Minnesota Wood

Residue Studies

CONDUCTED

BY

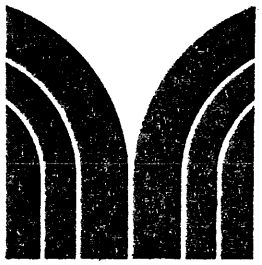
THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES

IN AGREEMENT

WITH

THE MINNESOTA ENERGY AGENCY

NOVEMBER 1980



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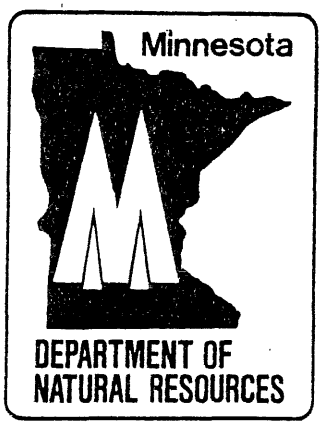

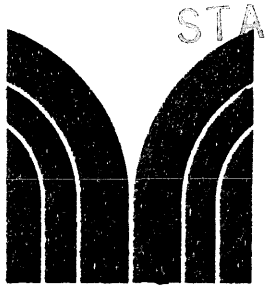

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ABSTRACT

This document is a compilation of five extensive studies into the feasibility of utilizing Minnesota's wood resource for energy. The intent was to assess the immediate and short term potential of using wood and wood residues for energy. These studies show that there are nearly 3 million cord equivalents of wood materials currently available for fuel. The fuel value of this quantity is equivalent to one-third of the total energy consumption for residential heating in Minnesota in 1978. The amount of surplus residues available for fuel will not change significantly within the next 5 years.

FORWARD

These four residue projects were conducted by the Minnesota Department of Natural Resources (DNR), Division of Forestry, with the cooperation and support of the Minnesota Energy Agency (MEA) and the Legislative Commission on Minnesota Resources (LCMR).

The Division of Forestry expresses their appreciation to the forestry consultants who were responsible for the collection of information, organizing, and coordinating the data to satisfy the goals and objectives of the projects. The consultants are:

Peggy Coleman, Project Coordinator, St. Paul
Jerrilyn LaVarre Thompson, St. Paul
Christopher Conway, St. Paul
Marilyn Griffith, St. Paul
Denise Mitten, St. Paul

The MEA recognized that an intensive study of wood residue was important in order for them to determine the overall energy supplies for Minnesota. The MEA was also instrumental in coordinating the funding for these projects through LCMR. The invididuals who supported, reviewed, and encouraged these projects are:

Ronald Visness, Assistant Director,
Alternative Energy, MEA, St. Paul
Dave Givers, MEA, St. Paul
Mary Lesch, MEA, St. Paul

The primary processors survey and the logged area residue survey required a considerable amount of field data. This data was collected by the DNR-Forestry Regional Forest Product Utilization Specialists. They are:

Phil Vieth, St. Paul
Carl Prosek, Grand Rapids
Dave Martodam, Grand Rapids
John Mathweg, Bemidji
Bob Pajala, Bemidji
Tom Kraemer, Brainerd

The overall responsibility of directing, assisting and reviewing these projects belonged to the Forest Resources and Products Section, DNR-Forestry, These individuals are:

Dr. Chung-Muh Chen, Biometrician, St. Paul
Wayne Hanson, Section Supervisor, St. Paul
Eugene Jamrock, Scaling Specialist, Grand Rapids
John Krantz, Utilization and Marketing, St. Paul

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EXECUTIVE SUMMARY

The use of timber and wood residues for energy purposes has been growing at a rapid rate. Decisions which promote wood as an energy resource should be based upon a correct assessment of accurate data. The Minnesota Department of Natural Resources - Division of Forestry, in cooperation with the Minnesota Energy Agency conducted a comprehensive study of wood residue currently and potentially available for use as fuelwood. All of the readily available sources of residue were studied. The general conclusion is that wood residues could supply a substantial portion of the energy needed for residential heating now and in the near future.

PROJECT DESCRIPTION AND HIGHLIGHTS

A brief description of the five projects and a highlight of each is as follows:

1) Resource Analysis - The current and projected supply of wood for fuel available from standing trees, tops and limbs from annual harvest, land clearing, and other sources was determined. The wood energy available from logging residues, low productivity forests, and land clearing during 1979 could have supplied twice the amount of wood that was actually burned for residential heating during the 1979-80 heating season.

2) Logged Area Residue Survey - A measurement was made of the volume and type of wood residue remaining on site after harvest was completed by loggers. A survey of 1300 acres on 79 sites by timber type and logging methods was conducted. Approximately 5 cords of residue per acre remain following an aspen harvest and over 10 cords per acre are available following a hardwood clearcut operation.

3) Primary and Secondary Processors Residue Survey - The location, volume, and type of residue material available for energy following initial roundwood and lumber processing was established through on-site contact with over 650 primary processors. It was found that approximately one-third of the residue generated by primary processors is unused and available for energy. A phone survey of over 800 secondary processors found that wood residues for energy from secondary manufacturing is concentrated in the Twin Cities area.

