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Mencel, A., Ratajczak, E., Strykowski, W., Skalecki, C. and Szostak, A.

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WORKING PAPER

POTENTIAL EFFECTS OF INDUSTRIAL AIR POLLUTION ON WOOD-PRODUCT SUPPLY AND DEMAND, AND STRUCTURE OF THE WOOD-PRODUCTS INDUSTRY, IN POLAND

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FOREWORD

Within IIASA's Environment Program, the Biosphere Dynamics Project seeks to clarify the policy implications of long-term, large-scale interactions between the world's economy and its environment. The project conducts its work through a variety of basic research efforts and applied case studies. One such case study, the Forest Study, has been underway since March 1986 and focuses on the forest-decline problem in Europe. Objectives of the Forest Study are:

a) to gain an objective view of the future development of the European forest resources;

b) to illustrate the future development of forest decline attributed to air pollution and the effects of this decline on the forest sector, international trade and society in general;

c) to build a number of alternative and consistent scenarios about the future decline and its effects; and

d) to identify meaningful policy options, including institutional, technological and research/monitoring responses, that should be pursued to deal with these effects.

In the framework of the Forest Study a whole series of working papers on the conditions of the Polish forest sector have been published. This paper is one in the Polish series under the auspices of the Forest Study. Due to the estimated increase of future forest decline in Poland, the industrial structure has to be adapted to the new conditions. The objective of this study is to illustrate some of the effects of increasing forest decline on the industrial structure in Poland.

B.R. Döös
Leader
Environment Program

ABSTRACT

This study aimed to determine potential changes in the production structure of the wood-processing industry up to 2020, resulting from unfavorable impact of industrial pollutants upon forests in Poland. The paper consists of four chapters. In the first section, forecasts of consumer demand for forest products, based on patterns of actual demand, are presented. The structure of industrial demand for wood assortments, and the degree to which it is met, are the topics of the second chapter. In the third chapter, we present forecasts of the possibilities of wood-raw-material consumption by industry with regard to the unfavorable impact of industrial pollution. The last chapter contains forecasts of production regarding foreseen changes in the structure of the wood-processing industry, taking into account qualitative changes in wood raw-material and expected changes in techniques and technology. Our results show that, up to 2020, negative effects of industrial pollutants on forests will have a significant influence on the degree of meeting consumer demands for wood products.

CONTENTS

POTENTIAL EFFECTS OF INDUSTRIAL AIR POLLUTION ON WOOD-PRODUCT SUPPLY AND DEMAND, AND STRUCTURE OF THE WOOD-PRODUCTS INDUSTRY, IN POLAND

Anna Mencel, Ewa Ratajczak, Władysław Strykowski, Czesław Skałecki and Aleksandra Szostak

INTRODUCTION

The idea of this work was to determine the potential changes in production structure of the wood-processing industry in the long term resulting from unfavorable impacts of industrial pollution emissions on the raw-material base.

The essential difficulty in executing this work resulted from two factors – the relatively long time of the forecast period, and the as-yet preliminary nature of results from studies of air-pollution effects on the state of Polish forests, wood properties, and quality obtained from its products. Also, until now the traditional period of forecasts did not cover so long a time for both the raw-material base and the possibilities of its conversion.

The gradual degradation of Polish forests, mainly under the impact of industrial air pollution, causes invalidation of previously-prepared forecasts of the development of the forest stock and the possibilities of harvesting. This influences the forecasts of wood-processing industry development, which have to be verified according to changes in the raw-material base. These forecasts are elaborated taking into regard current results concerning the negative influence of air pollution on the state of the forest stock and possibilities and means of its utilization.

As a starting point, the paper covers on the one side the problems of consumer demand for products – with regard to demographic forecasts – and on the other side, demand of industry for wood raw-materials and the degree to which it can be met. Later in the paper, we show two sets of possibilities of harvesting and use of raw material by industry for the years 1990, 2000, 2010, and 2020. In the last section – on the image of forecasted changes in raw-material supply and the structure of the wood-processing industry – we present forecasts on the amount of production of basic wood products with regard to consumer demand.

1. SOCIAL DEMAND FOR BASIC WOOD PRODUCTS IN THE PERIOD 1985–2020

1.1. Methodological Assumptions for Determination of the Demand in 1986 and for Elaboration of Demand Forecasts to the Year 2020

Consumer demand was determined for coniferous sawnwood, non-coniferous sawnwood, wood-based panels (particleboards, fiberboards and plywood), and pulp (including cellulose). Export demands were excluded from this analysis. The basis of the demand determination for particular wood products in the year 1986 was a set of enquiries to customers. Taking into account the so-called "producers' market" and "outlayed demand" that have existed in Poland for many years, the declared size of the demands could be overstated. The demand for pulp in 1986 was determined additionally as a function of

demand for paper and cardboards (estimated by specialists on the basis of customer enquiries) and mean index of consumption of pulp. This permitted verification of the enquiry data.

Due to the availability and accuracy of obtainable information for forecasting, and of actual assumptions for future changes in demand, another approach was applied for the year 2000 and for further years (2000–2020). With respect to sawnwood, the demand to the year 2000 was estimated by the analytical-balance method and the raw-material indexes method (Fabisiak et al. 1979). The considerations were based on forecasts of development among the main sawnwood customers, including building construction, the furniture industry, and the packaging industry. Simultaneously, due to the close contact between sawnwood use and raw-material stock, a rationalization of raw-material use was taken into account, including the need to increase sawnwood substitution. Material-use indexes were estimated taking into account the influence of technical advances.

For estimating the demand for sawnwood after 2000, the method of international comparisons was applied (Roberts and Luck 1985). On the basis of analysis of sawnwood use for one inhabitant in highly developed countries that resemble Poland with respect to forest area and structure of wood-raw-material stock, the incoming level in Poland was estimated – see Appendix 1. The amounts of demand were calculated with the use of demographic forecasts for our country – see Appendix 2. In the forecast for sawnwood, changes in the reduction coefficient of sawnwood-use trend versus the use trend for wood-based panels were taken into account.

