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Prospects for the Use of Forest Biomass in Quebec

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FOREWORD

ENFOR is the acronym for the Canadian Government's ENergy from the FORest (ENergie de la FORêt) program of research and development aimed at securing the knowledge and technical competence to facilitate in the medium to long-term, a greatly increased contribution from forest biomass to our nation's primary energy production. This program is part of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing our dependance on petroleum and other non-renewable energy sources.

The Canadian Forestry Service (CFS) administers the ENFOR Biomass Production program component which deals with such forest-oriented subjects as inventory, harvesting technology, silviculture, and environmental impacts. (The other component, Biomass Conversion, deals with the technology of converting biomass to energy or fuels, and is administered by the Renewable Energy Branch of the Department of Energy, Mines and Resources). Most Biomass Production projects, although developed by CFS scientists in the light of ENFOR program objectives, are carried out under contract by forestry consultants and research specialists. Contractors are selected in accordance with science procurement tendering procedures of the Department of Supply and Services. For further information on the ENFOR Biomass Production program, contact...

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...or a CFS research laboratory.

This report, a result of ENFOR project P-157, was prepared under contract (DSS File No. 09SD-KL004-0-C-019) by Louis-Jean Lussier, For. Eng., Ph.D. and Jacques Maranda, For. Eng., M.Sc.A. Data found in this report directly result from work carried out during the mandate and conclusions formulated by the authors do not necessarily reflect the position of the Canadian Forestry Service or the ENFOR Program.

This report is unique in that it appears to be the first time all available forest statistics have been compiled and used to obtain an overall picture of actual and future use of forest biomass in the province of Quebec.

ABSTRACT

In Quebec, the availability of forest biomass is assessed by management zones and administrative regions. This report examines current use (1981) of forest biomass, as well as quantities of surplus biomass by biomass source and product category.

The uses of surplus biomass over the next decade are forecasted and possible conflicts between current and future uses are analyzed.

The total above-ground wood biomass available annually, in Quebec's forests, is 35 million m^3 or 15 million oven-dry metric tonnes under extensive management. Logging residues represent 10% of this quantity, merchantable full trees 60%, and unmerchantable trees 30%.

RÉSUMÉ

La disponibilité de biomasse forestière, au Québec, est estimée par zones d'aménagement et par régions administratives. Ce rapport examine l'utilisation actuelle (1981) de cette biomasse, ainsi que les quantités de biomasse excédentaire par source de biomasse et catégorie de produit.

L'utilisation de la biomasse excédentaire, au cours de la prochaine décennie, fait l'objet de prévisions et les conflits possibles entre les utilisations actuelles et futures de biomasse sont analysés.

Le volume total de biomasse aérienne disponible annuellement, dans les peuplements forestiers du Québec, se chiffre à 35 millions de m^3 ou encore à 15 millions de tonnes métriques anhydres, sous aménagement extensif. Les résidus de coupe représentent 10 % de cette quantité, les arbres entiers marchands 60 % et les tiges non-marchandes 30 %.

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SUMMARY

Note: All results presented in the summary are in round figures. Exact figures are given in the body of the report.

1. *The main objectives of this study were to assess the production potential of forest biomass in Quebec; determine the current use of this potential; estimate surplus biomass by source and by product category; forecast the use of surplus biomass over the next decade, quantify the practical availability during the same period; examine possible conflicts between current and new uses of biomass; suggest, if necessary, means of reducing these conflicts; and lastly, make general recommendations with regard to the use of surplus forest biomass over the next ten years.*

2. *Since Quebec forests cover a vast area, about 500 000 km^2, the territory was divided into 26 separate study units. These units comprise the nine administrative regions officially recognized in Quebec and the four large management zones recognized by the province's Forest Management Service.*

3. *To obtain uniform results for all regions while taking into account the specific goals of the study, a simple method was devised for calculating the allowable cut. Among other things, it presumes that the allowable cut for balsam fir, spruces, and jack pine equals the current harvest of these species; that the allowable cut for other softwoods in predominantly softwood stands is a function of this harvest; that the allowable cut for tolerant hardwoods in predominantly hardwood stands equals 1.1% of the merchantable standing stock of these species; that the allowable cut for intolerant hardwoods in predominantly hardwood stands equals 1.7% of the merchantable standing stock of these species; and lastly, that the allowable cut for softwoods other than fir, spruces and jack pine in predominantly hardwood stands is a function of the allowable cut for hardwood species.*

4. *The data covering the annual harvest were obtained from the Quebec Department of Energy and Resources for public forests and from the Federation of Wood Producers of Quebec for private forests. The availability of merchantable volumes in a study unit was calculated as the difference between the allowable cut and the current harvest.*

5. *The biomass factors used for estimating the volume of non-merchantable trees and of branches and tops were taken mainly from a study conducted*

by the Quebec Department of Energy and Resources in 1978, entitled "Volume Tables of Full Trees". For the purposes of this study, it was assumed that the bark of merchantable boles, and stumps and roots represented respectively 12 and 15% of the merchantable volume inside bark.

6. *The quantities of available biomass are expressed in volume ('000 m^3), weight ('000 oven-dry tonnes), energy equivalent (millions of litres of No. 2 oil) and market value ($ millions).*

7. *In addition to estimating the quantities of biomass available in the forest, volumes available in the form of mill wood residues (sawdust and planing chips) were also evaluated. To this end, a survey was conducted among all pulp and paper producers and among lumber producers turning out 15 million b.f. or more annually. In this survey, the current and forecast production and consumption of mill residues for the years 1980 and 1985 were established. Current and future volumes of standing forest biomass used in industrial applications, such as pulp and paper, particleboard and iron and steel manufacturing, were also determined.*

8. *The total allowable cut of Quebec's productive forests is 47 million m^3 under extensive management (about 16 million cunits). This corresponds closely to Quebec's Department Energy and Resources data (about 15 million cunits). The allowable cut for private forests represents 20% of the total, and this also agrees with Quebec's Department of Energy and Resources data. The allowable cut for inhabited forests (both private and public "commuter"* forests) represents 60% of the total. Available volumes of merchantable boles amount to, for Quebec as a whole, 15 million m^3, 80% of which consists of hardwood species. About 70% of available volumes are in inhabited forests.*

9. *The total volume of above-ground forest biomass available annually in the forest amounts to 35 million m^3 or 15 million oven-dry tonnes (extensive management). Logging residues represent 10% of this quantity, merchantable full trees 60% and non-merchantable stems 30%, on a weight basis.*

10. *The energy equivalent of this available biomass is evaluated at 3.6 billion litres of No. 2 oil, which represents a market value of 1 billion dollars per year.*

11. *The annual production of bark in pulp and paper mills and sawmills is estimated at 1.65 million oven-dry tonnes (1980), and consumption at*

* *Lussier suggests this term to connote forest stretches to which workers can commute on a daily basis (translator's note)*

0.95 million tonnes, giving a surplus of bark of 0.7 million tonnes. The pulp and paper industry alone consumes, for energy purposes, 92% of all bark used.

12. *Annual production of sawdust and planing chips is evaluated at 1.37 million tonnes, and consumption at 1.03 million tonnes, giving a surplus of 0.34 million tonne. Industrial consumption of these residues represents 65%, the rest is used for energy purposes.*

13. *Several regions are already experiencing shortages of mill wood residues. The St. Maurice region (04) is already importing 215 000 tonnes of sawdust and planing chips (i.e. 80% of its requirements) from other regions (Abitibi and Lac-St-Jean).*

14. *Within five years, consumption of mill wood residues will equal production, i.e. 1.85 million tonnes of bark and 1.40 million tonnes of sawdust and planing chips.*

15. *Total available forest biomass (in the forest and at mills) is evaluated at 17 million oven-dry tonnes, or the equivalent of 4 billion litres of No. 2 oil, representing a value of one billion dollars.*

16. *Total surplus biomass in Quebec, under intensive management and including stumps and roots, is estimated at 30 million oven-dry tonnes, representing 7 billion litres of No. 2 oil and a value of about two billion dollars.*

17. *The practical and economical availability of biomass is estimated to be 30% of total surplus biomass, or about 10 million tonnes. Almost 80% of this amount is located in inhabited forests, and of this, 80% is in the form of both merchantable and non-merchantable full trees.*

18. *The pulp and paper industry in 1980 consumed about 1.62 million tonnes of wood residues. It is expected to consume 2.75 million tonnes in 1985 and 4.0 millon tonnes in 1990. Total production of mill wood residues was evaluated at 3.0 million tonnes in 1980, and is expected to reach 3.3 million in 1985 and 3.5 million in 1990. This means that, before the end of the present decade, requirements in mill wood residues for the pulp and paper industry alone will very likely exceed production of these residues.*

19. *Total consumption of mill wood residues was evaluated at 2.0 million tonnes in 1980, and is expected to be 3.2 million tonnes in 1985 and 4.5*

million tonnes in 1990. We conclude that, according to the best possible forecasts, requirements for wood residues will, beginning in 1986, exceed the production volume, and that we will then have to turn to other sources of wood, in particular surplus biomass in the forests. A rapid rise in wood residues prices can also be expected in the near future; by 1985 wood residues should cost almost as much as their energy equivalents, or about $40 per oven-dry tonne in 1980 dollars.

20. *Total consumption of forest biomass (forest and mills) will rise from 2.3 million tonnes in 1980 to 4.9 million tonnes in 1990. The pulp and paper industry will remain the principal consumer of surplus biomass, i.e. 75% of total production.*

21. *In 1980, forest biomass cost prices were evaluated approximately as follows (average transportation distance, 50 km):*

		$/oven-dry tonne
Mill residues	*Bark*	*11*
	Sawdust and planing chips	*20*
	Residues in cut-over area	*38*
	Residues at roadside	*30*
Logging residues	*Processing of full trees at pulp mill*	*10 (additional cost)*
	Harvesting of full trees	*40*
	Energy plantations	*52*

22. *With the exception of full-tree processing at the pulp mill (additional cost of $10), all other sources of biomass in the forest are more expensive than mill wood residues. This explains the users' reluctance to draw on these biomass sources. The strongest competition to available biomass in the forest comes from surplus mill wood residues, rather than oil. However, this surplus is rapidly dwindling, and it will not be long before logging resides and full trees are used.*

23. *Energy plantations costs are currently too high for them to represent a economically attractive biomass potential.*

24. *Among other sources of biomass, full-tree harvesting appears on the surface to be the least attractive. However, this is not the case; in fact we should be considering it as our main source of supply. The*

availability of other sources is rather low if we take into account the transportation constraints (no river driving or public highway transportation possible for full trees processed at the mill, no river driving for other logging residues). In addition, cost estimates are very approximate and true costs might exceed those indicated in this report, especially if we consider that in many cases the transportation distance is more than 50 km. Lastly, sources other than full trees are located in regions 02 and 08, in which considerable quantities of mill wood residues will still be available in 1985. For these various reasons, the harvesting of full trees becomes a priority, especially since this source represents at least 80% of available biomass, and its locations are in southern Quebec near wood-consuming mills.

25. *For this harvest to be more economical, however, research and development in a number of fields must be intensified: the development of harvesting machinery and of work methods designed specifically for harvesting degraded forest stands; the development of new markets and new uses; the balanced integration of full-tree harvesting with the reclamation of degraded forests; and the development of an appropriate method of economic analysis which will take account of all the socio-economic elements implicated in the use of forest biomass.*

26. *If we compare the biomass requirements forecast for 1990 (5 million tonnes) with its total availability (30 million tonnes), there is no real conflict in its use in purely practical terms. However, competition in mill wood residues sectors will entail a large increase in prices and will compel the industries that consume these products to look for alternative sources of supply--of which the main one is the biomass available in the forest.*

27. *In the short term, conflicts are foreseen in the sawdust and planing chips sector, and in the medium term, strong competition is forecasted in the demand for bark.*

28. *The St. Maurice (04) and Lower St.Lawrence-Gaspé (01) regions will suffer from the negative effects of these conflicts more than other regions, whereas the Lac St.Jean (02) and North-West (08) regions will hardly be affected and should continue exporting wood residues.*

29. *Harvesting biomass in the forest constitutes the best means of counteracting the negative effects of these conflicts and this competition. To start with, degraded forest stands should be harvested, but as they begin to disappear, emphasis must shift to short-rotation plantations and the harvesting of logging residues.*

30. *In conclusion, the quantity of physically available forest biomass in Quebec is enormous, but much remains to be done before it can be economically harvested. In addition to the research and development already mentioned, biomass harvesting must be included in appropriate management plans. Lastly, more research must be done on the problems arising out of conflicts in use, by developing and implementing an appropriate economic model of supply and demand for the various forest biomass product categories.*

1. INTRODUCTION

Since the beginning of the oil crisis, every country in the Western world has intensified its search for new sources of energy. Although Canada's petroleum resources are sizable, it must import large quantities of hydrocarbons (about 65 million litres per day). Because of this, like other Western countries, it too is working hard to find new sources of energy. Since it possesses vast forest resources, some of its efforts are naturally directed toward the use of forest biomass, especially since more than 75 per cent of the country's wood production potential is underutilized. Government research in this field is mainly the responsibility of the Canadian Forestry Service, which has established the ENFOR program. This study is part of that program.

2. OBJECTIVES

Determining the extent of the theoretical forest biomass potential is a time-consuming but relatively easy undertaking. The task consists in taking the annual allowable cut (calculated in the usual way), and applying the appropriate biomass factors, so that on the basis of the merchantable volume, one can estimate additional wood fibre volumes available in the form of non-merchantable full trees, as well as branches, tops, bark, and stumps. These factors, as rough estimates, already exist for most Canadian forest species and stands.

However, the problem becomes considerably more complicated when it comes to establishing suitably precise estimates of surplus biomass, i.e. the difference between the biomass production potential and the current and projected consumption of wood pulp by the wood industry--if, that is, we want to have these estimates in practical and economic terms, and if we want to take a closer look at the possible conflicts between traditional and new uses.

This study deals with these objectives. Specifically, we established the following objectives with reference to Quebec's entire forest area:

a. Estimate the forest biomass production potential and break down the amounts obtained into species groups and product categories: non-merchantable full trees, merchantable i.b. trunks, branches, tops, bark, stumps, sawdust, planing chips.
b. Determine current and projected consumption of these products by the forest industry.
c. On the basis of the preceding data, determine surplus biomass, by species group and product category.
d. Determine surplus biomass by origin: harvesting residues, mill residues, biomass of non-harvested merchantable trees and non-merchantable stems, and biomass of energy plantations.
e. Present the preceding estimates in relation to two different management intensities: extensive and intensive.
f. Express this biomass potential in practical and economic terms.
g. Examine, by category and product, possible conflicts between current and new uses of forest biomass, and if need be suggest means of reducing these conflicts.
h. Make general recommendations concerning the use of surplus forest biomass over the next ten years.

3. METHODOLOGY

With these various objectives in mind, the first step was to consult the available documentation, obtained mainly from the Quebec government and from wood producers associations and the forest industry. Next, on the basis of this information, specific methods for attaining these objectives were devised. These are summarized.

3.1 Division of the forest area

Quebec possesses an immense expanse of both productive and accessible forest land; it covers some 500 000 km^2, or almost twice the area of

Sweden. To produce an economic analysis of biomass availability in an area this size, it must be divided into study units. We selected Quebec government's nine administrative regions, on which we superimposed the four large socio-economic areas which are officially recognized by this government:

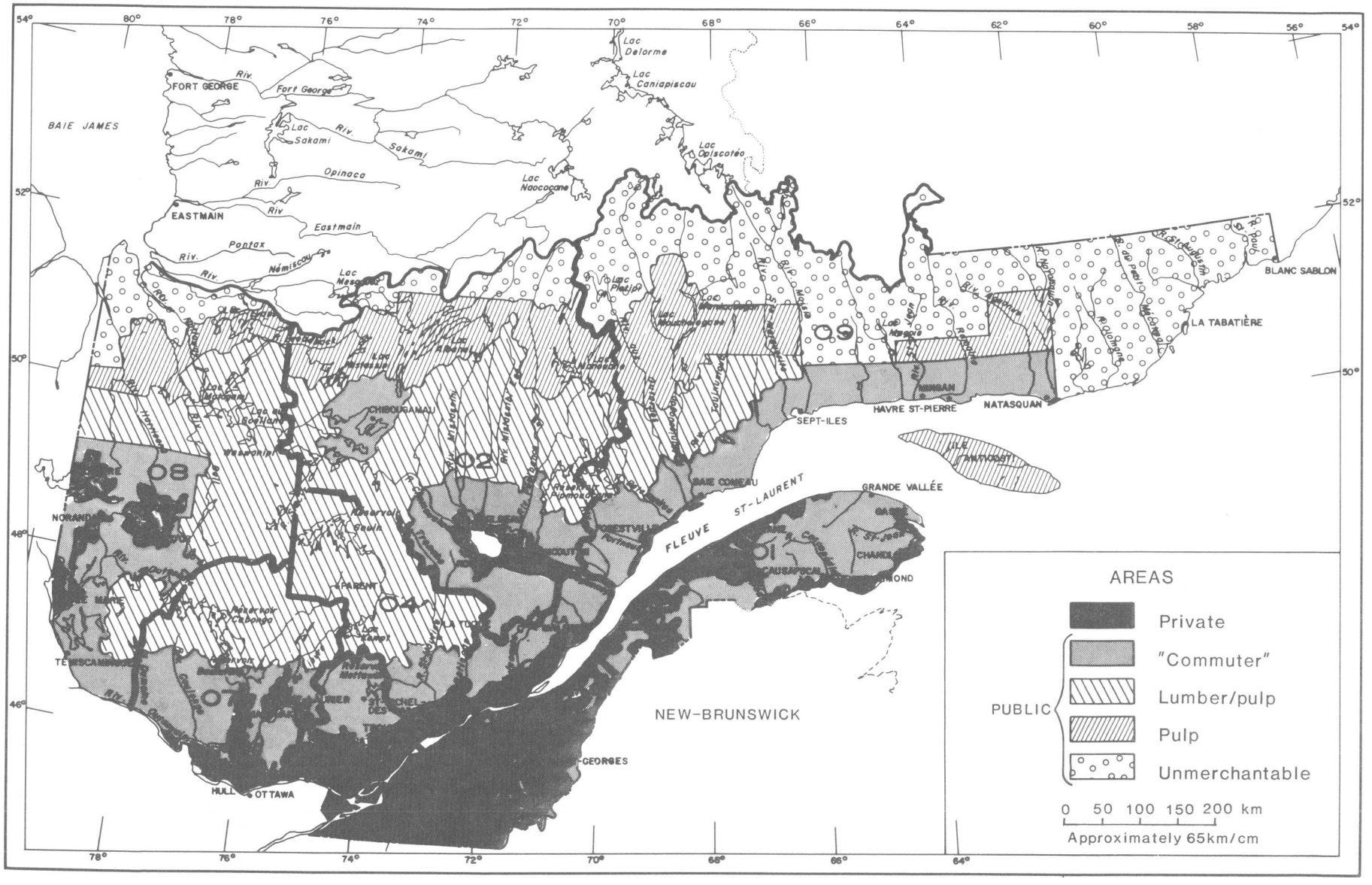
- private forest land situated in southern Quebec;
- the so-called "commuter" public forests, adjacent to private forests and with a boundary line some 60 kilometres from towns of 3 000 or more inhabitants and 30 kilometres from the most remote villages. Private and public "commuter" forest lands (known as inhabited forest lands) have many advantages: the highest production potential in Quebec, proximity to wood-consuming mills, excellent infrastructure, ample forest manpower, the possibility for forest workers to enjoy a normal social and family life, and the possibility also of checking the exodus from the countryside through a rational forest management program, of training sylviculturists, and of ensuring that enough qualified manpower will be available in the future;
- public forest land in Quebec's main forest area, used for major lumber and pulpwood operations;
- public forest land in the far north, which, because of the small size of the trees, is harvested mainly for pulpwood.