4) Fuelwood Vendor Survey - A survey of 376 potential fuelwood vendors was conducted by MEA and was designed to coordinate the needs of wood users with the source and type of supply. A directory of fuelwood vendors resulted. Results indicate that the majority of fuelwood consumed

is harvested by individuals cutting wood for their own use.

5) Logging and Transportation Cost Study - Fuelwood harvesting costs, by type of harvesting method, was determined. It was concluded that tops and limbs should be removed in conjunction with, rather than following commercial logging to be cost effective. The transportation costs of fuelwood, for both commercial loggers as well as the individual firewood user was studied. Cost-effective travel distance for the individual is quite limited.

The graph on Page 3 summarizes the wood and wood residues produced in Minnesota that are currently unused and are available for wood energy.

CONCLUSIONS

These studies show that in 1980 there are nearly 3,000,000 cord equivalents of wood residues currently available for use as fuelwood.

This volume represents a total energy potential of about 33% of the 1978 energy consumption for residential heating in Minnesota. It could have even greater significance in areas outside the Twin City area where energy from wood has its greatest potential.

However, at the level of production shown on the graph, not all of this material will be in the conventional round form that is presently used. Some of this wood will be available for use only as chipped material. These conditions will require major changes in the fuelwood industry.

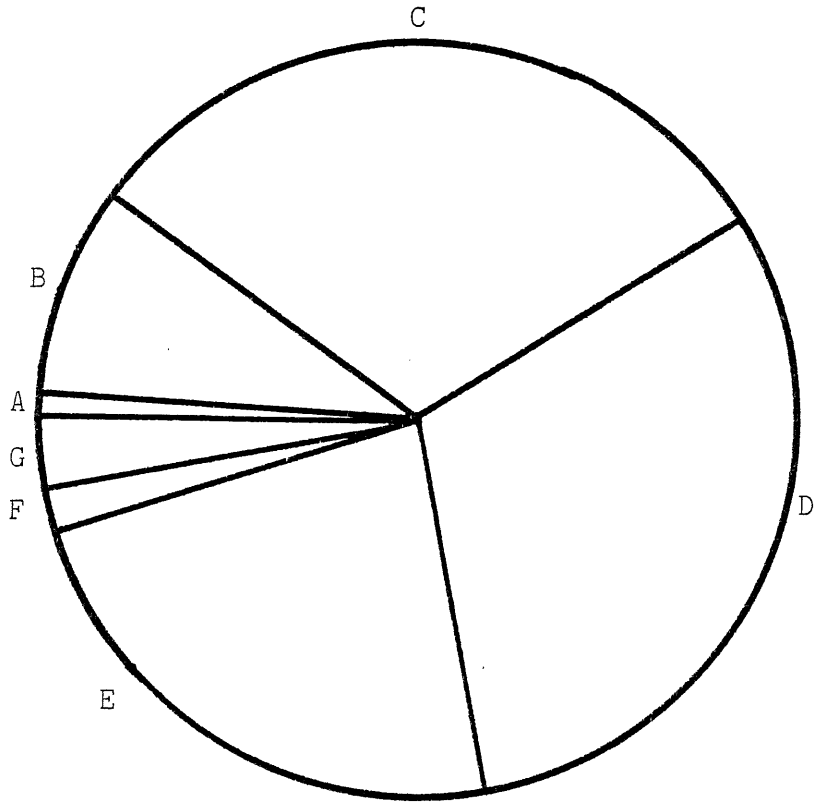
As the demand for Minnesota's wood resource by forest industry continues to increase, generated residue will also increase. However, changes in the technology of harvesting and processing will probably lead to greater utilization of these additional residues by the wood products industries and there will not be much change in the amount of surplus residues available within the next five years.

RECOMMENDATIONS

A further follow-up to these studies should consider the following:

1) An additional analysis of Minnesota's timber demand and supply to the year 2000 and 2020 which would further identify the amount and type of wood available for energy and other competitive uses for the resource base.
2) Changes are required in equipment and harvesting methods in order to utilize large volumes of timber and logging residues. Low interest loans and investment credits could encourage change in the logging industry. An investigation of the effects of loans and credits should be conducted.
3) Support a demonstration program that would identify improved handling, storage, processing and drying systems of residue.