The demand for wood-based panels after the year 2000 was determined on the basis of the main customers of boards, in which the needs were determined according to forecasts of production development (Osika 1984). The basis of forecast elaboration for 2000 and beyond consisted of the demographic forecast and assumed rates of wood-based-panels consumption by their main consumers, taking into account the substitution processes of sawnwood with such panels.

The demand for pulp (subchemical pulp excluded) is outlined by the assortment structure of the demand for paper and cardboard, and by the unit of raw-material consumption. The first variant of demand for paper and cardboard was determined by pulp customers through enquiries, while the second variant results from demand for paper and cardboard. In forming the consumption index per unit of pulp, changes resulting from technical advancement were taken into account. The determination of pulp demand after the year 2000 was based on international comparisons of current consumption of paper and cardboard per capita, and assumptions of reaching particular levels of consumption in Poland. Estimation of the index of raw materials for production of paper and cardboard were made, taking account of increases in future shares of paper wastes and other raw materials for pulp.

1.2. Demand for Basic Wood Products in Poland in 1986 and the Degree of Its Fulfillment

The national demand for most forest products was in 1986 higher than their supply (Table 1). Demand for coniferous sawnwood was 79% fulfilled, the major consumers being: producers of opening joinery, the building industry, mining and energy works, the furniture industry, and railway-track producers.

The needs of the main consumers of non-coniferous sawnwood were fulfilled to 68%. The demand for sawnwood flooring materials was covered to nearly 90%. The needs of the furniture industry, especially for assortments of higher quality, were covered to a lower degree. In the remaining group of other non-coniferous sawnwood consumers, communications has a leading role.

Table 1. The state of fulfillment of the demand for basic wood products in Poland in 1986.

Product	Units for Demand Level	Level of Demand	Degree of Demand Fulfillment[1] (%)
Sawnwood			
– Coniferous	10^3 m^3	6,900	79
– Non-coniferous	10^3 m^3	900	68
Natural Veneers	10^6 m^2	42.3[2]	92
Wood-Based Panels			
– Particleboards	10^3 m^3	1,770	72
– Fiberboards	10^3 m^3	731	86
– Hard Fiberboards	10^3 m^3	438	77
– Soft Fiberboards	10^3 m^3	293	98
– Plywood	10^3 m^3	229	66
Pulp			
– A[3]	10^3 t	915	87
– B	10^3 t	999	79

Source: Our own elaboration on the basis of Anonymous 1988; Chwiłkowski et al. 1987; Depczyk and Rószczyk 1987; Ferens 1987; and Mencel et al. 1988.

(1) Calculated as ratio of the deliveries of product to the size of the demand.

(2) This demand derives from the furniture-production program in 1986. In fact domestic demand is higher, as expressed in demand forecasts.

(3) **A** represents the demand level resulting from customer questionnaires, whereas **B** represents the demand level resulting from demand for paper and cardboard (in the amount of 1.64 million tons), when a raw-material conversion index of 60.9 kg cellulose and pulp per 100 kg paper and cardboard is applied (Depczyk and Roszczyk 1987).

Regarding the products of the wood-based panels industry, in 1986 the highest shortage was in plywood and particleboards. Demands for softboards were fully met. The customers of various kinds and types of plywood have mainly been: the furniture industry, producers of communication systems, and the building construction industry.

In the fiberboards group, the demands of the joinery industry, furniture industry, general building industry, and small producers were covered to 86%. However, a distinctly lower degree of satisfaction of home-market demands (some 62%) was observed for finished hard fiberboards which are used mainly by the furniture industry (half of the consumption).

The highest deficiency with respect to quantity of wood-based panels in 1986 was in particleboards. Only some 75% of the demand, especially from the furniture industry, was fulfilled.

The demand for pulp is evaluated in two ways – from the point of view of direct customer demand, and as a derivative of the demand for paper and cardboard. In 1986, the demand declared by the paper industry for pulp was covered by domestic sources only to 87% (see Table 1). Another estimate can be determined from the demand for pulp as a

derivative of demand for paper and cardboard, and the mean coefficient of consumption of raw material. Using this estimate, demand was covered to 79%. The perennial deficiency of paper on the Polish market creates difficulties in evaluating the real amount of customer demand.

1.3. Forecast of Demand for Basic Wood Products for the Period 1990–2020

Future demand for basic wood products, determined according to the adopted methods, is shown in Table 2. The total demand for sawnwood will be increasing slowly, mainly due to demands of the building and furniture industries. The communications and minery demands will be rather stable, and the consumption of coniferous sawnwood for packaging will be limited. The main determinants of increased demand for non-coniferous sawnwood will come from flooring producers and the furniture industry. Simultaneously, the substitution rate of solid wood by wood-based materials will be increasing (see Table 2).

Table 2. Forecasts of domestic demand for basic wood products in Poland.

		Year							
		1990		2000		2010		2020	
Products	Units	Low	High	Low	High	Low	High	Low	High
Sawnwood	10^3 m^3	6,501	7,684	6,900	8,216	7,361	8,594	7,615	9,056
– Coniferous	10^3 m^3	5,665	6,675	5,970	7,120	6,138	7,366	6,380	7,615
– Non-coniferous	10^3 m^3	836	1,009	930	1,096	1,123	1,228	1,235	1,441
Natural Veneers	10^6 m^2	99	121	107	133	123	155	144	173
Wood-Based Panels	10^3 m^3	3,172	3,172	3,358	3,700	3,846	4,337	4,363	4,939
– Particleboards	10^3 m^3	2,061	2,061	2,184	2,406	2,537	2,864	2,964	3,293
– Fiberboards	10^3 m^3	852	852	899	993	982	1,064	1,029	1,153
– Plywood	10^3 m^3	259	259	275	303	327	409	370	493
Pulp(1)	10^3 t	993	1,290	1,163	1,520	1,395	1,643	1,380	1,750
(Paper/Cardboard)	10^3 t	1,827	1,955	2,208	2,533	2,537	2,987	2,759	3,500

Source: Our own elaboration on the basis of Depczyk and Rószczyk 1987; Grosicki and Michalski 1985; Marcinkiewicz 1984; Mencel et al. 1983; Osika 1984; Appendices I and II; and our own research.