The maps on the next two pages illustrate the 26 study units for which precise forest biomass data are given.

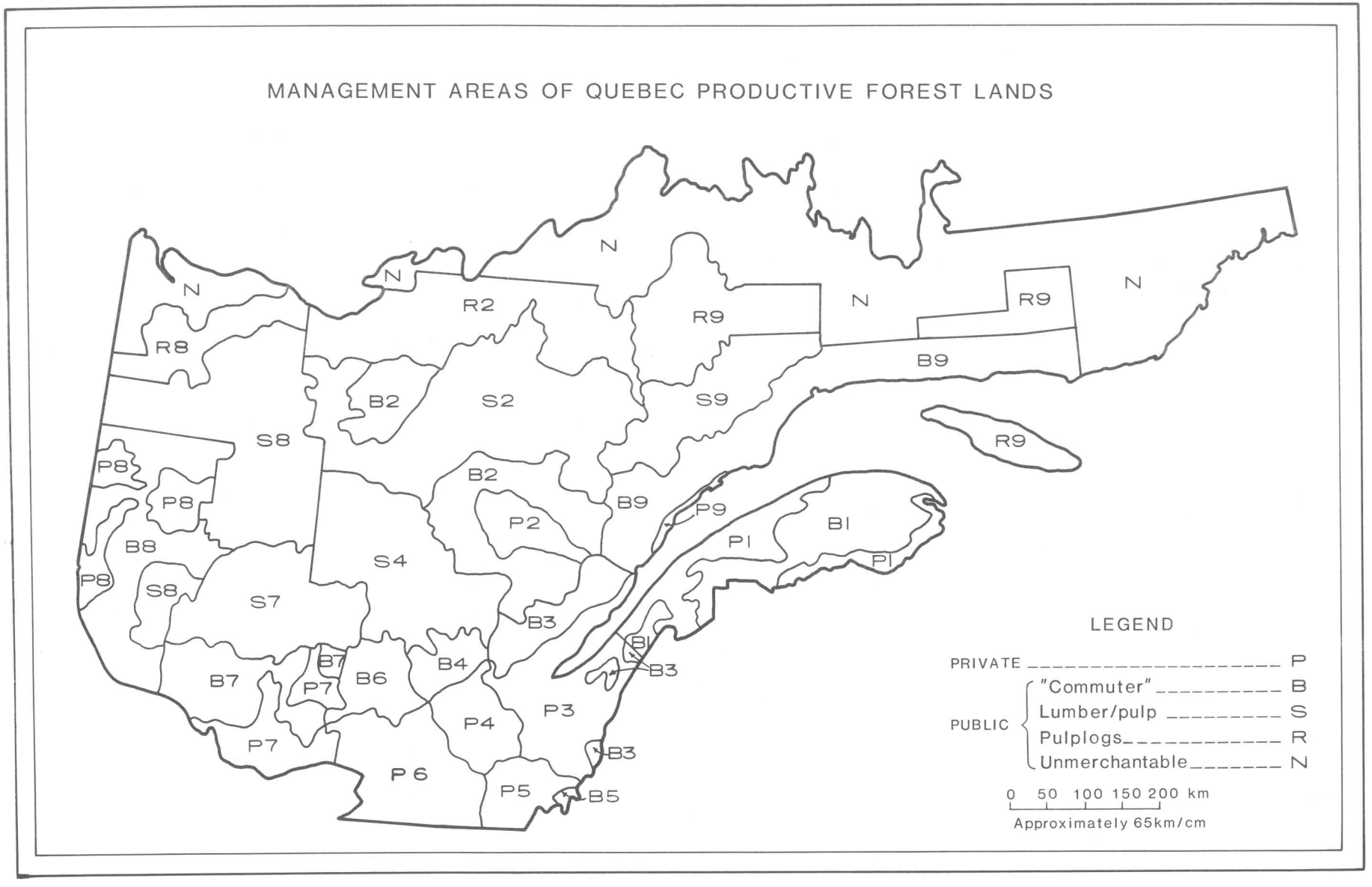
3.2 Basic forest data

The basic forest data cover three main components:

- merchantable standing stocks by species group, on the basis of which each study unit's allowable cut is calculated;
- current harvest by species group and study unit--the difference between the harvest and the allowable cut giving the availability of merchantable volume;
- biomass factors which, applied to harvest volume and availability of merchantable volume, make it possible to assess gross quantities (not



MANAGEMENT AREAS OF QUEBEC PRODUCTIVE FOREST LANDS


MANAGEMENT AREAS OF QUEBEC PRODUCTIVE FOREST LANDS
N
R8
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R9
B9
R9
B2
S2
S9
S8
P8
B2
P8
P2
B9
P9
B8
P8
S4
P1
B1
P1
S8
S7
B3
B1
B7
B7
B6
B4
B3
P7
P3
P4
P7
B3
P6
P5
B5
LEGEND
PRIVATE P
PUBLIC
"Commuter" B
Lumber/pulp S
Pulplogs R
Unmerchantable N
0 50 100 150 200 km
Approximately 65km/cm

including mill residues) of surplus biomass by study unit, species group and product category.

Data on merchantable standing stocks and biomass factors were obtained from the Quebec Department of Energy and Resources (DER) which in 1978 had prepared full-tree volume tables covering the main hardwood and softwood species found in the province of Quebec. These data were then applied to the merchantable volumes of the province's productive forests which had previously been divided into 112 compilation blocks. These data were reorganized to make them correspond to the 26 study units selected for the project. In the case of areas for which no data were available, (mainly the south shore of the St.Lawrence, upstream from Ste.Anne de la Pocatière), figures taken from the provincial forest inventory were used. For the allowable cut calculations the information was broken down into three main types of stands, i.e.: softwood stands or mixed stands with a predominance (50% or more) of softwoods (S + M(S)); tolerant hardwood stands and mixed stands with a predominance of tolerant hardwood species (H1 + M(H1)); and intolerant hardwood stands and mixed stands with a predominance of intolerant hardwoods species (H2 + M(H2)).

A computer program created specifically for this project was used. Detailed results of the compilation are presented in Appendix 3. Page 7 is an example of the data provided on each page of Appendix 3.

3.3 Allowable cut calculation

To calculate the allowable cut of each study unit, the merchantable stock was first determined for three main types of species:

s_1 = spruce, fir, and jack pine

s_2 other softwoods

h = hardwoods.

Then the calculations were made on the basis of the three main types stands described in paragraph 3.2.

Volume of stems, branches, crowns, unmerchantable stems (1 000 m^3)

Block:2 Region:1 MANAG.AREA:PRIVATE 47 (MANAG. UNIT - PRIVATE FOREST)

SPECIES	SOFTWOODS, MIXEDWOODS					HARDWOODS, MIXEDWOODS *					GRAND TOTAL				
	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL
SAP/EP	2510	301	397	400	3608	275	33	43	45	395	2784	334	441	445	4004
PIG	2	0	0	0	2	0	0	0	0	0	2	0	0	0	2
PIB	3	0	1	0	4	0	0	0	0	0	4	0	1	0	5
THO	511	61	67	122	761	56	7	7	14	83	567	68	74	135	844
PRU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEL	20	2	3	3	28	2	0	0	0	3	22	3	3	4	31
AH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T•RES	3046	365	467	526	4404	333	40	51	58	483	3379	405	518	584	4886
BOP	160	19	40	107	326	111	13	29	56	209	271	33	69	162	534
BOJ	45	5	12	14	76	31	4	9	7	51	77	9	21	21	127
PE	652	78	117	113	961	452	54	85	59	650	1104	132	203	172	1611
ERS	134	16	41	61	253	93	11	30	32	166	228	27	71	93	419
ERR	83	10	34	70	197	57	7	25	37	126	140	17	58	107	322
HEG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH	1	0	0	0	1	0	0	0	0	1	1	0	0	0	2
TIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AF	28	3	11	18	61	19	2	8	10	39	48	6	19	28	100
T•FEU	1104	132	255	383	1875	765	92	186	200	1242	1869	224	441	583	3117
TOTAL	4149	498	722	909	6278	1098	132	237	258	1725	5247	630	959	1167	8003

* BREAKDOWN OF FOREST TYPES (HARDWOODS, MIXEDWOODS)

STAND **	SOFTWOODS					HARDWOODS					TOTAL				
	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL	STEMS (i.b)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL
FM(1)	39	5	4	2	50	150	18	40	31	239	189	23	45	33	289
FM(2)	294	35	47	56	432	615	74	145	169	1003	909	109	192	225	1435
TOTAL	333	40	51	58	483	765	92	186	200	1242	1098	132	237	258	1725

** (1) HARDWOODS, MIXEDWOODS (SHADE TOLERANT)
(2) HARDWOODS, MIXEDWOODS (SHADE INTOLERANT)

i. Hardwood stands

For H1 + M(H1) stands, it was assumed that the net allowable cut was 1.1% of the merchantable stock, and for H2 + M(H2), 1.7%. The allowable cut so obtained was apportioned by species groups, s_1, s_2, and h, in proportion to these group's current merchantable stock.

ii. Softwood stands

For S + M(S) stands, it was first assumed that the allowable cut for fir, spruce, and jack pine (s_1) was the same as the harvest. Insofar as the true allowable cut for the various study units is concerned, the assumption may be debatable. In the present context, however, it is quite realistic, because:

- in most units in southern Quebec, the true allowable cut of these species is the same as the harvest.
- for these species the harvest--whether above or below the true allowable cut in some units--is the basis for determining available logging residues over the next five years.

The assumption would not have been valid in the case of hardwood stands, because these are often large, degraded forest areas in southern Quebec where biomass can be produced immediately. This is not true of the unused allowable cut of softwoods in the northern units, where the biomass potential (in the form of logging residues) will not be used until the allowable cut is harvested for conventional products (pulp and paper, lumber).

The allowable cut (AC) for the s_1 group was estimated as follows in the three main types of stands:

- Allowable cut for s_1 in S1 + M(S1) = $AC_1 s_1$ = 1.1% of the stock
- " " " " " S2 + M(S2) = $AC_2 s_2$ = 1.7% of the stock
- " " " " " H + M(H) = Harvest of s_1 - ($AC_1 s_1 + AC_2 s_2$).

The allowable cut of the other softwoods (s_2 group) and of the hardwoods (h group) in softwood stands and mixed stands with a predominance of softwoods was determined as follows:

$$- \text{ Allowable cut } s_2 = \frac{s_2 \text{ current stock}}{s_1 \text{ current stock}} \times s_1 \text{ allowable cut}$$

$$- \text{ Allowable cut } h = \frac{h \text{ current stock}}{s_1 \text{ current stock}} \times s_1 \text{ allowable cut}$$

3.4 Current harvest

Information for estimating the current harvest was obtained from the DER and the Federation of Wood Producers of Quebec. Data are available for the three species groups selected (s_1, s_2 and h).

3.5 Availability of merchantable volumes

The availability of merchantable volumes in each study unit is calculated as the difference between allowable cut and harvest. It is obvious that the availability of fir, spruce, and jack pine is nil, since it was assumed that the harvest was equal to the allowable cut.

3.6 Biomass factors and example of utilization

The biomass factors selected for this study were taken mainly from the DER data, but they were broken down, reorganized, and completed in the manner described in paragraph 3.2. The factors were established as shown on page 10.

FACTORS	PURPOSE	ASSESSMENT METHOD
B1 and B2	Estimate, from the harvest and the availability of merchantable trees, the volume of non-merchantable stems (2.5 cm < dbh < 10 cm)	$B1 = \frac{\text{Softwood stock } \phi < 10 \text{ cm}}{\text{Total stock } \phi \geq 10 \text{ cm, i.b.}}$ $B2 = \frac{\text{Hardwood stock } \phi < 10 \text{ cm}}{\text{Stock total } \phi \geq 10 \text{ cm, i.b.}}$
B3 and B4	Estimate, from the harvest and the availability of merchantable trees, the volume of branches and tops of these trees	$B3 = \frac{\text{Volume of softwoods branches and tops, o.b.}}{\text{Softwood merch. vol., i.b.}}$ $B4 = \frac{\text{Volume of hardwoods branches and tops, o.b.}}{\text{Hardwood merch. vol., i.b.}}$
B5	Estimate bark volume of merchantable available i.b. trunks	B5 = 12% of merch. vol., i.b.

As an example of the utilization of these various factors, the data for region 01, private forest area, are shown on page 11.

EXAMPLE OF BIOMASS FACTORS UTILIZATION

	1000 m^3					
	HARVEST		AVAILABILITY		TOTAL	
	SOFTWOODS	HARDWOODS	SOFTWOODS	HARDWOODS	SOFTWOODS	HARDWOODS
Merchantable volume, i.b.	891.6	276.6	150.1	246.2	1564.5	
Biomass factor	B3 = .140	B4 = .236	B3 = .140	B4 = .236	B1 = .096	B2 = .065
Biomass volume*	124.8 Branches and tops, o.b. softwoods	65.3 Branches and tops, o.b. hardwoods	21.0 Branches and tops, o.b. softwoods	58.1 Branches and tops, o.b. hardwoods	150.2 Non-merch. stems softwoods	101.7 Non-merch. stems hardwoods

Bark of available softwoods = 150.1 x .12 = 18.0 (1000 m^3)

Bark of available hardwoods = 246.2 x .12 = 29.5 (1000 m^3)

*The total biomass volume is obtained by applying the various biomass factors to the merchantable volumes i.b. In this example, the total biomass volume is 568 600 m^3, i.e. the addition of all components, including bark.

3.7 Species density

To express surplus biomass quantities in oven-dry tonnes, the following average densities, by broad management area, were used:

	SPECIES GROUPS	
MANAGEMENT AREA	SOFTWOODS	HARDWOODS
Private	.33	.54
Public, "commuter"	.35	.56
Public, lumber	.39	.52
Public, pulp	.40	.50

3.8 Energy equivalent and market value

Expressing surplus biomass quantities in terms of energy equivalents and market value gives an idea of their importance. An equivalent of 225 L of No. 2 oil per oven-dry tonne was selected, assuming the wood's moisture content to be 45%, the conversion rate of efficiency of biomass 65%, and that of oil 85%. On the basis of a price of $0.25 per litre, an oven-dry tonne of wood fibre has a market value, in terms of No. 2 oil, of $56.25; this tallies with the results of previous studies on the subject.

3.9 Mill residues

The preceding calculations allow for the estimation of biomass available in the forest only. In addition, there are mill residues in the form of bark, sawdust, and planing chips. To find out what quantities were currently being produced and used, and what quantities were expected to be produced and used within the next five years, the appropriate officials in every pulp and paper mill and every peeling mill or sawmill whose annual production was 35 000 m^3 (15 million b.f.) or more were consulted. Available volumes for smaller mills, which were not consulted, were obtained by simple extrapolation. During this survey, the current and future volumes of harvested forest biomass used for energy in industrial sectors such as pulp and paper, particleboard and iron and steel mills were also determined.

These calculations and the results of the survey allow to determine, for each administrative region or, if applicable, management area, the net current availability of forest biomass by origin (logging residues, unharvested species and stems, mill residues) and by product category in each species group (merchantable trunks, unmerchantable stems, branches and tops, bark, sawdust, and planing chips).

3.10 Forest biomass utilization forecasts

The results of this survey were used not only to determine current biomass availability but also to forecast utilization over the next five years and to identify some trends for the next decade. These predictions allow to evaluate the extent to which surplus biomass be utilized for various purposes, and to pinpoint any conflicting situations that may arise.

4. RESULTS OF THE STUDY

Because the detailed results of the study are voluminous, they appear as Appendix 3. In this part of the report, a complete summary of the main findings will simply be provided. Allowable cut, harvest, and availability are always expressed on an annual basis.

4.1 Allowable cut, harvest, and availability of merchantable trunks i.b

Table 1 shows data on the allowable cut, harvest, and availability of merchantable trunks i.b. These data, and the biomass factors determined in the manner previously described, constitute the basic inputs for estimating the annual available forest biomass quantities in relation with the study units and the product categories selected.

The data in Table 1 show that:

- The allowable cut, under extensive management, for the whole of Quebec was calculated as 47 099 000 m^3 (about 16 million cunits); this figure is fairly close to the official DER figure (about 15 million cunits).

Table 1. Allowable cut, harvest, and availability of merchantable trunks i.b.