TOTAL WOOD AND WOOD RESIDUES AVAILABLE FOR ENERGY MINNESOTA - 1980

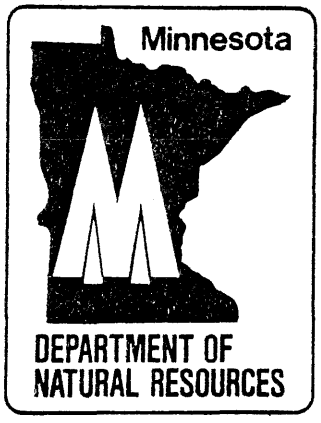


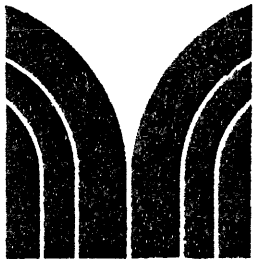
	SOURCE OF WOOD FUEL	CORD EQUIVALENTS	HEATING VALUES (MILLION BTU)
A.	RESIDUE FROM SECONDARY WOOD PRODUCTS MANUFACTURERS - Industries which use lumber and other finished wood materials to produce furniture, pallets, boxes, millwork, homes, etc.	14,000	500,000
B.	RESIDUE FROM PRIMARY WOOD PRODUCTS MANUFACTURERS - Industries which use roundwood or wood chips to produce lumber, poles and posts, chips, waferboard, paper, etc.	290,000	4,500,000
C.	RESIDUE FROM ANNUAL HARVEST - The unmerchantable volumes of tops and limbs, cull trees, etc., which result from timber harvesting.	930,000	16,100,000
D.	HARVEST OF LOW PRODUCTIVITY FORESTS - The utilization of biomass on lands which cannot be economically managed for timber production.	910,000	15,700,000
E.	VOLUME FROM TIMBER REMOVED BUT CURRENTLY UNUSED - Volume available from land clearing, timber stand improvement projects such as thinning, etc.	670,000	11,600,000
F.	VOLUME AVAILABLE FROM ANNUAL MORTALITY - Volume from trees which are killed by insects, disease, fire, etc.	60,000	1,100,000
G.	VOLUME FROM HARVEST OF NON-COMMERCIAL FOREST LANDS - Volume from harvest of urban forest, pasture land, etc.	80,000	1,400,000
	TOTAL	2,954,000	50,900,000

MINNESOTA RESOURCE ANALYSIS
(BIOMASS ASSESSMENT)
- 1979 -

Project #1

November 1980





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ABSTRACT

This report summarizes the results of an analysis of Minnesota's forest resources to determine the volumes of biomass available for wood fuel. The analysis concludes that material recoverable from low productivity forests, timber harvesting residues, land clearing, urban forests, and other sources can provide over 2.5 million cord equivalents of wood per year through the short-term future.

1 Resource Analysis (Biomass Assessment)

1.A INTRODUCTION

Since the advent of the energy crisis, there has been continuing research on the technologies of converting biomass into useable energy. Since forests cover one third of Minnesota, wood is a possible fuel source to consider. This report analyzed five different wood fuel sources. They are: (1) the unmerchantable residue remaining following harvesting operations, (2) the harvest of timber from low productive forest land where soil quality and growth factors limit its value for industry, (3) the volume of timber removed and not utilized from land clearing, timber stand improvement, and other changes in land use, (4) the volume which is lost annually by disease, insects, fire, and other damages, and (5) the volume available from the harvest of noncommercial forest lands such as urban areas, farm woodlots and windbreaks, pastureland, etc.

Objectives of the Resource Analysis Study

The objective of the resource analysis study was to determine the amount of biomass material available annually for wood fuel while maintaining the integrity of the State's forest resources. This determination was made based on the standards of merchantable wood material currently utilized by the wood industries in Minnesota.

Study Methods

This study analyzed inventory data from the 1977 Minnesota Forest Survey in addition to 1979 harvest volumes and acreages for Minnesota. Realistic assessments and consideration were then determined from the base data for each of the five source classes. These determinations and sequence of calculations are outlined in the appendix of this report.

1.B SUMMARY OF FINDINGS

Minnesota's Total Timber Resource (Table 1)

The total wood biomass represented by Minnesota's forests is shown in Table 1. This total gross volume is shown only for comparison purposes and includes all forest types from all land ownerships in Minnesota.

TABLE 1. MINNESOTA'S TOTAL TIMBER RESOURCE

	UNIT I	UNIT 2	UNIT 3	UNIT 4	STATE
VOLUME[1] (thousand cu.ft.)	11,789,049	13,717,242	4,044,982	1,028,998	30,580,271
BIOMASS[2] (green tons)	250,790,978	302,149,008	97,784,090	23,971,579	674,695,655
FUEL VALUE[3] (million BTU)	2,131,723,313	2,568,266,568	831,164,765	203,758,422	5,734,913,068