(1) The following indexes were adopted for the consumption of pulp (in kg per 100 kg of paper and cardboard): in 1990 – 66, in 2000 – 60, in 2010 – 55 and in 2020 – 50.

Despite the existing deficiency of meeting the demand for wood-based panels, especially particleboards and plywood, there is expected to be a further increase in demand for all kinds of wood-based panels. The greatest increased rate is expected for particleboards. A general characteristic of the future demand trends for wood-based panels will be a greater increase for finished boards than for raw boards. We have in mind mainly veneered and laminated boards, hard lacquered fiberboards, bitumen boards, medium-density fiberboards (MDF), and special kinds of plywood. Also, due to the shortage of raw material, we foresee a wider substitution of solid wood by some wood-based panels.

As stated above, the determination of real demand for various products and an indication of what level their consumption should attain in the actual condition of our economy is extremely difficult. Therefore, an indispensable condition of the effectiveness of forecasts is their verification on the basis of systematically conducted investigations, enabling the detection of changes in factors determining demand levels and periodic updating of the assumptions adopted.

2. THE STRUCTURE OF INDUSTRIAL DEMAND FOR WOOD ASSORTMENTS AND DEGREE OF FULFILLMENT OF SUCH DEMANDS BY POLISH FORESTS FOR THE YEAR 1986

The present structure of the demand for raw-material assortments was determined on the basis of enquiries in all wood-working enterprises of the pulp-and-paper industry and wood-based panels and in sawmills producing jointly ca. 90% of the home sawnwood production (the so-called "key-industry") (Mencel et al. 1986). The main criteria for determining demand were production capacities of the enterprises. The factors governing the use of such capacities were also taken into account (Mencel et al. 1983).

For determination of the degree of fulfillment of the demand for wood assortments, information elaborated by the Informatics Center of Forestry and Forest Industries on the raw-material deliveries in 1986 for the sawmilling and wood-based industries was used. Deliveries to the pulp industry were determined on the basis of data from the Paper Industry Association (Depczyk and Rószczyk 1987).

Taking into account the structure of demand and wood supplies, we have used the above method to synthesize the results of the degree of fulfillment of demands of the industry for wood assortments in 1986. The tabulated results (Table 3) indicate that in 1986, demands for raw material of higher quality have not been satisfied. The deficiencies range from 6% in the fiberboard industry to 26% in the plywood industry. In sawmilling, the raw-material deficiency was 12%. In the particle- and fiberboard industries, the deliveries were higher than demand by about 13%.

Leading to such a situation in supply of raw materials to the wood-processing industry, the following factors have had significant influence:

(a) improving the sanitary state of forests, which increased wood supply for board production (creation of the reserve); and

(b) unfavorable forest age-class structure, characterized by a deficiency of big-dimension logs (in the period 1950–1980, harvesting in Poland exceeded annual growth by an average of about 15% yearly) (Anonymous 1986).

Based on our analysis of assortment deliveries of wood raw-material against the demand structure, it can be stated that the situation of particular industry branches was differentiated. In the sawmilling industry, despite unfulfilled overall demands, the structure of required raw material, in terms of proportion of coniferous and non-coniferous wood, was preserved. In other industries, relations between supply and demand for particular assortments changed in various degrees. Examples are: (a) in the plywood industry, increased share of coniferous wood; (b) in the particle- and fiberboard industries, increased deliveries of wood directly from forests instead of industrial residues; and (c) in the pulp industry, slightly decreased deliveries of coniferous pulpwood and more non-coniferous pulpwood and industrial residues.

Table 3. The degree of covering demands, and the structure of demand and supply according to the kind of raw material and directions of processing in Poland in 1986.

Industry	Kind of Raw Material	Degree of Covering Demand %	Structure	
			Demand %	Supply %
Sawmilling	Coniferous Saw Logs	88	88	88
	Non-Coniferous Saw Logs	88	12	12
	Total	88	100	100
Plywood	Coniferous Logs	95	30	40
	Non-Coniferous Logs	65	70	60
	Total	74	100	100
Particleboards	Coniferous Pulpwood	86	33	25
	Wood for Boards	321	15	43
	Coniferous Fuelwood	0	6	–
	Non-Coniferous Fuelwood	0	–	–
	Small Wood	104	24	23
	Industrial Wood Wastes	48	22	9
	Total	111	100	100
Fiberboards	Coniferous Pulpwood	51	5	2
	Wood for Boards	–	–	20
	Coniferous Fuelwood	0	–	–
	Non-Coniferous Fuelwood	–	–	–
	Small Wood	112	50	48
	Industrial Wood Wastes	76	45	30
	Total	116	100	100
Pulp	Coniferous Pulpwood	87	84	81
	Non-Coniferous Pulpwood	106	16	18
	Coniferous Fuelwood	–	–	–
	Non-Coniferous Fuelwood	–	–	–
	Industrial Wood Wastes	–	–	1
	Other Coniferous Wood for Industrial Purposes	0	–	–
	Total	94	100	100

Source: Our own elaboration on the basis of Mencel et al. 1983 and 1986 for demand structure; basic statistic data on the activity of branches and enterprises, Anonymous 1986; and Depczyk and Rószczyk 1987 for pulp supply structure.