REGION	PRIVATE		COMMUTER		LUMBER		PULP		ALL		TOTAL	%
	SFTWD*	HRDWD*	SFTWD*	HRDWD*	SFTWD*	HRDWD*	SFTWD*	HRDWS*	SFTWD*	HRDWD*		
	ALLOWABLE CUT (1000 m^3)											
01	1 042	523	3 140	562	-	-	-	-	4 182	1 085	5 267	11.2
02	359	247	1 983	648	6 009	890	51	92	8 402	1 877	10 279	21.8
03	1 262	922	939	355	-	-	-	-	2 201	1 277	3 478	7.4
04	446	557	571	327	1 804	1 065	-	-	2 821	1 949	4 770	10.1
05	462	429	3	42	-	-	-	-	465	471	936	2.0
06	462	836	1 032	842	-	-	-	-	1 494	1 678	3 172	6.7
07	509	763	676	1 436	1 155	934	-	-	2 340	3 133	5 473	11.6
08	60	118	2 926	1 588	4 570	1 208	26	40	7 582	2 954	10 536	22.4
09	139	44	672	205	1 808	228	27	65	2 646	542	3 188	6.8
TOTAL	4 741	4 439	11 942	6 005	15 346	4 325	104	197	32 133	14 966	47 099	100.0
%	10.1	9.3	25.4	12.8	32.6	9.2	0.2	0.4	68.3	31.7	100.0	
	HARVEST (1000 m^3)											
01	892	277	3 035	254	-	-	-	-	3 927	531	4 458	13.3
02	331	60	1 979	61	5 992	68	-	-	8 302	189	8 491	25.4
03	1 121	264	931	99	-	-	-	-	2 052	363	2 415	7.2
04	315	88	565	106	1 786	86	-	-	2 666	280	2 946	8.8
05	293	198	3	12	-	-	-	-	296	210	506	1.5
06	236	382	916	223	-	-	-	-	1 152	605	1 757	5.2
07	250	354	525	496	1 112	91	-	-	1 887	941	2 828	8.5
08	58	30	2 447	218	4 516	107	-	-	7 021	355	7 376	22.1
09	133	11	669	13	1 807	6	27	-	2 636	30	2 666	8.0
TOTAL	3 629	1 664	11 070	1 482	15 213	358	27	-	29 939	3 504	33 443	100.0
%	10.9	5.0	33.1	4.4	45.4	1.1	0.1	-	89.5	10.5	100.0	
	AVAILABILITY (1000 m^3)											
01	150	246	105	308	-	-	-	-	255	554	809	5.9
02	28	187	4	587	17	822	51	92	100	1 688	1 788	13.1
03	141	658	8	256	-	-	-	-	149	914	1 063	7.8
04	131	469	6	221	18	979	-	-	155	1 669	1 824	13.4
05	169	231	-	30	-	-	-	-	169	261	430	3.1
06	226	454	116	619	-	-	-	-	342	1 073	1 415	10.4
07	259	409	151	940	43	843	-	-	453	2 192	2 645	19.4
08	2	88	479	1 370	54	1 101	26	40	561	2 599	3 160	23.1
09	6	33	3	192	1	222	-	65	10	512	522	3.8
TOTAL	1 112	2 775	872	4 523	133	3 967	77	197	2 194	11 462	13 656	100.0
%	8.1	20.3	6.4	33.1	1.0	29.1	0.6	1.4	16.1	83.9	100.0	

*SFTWD = Softwoods

*HRDWD = Hardwoods

- The allowable cut in private forests is 9 180 000 m^3, or 19% of the total; once again, this agrees with DER data.
- The allowable cut in inhabited forests (private and public "commuter" forests) is almost 60% of the total; i.e. 27 127 000 m^3.
- The availability of merchantable trunks for the whole of Quebec is 13 656 000 m^3, 84% of which are of hardwood species.
- Inhabited forests account for 68% of available merchantable trunks.
- Regions 07 and 08 alone account for 43% of all available merchantable trunks.

4.2 Surplus biomass available in the forest

The data bank that was used to calculate the allowable cut and the biomass factors for the various study units was also used for estimating surplus biomass available in the forest in each unit (or management area). Results are shown in Tables 2 to 6:

Table 2 - Volume of available biomass annually (1 000 m^3)
Table 3 - Weight of available biomass annually (1 000 oven-dry tonnes)
Table 4 - Energy equivalent of available biomass annually (millions liters of oil)
Table 5 - Market value of available biomass annually (millions of dollars)
Table 6 - Biomass factors

Since at present only small quantities of biomass are being used in the form of full trees and fuelwood (approximately 300 000 tonnes per year), we may consider that the data in these tables correspond to the net surplus biomass available in the forest. To this will of course be added mill residues available in the form of bark, sawdust, and planing chips.

Table 2, 3, 4, and 5 show that, for the whole of Quebec, the oven-dry availability of biomass in the forest is about 34 million m^3, or 16 million oven-dry tonnes. This is the equivalent of 3.6 billion litres of oil or about one billion dollars. Logging residues amount to 12% of the total weight, merchantable full trees 57% and unmerchantable stems 31%. Hardwood species alone account for 90% of the weight of merchantable full trees.

Table 2. Volume of available biomass annually ($1\,000\ m^3$)

MANAG. AREA	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.) SFTWD	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.) HRDWD	NON-HARVESTED SPECIES: SOFTWOODS STEMS (i.b.)	SOFTWOODS STEM BARK	SOFTWOODS BRANCHES CROWNS (o.b.)	HARDWOODS STEMS (i.b.)	HARDWOODS STEMS BARK	HARDWOODS BRANCHES CROWNS (o.b.)	UNMERCHANTABLE STEMS (o.b.) SFTWD	UNMERCHANTABLE STEMS (o.b.) HRDWD	TOTAL, SFTWDS AND HRDWDS: STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL
F1	125.1	65.2	150.1	18.0	21.1	246.2	29.5	58.0	275.5	318.8	396.3	47.6	269.4	594.3	1307.5
B1	391.9	53.9	105.7	12.7	13.6	307.6	36.9	65.2	645.0	652.7	413.3	49.6	524.6	1297.6	2285.1
F2	59.4	12.8	28.5	3.4	5.1	187.6	22.5	40.1	154.2	184.0	216.1	25.9	117.5	338.2	697.7
B2	287.6	11.6	4.3	0.5	0.6	587.1	70.5	110.9	497.8	341.8	591.4	71.0	410.7	839.6	1912.6
S2	886.0	12.5	17.3	2.1	2.6	822.4	98.7	152.7	980.0	353.0	839.7	100.8	1053.8	1333.0	3327.2
R2			50.6	6.1	6.4	92.4	11.1	17.8	26.5	20.8	143.0	17.2	24.2	47.3	231.7
F3	128.2	57.4	140.7	16.9	16.1	657.4	78.9	142.8	240.2	243.1	798.1	95.8	344.5	483.2	1721.6
B3	125.0	20.5	8.3	1.0	1.1	255.4	30.6	52.6	284.1	137.1	263.7	31.6	199.1	421.2	915.6
F4	37.3	23.2	131.2	15.7	15.5	468.6	56.2	123.0	111.6	149.6	599.8	72.0	199.0	261.2	1132.0
B4	39.1	21.5	6.1	0.7	0.4	221.1	26.5	45.1	78.1	69.8	227.2	27.3	106.1	147.9	508.5
S4	246.2	16.0	18.8	2.3	2.6	978.7	117.4	181.8	465.3	213.5	997.5	119.7	446.7	678.8	2242.7
F5	23.0	46.4	168.7	20.2	13.2	230.6	27.7	54.1	21.2	70.0	399.3	47.9	136.7	91.2	675.1
B5	0.3	2.5				29.7	3.6	6.0	2.8	3.1	29.7	3.6	8.8	5.8	47.8
F6	24.0	87.0	226.7	27.2	23.1	453.8	54.5	103.3	105.2	167.7	680.5	81.7	237.3	272.9	1272.4
B6	96.1	44.4	116.0	13.9	12.2	618.6	74.2	122.8	155.5	137.1	734.6	88.2	275.5	292.5	1390.8
F7	28.7	79.1	258.9	31.1	29.7	409.8	49.2	91.7	115.2	175.5	668.7	80.2	229.2	290.7	1268.9
B7	49.6	96.1	151.7	18.2	14.3	940.4	112.8	182.3	125.8	123.5	1092.1	131.1	342.3	249.3	1814.8
S7	132.3	16.7	42.8	5.1	5.1	843.3	101.2	154.4	213.9	86.6	886.1	106.3	308.6	300.5	1601.5
F8	13.3	5.7	1.8	0.2	0.4	88.6	10.6	16.9	66.3	56.1	90.4	10.8	36.3	122.3	259.9
B8	349.5	40.2	479.4	57.5	68.5	1369.4	164.3	252.2	664.8	366.7	1848.8	221.9	710.4	1031.5	3812.5
S8	728.5	18.6	53.6	6.4	8.6	1100.7	132.1	191.1	893.6	280.8	1154.3	138.5	946.9	1174.4	3414.1
R8			25.9	3.1	5.3	40.0	4.8	6.5	18.1	2.3	65.9	7.9	11.7	20.4	105.9
F9	20.7	2.2	5.9	0.7	0.9	33.0	4.0	6.5	42.4	31.3	38.9	4.7	30.3	73.6	147.5
B9	87.6	2.4	2.8	0.3	0.4	192.2	23.1	35.9	181.0	110.3	195.0	23.4	126.2	291.3	636.0
S9	231.5	1.2	1.3	0.2	0.2	221.7	26.6	41.4	396.5	428.8	223.0	26.8	274.2	825.3	1349.3
R9	3.6					65.3	7.8	15.5	16.1	1.3	65.3	7.8	19.1	17.4	109.7
TOTAL 1	517.0	119.1	255.8	30.7	34.7	553.8	66.5	123.2	920.5	971.4	809.6	97.2	794.0	1891.9	3592.6
TOTAL 2	1233.1	36.9	100.7	12.1	14.7	1689.5	202.7	321.5	1658.5	899.6	1790.2	214.8	1606.1	2558.1	6169.2
TOTAL 3	253.2	77.9	149.0	17.9	17.2	912.8	109.5	195.3	524.2	380.2	1061.8	127.4	543.6	904.4	2637.3
TOTAL 4	322.6	60.7	156.1	18.7	18.6	1668.4	200.2	349.9	654.9	433.0	1824.5	218.9	751.8	1087.9	3883.1
TOTAL 5	23.3	48.9	168.7	20.2	13.2	260.3	31.2	60.0	24.0	73.1	429.0	51.5	145.5	97.0	723.0
TOTAL 6	120.1	131.3	342.7	41.1	35.2	1072.4	128.7	226.1	260.7	304.7	1415.1	169.8	512.8	565.5	2663.2
TOTAL 7	210.6	191.9	453.4	54.4	49.2	2193.5	263.2	428.4	454.9	385.6	2646.9	317.6	880.1	840.5	4685.1
TOTAL 8	1091.3	64.5	560.7	67.3	82.8	2598.7	311.8	466.8	1642.7	705.9	3159.4	379.1	1705.3	2348.5	7592.4
TOTAL 9	343.4	5.8	10.0	1.2	1.4	512.2	61.5	99.3	636.0	571.7	522.2	62.7	449.9	1207.7	2242.5
TOTAL F	459.7	379.0	1112.5	133.5	125.2	2775.6	333.1	636.5	1131.7	1396.0	3888.1	466.6	1600.3	2527.7	8482.7
TOTAL B	1426.7	292.9	874.3	104.9	111.1	4521.5	542.6	872.9	2634.7	1942.1	5395.8	647.5	2703.6	4576.8	13323.7
TOTAL S	2224.6	65.1	133.8	16.1	19.1	3966.8	476.0	721.5	2949.3	1362.6	4100.6	492.1	3030.2	4311.9	11934.7
TOTAL R	3.6		76.5	9.2	11.6	197.7	23.7	39.8	60.7	24.4	274.2	32.9	55.0	85.1	447.3
TOTAL	4114.5	737.0	2197.1	263.7	267.0	11461.6	1375.4	2270.6	6776.3	4725.2	13658.7	1639.0	7389.1	11501.5	34188.3

Table 3. Weight of available biomass annually (1 000 oven-dry tonnes)

MANAG. AREA	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.) SFTWD	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.) HRDWD	NON-HARVESTED SPECIES: SOFTWOODS STEMS (i.b.)	SOFTWOODS STEM BARK	SOFTWOODS BRANCHES CROWNS (o.b.)	HARDWOODS STEMS (i.b.)	HARDWOODS STEMS BARK	HARDWOODS BRANCHES CROWNS (o.b.)	UNMERCHANTABLE STEMS (o.b.) SFTWD	UNMERCHANTABLE STEMS (o.b.) HRDWD	TOTAL, SFTWDS AND HRDWDS STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL
P1	41.3	35.2	49.5	5.9	7.0	132.9	16.0	31.3	90.9	172.1	182.5	21.9	114.8	263.1	582.2
B1	137.2	30.2	37.0	4.4	4.8	172.3	20.7	36.5	225.7	365.5	209.3	25.1	208.6	591.2	1034.2
P2	19.6	6.9	9.4	1.1	1.7	101.3	12.2	21.7	50.9	99.4	110.7	13.3	49.9	150.3	324.1
B2	100.7	6.5	1.5	0.2	0.2	328.8	39.5	62.1	174.2	191.4	330.3	39.6	169.5	365.6	905.0
S2	345.5	6.5	6.7	0.8	1.0	427.6	51.3	79.4	382.2	183.6	434.4	52.1	432.4	565.7	1484.7
R2			20.2	2.4	2.5	46.2	5.5	8.9	10.6	10.4	66.4	8.0	11.5	21.0	106.9
P3	42.3	31.0	46.4	5.6	5.3	355.0	42.6	77.1	79.3	131.3	401.4	48.2	155.7	210.5	815.8
B3	43.7	11.5	2.9	0.3	0.4	143.0	17.2	29.4	99.4	76.8	145.9	17.5	85.0	176.2	424.7
P4	12.3	12.5	43.3	5.2	5.1	253.0	30.4	66.4	36.8	80.8	296.3	35.6	96.4	117.6	545.9
B4	13.7	12.1	2.1	0.3	0.1	123.8	14.9	25.2	27.3	39.1	126.0	15.1	51.1	66.4	258.6
S4	96.0	8.3	7.3	0.9	1.0	508.9	61.1	94.6	181.5	111.0	516.3	62.0	199.9	292.5	1070.6
P5	7.6	25.1	55.7	6.7	4.4	124.5	14.9	29.2	7.0	37.8	180.2	21.6	66.2	44.8	312.8
B5	0.1	1.4				16.6	2.0	3.4	1.0	1.7	16.6	2.0	4.8	2.7	26.2
P6	7.9	47.0	74.8	9.0	7.6	245.1	29.4	55.8	34.7	90.5	319.9	38.4	118.3	125.3	601.8
B6	33.6	24.8	40.6	4.9	4.3	346.4	41.6	68.8	54.4	76.8	387.0	46.4	131.5	131.2	696.2
P7	9.5	42.7	85.4	10.3	9.8	221.3	26.6	49.5	38.0	94.8	306.7	36.8	111.5	132.8	587.9
B7	17.4	53.8	53.1	6.4	5.0	526.6	63.2	102.1	44.0	69.2	579.7	69.6	178.3	113.2	940.7
S7	51.6	8.7	16.7	2.0	2.0	438.5	52.6	80.3	83.4	45.0	455.2	54.6	142.6	128.4	780.9
P8	4.4	3.1	0.6	0.1	0.1	47.8	5.7	9.2	21.9	30.3	48.4	5.8	16.7	52.1	123.1
B8	122.3	22.5	167.8	20.1	24.0	766.9	92.0	141.3	232.7	205.4	934.7	112.2	310.0	438.0	1794.9
S8	284.1	9.7	20.9	2.5	3.4	572.4	68.7	99.4	348.5	146.0	593.3	71.2	396.6	494.5	1555.5
R8			10.4	1.2	2.1	20.0	2.4	3.2	7.2	1.1	30.4	3.6	5.3	8.4	47.7
P9	6.8	1.2	1.9	0.2	0.3	17.8	2.1	3.5	14.0	16.9	19.8	2.4	11.8	30.9	64.9
B9	30.7	1.3	1.0	0.1	0.1	107.6	12.9	20.1	63.3	61.8	108.6	13.0	52.2	125.1	299.0
S9	90.3	0.6	0.5	0.1	0.1	115.3	13.8	21.5	154.6	223.0	115.8	13.9	112.5	377.6	619.8
R9	1.4					32.6	3.9	7.7	6.4	0.7	32.6	3.9	9.2	7.1	52.9
TOTAL 1	178.5	65.4	86.5	10.4	11.7	305.2	36.6	67.8	316.6	537.6	391.7	47.0	323.4	854.3	1616.4
TOTAL 2	465.8	19.9	37.9	4.5	5.5	903.9	108.5	172.1	617.9	484.7	941.8	113.0	663.2	1102.6	2820.7
TOTAL 3	86.1	42.5	49.3	5.9	5.7	498.0	59.8	106.5	178.7	208.0	547.4	65.7	240.7	386.7	1240.5
TOTAL 4	122.0	32.9	52.8	6.3	6.3	885.8	106.3	186.2	245.6	230.9	938.5	112.6	347.4	476.5	1875.1
TOTAL 5	7.7	26.5	55.7	6.7	4.4	141.2	16.9	32.5	8.0	39.5	196.8	23.6	71.1	47.5	339.0
TOTAL 6	41.5	71.8	115.4	13.8	11.9	591.5	71.0	124.6	89.1	167.3	706.9	84.8	249.8	256.4	1297.9
TOTAL 7	78.4	105.2	155.2	18.6	16.8	1186.4	142.4	231.9	165.5	209.0	1341.7	161.0	432.4	374.4	2309.5
TOTAL 8	410.8	35.3	199.6	24.0	29.6	1407.1	168.8	253.0	610.3	382.8	1606.7	192.8	728.7	993.0	3521.2
TOTAL 9	129.2	3.2	3.4	0.4	0.5	273.4	32.8	52.9	238.4	302.3	276.8	33.2	185.7	540.7	1036.5
TOTAL P	151.7	204.7	367.1	44.1	41.3	1498.8	179.9	343.7	373.4	753.9	1865.9	223.9	741.4	1127.3	3958.5
TOTAL B	499.3	164.0	306.0	36.7	38.9	2532.0	303.8	488.8	922.1	1087.6	2838.0	340.6	1191.1	2009.7	6379.4
TOTAL S	867.6	33.8	52.2	6.3	7.4	2062.7	247.5	375.2	1150.2	708.6	2114.9	253.8	1284.0	1858.8	5511.5
TOTAL R	1.4		30.6	3.7	4.6	98.8	11.9	19.9	24.3	12.2	129.4	15.5	26.0	36.5	207.5
TOTAL	1520.1	402.5	755.9	90.7	92.3	6192.4	743.1	1227.6	2470.1	2562.2	6948.4	833.8	3242.4	5032.3	16056.9

Table 4. Energy equivalent of available biomass annually (millions liters of oil)