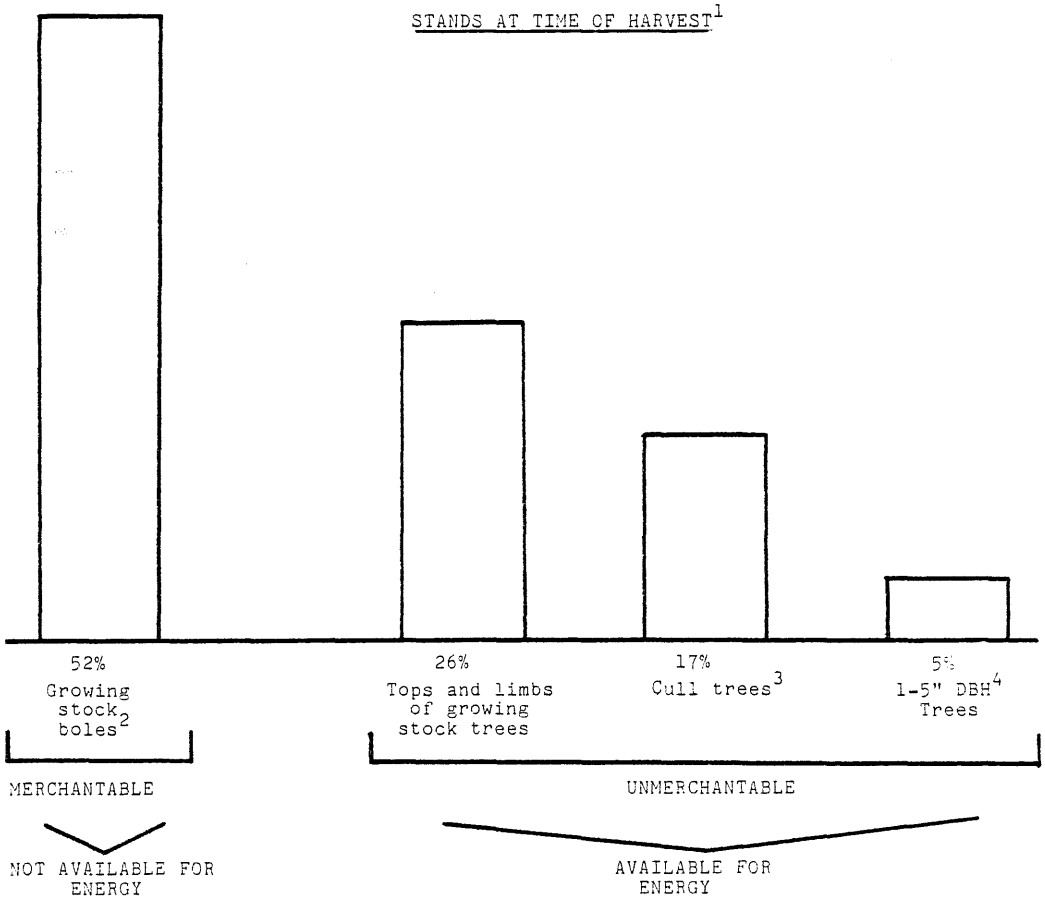
1. Source: NCFES, Table BIV5 (all live volume).
2. Source: NCFES, Table BIO5 (all live biomass).
3. Assumes 50% moisture content (green weight basis): calculated as (green tons) x (1 dry ton/2 green tons) x (17 million BTU/dry ton).

Wood Recoverable Annually For Energy Use (Figure 1, Table 2, Figure 2)

Figure 1 shows the approximate amount of merchantable and unmerchantable wood available in a forest stand at the time of harvest. The unmerchantable portion is considered residue available for another product use, possibly wood fuel.

The figure shows that in an average stand of harvest age, slightly less than half of the total biomass is unmerchantable and available for energy.

FIGURE 1 - COMPOSITION OF MINNESOTA FOREST STANDS AT TIME OF HARVEST[1]



1. Source: NCFES, Table BI04 (all live biomass by component).
2. Growing stock boles include the volume of all trees of commercial species greater than 5" in diameter from a one foot stump to a four inch diameter top.
3. Includes trees of undesirable species or form.
4. Diameter at breast height.

Table 2 summarizes the volume of wood fuel which is recoverable annually for evergy use from each of the five major source classes over the next ten years.

TABLE 2
UNIT ALL

MINNESOTA
WOOD RECOVERABLE ANNUALLY FOR ENERGY USE[1]
(Thousand Cubic Feet)

SOURCE OF BIOMASS	YEAR AND METHOD OF RECOVERY				
	1980		1985		1990
	Manual[2] Recovery (roundwood)	Mechanical[3] Chipping	Manual[2] Recovery (roundwood)	Mechanical[3] Chipping	Residue Amount
Residue from actual and projected annual harvest[4]	52,800	84,600	68,200	109,100	same
Harvest of low productivity forests[5]	71,800	82,600	71,800	82,600	same
Volume from timber "removed" but not used[6]					
- Merchantable timber	41,200	41,200	28,700	28,700	less
- Residue	12,300	19,700	12,300	19,700	
Annual mortality[7]	4,810	5,570	9,620	11,140	more
Volume available from non-commercial forest land[8]					
- Urban	6,370	7,340	6,370	7,340	less
- Other	12,920	--	12,920	--	
TOTAL AVAILABLE	202,200	241,010	209,910	258,580	

1. All figures based on known merchantable volumes and calculated as follows: Merchantable volume x 1.37 = Residue volume.
2. Assumes 25% of the residual volumes are recoverable by manual harvesting methods.
3. Assumes 40% of the residual volumes are recoverable by mechanical tree chipping.
4. Based on 1979 actual harvest and projected through 1985 (Appendix Worksheet # 6-11).
5. Includes forest stands on poor sites (low site index) that cannot be economically managed for coventional forest products. The annual figures are based on a 20 year liquidation harvest schedule (Appendix Worksheet # 12-23).
6. Wood removed from commercial forest land but not utilized as a product. This includes land clearing, right of way clearing, timber stand improvement and reclassification of commercial forest land (Appendix Worksheet # 24).
7. Assumes 2.5 recovery of annual mortality in forest stands due to scattered wide spread distribution patterns. The amount increases due to increased harvesting which creates additional access.
8. Assumes .05 cords per acre annually available from trees on urban land based on a 60 year rotation and .2 cords per acre annually available on other non-commercial forest land(Appendix Worksheet# 25).

A summary of Table 2 shows that:

1. The harvest of low productivity forests could potentially yield one-third of the annual recovery of wood fuel over the next 10 years and, at the same time, allow for inexpensive site preparation on those sites where conversion to more productive tree species is planned.

2. The timber removed in agricultural land clearing, residential development, right-of-way clearing, and timber stand improvement is often burned and buried. If available for fuel, this material could account for one-third of the annual wood fuel supply.