3. POSSIBILITIES OF INDUSTRIAL USE OF WOOD RAW-MATERIAL TO THE YEAR 2020 WITH REGARD TO UNFAVORABLE IMPACTS OF INDUSTRIAL POLLUTION

3.1. Methodological Assumptions for the Prognosis of Possibilities of Harvesting and Use of Wood Raw-Material to the Year 2020

In Poland, forecasting the development of forest resources and possibilities of their use is mainly the task of the Forest Research Institute in Warsaw. Elaborations from this Institute are the basis for forecasting the development of the forest industries processing this raw material. For this paper, we have used an initial set of wood-harvest forecasts prepared by a team from the Forest Research Institute (Trampler 1988). The team presented in their forecast two forest-resources variants and only one wood-harvest variant accounting for reduced increment resulting from industrial air pollution. This is the only set of forecasts we could obtain for determining the possibilities of harvesting wood until the year 2020. The wood-harvest forecast was subject to discussions among specialists representing centers executing forest policy in Poland, with our participation. Experts participating in the discussions have verified and approved the wood-harvest forecast we used, and also discussed the relations between final cuttings and intermediate cuttings influencing the assortment structure of wood raw-material. Thus, the initially elaborated forecast and the opinions of the experts were used as bases for two variants of possibilities of wood-raw-material assortment supply (Appendices 3 and 4). Variant II (Appendix 4) of our forecasts corresponds fully with the wood-harvest forecast we received from the team at the Forest Research Institute. Variant I (Appendix 3), in the part pertaining to the year 1990, results from forest-management plans currently in place (Anonymous 1987b), but for the years 2000–2020 the total amounts of harvest of merchantable boles are the same as in Variant II, and differences occur only in the assortment structure harvested. The latter result from changes we made in the proportion of harvesting coniferous and non-coniferous wood, and from differences of relations between final cuttings and intermediate cuttings.

The wood raw-material in Poland is harvested in forests of various kinds of ownership, but State Forests experience 92% of all wood harvest in Poland, and this is the main source of supply to the wood-processing industry. Other forests usually supply only their owners and small customers. Harvesting in these other forests has for many years remained at the same level. For the time span of the forecast, cutting in those forests according to the mean level for recent years was adopted in both forecast variants.

Initial forecasts for State Forests were elaborated using the results of the forest inventory from January 1986. Based on those resources and reductions in their current yearly increment affected by noxious pollutants, the team (Trampler 1988) computed the increment of forest resources for various years within the forecast period. They applied reducing coefficients of actual forest-stand increment, varying among particular country regions. The Forest Research Institute supplied documentary evidence in this respect. They also adopted the additional assumption that harvesting in stands of a given species could not be higher than the mean increment of forest resources. Their results revealed that various degrees of air-pollution damage to our forests will cause forest resources on various terrains to be heterogeneously slower growing and later in reaching technical maturity.

To determine the relation between final cuttings and intermediate cuttings and harvesting of coniferous and non-coniferous wood, it was assumed that the health and sanitary state of forests has an important impact on the structure of logging. Weakening of forest stands as a result of increasing air pollution causes various calamity phenomena, including noxious insect infestations, fungal diseases, and wind damages. These calamities urge further changes of harvesting structure in addition to those determined by the forest age-class structure. The actual and forecasted unfavorable sanitary and health state of forests will require, after exceeding reasonable levels of intermediate cutting, proper compensato-

ry decreases in the amount of final cuttings (Anonymous 1987a). In forecast Variant II, the structure of the possibilities of using wood raw-material takes into account a higher intensity of calamity phenomena as the result of industrial pollution than in Variant I.

While determining the possibilities of use of wood raw-material by industry for both forecast variants of wood harvests to the year 2020 (Table 4), the following criteria were taken into account:

(a) consumer demand for products;

(b) actual production capacities of the wood-processing industries together with ongoing investments; and

(c) destination of wood raw-material in those directions which allow the best use value of particular wood assortments for fulfilling consumer demands (among others, taking into respect replacement among wood assortments and substitution of wood with other materials and products).

3.2. Forecast of Possibilities of Industrial Consumption of Wood Raw-Material to the Year 2020

Table 4, presenting two possibilities of the use of raw material by industry over the forecast period, was elaborated on the basis of data contained in Appendices 3 and 4. There are differences between the forecasts of possibilities of consumption of wood raw-material, and the wood totals resulting from possibilities of its consumption by industry. There are two main causes for those differences: first is the need to satisfy small market customers, particularly for fuelwood and other uses in communal households; and the second results from different possibilities of consumption of small wood – in Variant II, small wood is used, while in Variant I only small wood suitable for industrial conversion is accounted for (the rest can be used for energy purposes). Besides the seven main directions of possibilities of raw-material use (i.e., veneers, plywood, sawnwood, pulp, new kinds of boards, fiberboards, and pitprops and shores), we also took into account the possibility of directing wood raw-material to other products (e.g., wood-wool, charcoal, tannins, matches, compreg, and others).

The influence of air pollution in decreasing the annual increment of forest resources will lead to development of particular wood-processing industries under conditions of a changing structure of raw materials. The highest possibilities of changes exist for the industries that process raw materials of lower usable quality, especially the wood-based panels industry, and also to some degree, the pulp industry.

The structure of wood, which could be directed to the particleboard industry in 2020 in comparison with 1986, will be characterized by a decrease of pulpwood from 25% to 14%, a decrease of other industrial wood from 43% to 16%, and an increase of lower-quality materials, such as fuelwood, small wood and industrial wastes, from 32% to 70%.

Consumption of pulpwood (in 1986, 2%) and other industrial wood (in 1986, 20%) for the sake of fuelwood, small wood, and industrial residues, has to be completely eliminated in the fiberboard industry. Similar changes are expected in wood-raw-material consumption structure in production of pulp, which will be connected with changes in techniques and technology. Thus, in 2020 there will be, compared to 1986, a decrease of pulpwood consumption from 99% to 65% and an increase of consumption of residues from 1% to 3%. Simultaneously, this industry will begin to use previously unused raw materials such as: other industrial wood (11%), fuelwood (6%), small wood (7%), and fresh stumpwood (8%).

Table 4. Forecasts for deliveries to different uses of wood assortments in Poland. Figures are in thousand cubic meters. Scenario Variant I follows forest-decline scenario I in Appendix III, whereas Variant II follows forest-decline scenario II in Appendix IV.