MANAG. AREA	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.)		NON-HARVESTED SPECIES: SOFTWOODS			NON-HARVESTED SPECIES: HARDWOODS			UNMERCHANTABLE STEMS (o.b.)		TOTAL, SFTWDS AND HRDWDS				
	SFTWD	HRDWD	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	STEMS (i.b.)	STEMS BARK	BRANCHES CROWNS (o.b.)	SFTWD	HRDWD	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL
F1	9.29	7.92	11.14	1.34	1.56	29.91	3.59	7.05	20.46	38.73	41.06	4.93	25.82	59.19	131.00
B1	30.86	6.79	8.32	1.00	1.08	38.76	4.65	8.21	50.79	82.23	47.08	5.65	46.94	133.02	232.69
F2	4.41	1.55	2.12	0.25	0.38	22.79	2.74	4.88	11.45	22.36	24.91	2.99	11.22	33.81	72.93
B2	22.65	1.46	0.34	0.04	0.05	73.97	8.88	13.97	39.20	43.06	74.31	8.92	38.13	82.26	203.62
S2	77.75	1.47	1.52	0.18	0.22	96.22	11.55	17.86	85.99	41.30	97.74	11.73	97.30	127.29	334.06
R2			4.55	0.55	0.57	10.39	1.25	2.01	2.39	2.34	14.95	1.79	2.58	4.73	24.05
F3	9.52	6.97	10.45	1.25	1.19	79.87	9.58	17.35	17.83	29.53	90.32	10.84	35.04	47.36	183.56
B3	9.84	2.58	0.65	0.08	0.09	32.18	3.86	6.62	22.37	17.28	32.83	3.94	19.13	39.65	95.55
F4	2.77	2.82	9.74	1.17	1.15	56.93	6.83	14.94	8.28	18.18	66.68	8.00	21.68	26.47	122.82
B4	3.08	2.71	0.48	0.06	0.03	27.86	3.34	5.68	6.15	8.80	28.34	3.40	11.51	14.95	58.19
S4	21.61	1.87	1.65	0.20	0.23	114.51	13.74	21.28	40.83	24.98	116.16	13.94	44.98	65.81	240.89
F5	1.71	5.64	12.53	1.50	0.98	28.02	3.36	6.57	1.57	8.51	40.54	4.87	14.90	10.08	70.39
B5	0.02	0.31				3.74	0.45	0.75	0.22	0.39	3.74	0.45	1.09	0.60	5.88
F6	1.78	10.57	16.83	2.02	1.71	55.14	6.62	12.55	7.81	20.37	71.97	8.64	26.61	28.19	135.40
B6	7.57	5.59	9.13	1.10	0.96	77.94	9.35	15.48	12.24	17.27	87.08	10.45	29.59	29.51	156.64
F7	2.13	9.61	19.22	2.31	2.21	49.79	5.97	11.14	8.55	21.33	69.01	8.28	25.09	29.88	132.27
B7	3.91	12.11	11.95	1.43	1.13	118.49	14.22	22.97	9.91	15.57	130.44	15.65	40.11	25.47	211.67
S7	11.61	1.95	3.76	0.45	0.45	98.67	11.84	18.07	18.77	10.13	102.42	12.29	32.08	28.90	175.69
F8	0.99	0.69	0.13	0.02	0.03	10.76	1.29	2.06	4.92	6.81	10.90	1.31	3.77	11.73	27.70
B8	27.52	5.06	37.75	4.53	5.39	172.54	20.71	31.78	52.35	46.21	210.30	25.24	69.76	98.56	403.85
S8	63.93	2.18	4.70	0.56	0.76	128.78	15.45	22.36	78.41	32.85	133.49	16.02	89.23	111.26	349.99
R8			2.33	0.28	0.47	4.50	0.54	0.73	1.63	0.26	6.83	0.82	1.20	1.89	10.73
F9	1.53	0.27	0.44	0.05	0.07	4.01	0.48	0.79	3.15	3.80	4.45	0.53	2.67	6.95	14.59
B9	6.90	0.30	0.22	0.03	0.03	24.22	2.91	4.52	14.25	13.90	24.44	2.93	11.75	28.16	67.27
S9	20.31	0.14	0.11	0.01	0.01	25.94	3.11	4.85	34.80	50.17	26.05	3.13	25.31	84.96	139.45
R9	0.33					7.35	0.88	1.74	1.45	0.15	7.35	0.88	2.07	1.60	11.89
TOTAL 1	40.15	14.71	19.47	2.34	2.64	68.67	8.24	15.26	71.25	120.97	88.14	10.58	72.76	172.21	363.69
TOTAL 2	104.81	4.48	8.53	1.02	1.23	203.38	24.41	38.72	139.03	109.06	211.91	25.43	149.23	248.09	634.66
TOTAL 3	19.36	9.55	11.10	1.33	1.28	112.05	13.45	23.97	40.20	46.81	123.16	14.78	54.17	87.01	279.11
TOTAL 4	27.45	7.40	11.87	1.42	1.42	199.30	23.92	41.90	55.26	51.96	211.17	25.34	78.17	107.22	421.90
TOTAL 5	1.73	5.95	12.53	1.50	0.98	31.76	3.81	7.32	1.79	8.89	44.29	5.31	15.99	10.68	76.27
TOTAL 6	9.35	16.16	25.97	3.12	2.67	133.08	15.97	28.03	20.06	37.64	159.05	19.09	56.20	57.70	292.04
TOTAL 7	17.65	23.67	34.93	4.19	3.78	266.95	32.03	52.18	37.23	47.02	301.87	36.22	97.28	84.25	519.63
TOTAL 8	92.44	7.93	44.92	5.39	6.65	316.59	37.99	56.93	137.31	86.13	361.51	43.38	163.95	223.44	792.28
TOTAL 9	29.07	0.71	0.77	0.09	0.11	61.51	7.38	11.90	53.65	68.02	62.28	7.47	41.79	121.66	233.21
TOTAL F	34.13	46.05	82.60	9.91	9.29	337.24	40.47	77.33	84.03	169.62	419.84	50.38	166.80	253.64	890.67
TOTAL B	112.35	36.90	68.85	8.26	8.75	569.71	68.37	109.99	207.48	244.70	638.56	76.63	267.99	452.18	1435.37
TOTAL S	195.20	7.61	11.74	1.41	1.67	464.12	55.69	84.41	258.80	159.43	475.86	57.10	288.90	418.22	1240.09
TOTAL R	0.33		6.88	0.83	1.05	22.24	2.67	4.47	5.46	2.75	29.13	3.50	5.85	8.21	46.68
TOTAL	342.01	90.57	170.08	20.41	20.76	1393.30	167.20	276.21	555.77	576.50	1563.38	187.61	729.55	1132.27	3612.80

Table 5. Market value of available biomass annually (millions of dollars)

MANAG. AREA	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.)		NON-HARVESTED SPECIES SOFTWOODS			NON-HARVESTED SPECIES HARDWOODS			UNMERCHANTABLE STEMS (o.b.)		TOTAL, SFTWDS AND HRDWDS				
	SFTWD	HRDWD	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	STEMS (i.b.)	STEMS BARK	BRANCHES CROWNS (o.b.)	SFTWD	HRDWD	STEMS (i.b.)	STEM BARK	BRANCHES CROWNS (o.b.)	UNMERCH. STEMS (o.b.)	TOTAL
F1	2.32	1.98	2.79	0.33	0.39	7.48	0.90	1.76	5.11	9.68	10.26	1.23	6.46	14.80	32.75
B1	7.72	1.70	2.08	0.25	0.27	9.69	1.16	2.05	12.70	20.56	11.77	1.41	11.73	33.26	58.17
F2	1.10	0.39	0.53	0.06	0.10	5.70	0.68	1.22	2.86	5.59	6.23	0.75	2.81	8.45	18.23
B2	5.66	0.36	0.08	0.01	0.01	18.49	2.22	3.49	9.80	10.77	18.58	2.23	9.53	20.57	50.91
S2	19.44	0.37	0.38	0.05	0.06	24.06	2.89	4.47	21.50	10.32	24.43	2.93	24.32	31.82	83.52
R2			1.14	0.14	0.14	2.60	0.31	0.50	0.60	0.59	3.74	0.45	0.65	1.18	6.01
F3	2.38	1.74	2.61	0.31	0.30	19.97	2.40	4.34	4.46	7.38	22.58	2.71	8.76	11.84	45.89
B3	2.46	0.65	0.16	0.02	0.02	8.05	0.97	1.66	5.59	4.32	8.21	0.99	4.78	9.91	23.89
F4	0.69	0.70	2.44	0.29	0.29	14.23	1.71	3.74	2.07	4.55	16.67	2.00	5.42	6.62	30.71
B4	0.77	0.68	0.12	0.01	0.01	6.96	0.84	1.42	1.54	2.20	7.08	0.85	2.88	3.74	14.55
S4	5.40	0.47	0.41	0.05	0.06	28.63	3.44	5.32	10.21	6.25	29.04	3.48	11.25	16.45	60.22
F5	0.43	1.41	3.13	0.38	0.25	7.00	0.84	1.64	0.39	2.13	10.14	1.22	3.72	2.52	17.60
B5	0.01	0.08				0.94	0.11	0.19	0.05	0.10	0.94	0.11	0.27	0.15	1.47
F6	0.45	2.64	4.21	0.50	0.43	13.78	1.65	3.14	1.95	5.09	17.99	2.14	6.65	7.05	33.85
B6	1.89	1.40	2.28	0.27	0.24	19.49	2.34	3.87	3.06	4.32	21.77	2.61	7.40	7.38	39.16
F7	0.53	2.40	4.81	0.58	0.55	12.45	1.49	2.79	2.14	5.33	17.25	2.07	6.27	7.47	33.07
B7	0.98	3.03	2.99	0.36	0.28	29.62	3.55	5.74	2.48	3.89	32.61	3.91	10.03	6.37	52.92
S7	2.90	0.49	0.94	0.11	0.11	24.67	2.96	4.52	4.69	2.53	25.61	3.07	8.02	7.22	43.92
F8	0.25	0.17	0.03		0.01	2.69	0.32	0.51	1.23	1.70	2.72	0.33	0.94	2.93	6.93
B8	6.88	1.27	9.44	1.13	1.35	43.14	5.18	7.95	13.09	11.55	52.57	6.31	17.44	24.64	100.96
S8	15.98	0.55	1.18	0.14	0.19	32.20	3.86	5.59	19.60	8.21	33.37	4.00	22.31	27.82	87.50
R8			0.58	0.07	0.12	1.12	0.13	0.18	0.41	0.06	1.71	0.20	0.30	0.47	2.68
F9	0.38	0.07	0.11	0.01	0.02	1.00	0.12	0.20	0.79	0.95	1.11	0.13	0.67	1.74	3.65
B9	1.73	0.07	0.06	0.01	0.01	6.05	0.73	1.13	3.56	3.48	6.11	0.73	2.94	7.04	16.82
S9	5.08	0.03	0.03			6.48	0.78	1.21	8.70	12.54	6.51	0.78	6.33	21.24	34.86
R9	0.08					1.84	0.22	0.44	0.36	0.04	1.84	0.22	0.52	0.40	2.97
TOTAL 1	10.04	3.68	4.87	0.58	0.66	17.17	2.06	3.82	17.81	30.24	22.03	2.64	18.19	48.05	90.92
TOTAL 2	26.20	1.12	2.13	0.26	0.31	50.85	6.10	9.68	34.76	27.27	52.98	6.36	37.31	62.02	158.67
TOTAL 3	4.84	2.39	2.78	0.33	0.32	28.01	3.36	5.99	10.05	11.70	30.79	3.69	13.54	21.75	69.78
TOTAL 4	6.86	1.85	2.97	0.36	0.35	49.83	5.98	10.47	13.81	12.99	52.79	6.34	19.54	26.81	105.48
TOTAL 5	0.43	1.49	3.13	0.38	0.25	7.94	0.95	1.83	0.45	2.22	11.07	1.33	4.00	2.67	19.07
TOTAL 6	2.34	4.04	6.49	0.78	0.67	33.27	3.99	7.01	5.01	9.41	39.76	4.77	14.05	14.43	73.01
TOTAL 7	4.41	5.92	8.73	1.05	0.95	66.74	8.01	13.04	9.31	11.76	75.47	9.06	24.32	21.06	129.91
TOTAL 8	23.11	1.98	11.23	1.35	1.66	79.15	9.50	14.23	34.33	21.53	90.38	10.85	40.99	55.86	198.07
TOTAL 9	7.27	0.18	0.19	0.02	0.03	15.38	1.85	2.98	13.41	17.00	15.57	1.87	10.45	30.42	58.30
TOTAL F	8.53	11.51	20.65	2.48	2.32	84.31	10.12	19.33	21.01	42.40	104.96	12.60	41.70	63.41	222.67
TOTAL B	28.09	9.23	17.21	2.07	2.19	142.43	17.09	27.50	51.87	61.18	159.64	19.16	67.00	113.05	358.84
TOTAL S	48.80	1.90	2.94	0.35	0.42	116.03	13.92	21.10	64.70	39.86	118.96	14.28	72.23	104.56	310.02
TOTAL R	0.08		1.72	0.21	0.26	5.56	0.67	1.12	1.37	0.69	7.28	0.87	1.46	2.05	11.67
TOTAL	85.50	22.64	42.52	5.10	5.19	348.33	41.80	69.05	138.94	144.12	390.85	46.90	182.39	283.07	903.20

Table 6. Biomass factors

MANAG. AREA	FOR. TYPE	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.) SFTWD	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.) HRDWD	NON-HARVESTED SPECIES SOFTWOODS STEMS (i.b.)	SOFTWOODS STEMS BARK	SOFTWOODS BRANCHES CROWNS (o.b.)	HARDWOODS STEMS (i.b.)	HARDWOODS STEMS BARK	HARDWOODS BRANCHES CROWNS (o.b.)	UNMERCHANTABLE STEMS (o.b.) SFTWD	UNMERCHANTABLE STEMS (o.b.) HRDWD
1-P	R+MR	0.142	0.244	1.000	0.120	0.142	1.000	0.120	0.244	0.130	0.075
	F+MF	0.126	0.221	1.000	0.120	0.126	1.000	0.120	0.221	0.046	0.129
1-B	R+MR	0.129	0.212	1.000	0.120	0.129	1.000	0.120	0.212	0.131	0.031
	F+MF	0.129	0.212	1.000	0.120	0.129	1.000	0.120	0.212	0.043	0.146
1-S	R+MR										
	F+MF										
1-R	R+MR										
	F+MF										
2-P	R+MR	0.186	0.221	1.000	0.120	0.186	1.000	0.120	0.221	0.192	0.135
	F+MF	0.142	0.204	1.000	0.120	0.142	1.000	0.120	0.204	0.062	0.169
2-B	R+MR	0.148	0.192	1.000	0.120	0.148	1.000	0.120	0.192	0.142	0.031
	F+MF	0.116	0.186	1.000	0.120	0.116	1.000	0.120	0.186	0.047	0.099
2-S	R+MR	0.149	0.195	1.000	0.120	0.149	1.000	0.120	0.195	0.122	0.009
	F+MF	0.098	0.168	1.000	0.120	0.098	1.000	0.120	0.168	0.020	0.042
2-R	R+MR	0.149	0.200	1.000	0.120	0.149	1.000	0.120	0.200	0.126	0.007
	F+MF	0.126	0.193	1.000	0.120	0.126	1.000	0.120	0.193	0.060	0.139
3-P	R+MR	0.115	0.234	1.000	0.120	0.115	1.000	0.120	0.234	0.089	0.052
	F+MF	0.112	0.205	1.000	0.120	0.112	1.000	0.120	0.205	0.020	0.060
3-B	R+MR	0.138	0.203	1.000	0.120	0.138	1.000	0.120	0.203	0.182	0.037
	F+MF	0.103	0.208	1.000	0.120	0.103	1.000	0.120	0.208	0.037	0.069

Table 6. (cont'd)

MANAG. AREA	FOR. TYPE	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.) SFTWD	LOGGING RESIDUES: BRANCHES AND CROWNS (o.b.) HRDWD	NON-HARVESTED SPECIES: SOFTWOODS STEMS (i.b.)	SOFTWOODS STEMS BARK	SOFTWOODS BRANCHES CROWNS (o.b.)	HARDWOODS STEMS (i.b.)	HARDWOODS STEMS BARK	HARDWOODS BRANCHES CROWNS (o.b.)	UNMERCHANTABLE STEMS (o.b.) SFTWD	UNMERCHANTABLE STEMS (o.b.) HRDWD
3-S	R+MR										
	F+MF										
3-R	R+MR										
	F+MF										
4-P	R+MR	0.120	0.354	1.000	0.120	0.120	1.000	0.120	0.354	0.092	0.060
	F+MF	0.115	0.220	1.000	0.120	0.115	1.000	0.120	0.220	0.019	0.089
4-B	R+MR	0.061	0.206	1.000	0.120	0.061	1.000	0.120	0.206	0.052	0.025
	F+MF	0.106	0.203	1.000	0.120	0.106	1.000	0.120	0.203	0.035	0.053
4-S	R+MR	0.146	0.191	1.000	0.120	0.146	1.000	0.120	0.191	0.120	0.028
	F+MF	0.110	0.183	1.000	0.120	0.110	1.000	0.120	0.183	0.042	0.047
4-R	R+MR										
	F+MF										
5-P	R+MR	0.072	0.326	1.000	0.120	0.072	1.000	0.120	0.326	0.011	0.027
	F+MF	0.101	0.202	1.000	0.120	0.101	1.000	0.120	0.202	0.013	0.051
5-B	R+MR	0.093	0.259	1.000	0.120	0.093	1.000	0.120	0.259	0.048	0.017
	F+MF	0.101	0.202	1.000	0.120	0.101	1.000	0.120	0.202	0.013	0.051
5-S	R+MR										
	F+MF										
5-R	R+MR										
	F+MF										

Table 6. (cont'd)