3. The trees lost through disease, insects, and other natural mortality currently yield only a small portion for energy use due to their scattered, widely dispersed location.

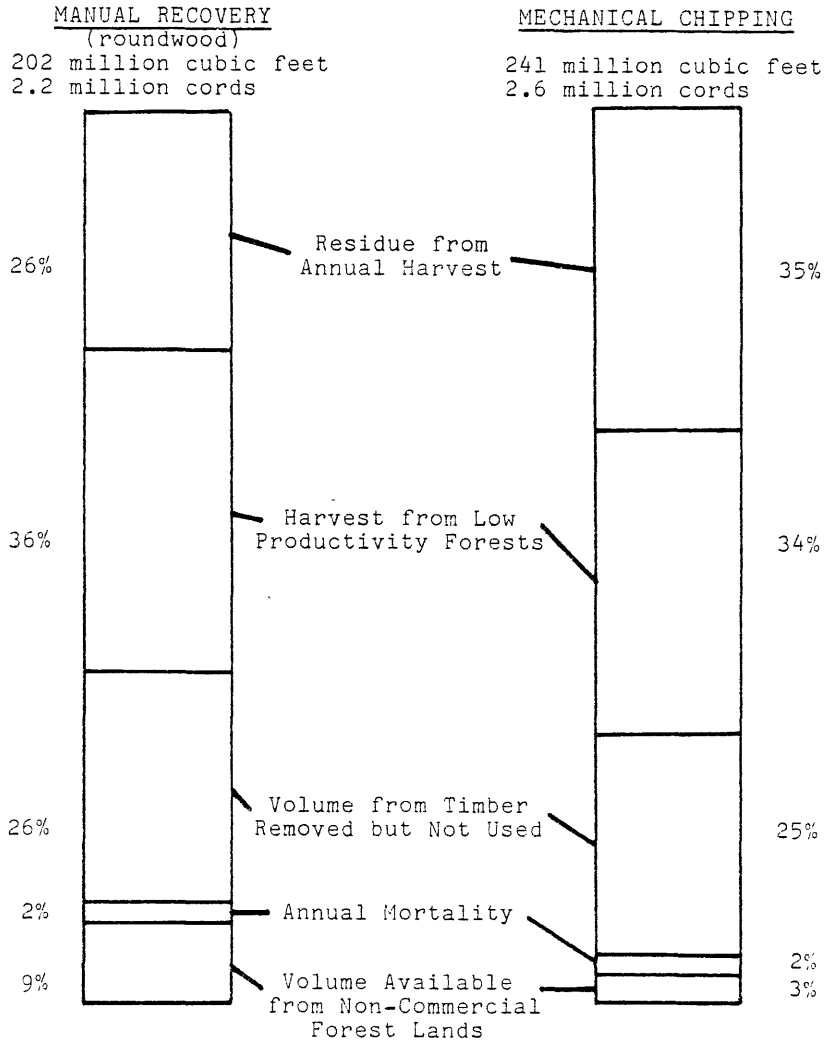
4. The residue remaining on a site following harvest can yield one-third of the wood volume available for fuel. However, much of this residue is of smaller size than traditionally used for residential heating.

Figure 2 diagrams the total volume of wood recoverable for energy use by source and method of recovery.

FIGURE 2

VOLUME AND SOURCES OF WOOD RECOVERABLE FOR ENERGY USE

(In Percent of Total from Each Source)
1980 Estimates



1.C CONCLUSIONS (Table 3)

Table 3 shows the total potential wood fuel supply by method of recovery.

TABLE 3 MINNESOTA'S POTENTIAL ANNUAL TIMBER RESOURCE AVAILABLE FOR ENERGY USE

	YEAR AND METHOD OF RECOVERY			
	1980		1985	
	MANUAL[6]	CHIPPING[7]	MANUAL[6]	CHIPPING[7]
VOLUME(THOUSAND CU.FT.)[1]	202,200	241,000	209,900	258,600
BIOMASS (GREEN TONS)[2]	4,523,200	5,391,400	4,695,700	5,784,400
FUEL VALUE (MILLION BTU)[3]	38,447,000	45,827,000	39,913,000	49,168,000
CORD EQUIVALENTS[4]	2,222,000	2,648,000	2,307,000	2,842,000
EQUIVALENT GALLONS OF #2 FUEL OIL[5]	252,000,000	300,000,000	261,000,000	322,000,000

1. FROM TABLE 2
2. CALCULATED BY ASSUMING 86% OF VOLUME IS WOOD WITH AN AVERAGE DENSITY OF 46 LB/FT^3 AND 14% OF VOLUME IS BARK WITH A DENSITY OF 37 LB/FT^3.
3. CALCULATED AS (GREEN TONS)X(1DRY TON/2 GREEN TONS)X(17 MILLION BTU/DRY TON).
4. CALCULATED AS VOLUME (THOUSAND CU.FT.)÷ 91 FT^3/CORD.
5. ASSUMES AVERAGE BURNING EFFICIENCIES FOR BOTH THE FUELS.
6. ASSUMES 25% OF AVAILABLE VOLUMES ARE RECOVERABLE BY MANUAL HARVESTING METHODS.
7. ASSUMES 40% OF AVAILABLE VOLUMES ARE RECOVERABLE BY MECHANICAL TREE CHIPPING.