Harvested Assortment and Uses	Volumes Delivered to Each Use							
	1990		2000		2010		2020	
	I	II	I	II	I	II	I	II
VALUABLE LOGS								
Veneer/Plywood								
– Coniferous	80	80	80	80	90	90	90	90
– Non-coniferous	150	150	180	180	200	200	210	210
Other Ind. Uses								
– Coniferous	20	20	20	20	20	20	20	20
– Non-coniferous	50	50	50	50	50	50	50	50
Total	300	300	330	330	360	360	370	370
– Coniferous	100	100	100	100	110	110	110	110
– Non-coniferous	200	200	230	230	250	250	260	260
SAWLOGS								
Veneer/Plywood								
– Coniferous	30	30	30	30	50	40	50	40
– Non-coniferous	60	60	60	60	40	50	50	50
Sawnwood								
– Coniferous	8,140	7,150	7,620	7,420	8,250	7,770	8,680	8,200
– Non-coniferous	1,500	1,600	1,600	1,850	1,740	2,030	1,860	2,150
Other Ind. Uses								
– Coniferous	50	40	50	40	50	40	70	60
– Non-coniferous	50	50	50	50	50	50	60	60
Total	9,830	8,930	9,410	9,450	10,180	9,980	10,770	10,560
– Coniferous	8,220	7,220	7,700	7,490	8,350	7,850	8,800	8,300
– Non-coniferous	1,610	1,710	1,710	1,960	1,830	2,130	1,970	2,260
PITPROPS								
Pitprops	1,720	1,720	1,630	1,630	1,630	1,630	1,630	1,630

Table 4. Continued ...

Harvested Assortment and Uses	Volumes Delivered to Each Use							
	1990		2000		2010		2020	
	I	II	I	II	I	II	I	II
PULPWOOD								
Sawnwood	200	200	200	200	200	200		
Pulp	4,040	4,080	4,350	4,090	4,240	4,260	4,150	3,990
Particleboards	400	500	540	550	430	400	500	530
Other Ind. Uses	300	220	250	230	160	140	60	50
Total	4,940	5,000	5,340	5,070	5,030	5,000	4,710	4,570
OTHER IND. WOOD								
Pulp	400	360	470	570	790	670	600	650
Particleboards	470	375	570	640	550	660	550	540
Other Ind. Uses	300	310	350	270	420	350	350	310
Total	1,170	1,045	1,390	1,480	1,760	1,680	1,500	1,500
FUELWOOD								
Pulp	100	100	330	350	350	350	400	400
Particleboards	290	290	300	270	300	340	340	370
Fiberboards	185	185	130	130	130	140	150	150
Other Ind. Uses	95	95	150	100	250	190	350	350
Total	670	670	910	850	1,030	1,020	1,240	1,270
ALL MERCH. BOLES								
Veneer/Plywood	320	320	350	350	380	380	390	390
Sawnwood	9,840	8,950	9,420	9,470	10,190	10,000	10,540	10,350
Pulp	4,540	4,540	5,150	5,010	5,380	5,280	5,150	5,040
Particleboards	1,160	1,165	1,410	1,460	1,280	1,400	1,390	1,440
Fiberboards	185	185	130	130	130	140	150	150
Pitprops	1,720	1,720	1,630	1,630	1,630	1,630	1,630	1,630
Other Ind. Uses	865	785	920	760	1,000	840	960	900
Total	18,630	17,665	19,010	18,810	19,990	19,670	20,210	19,900
SMALLWOOD								
Pulp			250	200	200	230	400	400
Particleboards	885	880	1,100	1,120	1,200	1,260	1,170	1,180
Fiberboards	670	670	710	750	740	790	730	730
Total	1,555	1,550	2,060	2,070	2,140	2,280	2,300	2,310

Table 4. Continued ...

Harvested Assortment and Uses	Volumes Delivered to Each Use							
	1990		2000		2010		2020	
	I	II	I	II	I	II	I	II
FRESH STUMPWOOD								
Pulp					400	400	500	500
INDUSTRIAL WASTES								
Pulp	120	120	170	160	200	160	200	200
Particleboards	800	800	600	750	700	800	900	950
Fiberboards	430	430	500	500	500	500	550	600
Other Ind. Uses	145	115	150	150	150	150	150	150
Total	1,495	1,465	1,420	1,560	1,550	1,610	1,800	1,900
TOTAL, ALL WOOD								
Veneer/Plywood	320	320	350	350	380	380	390	390
Sawnwood	9,840	8,950	9,420	9,470	10,190	10,000	10,540	10,350
Pulp	4,660	4,660	5,570	5,370	6,180	6,070	6,250	6,140
Particleboards	2,845	2,845	3,110	3,330	3,180	3,460	3,460	3,570
Fiberboards	1,285	1,285	1,380	1,380	1,370	1,430	1,430	1,480
Pitprops	1,720	1,720	1,630	1,630	1,630	1,630	1,630	1,630
Other Ind. Uses	1,010	900	1,070	910	1,150	990	1,110	1,050
Total	21,680	20,680	22,530	22,440	24,080	23,960	24,810	24,610

4. EXPECTED CHANGES IN THE STRUCTURE OF THE WOOD-PROCESSING INDUSTRY IN POLAND TO THE YEAR 2020

4.1. General Remarks

The running of a socialist economy and its industry was very clearly determined by the Hungarian economist J. Kornai (Kornai 1976, 1980). Kornai's main thesis is one of continuous disbalance in a planned economy because of higher demand than possibilities of supply of investment goods. However, the introduction of economic reform in Poland is an attempt to change this state, but in the forest industrial complex there are serious constraints to growth of production, the main one being wood raw-material.

While our main topic of investigation was determining the influence of industrial pollutants on the structure of the wood-processing industry, we realize that the changes will be formed also by other factors. We have attempted to take them into consideration. Changes in the structure of the wood-processing industry resulting from changes in the supply of wood raw-material were elaborated taking into account:

(a) qualitative changes in wood raw-material on the basis of the results of investigations of Polish and foreign authors;

(b) forecasted changes in techniques and technology;

(c) needs of maintaining reserves of production capacities resulting from periodic surpluses of wood raw-material; and

(d) limited possibilities of investments resulting from the debt of the country.