MANAG. AREA	FOR. TYPE	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.) SFTWD	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.) HRDWD	NON-HARVESTED SPECIES SOFTWOODS STEMS (i.b.)	SOFTWOODS STEMS BARK	SOFTWOODS BRANCHES CROWNS (o.b.)	HARDWOODS STEMS (i.b.)	HARDWOODS STEMS BARK	HARDWOODS BRANCHES CROWNS (o.b.)	UNMERCHANTABLE STEMS (o.b.) SFTWD	UNMERCHANTABLE STEMS (o.b.) HRDWD
6-P	R+MR	0.098	0.248	1.000	0.120	0.098	1.000	0.120	0.248	0.065	0.042
	F+MF	0.109	0.222	1.000	0.120	0.109	1.000	0.120	0.222	0.016	0.088
6-B	R+MR	0.107	0.203	1.000	0.120	0.107	1.000	0.120	0.203	0.062	0.025
	F+MF	0.093	0.196	1.000	0.120	0.093	1.000	0.120	0.196	0.021	0.048
6-S	R+MR										
	F+MF										
6-R	R+MR										
	F+MF										
7-P	R+MR	0.117	0.213	1.000	0.120	0.117	1.000	0.120	0.213	0.066	0.044
	F+MF	0.110	0.227	1.000	0.120	0.110	1.000	0.120	0.227	0.025	0.094
7-B	R+MR	0.099	0.191	1.000	0.120	0.099	1.000	0.120	0.191	0.044	0.019
	F+MF	0.091	0.194	1.000	0.120	0.091	1.000	0.120	0.194	0.016	0.039
7-S	R+MR	0.128	0.184	1.000	0.120	0.128	1.000	0.120	0.184	0.080	0.018
	F+MF	0.094	0.183	1.000	0.120	0.094	1.000	0.120	0.183	0.023	0.023
7-R	R+MR										
	F+MF										
8-P	R+MR	0.237	0.208	1.000	0.120	0.237	1.000	0.120	0.208	0.303	0.106
	F+MF	0.216	0.189	1.000	0.120	0.216	1.000	0.120	0.189	0.069	0.208
8-B	R+MR	0.146	0.186	1.000	0.120	0.146	1.000	0.120	0.186	0.115	0.022
	F+MF	0.121	0.183	1.000	0.120	0.121	1.000	0.120	0.183	0.032	0.059

Table 6. (cont'd)

MANAG. AREA	FOR. TYPE	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.)		NON-HARVESTED SPECIES						UNMERCHANTABLE STEMS (o.b.)	
				SOFTWOODS			HARDWOODS				
		SFTWD	HRDWD	STEMS (i.b.)	STEMS BARK	BRANCHES CROWNS (o.b.)	STEMS (i.b.)	STEMS BARK	BRANCHES CROWNS (o.b.)	SFTWD	HRDWD
8-S	R+MR	0.163	0.178	1.000	0.120	0.163	1.000	0.120	0.178	0.126	0.010
	F+MF	0.128	0.169	1.000	0.120	0.128	1.000	0.120	0.169	0.029	0.039
8-R	R+MR	0.192	0.163	1.000	0.120	0.192	1.000	0.120	0.163	0.196	0.004
	F+MF	0.203	0.161	1.000	0.120	0.203	1.000	0.120	0.161	0.079	0.031
9-P	R+MR	0.156	0.200	1.000	0.120	0.156	1.000	0.120	0.200	0.188	0.048
	F+MF	0.138	0.194	1.000	0.120	0.138	1.000	0.120	0.194	0.043	0.123
9-B	R+MR	0.132	0.192	1.000	0.120	0.132	1.000	0.120	0.192	0.156	0.013
	F+MF	0.121	0.185	1.000	0.120	0.121	1.000	0.120	0.185	0.050	0.112
9-S	R+MR	0.128	0.185	1.000	0.120	0.128	1.000	0.120	0.185	0.111	0.011
	F+MF	0.149	0.194	1.000	0.120	0.149	1.000	0.120	0.194	0.084	0.200
9-R	R+MR	0.152	0.195	1.000	0.120	0.152	1.000	0.120	0.195	0.130	0.004
	F+MF	0.136	0.237	1.000	0.120	0.136	1.000	0.120	0.237	0.045	0.010
TOTAL 1	R+MR	0.132	0.229	1.000	0.120	0.136	1.000	0.120	0.227	0.131	0.044
	F+MF	0.128	0.216	1.000	0.120	0.127	1.000	0.120	0.215	0.044	0.141
TOTAL 2	R+MR	0.150	0.203	1.000	0.120	0.169	1.000	0.120	0.197	0.131	0.022
	F+MF	0.112	0.186	1.000	0.120	0.127	1.000	0.120	0.182	0.030	0.066
TOTAL 3	R+MR	0.126	0.225	1.000	0.120	0.116	1.000	0.120	0.225	0.124	0.046
	F+MF	0.108	0.206	1.000	0.120	0.112	1.000	0.120	0.206	0.027	0.063
TOTAL 4	R+MR	0.124	0.248	1.000	0.120	0.121	1.000	0.120	0.239	0.101	0.034
	F+MF	0.110	0.202	1.000	0.120	0.114	1.000	0.120	0.196	0.036	0.057

Table 6. (cont'd)

MANAG. AREA	FOR. TYPE	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.) SFTWD	LOGGING RESIDUES BRANCHES AND CROWNS (o.b.) HRDWD	NON-HARVESTED SPECIES SOFTWOODS STEMS (i.b.)	SOFTWOODS STEMS BARK	SOFTWOODS BRANCHES CROWNS (o.b.)	HARDWOODS STEMS (i.b.)	HARDWOODS STEMS BARK	HARDWOODS BRANCHES CROWNS (o.b.)	UNMERCHANTABLE STEMS (o.b.) SFTWD	UNMERCHANTABLE STEMS (o.b.) HRDWD
TOTAL 5	R+MR	0.072	0.326	1.000	0.120	0.072	1.000	0.120	0.326	0.012	0.027
	F+MF	0.101	0.202	1.000	0.120	0.101	1.000	0.120	0.202	0.013	0.051
TOTAL 6	R+MR	0.106	0.226	1.000	0.120	0.102	1.000	0.120	0.217	0.063	0.032
	F+MF	0.098	0.213	1.000	0.120	0.105	1.000	0.120	0.208	0.019	0.064
TOTAL 7	R+MR	0.121	0.202	1.000	0.120	0.114	1.000	0.120	0.192	0.063	0.025
	F+MF	0.094	0.204	1.000	0.120	0.099	1.000	0.120	0.196	0.020	0.046
TOTAL 8	R+MR	0.158	0.184	1.000	0.120	0.148	1.000	0.120	0.183	0.125	0.017
	F+MF	0.128	0.179	1.000	0.120	0.146	1.000	0.120	0.177	0.031	0.050
TOTAL 9	R+MR	0.130	0.193	1.000	0.120	0.146	1.000	0.120	0.188	0.128	0.013
	F+MF	0.131	0.188	1.000	0.120	0.130	1.000	0.120	0.200	0.071	0.166
TOTAL P	R+MR	0.128	0.248	1.000	0.120	0.113	1.000	0.120	0.256	0.095	0.058
	F+MF	0.119	0.216	1.000	0.120	0.111	1.000	0.120	0.214	0.028	0.094
TOTAL B	R+MR	0.132	0.200	1.000	0.120	0.133	1.000	0.120	0.194	0.112	0.026
	F+MF	0.108	0.196	1.000	0.120	0.103	1.000	0.120	0.192	0.035	0.082
TOTAL S	R+MR	0.149	0.186	1.000	0.120	0.149	1.000	0.120	0.187	0.117	0.013
	F+MF	0.109	0.178	1.000	0.120	0.103	1.000	0.120	0.178	0.033	0.056
TOTAL R	R+MR									0.142	0.005
	F+MF	0.136		1.000	0.120	0.152	1.000	0.120	0.201	0.059	0.076
TOTAL	R+MR	0.141	0.221	1.000	0.120	0.124	1.000	0.120	0.205	0.111	0.027
	F+MF	0.111	0.204	1.000	0.120	0.114	1.000	0.120	0.194	0.033	0.074

It should also be noted that the inhabited forest area (composed of private and public "commuter" forests), which is the most accessible in terms of biomass harvest, contains about 65% of the total available weight, mainly in regions 08, 01, and 07 (about 10% each), and in regions 06, 02, 04, and 03 (about 8% each).

Lastly, with regard to biomass factors as described in paragraph 3.6, the following (rounded) figures were obtained for all of Quebec:

Branches and tops of softwood species:	0.14 (all stands)
Branches and tops of hardwood species:	0.21 (all stands)
Unmerchantable stems of softwood species:	0.11 (softwood stands)
Unmerchantable stems of hardwood species:	0.07 (hardwood stands)
Bark:	0.12 (input data)

4.3 Current production and consumption of mill residues

Table 7 shows the current production and use of mill residues (bark, sawdust, and planing chips). These data were obtained from the survey already mentioned and their degree of precision is acceptable. It should be noted that production is almost entirely within the inhabited forest area.

The following facts emerge concerning production and use of mill residues:

- Total annual bark production is 1 652 100 oven-dry tonnes, whereas consumption is 959 300 tonnes; this gives an utilization rate of 58% and an availability of 692 800 tonnes.
- The pulp and paper industry remains the largest consumer of bark, accounting for 92% of total consumption. The remainder is used by the lumber industry.
- Region 05 already has a shortage of bark and must import 18 800 tonnes from other regions.

Table 7. Current production and consumption of mill residues (bark, sawdust, and planing chips) by region in oven-dry tonnes per year**

REGION	BARK					SAWDUST AND PLANING CHIPS			
	PRODUCTION			CONSUMPTION	AVAILABILITY	PRODUCTION	CONSUMPTION		AVAILABILITY
	PULP AND PAPER	LUMBER AND OTHERS	TOTAL				INDUSTRIAL	ENERGY	
1	71 100	110 000	181 100	137 300	43 800	145 500	84 600	33 000	27 900
2	81 100	284 500	365 600	179 700	185 900	336 600	24 300	80 900	231 400
3	102 300	97 300	199 600	88 600	111 000	178 000	50 600	42 200	85 200
4	156 300	28 200	184 500	137 600	46 900	50 900	253 700	10 800	(213 600)
5	36 300	30 000	66 300	85 100	(18 800)	49 800	32 200	28 100	(10 500)
6	5 500	20 900	26 400	3 000	23 400	34 700	3 800	13 000	17 900
7	125 800	64 500	190 300	136 700	53 600	98 600	119 600	48 500	(69 500)
8	41 300	337 400	378 700	150 500	228 200	433 800	100 000	84 500	249 300
9	27 200	32 400	59 600	40 800	18 800	40 600	-	22 700	17 900
TOTAL	646 900	1 005 200	1 652 100	959 300	692 800	1 368 500	668 800	363 700	336 000

** Data from Table 7 do not correspond with data in Appendix 2. Table 7 takes into account all sawmills whereas Appendix 2 includes only those sawmills whose annual production is 35 000 m^3 and over (15 million b.f.)

- Regions 01, 04, 07, and 09 are moving toward a shortage, as they consume about 70% of the regional bark production.
- Regions 02, 03, and 08 have the highest bark availability (525 100 tonnes or 75% of total availability).
- Total sawdust and planing chips production is 1 368 500 tonnes, whereas current consumption is 1 032 500 tonnes; this gives an utilization rate of 75% and an availability of 336 000 tonnes.
- Industrial consumption of sawdust and planing chips accounts for 65% of the total; the remainder, i.e. 363 700 tonnes, is used for energy purposes by the lumber and pulp and paper sectors in almost equal proportions.
- Regions 04, 05, and 07 already have a shortage of sawdust and planing chips (293 600 tonnes). Region 04 alone must import 213 600 tonnes (i.e. 81% of its current consumption) from other regions.
- Region 08 shows a surplus of 249 300 tonnes of sawdust and planing chips, and is therefore the main supplier for regions experiencing shortages, especially region 04. Note that there are no plans to use these products at the new Donohue-Normick mill at Amos, and they should remain available for region 04.

4.4 Forecast production and consumption of mill residues

Survey participants were also asked to estimate their consumption of mill residues over the next five years. Results are shown in Table 8. The main facts are:

- Consumption of bark will equal production, i.e. about 1 854 000 tonnes per year.
- Regions 01, 04, and 05 will be short of bark.
- Regions 08 and 02 will be the main exporters of bark.
- Production of sawdust and planing chips is expected to be 1 402 600 tonnes. Availability will be about 69 500 tonnes. In practical terms, it will be nil.
- Regions 01, 04, 05, and 07 will be short of sawdust and planing chips.

Table 8. Forecasted (next five years) production and consumption of mill residues (bark, sawdust, and planing chips) by region in oven-dry tonnes per year

REGION	BARK					SAWDUST AND PLANING CHIPS			
	PRODUCTION			CONSUMPTION	AVAILABILITY	PRODUCTION	CONSUMPTION		AVAILABILITY
	PULP AND PAPER	LUMBER AND OTHERS	TOTAL				INDUSTRIAL	ENERGY	
1	116 100	110 000	226 100	336 000	(109 900)	145 500	84 600	75 200	(14 300)
2	85 100	284 500	369 600	279 900	89 700	336 600	24 300	141 400	170 900
3	109 100	97 300	206 400	181 000	25 400	178 000	50 600	81 300	46 100
4	156 300	28 200	184 500	341 100	(156 600)	50 900	253 700	65 800	(268 600)
5	45 400	30 000	75 400	112 800	(37 400)	49 800	32 200	35 300	(17 700)
6	5 500	20 900	26 400	8 500	17 900	34 700	3 800	13 000	17 900
7	222 900	64 500	287 400	247 500	39 900	108 600	119 600	67 600	(78 600)
8	41 300	364 400[1]	405 700	284 500	121 200	437 800[2]	140 000	89 400	208 400
9	27 200	44 400	71 600	63 500	8 100	60 700	-	55 300	5 400
TOTAL	808 900	1 044 200	1 853 100	1 854 800	(1 700)	1 402 600	708 800	624 300	69 500

1) Including PANOFOR, 27 000 tonnes.
2) Including PANOFOR, 4 000 tonnes.

- Regions 04 will have the greatest shortage of sawdust and planing chips (268 600 tonnes) and will import these products mainly from regions 08 and 02.

4.5 Summary of net availability of forest biomass

On the basis of the preceding data (Tables 3, 7, and 8), net forest biomass availability for 1980 may be summarized as follows:

SUMMARY OF AVAILABLE FOREST BIOMASS IN QUEBEC

(extensive management)

(1000 oven-dry tonnes)

REGION	BIOMASS IN THE FOREST	BARK	SAWDUST AND PLANING CHIPS	TOTAL	%
01	1 616	44	28	1 688	9.9
02	2 821	186	231	3 238	19.0
03	1 241	111	85	1 437	8.4
04	1 875	47	(214)	1 708	10.0
05	339	(19)	(11)	309	1.8
06	1 298	23	18	1 339	7.8
07	2 310	54	(70)	2 294	13.4
08	3 521	228	249	3 998	23.4
09	1 037	19	18	1 074	6.3
Total	16 058	693	334	17 085	100.0
%	94.0	4.1	1.9	100.0	

The above table shows that, to a large extent, in Quebec available biomass means biomass available in the forest, as it represents 94% of the total. Thus the data in Tables 2 to 5 give a good estimation of forest biomass availability, energy equivalent, market value, and regional distribution.

It is evident that, as of today, regions 02 (Chibougamau-Lac St.Jean) and 08 (Abitibi-Témiscamingue) have the highest quantity of available biomass, i.e. 7.2 million oven-dry tonnes or 42% of the provincial total.

4.6 Total surplus biomass in Quebec

Until now, only above-ground biomass and extensive management have been covered. What should be the total surplus biomass which might be expected with more intensive management and with the harvesting of stumps and roots?

First, the following assumptions were made:

- Stumps and roots as a percentage of the weight of i.b. trunk: 15%
- Rate of increase of the allowable cut as a function of silvicultural treatments (excluding energy plantations):
  - Private forest: 50%
  - Public forest - "commuter": 30%
  - Public forest - lumber: 15%
  - Public forest - pulp: nil
- Energy plantations (see Table 9)
  - Plantation of 25% of abandoned agricultural land (Source: DER, D. Langevin, For. Eng.)
  - Yield of 9 oven-dry tonnes per hectare per year (Source: DER, Dr. G. Vallée, Forest Eng.).

Table 9, dealing with energy plantations potential, clearly shows that regions 01, 03, and 05 have the highest potential of forest biomass production if the energy plantation concept is implemented.

Table 10 (pages 32 and 33) shows the production potential calculated on the basis of the various assumptions, current use (1980) and total surplus biomass for the whole of Quebec. The latter is about 20 million tonnes under extensive management (including 3 million tonnes of stumps and roots) and 30 million tonnes under intensive management. Under intensive management, inhabited forest (private and "commuter") biomass represents 70% of total surplus biomass, or about 20 million tonnes.