A summary of Table 3 shows that:

1. The volume available from chipping in 1980 represents a total energy potential equal to approximately 28% of the total residential energy consumption for home heating in Minnesota.

2. By 1985, the increased harvesting of merchantable timber will yield additional logging residue. However, changes in harvesting technology will probably utilize this potential additional residue.

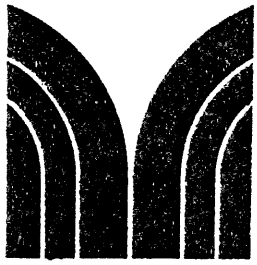
3. Approximately two-thirds (66%) of the residue available for fuel in Minnesota is located in the northern two survey units in Minnesota (Unit 1 and 2).

MINNESOTA LOGGED AREA RESIDUE ANALYSIS

- 1979 -

Project #2

November 1980



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ABSTRACT

This report summarizes the results obtained by measuring the volume and type of wood residue remaining on a site following the harvest of merchantable timber. The analysis concludes that the volume of residue available for wood fuel from harvested sites in 1979 totaled nearly 600,000 cord equivalents. The totals for different forest types and harvesting methods common to Minnesota are also presented in this report.

2 Logged Area Analysis

2.A INTRODUCTION

Definition of Logged Area Residue

Logged area residue is the wood material remaining on a site after the merchantable timber has been harvested. The types of materials which make up the logged area residue volume include: tops of trees, branches, leaves of harvested trees, whole trees too small to be harvested, wood of species which are not marketable, and wood with defects such as poor form or decay.

Currently most of the logged area residue is not utilized and is left on the harvest site. A small portion is being recovered by individuals for firewood.

Objectives of the Logged Area Residue Study

The objective of the logged area residue study was to determine the volume of wood remaining on a site following a harvest operation. The composition of the wood residue by species was also determined since each tree species has varying heat values and desirability for use as a fuel.

Study Methods

Logged areas throughout Minnesota were sampled to get a general picture of statewide logged area residue volumes. Seventy-six geographically distributed logged tracts totaling 1,316 acres were surveyed to measure volumes of wood residue. The statewide sample was broken down into four major timber types: Pine, Spruce-balsam, Aspen-birch, and Northern hardwoods and four common harvesting methods; clearcut shortwood, tree length, full tree, and partial cut, in order to identify the residue volumes under varying situations.

The method used to collect field data was the United States Forest Service line-intersect sampling technique. Briefly, this technique requires the diameter measurement of all logging residue (to a minimum diameter of 2.6") intersected by an established sample line. The sample line is one chain long (66') with an average of 2 lines per acre. The sampling error of our data is well under 10%.

A 20% subsample was taken to record length, potential product, and condition of the wood being measured in order to determine basic characteristics of the residue.

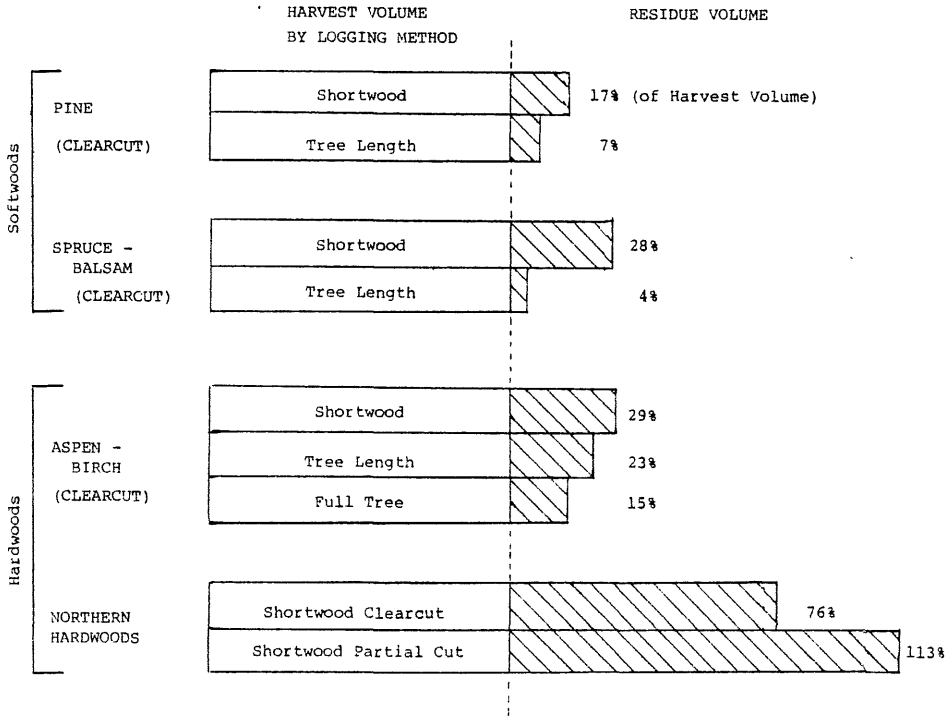
Because the line-intersect method only measures residue on the ground, an additional measurement was made of all standing timber which was included in the harvest area and of the residues piled on the landing site.

2.B SUMMARY OF FINDINGS

Residue per Volume Harvested (Figure 1)

The volume of wood residue following a harvest operation varies according to forest type as well as the harvest method used.