4.2. Qualitative Changes in Wood Raw-Material

The quality of wood from damaged forest stands and its consequences for the industry and wood products have for some time been topics of intensive research in Poland (Anonymous 1986; Babicki and Mencel 1988; Buchholz and Metkowski 1988; Spława-Neyman 1988; Spława-Neyman et al. 1988; Szujecki 1988) and abroad (Blossfeld and Meyer 1988; Kairiukstis et al. 1987; Liese 1987). Due to the complexity of problems and their various solutions, the results are variable. Elaborating this part, we have had to use results of various authors verified by ourselves, and have considered:

(a) wood created before the action of noxious chemicals not showing any changes in technical properties;

(b) wood created under pollutant emissions, often with decreased annual rings and density and related changes in technological properties of wood such as compression strength, static and dynamic bending strength, elasticity modulus, shrinkage and swelling; and

(c) deadwood damaged by secondary pests, with lowered usable quality which has a variety of effects for particular wood-processing industries.

In the sawmilling industry, the conversion of deadwood damaged by secondary pests results in decreased machine efficiency (e.g., more frequent exchange of blades, higher dust share, breaking of wood), decrease of material output, worsening of assortment structure, and significant limitations of directing such sawnwood into products of higher value. Late felling of dead trees results in lowering wood strength and increased occurrence of sap stain.

In the particle- and fiberboard industries, use of wood damaged by secondary pests results in decreased quality of chips and wood fibers, increased quantities of dusts, higher electrical energy consumption during chipping, and shortened service life of cutting knives.

In the pulp industry, the main problem is lowered moisture content of wood and stronger adherence of bark. The latter leads to additional treatments and costs to ensure high quality of debarking. In addition, decay of sapwood causes higher abrasion of wood in the debarking operation.

4.3. Forecast Changes in Techniques and Technology

The elaboration of future changes in techniques and technology was based on:

(a) detailed evaluation of the state of development of wood-processing industries worked out by the Wood Technology Institute in 1988 (Mencel et al. 1988);

(b) current results of projects of scientific research centers working for the wood-processing industry in Poland, and directions of further investigations in research programs in the Wood Technology Institute in 1986 (Mencel et al. 1986); and

(c) forecasts and studies presenting the current state and future development of wood-processing industries (Chwiłkowski et al. 1987; Depczyk and Rószczyk 1987; Ferens 1987; Grosicki and Michalski 1985; Marcinkiewicz 1984; Mencel et al. 1983; Osika 1984).

4.3.1. Sawmilling industry

Until now, development of the sawmilling industry in Poland has been relatively low, as manifested in the low degree of mechanization in many enterprises. A characteristic feature of the majority of the enterprises is a low degree of wood conversion (the basic product being general-purpose sawnwood). The demand for sawnwood considerably exceeds the production possibilities of this industry, and the main constraint is raw material (Chwiłkowski et al. 1987; Mencel et al. 1988).

Future changes will be based mainly on:

(a) liquidation of old, unprofitable and badly situated (with respect to raw-material location) enterprises; and

(b) modernization of most enterprises.

This modernization will tend toward:

(a) mechanization of heavy work;

(b) increased output per raw-material unit used resulting from gluing of wood, aggregate wood conversion, and after 2000 the implementation of new production methods of wood material such as sector-wood, laminated veneer lumber and comply production (Becker 1987; Deppe 1987; Kossatz et al. 1987; Tillman 1985; UN 1980; USDA 1982);

(c) increased production capacities of thin wood conversion (e.g., pulpwood) into sawn materials;

(d) development of production potential enabling "deeper" wood conversion (e.g., drying and protecting sawnwood, and elements of a high state of machining);

(e) implementation of wood-economizing technologies in production of flooring materials and packages; and

(f) introduction of installations enabling the use of wood wastes for pulp and wood-based panels.

In larger sawmills, which generate large quantities of wood wastes, it is proposed to build small departments of particleboard production (10–20 thousands m^3 of boards per year) for use in the building industry.

4.3.2. Wood-based panels industry

In the structure of the production of wood-based panels in Poland, particleboards have the highest share. Analyzing future development of this sector, we took into account the degree to which demand for the products of this industry was fulfilled and the possibilities of use by this industry of raw material of lower quality. Applying these criteria, we forecast a considerable increase of particleboard production resulting from modernization of existing and establishment of new departments of particleboards.

With regard to experience of other countries (Deppe 1987; Kossatz et al. 1987; UN 1980), advancement of investigations in Poland, and methods of production (Ferens 1987; Mencel et al. 1983, 1988; Oniśko 1988; Osika 1984) based on currently implemented techniques and technologies, we expect increased quality (with decreases of free-formaldehyde content), lower density, decreased energy consumption, and wider use of lower quality wood. Simultaneously, the range of finishing of particleboards by its producers (lacquering, laminating, etc.) will increase.

After the year 2000, despite modernization and development of particleboard production, we forecast development of a factory for MDF boards, cement-bonded particleboards, gypsum-bonded particleboards and particleboards covered with gypsum.

Production of softboards in Poland is expected to cover present and future demand. In the range of hardboards, modest development in quantity produced is desirable. The development activity of this industry will concentrate mainly on modernization of technical equipment (Osika 1984; Mencel et al. 1983) for both ecological and economic reasons (Oniśko 1988). In hardboard production, the share of boards with finished surfaces will increase.

In the plywood industry, there is a lack of objective circumstances for a noticeable increase of production due to the very small raw-material base (Anonymous 1987b; Trampler 1988). Any changes will be based mainly on modernization. In production, there will be less general-purpose plywood and more product determined for particular uses. We forecast implementation of new types of plywood with variable finishing (Anonymous 1987b; Mencel et al. 1983; Osika 1984).

4.3.3. Pulp industry

In the pulp industry in Poland, there are very large differences among enterprises in production methods. Due to the relatively low degree to which consumer demand for paper products is met, development of this industry is desirable. The limited possibility of harvesting more wood to meet the demand for the products creates a need for implementation of new technologies, with regard to ecological needs and ensuring (Depczyk and Rószczyk 1987; Mencel et al. 1983; Surewicz 1988):

(a) decrease of wood losses in the process of preparing wood raw-material;

(b) increase of pulp output per unit of wood raw-material;

(c) wider application of wood raw-materials of lower quality and residues for production of pulp;

(d) implementation of technologies allowing high use of wood together with wood by-products; and

(e) increased use of wastepaper per unit of produced paper and cardboard.

