksi malleihin otettiin suhdannetilannetta kuvaava muuttuja. Kokeiltaessa kahta mallityyppiä vuoden 1967 tuotoksien ennustamiseen havaittiin, että ilman suhdannemuuttujaa muodostetut mallit antoivat tarkempia tuloksia kuin suhdannemuuttujan sisältävät mallit.

Poistuman laskentaan liittyvien muiden erien ennustamisessa käytettiin yksinkertaisia menetelmiä kuten esim. trendin ekstrapolointia.

Tutkimus päätyy seuraavaan kokonaispoistuman ennusteeseen v. 1970:

Teollisuustilaston sahat		11 775 000 m³
Muut sahat		1 700 000 "
Vaneriteollisuus		1 721 000 "
Lastulevyteollisuus		528 000 "
Hioketeollisuus		4 147 000 "
Puolisellüloosateollisuus		679 000 "
Sulfiittiselluloosateollisuus		7 069 000 "
Sulfaattiselluloosateollisuus		12 431 000 "
Kuitulevyteollisuus		664 000 "
Muu teollisuus		147 000 "
Teollisuuden käyttämä puuraaka-aine		*40 862 000 m³*
Liekopuu	60 000 m³	
Pystykuiva puu	200 000 "	
Teollisuusjätepuu	3800 000 "	
Tuontiraakapuu	2200 000 "	
Tuontijätepuu	137 000 "	
Vähennykset yhteensä		6 397 000 m³
Teollisuuden ainespuu		*34 465 000 m³*
Teollisuuden polttopuu		80 000 "
Kiinteistöjen puu		8 584 000 "
Vientipuu		1 100 000 "
Muu käyttö		200 000 "
Puun kokonaiskäyttö		*44 429 000 m³*
Metsähukkapuu		5 075 000 "
Uittohäviö		50 000 "
Luonnonpoistuma		1 000 000 "
Kokonaispoistuma		*50 554 000 m³*

Ennuste osoittaa 1.531 miljoonan k-m³:n kasvua vuoden 1969 ennakkoarviosta, 49.023 milj. k-m³. V. 1968 kokonaispoistuma oli 46.588 milj. k-m³.

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