Figure 1. RESIDUE VOLUME GENERATED PER HARVESTED VOLUME



The hardwood forest types generate the greater volumes of residue per volume of timber harvested. The northern hardwood type generates the greatest relative volumes of residue due primarily to the large crowns in proportion to the tree stems.

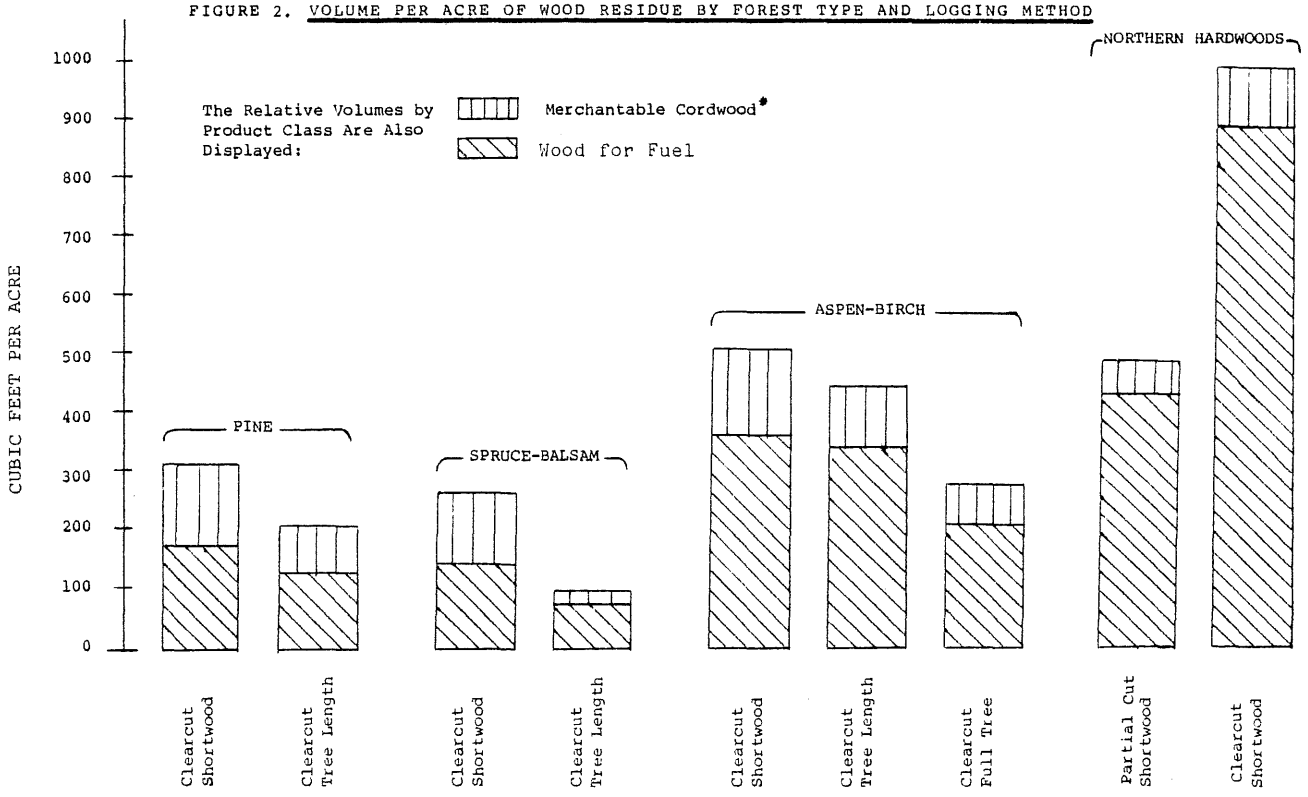
The tree length and full tree harvest methods which employ improved harvest techniques, generate less residue volumes per volume harvested regardless of forest type.

In the northern hardwood types, which are either partially cut or clearcut depending on management needs, much more residue volume than harvest volume is generated when partially cut. (In general, the products recovered from this type preclude the use of tree length and full tree harvest methods).

Residue Volume per Acre (Figure 2)

As expected, the residue volume per acre varies according to forest type and harvest method. Overall the volume is substantial; ranging from one to nearly 10 cords per acre.

FIGURE 2. VOLUME PER ACRE OF WOOD RESIDUE BY FOREST TYPE AND LOGGING METHOD



* Merchantable Cordwood: Roundwood residue that is merchantable according to its size and condition and could have been removed by the logger. It may include other species in the cover type.

Aspen-Birch and the northern hardwood types generate the greatest residue volumes per acre; especially the clearcut northern hardwood type.

The residue volume per acre decreases as the technology for harvesting a greater amount of the tree changes. A significant portion of the residue in all types is merchantable cordwood (4 inches or more in diameter and greater than 8 feet in length) which could have been removed during the harvest for a product other than wood fuel. Factors which cause merchantable wood to remain on the site following harvest include: 1) varying species which are not readily marketable, and 2) a certain amount of inefficiency on the part of the logger. Neither of these contributing factors is expected to change much in the next 10 years.