4.4. Possibilities for Reserves of Production Capacities

Pollution of the air will cause periodic difficulties for the Polish wood economy. This will require elastic adaptation in short periods to the changeable local wood supply. Low biological durability of our forests and the diversified degree of danger across space will cause the supply of wood to be changeable in time with respect to quantity, structure and displacement. Modification of supply will be made, above all, through increases of forest area and sanitary cuttings, and a tendency towards reconstruction of degraded and threatened forest stands (Anonymous 1986, 1987a).

The necessity to prepare industry for an elastic consumption of increased wood supply will result from overlapping of dangers. This applies mainly to the sawmilling industry, which has relatively the best spatial structure from the point of view of possibilities of adaptation to the raw-material base and relatively the lowest capital-consuming production (Babicki and Mencel 1988; Mencel 1985).

4.5. Financial Limits

The relatively high debts of Poland and the necessity to repay loans limits the scope of shaping development of the wood-processing industry. In the area of investment, this problem can be seen particularly in the pulp industry, where the cost of buying imported industrial installations is very high. Similarly, but to a lower degree, this problem will appear at implementation of new technologies of wood-based materials (for instance, MDF boards).

The debt of our country does not allow us to forecast imports of wood and fiber which are to be calculated in a balanced way. Changes in the wood-processing industry's structure are based on domestic raw material.

4.6. Forecast of Changes in the Wood-Processing Industry Structure to the Year 2020

The main determinant of development of the wood-processing industry is raw material, which, even in the case where other limitations did not occur, basically determines the volume and structure of production. We emphasize that from the forecasts of possibilities of harvesting raw material, even the lower forecast of product demand cannot be fulfilled from the domestic wood base. Therefore, forecasts were elaborated in two variants corresponding to the two forecasts of possibilities of obtaining raw material.

In each forecast variant, changes in the structure of wood conversion are presented in two ways:

(a) presentation of the share of various products in the structure of raw-material consumption in the years covered by the forecast in comparison with 1986 (Table 5);

(b) presentation of wood-raw-material consumption dynamics for basic products in the period covered by the forecast in comparison with 1986 (Table 6).

Analyzing the forecast changes in the wood-processing industry's structure according to raw-material consumption (Table 5), it can be stated that the share of sawnwood will decrease from 53% in 1986 to 45% or 46%, depending on the forecast variant in the year 2000. After 2000, stabilization of this share will take place. In comparison with 1986, the dynamics of the use of raw material for sawn materials (Table 6) show stabilization in 2000 and a slight increase by 2020 of about 9–11%, depending on the variant.

Relatively large changes in the structure of the wood-processing industry and simultaneously in the dynamics of raw-material consumption will take place in the pulp and wood-based panels industries. The share of consumed raw materials by the pulp industry will increase in 2020 to 27% in comparison with 1986, and the dynamics of wood consumption over this time will be about 160%.

In the wood-based panels group, internal structural changes will take place. From 2000 on, new kinds of wood-based panels will appear, the share of which will be about 1–2% in raw-material consumption for industrial purposes in the period 2010–2020. The particleboard industry will be the most developed direction of wood-based panels. Dynamics of raw-material consumption in this industry will be, in the year 2020, about 150% in comparison to 1986.

In calculating wood-consumption dynamics for various products against the dynamics of wood consumption for industry purposes (Table 6), we found that lower dynamics in general will take place in sawnwood, plywood, fiberboards, and other products.

In Table 7, we present production forecasts of basic products of the wood-processing industry resulting from the possibilities of harvesting raw material in Poland. A comparison of these forecasts with the forecasts of demand for basic wood products until 2020 (Table 2) shows that except for non-coniferous sawnwood, none of the production variants based on raw-material supply can cover the forecast of consumer demand.

On the basis of the presented forecasts, our general conclusion is that, in future, deficiencies of most wood products will occur. A major contributing factor here will be the unfavorable changes in wood-raw-material supply and a decrease of forest increment resulting from the impact of industrial air-pollutant emissions in Poland. This situation cannot be changed by the currently planned program of changes in the structure of the wood-processing industry.

Table 5. Forecasts of changes in the structure of the wood-processing industry, based on relative consumption of raw wood material. Based on Table 4.

WoodProduct[1]	Percent of Total Wood Delivered to Each Use								
	1986	1990		2000		2010		2020	
		I	II	I	II	I	II	I	II
Sawnwood	53	50	47	46	45	46	45	46	45
– Coniferous	44	42	39	38	36	38	36	38	36
– Non-coniferous	9	8	8	8	9	8	9	8	9
Wood-Based Panels	20	21	23	22	24	22	23	22	23
– Plywood	2	1	1	1	1	1	1	1	1
– Particleboards	12	14	15	14	15	14	14	14	14
– Fiberboards	6	6	7	6	7	6	6	6	6
– New panel types				1	1	1	2	1	2
Pulp	22	24	25	27	26	27	27	27	27
Other Ind. Uses	5	5	5	5	5	5	5	5	5
Total	100	100	100	100	100	100	100	100	100

(1) Veneer is too small a proportion to be meaningful in this table.

Table 6. Forecasts of changes of raw-material consumption for basic wood products. Data are percentages of 1986 raw-material consumption, except for new panel types for which the base year is 2000 (scenario Variant 1). Based on Table 4.

Wood Product	Percent of 1986 Consumption of Wood Raw-Material							
	1990		2000		2010		2020	
	I	II	I	II	I	II	I	II
Sawnwood	104	94	99	100	107	105	111	109
– Coniferous	107	94	100	98	109	102	111	105
– Non-coniferous	88	94	94	109	102	119	109	126
Veneer	98	98	115	115	131	131	131	131
Wood-Based Panels	124	124	133	141	137	146	147	151
– Plywood	99	99	106	106	114	114	118	118
– Particleboards	133	133	139	148	141	147	147	143
– Fiberboards	112	112	116	120	119	124	124	129
– New panel types			100	129	129	229	229	464
Pulp	120	120	144	139	160	157	162	159
Other Ind. Uses	113	101	120	102	128	111	124	117
Total	112	106	117	117	126	125	130	129

Table 7. Forecasts of production capacities for various wood products in Poland to 2020. Scenario Variant I follows forest-decline scenario I in Appendix III, whereas Variant II follows forest-decline scenario II in Appendix IV.