4.7 Practical availability of biomass

Obviously, the biomass surplus shown in Table 10 is not physically and economically available in its entirety. For instance, it is certain

Table 9. Data on energy plantations of hybrid poplar

REGION	AREA AVAILABLE FOR PLANTATION - %							
	25		50		75		100	
	TOTAL AREA	ANNUAL 1) YIELD	TOTAL AREA	ANNUAL YIELD	TOTAL AREA	ANNUAL YIELD	TOTAL AREA	ANNUAL YIELD
	000 ha	000.o.d.t.	000 ha	000 o.d.t.	000 ha	000.o.d.t.	000 ha	000 o.d.t.
1	30.2	271.8	60.3	542.7	90.4	813.6	120.6	1 085.4
2	10.5	94.5	21.0	189.0	31.6	284.4	42.0	378.0
3	57.2	514.8	114.3	1 028.7	171.4	1 542.6	228.6	2 057.4
4	18.0	162.0	36.0	324.0	54.0	486.0	72.0	648.0
5	35.1	315.9	70.2	631.8	105.3	947.7	140.4	1 263.6
6	26.4	237.6	52.8	475.2	79.1	711.9	105.6	950.4
7	5.9	53.1	11.8	106.2	17.8	160.2	23.9	215.1
8	9.3	83.7	18.6	167.4	27.9	251.1	37.2	334.8
9	2.7	24.3	5.4	48.6	8.0	72.0	10.7	96.3
TOTAL	195.3	1 757.7	390.4	3 513.6	585.5	5 269.5	781.0	7 029.0

1) Yield in 1 000 oven-dry tonnes

Table 10. Total surplus biomass in Quebec (intensive management)

BIOMASS SOURCE POTENTIAL PRODUCTION	1 000 OVEN-DRY TONNES															%
	PRIVATE			PUBLIC									TOTAL			
				"COMMUTER"			LUMBER/PULP			PULP						
	1**	2**	TOTAL	1	2	TOTAL	1	2	TOTAL	1	2	TOTAL	1	2	TOTAL	
1 Current harvest*	1 759	-	1 759	4 150	-	4 150	5 565	-	5 565	-	-	-	11 474	-	11 474	25.7
2 Bark of current harvest	210	-	210	495	-	495	664	-	664	-	-	-	1 369	-	1 369	3.1
3 Planing chips and sawdust	253	-	253	597	-	597	802	-	802	-	-	-	1 652	-	1 652	3.7
4 Branches and tops of current harvest	356	-	356	663	-	663	901	-	901	-	-	-	1 920	-	1 920	4.3
5 Availability of i.b. trunks	1 866	1 918	3 784	2 838	2 245	5 083	2 115	1 252	3 367	129	-	129	6 948	5 415	12 363	27.7
6 Bark of available volumes	224	230	454	341	269	610	254	150	404	15	-	15	834	649	1 483	3.3
7 Branches and tops of available volumes	385	396	781	528	418	946	383	227	610	25	-	25	1 321	1 041	2 362	5.3
8 Unmerchantable stems, harvest and availability	1 127	564	1 691	2 010	603	2 613	1 859	279	2 138	37	-	37	5 033	1 446	6 479	14.5
9 Energy plantations	-	1 758	1 758	-	-	-	-	-	-	-	-	-	-	1 758	1 758	3.9
Sub-total, above-ground biomass	6 180	4 866	11 046	11 622	3 535	15 157	12 543	1 908	14 451	206	-	206	30 551	10 309	40 860	91.5
10 Stumps, current harvest	264	-	264	623	-	623	835	-	835	-	-	-	1 722	-	1 722	4.3
11 Stumps, availability	280	287	567	426	337	763	317	188	505	19	-	19	1 042	812	1 854	4.2
Sub-total, below-ground biomass	544	287	831	1 049	337	1 386	1 152	188	1 340	19	-	19	2 764	812	3 510	8.5
GRAND TOTAL	6 724	5 153	11 877	12 671	3 872	16 543	13 695	2 096	15 791	225	-	225	33 315	11 121	44 436	100.0
%	15.1	11.6	26.7	28.5	8.7	37.2	30.9	4.7	35.6	0.5	-	0.5	75.0	25.0	100.0	

* Does not include bark, sawdust, and planing chips

** 1 Natural production
2 Additional production due to silviculture

Table 10. (cont'd)

BIOMASS SOURCE POTENTIAL PRODUCTION	1 000 OVEN-DRY TONNES															%
	PRIVATE			PUBLIC									TOTAL			
				"COMMUTER"			LUMBER/PULP			PULP						
	1**	2**	TOTAL	1	2	TOTAL	1	2	TOTAL	1	2	TOTAL	1	2	TOTAL	
CURRENT UTILIZATION (1980)																
Harvest	1 759	-	1 759	4 150	-	4 150	5 565	-	5 565	-	-	-	11 474	-	11 474	25.8
Bark	147	-	147	346	-	346	466	-	466	-	-	-	959	-	959	2.2
Planing chips and sawdust	158	-	158	373	-	373	502	-	502	-	-	-	1 033	-	1 033	2.3
Full-tree chips	32	-	32	78	-	78	-	-	-	-	-	-	110	-	110	0.2
Fuelwood	150	-	150	50	-	50	-	-	-	-	-	-	200	-	200	0.4
Total utilization	2 246	-	2 246	4 997	-	4 997	6 533	-	6 533	-	-	-	13 776	-	13 776	31.0
Total surplus biomass	4 478	5 153	9 631	7 674	3 872	11 546	7 162	2 096	9 258	225	-	225	19 539	11 121	30 660	69.3
%	14.6	16.8	31.4	25.0	12.6	37.6	23.4	6.8	30.2	0.7	-	0.7	63.7	36.3	100.0	100.0

** 1 Natural production
2 Additional production due to silviculture

that no biomass will be harvested from energy plantations in the course of the next five or ten years, and it is likewise very unlikely that, during this same period, any substantial volume of stumps and roots will be harvested.

Estimating the practical availability of forest biomass over the next decade is a useful but complex task, whose scope is well beyond the framework of this study. The estimate is based only on experience and judgment. The following assumptions, with regard to forest biomass practical availability during the eighties, are purely subjective:

Table 11. Practical availability of surplus forest biomass (1981)

SOURCE OF BIOMASS (See Table 10)	AVAILABILITY IN %					
	PRIVATE		"COMMUTER"		LUMBER/PULP	
	1*	2*	1*	2*	1*	2*
1	-	-	-	-	-	-
2	100	-	100	-	100	-
3	100	-	100	-	100	-
4	25	-	50	-	30	-
5	75	15	80	10	30	5
6	75	15	80	10	30	5
7	75	15	80	10	30	5
8	25	-	35	-	15	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-

*1 Natural production; 2 Additional production due to silviculture

Table 12 shows the results obtained with these assumptions. Practical availability is 9 million tonnes, or 30% of the total surplus biomass, which seems to be an acceptable figure. Note also that 80% of this amount comes from the inhabited forest and that 80% of it could be in the form of full trees (the sum of biomass sources 5 to 8).

4.8 Forecast production and consumption of forest biomass, next five and ten years

In this section, the production and consumption of forest biomass in 1985 and 1990 is forecasted, on the basis of the survey of the main users. Four main groups of wood consumers have been identified:

- the pulp and paper industry,
- the lumber and veneer industry,
- other industries (particleboard, iron, and steel),
- the fuelwood industry (residences and institutions).

i. The pulp and paper industry

The pulp and paper industry remains the main consumer of mill residues, and it may be expected that, within a few years, it will consume a large quantity of biomass available in the forest. In 1980, this industry consumed, for energy purposes, 884 000 tonnes of bark, which represented 54% of the bark produced and 92% of total bark consumption. In the same year it also consumed 734 000 tonnes of sawdust and planing chips, or 54% of production and 71% of total consumption. Of this, 22% was for energy production and 78% for pulp and paper manufacturing.

The pulp and paper industry is one of the largest consumers of energy in Quebec. It consumes the equivalent of 1.5 billion litres of No.2 oil annually, or $375 million at $0.25 a litre. As Quebec produces some 6.9 million tonnes of pulp and paper, the cost of energy comes to $55 a tonne, i.e. 15% of the total manufacturing cost. In 1985, this cost is expected to be $80 a tonne, for a production of 8.0 million tonnes, hence a value of $640 million.

Table 12. Practical availability of surplus forest biomass (1980-90)

	BIOMASS SOURCE	1 000 OVEN-DRY TONNES															%
		PRIVATE			PUBLIC									TOTAL			
					"COMMUTER"			LUMBER/PULP			PULP						
		1**	2**	TOTAL	1	2	TOTAL	1	2	TOTAL	1	2	TOTAL	1	2	TOTAL	
1	Current harvest**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Bark of current harvest	63	-	63	149	-	149	198	-	198	-	-	-	410	-	410	4.4
3	Planing chips and sawdust	95	-	95	224	-	224	300	-	300	-	-	-	619	-	619	6.7
4	Branches and tops of current harvest	89	-	89	332	-	332	270	-	270	-	-	-	691	-	691	7.5
5	Availability of i.b. trunks	1 400	288	1 688	2 270	225	2 495	635	63	698	-	-	-	4 305	576	4 881	52.6
6	Bark of available volumes	168	35	203	273	27	300	76	8	84	-	-	-	517	70	587	6.3
7	Branches and tops of available volumes	289	59	348	422	42	464	115	11	126	-	-	-	826	112	938	10.1
8	Unmerchantable stems, harvest and availability	282	-	282	592	-	592	279	-	279	-	-	-	1 153	-	1 153	12.4
9	Energy plantations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sub-total, above-ground biomass	2 386	382	2 768	4 262	294	4 556	1 873	82	1 955	-	-	-	8 521	758	9 279	100.0
10	Stumps, current harvest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Stumps, availability	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sub-total, below-ground biomass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	GRAND TOTAL	2 386	382	2 768	4 262	294	4 556	1 873	82	1 955	-	-	-	8 521	758	9 279 ***	100.0
	%	25.7	4.1	29.8	46.0	3.2	49.2	20.2	0.9	21.1	-	-	-	91.9	8.1	100.0	

* 1 Natural production
2 Additional production due to silviculture

** Does not include bark, sawdust, and planing chips

*** Represents 30% of total surplus biomass

If in 1980 the pulp and paper industry had produced 100% of its energy with forest biomass, it would be consuming 6.7 million oven-dry tonnes of wood, rising to 7.8 tonnes in 1985. Its current consumption of wood residues is 1 618 000 tonnes, or only 16% of its energy requirements. According to the survey, however, 2 143 000 tonnes are expected to be consumed in 1985, or almost 30% of requirements. For 1990, total requirements equivalent to 8.3 million tonnes of wood may be forecasted. If one assumes that wood will make up 40% of energy production requirements, the wood fibre demand for this specific goal will be 3 320 000 tonnes. Lastly, the industry is already using 60 000 tonnes of full-tree chips, and expects to consume 80 000 tonnes in 1985 and 120 000 tonnes in 1990.

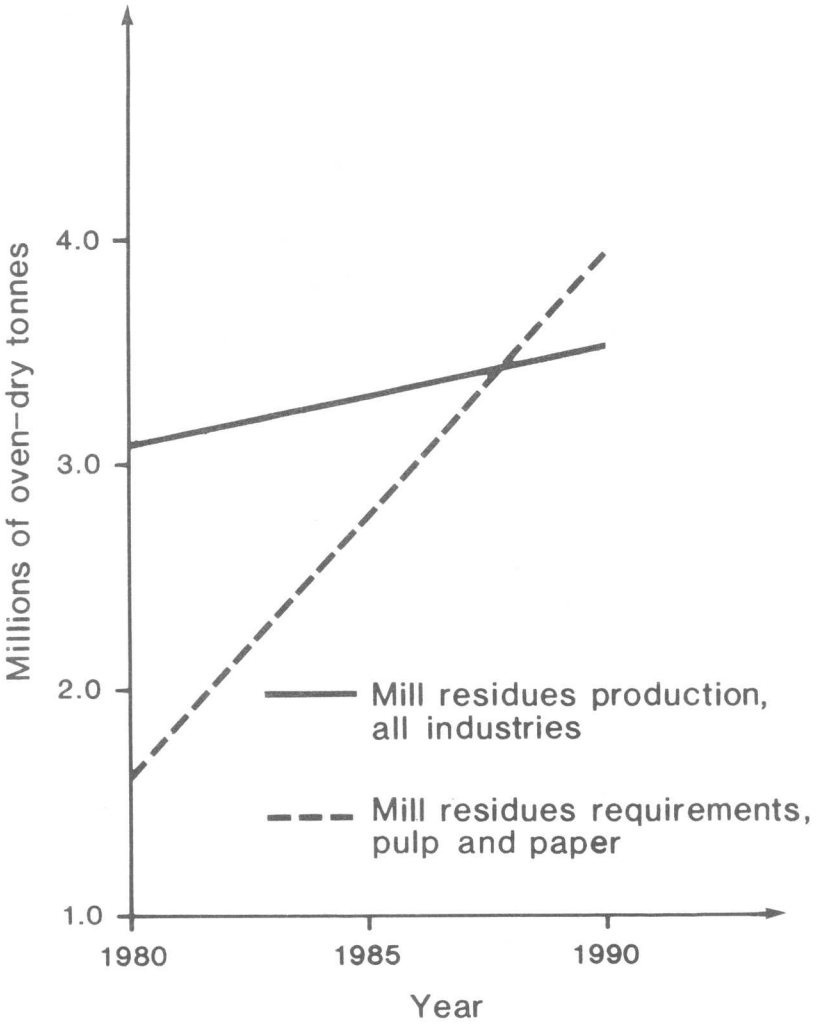
As for sawdust and planing chips uses for pulp and paper manufacturing, the consumption was 570 000 tonnes in 1980. It is expected to be 603 000 tonnes in 1985. If the 1980-85 trend continues, it should be 630 000 tonnes in 1990.

In summary, in 1980 the pulp and paper industry consumed 1 618 000 tonnes of mill residues; in 1985 the figure is expected to be 2 746 000 tonnes and in 1990, 3 950 000 tonnes. The survey also showed that production of these residues was 3 021 000 tonnes in 1980 and will be 3 256 000 and 3 455 000 tonnes respectively in 1985 and 1990. Therefore, before the end of the decade, *mill residues requirements for the pulp and paper industry alone will exceed production.*

Lastly, the pulp and paper industry currently consumes, in product-manufacturing, about 60 000 oven-dry tonnes of full-tree chips; this consumption is expected to reach 80 000 tonnes in 1985 and 120 000 tonnes in 1990.

ii. The lumber and veneer industry

In 1980, this industry consumed, for energy purposes, 75 000 oven-dry tonnes of bark, and 199 000 tonnes of sawdust and planing chips, for a total of 274 000 tonnes. Consumption in 1985 is expected to be 334 000 tonnes and in 1990, 410 000 tonnes.



Total mill residues production and
pulp and paper mill residues requirements

iii. Other industries

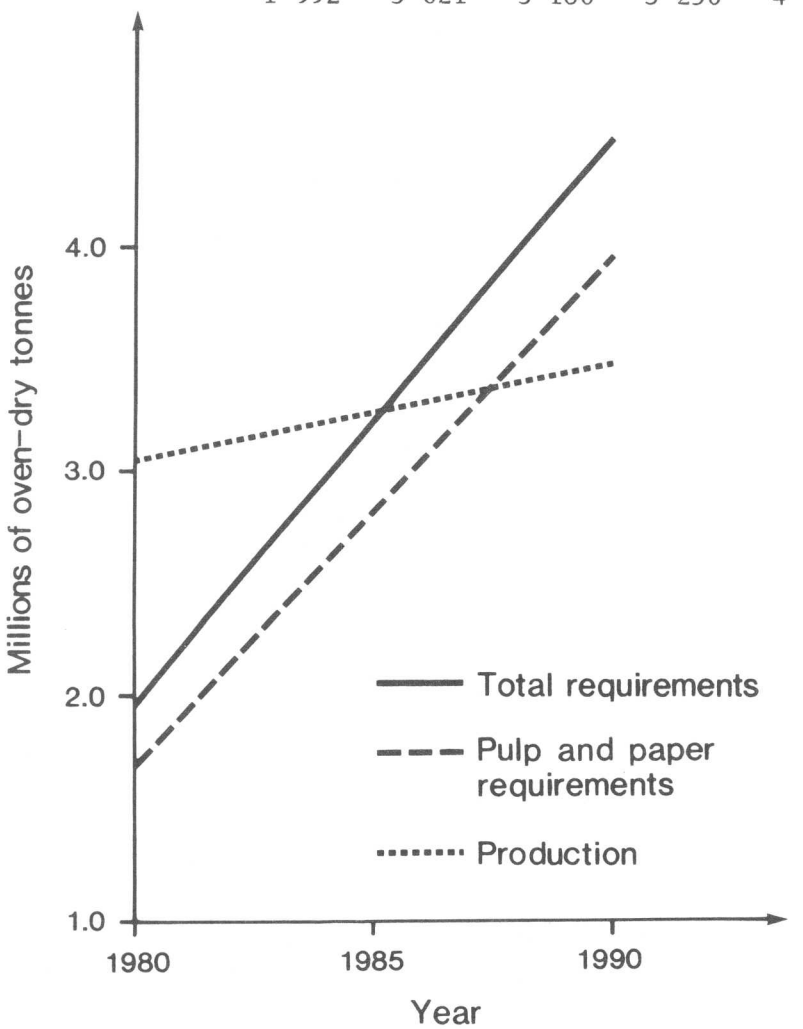
This covers mostly the particleboard industry, which consumes solely sawdust and planing chips. In 1980, consumption was 100 000 oven-dry tonnes, and it is expected to be 106 000 tonnes in 1985 and 120 000 tonnes in 1990. However, since the particleboard industry appears to be rapidly developing, these are conservative forecasts.

The particleboard industry and other industries which consume wood fibre utilized 50 000 tonnes of full-tree chips in 1980 and are expected to consume 100 000 tonnes in 1985 and 200 000 in 1990.

iv. Balance of requirements and industrial production

Mill residues requirements and production may therefore be summarized as follows:

	--------1 000 OVEN-DRY TONNES--------					
	1980		1985		1990	
	REQUIR.	PROD.	REQUIR.	PROD.	REQUIR.	PROD.
Pulp and paper	1 618		2 746		3 950	
Lumber and veneer	274		334		410	
Other industries	100		106		120	
Total	1 992	3 021	3 186	3 256	4 480	3 455



Wood mill residues supply and demand

We may conclude from preceding data that, according to the best possible forecasts, from 1985 on, mill residues wood requirements will exceed production, and that we will have to turn to other sources of wood, particularly surplus biomass in the forest. It may also be expected that wood residues prices will rise quickly in the near future, becoming comparable with oil prices by 1985 for the equivalent amount of energy.

v. The fuelwood industry

As a result of the energy crisis, the use of wood as fuel for heating residences and institutions is rapidly increasing. Quebec statistics on this subject are not very reliable, as they largely underestimate consumption.

The following estimates of fuelwood consumption in Quebec are very approximate and they should be considered only as a general indication.

Fuelwood consumption estimates made for 1980 and 1990:

YEAR	TOTAL HOUSEHOLDS IN QUEBEC	WOOD-CONSUMING HOUSEHOLDS		ANNUAL VOLUME PER CONSUMING HOUSEHOLD		m^3/YEAR	TONNES/YEAR DENSITY
		Number	%	Cords 16"	m^3		0.55
1980	1 625 000	162 500	10	3.0	2.4	390 000	214 500
1990	1 755 000	263 500	15	3.5	2.9	763 425	420 000

For this study, forest biomass consumption was evaluated at 200 000, 300 000, and 500 000 oven-dry tonnes for 1980, 1985, and 1990 respectively.