Products	Units	Production in 1986	Production Forecasts							
			1990		2000		2010		2020	
			I	II	I	II	I	II	I	II
Sawnwood										
– Total	10^3 m^3	6,418	6,580	5,990	6,230	6,180	6,660	6,550	6,940	6,830
– Coniferous	10^3 m^3	5,227	5,530	4,870	5,110	4,980	5,440	5,130	5,640	5,330
– Non-coniferous	10^3 m^3	1,191	1,050	1,120	1,120	1,300	1,220	1,420	1,300	1,500
Veneer	10^6 m^2	39	37	37	34	34	50	50	50	50
Wood-Based Panels										
– Total	10^3 m^3	2,010	2,490	2,490	2,680	2,835	2,800	3,000	3,060	3,185
– Plywood	10^3 m^3	116	115	115	125	125	135	135	145	145
– Particleboards	10^3 m^3	1,219	1,625	1,625	1,700	1,800	1,750	1,850	1,900	1,880
– Fiberboards	10^3 m^3	675	750	750	775	790	795	815	815	840
– New Panel Types	10^3 m^3				80	120	120	200	200	320
Pulp	10^3 t	790	980	980	1,150	1,100	1,280	1,250	1,300	1,300

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APPENDIX 1.

Forecast of consumption of basic products calculated for 1000 inhabitants. Scenario Variant I follows forest-decline scenario I in Appendix III, whereas Variant II follows forest-decline scenario II in Appendix IV.

Specification	Measurement Unit	1990[a]		2000[a]		2010[b]		2020[b]	
		I	II	I	II	I	II	I	II
Sawnwood									
- Total	m^3	170	200	169	201	175	210	185	220
- Coniferous	m^3	148	174	146	174	150	180	155	185
- Non-coniferous	m^3	32	26	23	27	25	30	30	35
Natural Veneers	thousand m^3	2.6	3.1	2.6	3.3	3.0	3.8	3.5	4.2
Wood-Based Panels									
- Total	m^3	83	83	84	93	94	106	106	120
- Particleboards	m^3	54	54	55	60	62	70	72	80
- Fiberboards	m^3	22	22	23	25	24	26	25	28
- Plywood	m^3	7	7	7	8	8	10	9	12
Pulp									
Paper and Cardboard	kg/inhab.	48	51	55	64	62	73	70	85

Source: Based on Table 2, Appendix II, and our own research.

(a) Consumption resulting from forecasted demand and the demographic forecast of Appendix II.

(b) Final consumption amount, adopted for determination of absolute data of demand.

APPENDIX 2.

Long-term demographic forecast for Poland.

Year	Number of Persons (thousands)
1986 (actual state)	37,456
1990	38,356
2000	39,818
2010	40,920
2020	41,164

Source: Anonymous 1988; Holzer and Balcerowicz 1987.

Note: For our calculations, a lower demographic forecast was adopted, accepted through consultation with representatives of the Planning Commission as more realistic.

APPENDIX 3.

Forecast of possibilities of consumption of wood raw-material in Poland till the year 2020 (in thousands of m^3 without bark).

Scenario I

Structure of Consumption	Harvest Levels				
	1986	1990	2000	2010	2020
Valuable Wood					
- Total	289	300	330	360	370
- Coniferous	97	100	100	110	110
- Non-coniferous	192	200	230	250	260
Sawnwood					
- Total	9,758	9,830	9,410	10,180	10,760
- Coniferous	8,538	8,220	7,700	8,350	8,800
- Non-coniferous	1,220	1,610	1,710	1,830	1,960
Pit-Props and Shores	1,623	1,720	1,630	1,630	1,630
Pulpwood	6,144	5,240	5,500	5,000	4,710
Other Wood for Industrial Purposes	1,485	2,130	1,990	1,760	1,500
Fuelwood	4,297	2,160	2,260	2,310	2,320
Total Merchantable Bole	24,141(1)	21,380	21,120	21,240	21,290
Smallwood	1,196	1,700	2,200	2,600	2,800
Fresh Stumpwood	6	-	-	500	600
Industrial Wood Wastes	785(2)	1,940	1,970	2,080	2,250
Total Wood	26,128	25,020	25,290	26,420	26,940

Source: The forecast was elaborated on the basis of Anonymous 1987b; Smykała 1983; and Trampler 1988; 1986 data are based on Polish statistics.

(1) In 1986 in merchantable boles is 545 thousand m^3 of raw material which was not included in the listed assortments.

(2) Real consumption of industrial wastes.

APPENDIX 4.

Forecast of possibilities of consumption of wood raw-material in Poland till the year 2020 (in thousands of m^3 without bark).

Scenario II

Structure of Consumption	Harvest Levels				
	1986	1990	2000	2010	2020
Valuable Wood					
- Total	289	300	330	360	370
- Coniferous	97	100	100	110	110
- Non-coniferous	192	200	230	250	260
Sawnwood					
- Total	9,758	8,930	9,450	9,980	10,560
- Coniferous	8,538	7,220	7,490	7,850	8,300
- Non-coniferous	1,220	1,710	1,960	2,130	2,260
Pit-Props and Shores	1,623	1,720	1,630	1,630	1,630
Pulpwood	6,144	5,640	5,460	5,200	4,910
Other Wood for Industrial Purposes	1,485	2,130	1,990	1,760	1,500
Fuelwood	4,297	2,160	2,260	2,310	2,320
Total Merchantable Bole	24,141(1)	20,880	21,120	21,240	21,290
Smallwood	1,196	3,670	3,520	3,240	2,940
Fresh Stumpwood	6	-	-	500	600
Industrial Wood Wastes	785(2)	1,800	1,960	2,030	2,200
Total Wood	26,128	26,350	26,600	27,010	27,030

Source: The forecasts for merchantable boles, smallwood and stumpwood are based on Trampler 1988; the forecasts for industrial wastes are our own; 1986 data are from Polish statistics.

(1) In 1986 in total merchantable boles is 545 thousand m^3 of raw material which was not included in the listed assortments.

(2) Real consumption of industrial wastes.