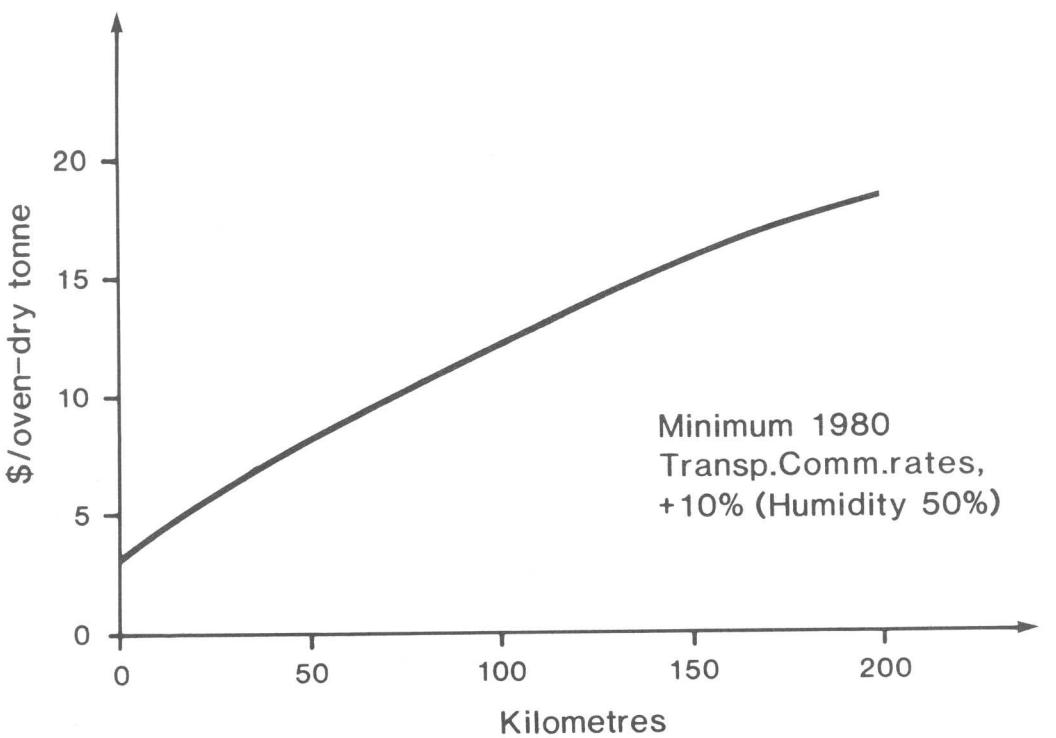
vi. Summary of forecasts

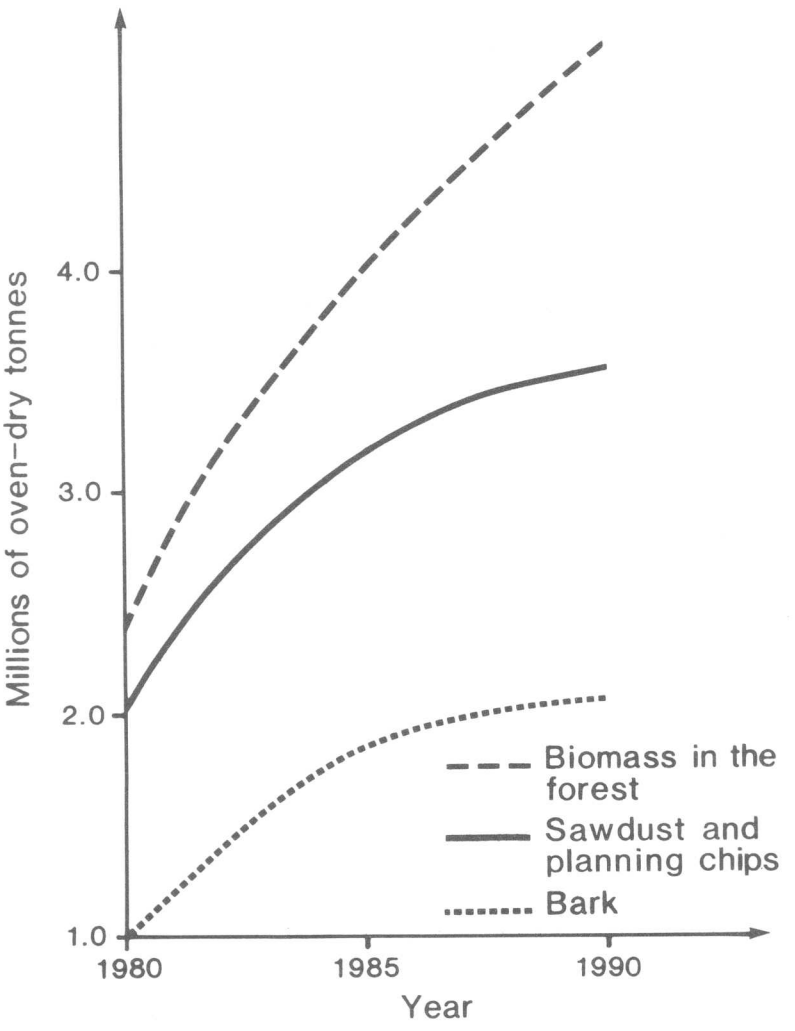
Tables 13 and 14 summarize the forecasts of wood mill residues and surplus forest biomass production and consumption in Quebec. Table 13 shows that the pulp and paper industry will, over the next decade, remain the main consumer surplus of forest biomass (about 75% of total consumption). Total consumption will increase from 2 302 000 oven-dry tonnes in 1980 to 4 930 000 oven-dry tonnes in 1990. The use of available biomass in the forest will increase from 310 000 tonnes in 1980 to 1 475 000 tonnes in 1990. These forecasts are illustrated on page 42.

4.9 Cost price and production costs of forest biomass

As far as selling prices and production costs are concerned, forest biomass has to be divided into two categories, mill residues and biomass available in the forest, generally produced in the form of wood chips.

Bark produced by the lumber industry was sold, in 1981, for $2.00 per oven-dry tonne, f.o.b. sawmill, whereas sawdust and planing chips were sold for $12 per tonne. To these prices are added transportation costs, as shown in the following graph.





Cumulated forecast consumption of forest biomass in Quebec

Table 13. Forecasted production and consumption of wood mill residues and surplus forest biomass by product category

	1000 OVEN-DRY TONNES					
	1980		1985		1990	
	PRODUCTION	CONSUMPTION	PRODUCTION	CONSUMPTION	PRODUCTION	CONSUMPTION
1. BARK						
- Pulp and paper	647	884	809	1 743	930	1 855
- Lumber and veneer	1 005	75	1 044	110	1 085	160
Sub-total	1 652	959	1 853	1 853	2 015	2 015
2. SAWDUST AND PLANING CHIPS						
- Pulp and paper						
. Industrial products	-	570	-	603	-	630
. Energy	-	164	-	400	-	440
- Lumber and veneer	1 369	199	1 403	224	1 440	250
- Other industries	-	100	-	106	-	120
Sub-total	1 369	1 033	1 403	1 333	1 440	1 440
3. FOREST BIOMASS						
- Pulp and paper						
. Industrial products	60	60	80	80	120	120
. Energy	-	-	300	300	655	655
- Lumber and veneer	-	-	-	-	-	-
- Other industries	50	50	100	100	200	200
- Heating, residences and institutions	200	200	300	300	500	500
Sub-total	310	310	780	780	1 475	1 475
TOTAL	3 331	2 302	4 036	3 966	4 930	4 930

Thus, a pulp and paper mill owner obtaining his bark supply from a distance of 100 km will pay about $14 per tonne, whereas, for the same distance, sawdust and planing chips will cost him $24 per tonne. Naturally his first choice will be to burn bark, which he does. As can be seen, both prices are well below the real value of the product as a source of energy, which ranges between $45 and $55 per tonne. On the basis of the preceding forecasts, one may expect that residues prices will reach this level within five to seven years (in 1980 dollars).

Table 14. Forecasted consumption of wood mill residues and surplus forest biomass by consumer category

	BARK	SAWDUST AND PLANING CHIPS	FOREST BIOMASS	TOTAL	%
YEAR 1980					
Pulp and paper	884	734	60	1 678	72.9
Lumber and veneer	75	199	-	274	11.9
Other industries	-	100	50	150	6.5
Heating	-	-	200	200	8.7
Total	959	1 033	310	2 302	100.0
%	41.7	44.9	13.4	100.0	-
YEAR 1985					
Pulp and paper	1 743	1 003	380	3 126	78.8
Lumber and veneer	110	224	-	334	8.4
Other industries	-	106	100	206	5.2
Heating	-	-	300	300	7.6
Total	1 853	1 333	780	3 966	100.0
%	46.7	33.6	19.7	100.0	-
YEAR 1990					
Pulp and paper	1 855	1 070	775	3 700	75.1
Lumber and veneer	160	250	-	410	8.3
Other industries	-	120	200	320	6.5
Heating	-	-	500	500	10.1
Total	2 015	1 440	1 475	4 930	100.0
%	40.9	29.2	29.9	100.0	-

As far as harvesting available biomass in the forest is concerned, there are two sub-categories of products, chips from full trees and logging residues.

The cost of felling full trees, hauling, and chipping them at roadside varies with their average diameter and the terrain conditions, ranging between $25 and $35 per oven-dry tonne. Transportation to the mill costs about $0.20 per tonne per kilometre for distances exceeding 50 km. For an average distance of 50 km, therefore, the cost price of full-tree chips is about $40 per tonne. This cost is close to that already established as the energy-equivalent cost. Since a surplus of low-cost mill residues still exists, and since in any case, the cost price of available biomass in the forest is hardly competitive with that of oil (1980), one can easily understand the mill owners' current reticence to use this biomass to produce energy.

Data on the cost price of logging residues are scanty; however, on the basis of a number of theoretical studies, it may be estimated as follows:

Options for collecting logging residues (softwoods)	Approximate cost price (oven-dry tonne) 50 km distance
Collecting logging residues in cutovers, crushing them at roadside	$38
Collecting and crushing logging residues (after full-tree delimbing), at roadside	$30
Transporting full trees to the mill, processing branches and tops at the mill	$10 (additional cost for transportation of full trees and processing of residues)

If estimates of the cost price of logging residues obtained through the full-tree transportation option are found to be accurate, this source of biomass might, in some cases, become very attractive within a few years. Of course without an operational experiment, no definite conclusion can be drawn.

Although roadside residues collecting is a much more expensive option, it is still attractive because large biomass volumes are already being produced by this logging method (300 000 to 500 000 oven-dry tonnes annually in Quebec) and because the cost price estimate is more reliable than the previous one.

As for collecting logging residues in the cutovers, this option does not appear to be very attractive at present, but it must be pointed out that experience in this sector is limited, and that the use of highly efficient collecting equipment currently under development may result in an appreciable reduction in collecting costs.

Expectations for the production of full-tree chips from non-utilized species and unmerchantable stems are fairly pessimistic because, although this source of biomass represents about 80% of surplus biomass, its high cost price (about $40 per o.d.t. for an average transportation distance of 50 km) is a deterrent to the user. It should be pointed out, however, that full-tree chips may become very attractive for industry and may constitute an important source of supply for the manufacture of traditional products and for energy production, if research and development in the following areas are intensified:

- Development of harvesting equipment, and of tools and work methods designed especially for harvesting smaller trees;
- Densification of biomass before transportation to the mill (compression, pelletization, etc...);
- Separation of fibre from bark after chipping;
- Sorting chips to increase quality (sorting chips for pulp, particleboard, energy);

- Development of new markets such as dimension lumber, waferboard (oriented or laminated), laminated veneer lumber, and composite panels or particleboard;
- Increased efficiency of wood pyrolysis, hydrolysis, and gasification;
- Integration of full-tree harvesting with degraded forests reclamation;
- Design and development of industrial forest projects which will combine the production of several different goods harmoniously;
- Development of an adequate economic analysis method covering all socio-economic factors involved in forest biomass use.

This list is not exhaustive, but it contains the most important areas of research. It should be added that, at the same time, the knowledge of the ecological impacts of forest biomass harvesting has to be increased.

4.10 Conflicts in forest biomass use

If the expected requirements in forest biomass for 1990 (5.0 million oven-dry tonnes) are compared with its availability (30.0 million oven-dry tonnes), there does not seem to be any reason to worry about conflicts in use since, at first glance, the supply will meet the demand. This is true on a purely physical availability base. However, the competition expected to arise in the mill wood residues sector will result in a price hike and will force the users of these residues to seek alternative sources of energy supply. In Quebec, since increased consumption of traditional sources of energy such as oil and hydro-electricity is prohibitive from the point of view of the national economy, the main alternative is forest biomass.

In the short term, conflicts in the sawdust and planing chips sector may be expected. While the pulp and paper industry will increase its consumption of these residues in the manufacture of traditional products, the particleboard industry, which uses the same type of residues, will no doubt expand, as its future seems promising. This will lead to an increase in prices which will make biomass harvesting in the forest more economical.

Furthermore, the increasing scarcity of sawdust and planing chips will in turn result in a shortage of bark. The price of this product will therefore probably also rise quite sharply, inciting current users to turn once again to biomass harvesting in the forest.

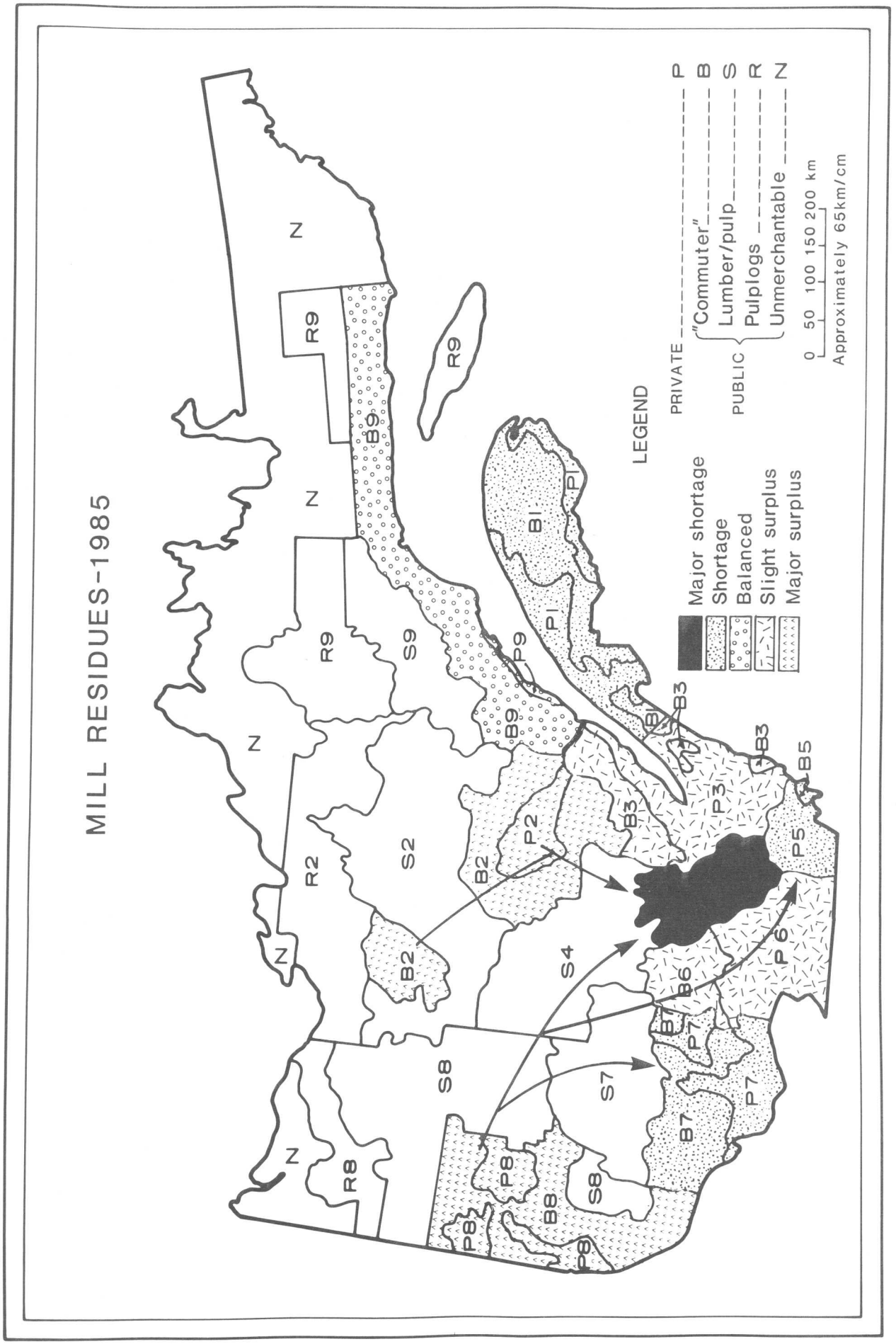
The map on page 49 shows the regional distribution of mill residues forecast for 1985.

Regions 04, 05, and 07 will be short more than 500 000 tonnes; this should be offset by similar surpluses from regions 02 and 08. However, any sizable industrial development using sawmill residues in these two regions will create serious problems of supply in the regions experiencing shortages, especially in region 04, whose expected shortfall is 425 000 tonnes.

In 1985, region 01 will probably be short of about 125 000 tonnes of residues; this shortfall may increase as a result of the rapid industrial development this region appears to be undergoing. Contrary to preceding regions showing a shortage, however, the possibility of compensating the shortage of region 01 through imports from other regions remains slight.

A large part of the mill residues in regions 03 and 05, comes from sawmills supplied by the United States. If that country were to set limits to the harvested volumes that can be exported to Canada, major problems of supply would arise in these regions, to the extent that some mills might have to shut down. As there is no short-term solution to this problem, let us hope that this will not happen. However, the governments might be well advised to seek, as soon as possible, long-term alternative solutions.

In summary, only regions 02 and 08 are in a strong position where mill residues are concerned. Regions 04 and 01 remain the most vulnerable, and will soon have to turn to biomass available in the forest. Research and development in this area should therefore be implemented as a priority in these two regions.


MILL RESIDUES-1985
LEGEND
Major shortage
Shortage
Balanced
Slight surplus
Major surplus
PRIVATE
PUBLIC
P "Commuter"
B Lumber/pulp
S Pulplogs
R Unmerchantable
Z
0 50 100 150 200 km
Approximately 65km/cm

From the above cost estimates, it may be concluded that efforts should first be directed to collecting logging residues ($14 to 38 per tonne) rather than harvesting degraded stands, stands containing non-commercial species, or unmerchantable stands with low potential ($40 per tonne). However, such is not the case. First, the lowest cost price, i.e. that which covers transportation of full trees to the mill ($10 per tonne) is approximate, and it must be proven before definite conclusions can be drawned. Furthermore, with this method it would be difficult to use public roads, and yet biomass would have to be transported over these roads in regions experiencing shortages. Lastly, the cost price of the other two options for collecting residues ($30 and $38 per tonne) are also approximate, and in any case, they are comparable to the cost of harvesting forest stands. In addition, roadside residues (cost price of $30 per tonne) are found mainly in regions 02 and 08, both of which presently have, and will still have in 1985, large surpluses of mill residues.

For all these reasons, it seems that biomass harvesting in the forest should be directed first to merchantable and unmerchantable degraded stands in southern Quebec. This action is all the more positive since it can be appropriately integrated with the redevelopment of the best sites in Quebec, which are occupied by biomass of little value for traditional products.

To ensure continuity of supply for mills consuming biomass, one must, as current logging areas are gradually redeveloped, turn to the use of logging residues and to plantations of fast-growing species such as hybrid poplar. In the latter case, however, means of reducing the cost price, which is currently too high to be competitive, must be found. This price is, for hybrid poplar as an example, determined as follows:

- Expected yield: 9 oven-dry tonnes/ha/year;
- Cutting cycle: 5 years;
- Number of harvests: 5;
- Initial investment: $2 200/ha;

- Harvest cost: $15/oven-dry tonne;
- Transportation cost: $0.20/tonne/km;
- Average distance: 50 km;
- Interest rate: 10%;
- Amortization of initial capital: 25 years.

Cost ($/oven-dry tonne)	
a. Amortization (capital and interest)	$27
b. Harvest	15
c. Transportation (50 km @ $0.20)	10
	$52

CONCLUSION

From this study it may be concluded that Quebec possesses an enormous quantity of physically available forest biomass, especially in the inhabited forest area (70% of the total potential), but that much remains to be done before it can be economically harvested. The total volume of available biomass in the forest, under extensive management amounts to 35 million m^3 annually, or about 15 million oven-dry tonnes. The energy equivalent of this biomass represents annually 3.6 billion litres of oil, i.e. a market value around $1 billion. Sixty percent of the biomass in the forest is composed of full trees of available merchantable size. Therefore research and development efforts must be directed toward this particular biomass source.

In addition to research and development efforts, biomass harvesting has to be included in appropriate development and management plans. At present, such plans do not exist in Quebec.

Lastly, better method of dealing with the problems caused by conflicts in use should be found. One method is development and use of an appropriate economic model of supply and demand for the various categories of forest biomass products.

ACKNOWLEDGMENTS

The authors wish to thank all those who, directly or indirectly, helped to make this work possible, especially the representatives of the Quebec Department of Energy and Resources, the Federation of Wood Producers of Quebec, and the Quebec Forest Industry.

APPENDIX 1

Harvest, allowable cut, and availability of gross merchantable volumes i.b.

Harvest, allowable cut and availability
of gross merchantable volumes i.b. by
region and management area

(000 m^3)

REGION	MANAGEMENT AREA	STANDS	ALLOWABLE CUT			HARVEST			AVAILABILITY	
			bF,S, jP	OTHER SOFTWOODS	HARDWOODS	bF,S, jP	OTHER SOFTWOODS	HARDWOODS	OTHER SOFTWOODS	HARDWOODS
01	PRIVATE	SFTWDS*+ MIXED (S)	812.1	145.9	338.7	812.1	7.7	179.2	138.2	159.5
		HRDWDS*+ MIXED (H)	71.1	12.6	184.1	71.1	0.7	97.4	11.9	86.7
		TOTAL	883.2	158.5	522.8	883.2	8.4	276.6	150.1	246.2
	PUBLIC	SFTWDS + MIXED (S)	2 868.0	160.6	334.7	2 868.0	58.7	151.6	101.9	183.3
	"COMMUTER"	HRDWDS + MIXED (H)	105.7	6.1	227.2	105.7	2.3	102.7	3.8	124.3
		TOTAL	2 973.7	166.7	561.9	2 973.7	61.0	254.3	105.7	307.6
02	PRIVATE	SFTWDS + MIXED (S)	279.3	24.9	144.7	279.3	0.8	34.9	24.1	109.8
		HRDWDS + MIXED (H)	50.7	4.5	102.6	50.7	0.1	24.8	4.4	77.8
		TOTAL	330.0	29.4	247.3	330.0	0.9	59.7	28.5	187.6
	PUBLIC	SFTWDS + MIXED (S)	1 816.4	7.3	310.6	1 816.4	3.3	29.3	4.0	281.2
	"COMMUTER"	HRDWDS + MIXED (H)	158.9	0.6	337.7	158.9	0.3	31.9	0.3	305.9
		TOTAL	1 975.3	7.9	648.3	1 975.3	3.6	61.2	4.3	587.1
	PUBLIC	SFTWDS + MIXED (S)	5 835.8	17.5	571.9	5 835.8	0.7	43.5	16.8	528.8
	LUMBER AND	HRDWDS + MIXED (H)	155.6	0.5	318.1	155.6	-	24.1	0.5	293.6
	PULP	TOTAL	5 991.4	18.0	890.0	5 991.4	0.7	67.6	17.3	822.4
	PUBLIC	SFTWDS + MIXED (S)	-	- **	-	-	-	-	-	-
	PULP	HRDWDS + MIXED (H)	-	50.6	92.4	-	-	-	50.6	92.4
		TOTAL		50.6	92.4	-	-	-	50.6	92.4
03	PRIVATE	SFTWDS + MIXED (S)	945.9	128.6	386.9	945.9	8.8	111.0	119.8	275.9
		HRDWDS + MIXED (H)	164.9	22.5	534.8	164.9	1.6	153.3	20.9	381.5
		TOTAL	1 110.8	151.1	921.7	1 110.8	10.4	264.3	140.7	657.4

* SFTWDS = Softwoods
HRDWDS = Hardwoods
** bF,S,jP included

Harvest, allowable cut and availability
of gross merchantable volumes i.b. by
region and management area

(000 m^3)

REGION	MANAGEMENT AREA	STANDS	ALLOWABLE CUT			HARVEST			AVAILABILITY	
			bF,S, jP	OTHER SOFTWOODS	HARDWOODS	bF,S, jP	OTHER SOFTWOODS	HARDWOODS	OTHER SOFTWOODS	HARDWOODS
03	PUBLIC "COMMUTER"	SFTWDS + MIXED (S)	811.9	21.1	161.6	811.9	13.8	45.3	7.3	116.3
		HRDWDS + MIXED (H)	103.7	2.8	193.3	103.7	1.8	54.2	1.0	139.1
		TOTAL	915.6	23.9	354.9	915.6	15.6	99.5	8.3	255.4
04	PRIVATE	SFTWDS + MIXED (S)	229.6	101.3	176.6	229.6	3.9	28.0	97.4	148.6
		HRDWDS + MIXED (H)	79.9	35.2	380.4	79.9	1.4	60.4	33.8	320.0
		TOTAL	309.5	136.5	557.0	309.5	5.3	88.4	131.2	468.6
	PUBLIC "COMMUTER"	SFTWDS + MIXED (S)	415.9	47.8	111.1	415.9	42.9	35.6	4.9	75.5
		HRDWDS + MIXED (H)	96.4	11.1	215.6	96.4	9.9	70.0	1.2	145.6
		TOTAL	512.3	58.9	326.7	512.3	52.8	105.6	6.1	221.1
	PUBLIC LUMBER AND PULP	SFTWDS + MIXED (S)	1 400.0	22.4	327.6	1 400.0	7.4	26.5	15.0	301.1
		HRDWDS + MIXED (H)	376.3	5.7	737.1	376.3	1.9	59.5	3.8	677.6
		TOTAL	1 776.3	28.1	1 064.7	1 776.3	9.3	86.0	18.8	978.7
05	PRIVATE	SFTWDS + MIXED (S)	225.0	136.8	113.4	225.0	4.5	52.5	132.3	60.9
		HRDWDS + MIXED (H)	62.0	37.7	315.2	62.0	1.3	145.5	36.4	169.7
		TOTAL	287.0	174.5	428.6	287.0	5.8	198.0	168.7	230.6
	PUBLIC "COMMUTER"	SFTWDS + MIXED (S)	-	-	-	-	-	-	-	-
		HRDWDS + MIXED (H)	3.0	0.1	41.9	3.0	0.1	12.2	-	29.7
		TOTAL	3.0	0.1	41.9	3.0	0.1	12.2	-	29.7
06	PRIVATE	SFTWDS + MIXED (S)	158.2	151.9	192.2	158.2	-	87.9	151.9	104.3
		HRDWDS + MIXED (H)	77.5	74.8	643.6	77.5	-	294.1	74.8	349.5
		TOTAL	235.7	226.7	835.8	235.7	-	382.0	226.7	453.8

Harvest, allowable cut and availability
of gross merchantable volumes i.b. by
region and management area

(000 m^3)

REGION	MANAGEMENT AREA	STANDS	ALLOWABLE CUT			HARVEST			AVAILABILITY	
			bF,S, jP	OTHER SOFTWOODS	HARDWOODS	bF,S, jP	OTHER SOFTWOODS	HARDWOODS	OTHER SOFTWOODS	HARDWOODS
06	PUBLIC "COMMUTER	SFTWDS + MIXED (S)	724.2	120.2	318.6	724.2	25.3	84.4	94.9	234.2
		HRDWDS + MIXED (S)	161.3	26.7	523.4	161.3	5.6	139.0	21.1	384.4
		TOTAL	885.5	146.9	842.0	885.5	30.9	223.4	116.0	618.6
07	PRIVATE	SFTWDS + MIXED (S)	179.6	190.0	187.5	179.6	1.8	87.0	188.2	100.5
		HRDWDS + MIXED (H)	67.5	71.4	575.9	67.5	0.7	266.6	70.7	309.3
		TOTAL	247.1	261.4	763.4	247.1	2.5	353.6	258.9	409.8
	PUBLIC "COMMUTER"	SFTWDS + MIXED (S)	170.0	118.5	116.3	170.0	53.8	40.1	64.7	76.2
		HRDWDS + MIXED (H)	228.4	159.4	1 319.8	228.4	72.4	455.6	87.0	864.2
		TOTAL	398.4	277.9	1 436.1	398.4	126.2	495.7	151.7	940.4
	PUBLIC LUMBER AND PULP	SFTWDS + MIXED (S)	745.9	94.7	296.1	745.9	63.6	28.9	31.1	267.2
		HRDWDS + MIXED (H)	279.1	35.6	638.4	279.1	23.9	62.3	11.7	576.1
		TOTAL	1 025.0	130.3	934.5	1 025.0	87.5	91.2	42.8	843.3
08	PRIVATE	SFTWDS + MIXED (S)	35.4	1.5	16.5	35.4	0.4	4.1	1.1	12.4
		HRDWDS + MIXED (H)	22.1	0.9	101.8	22.1	0.2	25.6	0.7	76.2
		TOTAL	57.5	2.4	118.3	57.5	0.6	29.7	1.8	88.6
	PUBLIC "COMMUTER"	SFTWDS + MIXED (S)	1 979.1	591.7	825.3	1 979.1	171.4	113.4	420.3	711.9
		HRDWDS + MIXED (H)	272.1	83.1	762.2	272.1	24.0	104.7	59.1	657.5
		TOTAL	2 251.2	674.8	1 587.5	2 251.2	195.4	218.1	479.4	1 369.4
	PUBLIC LUMBER AND PULP	SFTWDS + MIXED (S)	4 182.8	108.7	610.7	4 182.8	58.5	54.3	50.2	556.4
		HRDWDS + MIXED (H)	270.9	7.3	597.4	270.9	3.9	53.1	3.4	544.3
		TOTAL	4 453.7	116.0	1 208.1	4 453.7	62.4	107.4	53.6	1 100.7

Harvest, allowable cut and availability
of gross merchantable volumes i.b. by
region and management area

(000 m^3)

REGION	MANAGEMENT AREA	STANDS	ALLOWABLE CUT			HARVEST			AVAILABILITY	
			bF,S, jP	OTHER SOFTWOODS	HARDWOODS	bF,S, jP	OTHER SOFTWOODS	HARDWOODS	OTHER SOFTWOODS	HARDWOODS
08	PUBLIC	SFTWDS + MIXED (S)	-	-	-	-	-	-	-	-
	PULP	HRDWDS + MIXED (H)	-	25.9	40.0	-	-	-	25.9	40.0
	TOTAL		-	25.9	40.0	-	-	-	25.9	40.0
09	PRIVATE	SFTWDS + MIXED (S)	124.7	5.5	28.6	124.7	-	7.3	5.5	21.3
		HRDWDS + MIXED (H)	8.4	0.4	15.7	8.4	-	4.0	0.4	11.7
		TOTAL	133.1	5.9	44.3	133.1	-	11.3	5.9	33.0
	PUBLIC	SFTWDS + MIXED (S)	579.3	2.9	50.4	579.3	0.5	3.1	2.4	47.3
	"COMMUTER"	HRDWDS + MIXED (H)	89.4	0.5	154.5	89.4	0.1	9.6	0.4	144.9
		TOTAL	668.7	3.4	204.9	668.7	0.6	12.7	2.8	192.2
	PUBLIC	SFTWDS + MIXED (S)	1 771.1	3.5	180.6	1 771.1	2.2	5.1	1.3	175.5
	LUMBER AND	HRDWDS + MIXED (H)	33.5	-	47.5	33.5	-	1.3	-	46.2
	PULP	TOTAL	1 804.6	3.5	228.1	1 804.6	2.2	6.4	1.3	221.7
	PUBLIC	SFTWDS + MIXED (S)	-	-	-	-	-	-	-	-
	PULP	HRDWDS + MIXED (H)	26.6	-	65.3	26.6	-	-	-	65.3
		TOTAL	26.6	-	65.3	26.6	-	-	-	65.3

APPENDIX 2

Production and use of wood residues,
by administrative region, type of residues,
and industrial sector

Production and utilization of wood residues

Type of residues: Bark and rejects

Industrial sector: Pulp and paper

ADMINISTRATIVE REGION	CURRENT SITUATION			EXPECTED SITUATION		
	PRODUCTION	ENERGY USE	PURCHASE (SALE)	PRODUCTION	ENERGY USE	PURCHASE (SALE)
	(o.d.t.)(1)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)
01	71 111	126 111	55 000	116 111	325 066	208 955
02	81 126	179 746	98 620	85 098	279 860	194 762
03	102 345	82 096	13 605	109 148	174 508	65 360
04	156 301	131 824	10 896	156 301	333 977	177 676
05	36 280	79 816	43 536	45 350	107 479	62 129
06	5 454	-	-	5 454	5 454	-
07	125 782	130 317	4 535	222 945	241 085	18 140
08	59 434	113 839	54 405	59 434	213 839	154 405
09	27 210	40 815	13 605	27 210	63 490	36 280
TOTAL	665 043	884 564	294 202	827 051	1 744 758	917 707

(1) Oven-dry tonnes

Production and utilization of wood residues

Type of residues: Sawdust and planing chips

Industrial sector: Pulp and paper

ADMINISTRATIVE REGION	CURRENT SITUATION			EXPECTED SITUATION		
	PRODUCTION	ENERGY USE	PURCHASE (SALE)	PRODUCTION	ENERGY USE	PURCHASE (SALE
	(o.d.t.) (1)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)
01	-	31 200	31 200	-	73 405	73 405
02	-	43 512	43 512	-	102 188	102 188
03	-	-	-	-	36 525	36 525
04	-	3 540	3 540	-	58 506	58 506
05	-	22 675	22 675	-	29 931	29 931
06	-	-	-	-	-	-
07	4 082	8 617	4 535	4 082	17 687	13 605
08	-	36 280	36 280	-	36 280	36 280
09	-	22 675	22 675	-	49 885	49 885
TOTAL	4 082	168 499	164 417	4 082	404 407	400 325

(1) Oven-dry tonnes

Production and utilization of wood residues

Type of residues: Bark and rejects

Industrial sector: Sawmills

ADMINISTRATIVE REGION	CURRENT SITUATION			EXPECTED SITUATION		
	PRODUCTION	ENERGY USE	PURCHASE (SALE)	PRODUCTION	ENERGY USE	PURCHASE (SALE)
	(o.d.t.)(1)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)
01	84 463	11 156	(26 600)	84 918	10 884	(26 600)
02	274 433	-	(127 646)	274 433	-	(196 578)
03	37 920	6 525	-	37 920	6 525	-
04	20 826	5 814	-	20 826	7 064	(13 762)
05	30 032	5 262	(17 967)	30 032	5 262	(17 967)
06	7 082	3 000	-	7 082	3 000	-
07	8 175	6 359	-	8 175	6 359	-
08	337 448	36 678	(7 500)	337 448	36 678	(28 135)
09	32 442	-	-	40 605	-	(27 000)
TOTAL	832 821	74 794	(179 713)	841 439	75 772	(310 042)

(1) Oven-dry tonnes

Production and utilization of wood residues

Type of residues: Sawdust and planing chips

Industrial sector: Sawmills

ADMINISTRATIVE REGION	CURRENT SITUATION			EXPECTED SITUATION		
	PRODUCTION (o.d.t.)(1)	ENERGY USE (o.d.t.)	PURCHASE (SALE) (o.d.t.)	PRODUCTION (o.d.t.)	ENERGY USE (o.d.t.)	PURCHASE (SALE) (o.d.t.)
01	129 655	1 814	(72 060)	129 655	1 814	(72 060)
02	324 680	35 781	(121 072)	324 680	37 595	(177 306)
03	114 912	42 246	(17 685)	114 912	44 816	(17 685)
04	24 489	7 256	(17 233)	24 489	7 256	(17 233)
05	49 810	5 443	(43 035)	49 810	5 443	(43 035)
06	17 966	12 977	(4 082)	17 966	12 977	(4 082)
07	59 075	40 899	(10 908)	69 075	50 899	(10 908)
08	433 776	45 909	(374 292)	433 776	46 816	(373 385)
09	44 384	-	(33 500)	60 710	5 442	(33 500)
TOTAL	1 198 747	192 325	(693 867)	1 225 073	213 058	(749 194)

(1) Oven-dry tonnes

Production and utilization of wood residues

Type of residues: Unbarked chips

Industrial sector: Pulp and paper

ADMINISTRATIVE REGION	CURRENT SITUATION			EXPECTED SITUATION		
	PRODUCTION	ENERGY USE	PURCHASE (SALE)	PRODUCTION	ENERGY USE	PURCHASE (SALE)
	(o.d.t.)(1)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)	(o.d.t.)
01	7 200	7 200	-	22 200	22 200	-
02	-	-	-	-	-	-
03	3 628	3 628	-	45 350	45 350	-
04	-	-	-	-	-	-
05	-	-	-	-	-	-
06	-	-	-	-	-	-
07	-	-	-	-	-	-
08	-	-	-	-	16 320	16 320
09	-	-	-	-	-	-
TOTAL	10 828	10 828	-	67 550	83 870	16 320

(1) Oven-dry tonnes

APPENDIX 3

Biomass volumes by compilation blocks and study units

Appendix 3 is available, by written request, from:

ENFOR Program
Laurentian Forest Research Centre
1080, Route du Vallon, P.O. Box 3800
Sainte-Foy, Que.
G1V 4C7

This appendix is composed of 204 pages of computer printouts. An example can be found on page 7. It contains basic data and calculations used for this work and is mainly of local interest.

Canada