Residue Volume Generated Annually by Timber Type and Harvest Method. (Table 1)

TABLE 1 TOTAL LOGGED AREA RESIDUE[a] GENERATED FROM TIMBER HARVEST IN MINNESOTA - 1979

FOREST TYPE		LOGGING METHOD	ACRES HARVESTED[b]	RESIDUE GENERATED CU.FT/ACRES	TOTAL LOGGED AREA RESIDUE		
					CUBIC FEET	CORDS[c]	TONS[d]
SOFTWOODS	PINE	SHORTWOOD	11,613	303.9	3,529,200	38,800	62,600
		TREE LENGTH	4,977	213.5	1,062,600	11,700	19,200
	SPRUCE-BALSAM	SHORTWOOD	15,099	276.2	4,170,300	45,800	67,600
		TREE LENGTH	6,471	98.4	636,800	7,000	12,400
	ALL SOFTWOODS	ALL METHODS	38,160	---	9,398,900	103,300	161,800
HARDWOODS	ASPEN-BIRCH	SHORTWOOD	40,548	514.8	20,874,100	229,400	379,500
		TREE LENGTH	20,274	448.3	9,088,800	99,900	157,300
		FULL TREE	6,758	276.8	1,870600	20,500	32,200
	NORTHERN HARDWOODS	SHORTWOOD	3,842	995.6	3,825,100	42,000	89,200
		SHORTWOOD (PARTIAL CUT)	15,368	491.8	7,558,000	83,100	170,700
	ALL HARDWOODS	ALL METHODS	86,790	---	43,216,600	474,900	828,900
ALL TYPES		ALL METHODS	124,950	---	52,615,500	578,200	990,700

a. DOES NOT INCLUDE RESIDUE WITH A DIAMETER SMALLER THAN 2.6 INCHES

b. AREA TAKEN FROM TABLE 2 IN THE APPENDIX AND BROKEN DOWN INTO THE VARIOUS LOGGING METHODS CATEGORIES, DNR PERSONNEL ESTIMATED THAT 30% OF TOTAL HARVEST IS TREE LENGTH, 10% IS FULL-TREE AND THAT 80% OF THE NORTHERN HARDWOODS HARVEST IS BY SHORTWOOD PARTIAL CUT.

c. 91 CUBIC FEET PER CORD.

d. 45% MOISTURE CONTENT (DRY WEIGHT BASIS).

In order to determine the annual amount of logging residues being generated, the number of acres harvested was estimated. The number of acres was then multiplied by the appropriate volume per acre (Worksheets 1-9, Appendix) to show the total annual logged area residue.

The aspen-birch type generated 57% of the total logged area residues in the State in 1979.

Overall the conifer types compose 18% of the total logged area residue volume. They represent only 16% by weight of the total tons of residue.

Future Annual Residue Volumes Expected

The aspen acreage harvested is expected to increase 50% in the next five years while harvest of other types may only slightly increase. Residue volumes will not increase proportionately due to the fact the average volume per acre of the forest stands available for harvest is expected to decrease in the next 20 years. In addition, an increase in the use of tree length and full-tree harvesting to about 50% of all volume harvested is projected by 1990.

2.C CONCLUSIONS

There is a nationwide interest in the utilization of logged area residues. However, no commercial scale operations for recovery of the residues is known. Without a basis for comparison, it is difficult to determine the economic feasibility of residue recovery in Minnesota.

Two possible methods of recovering logged area residues include 1) manual removal of roundwood and 2) mechanical chipping of the residue for fuel. (Residue chips are not desirable for other products because of the bark).

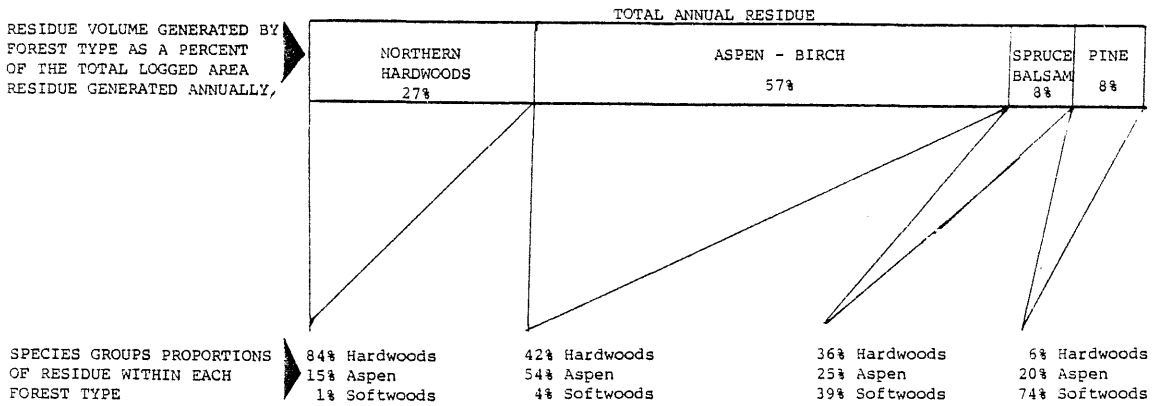
Manual Roundwood Recovery of Residues

The process in which an individual collects residue material using a chainsaw or other light equipment can be defined as manual recovery of roundwood.

This method is presently used on a small scale. Consequently, only the larger diameter and the best species of wood are selectively removed from the logged area. If employed in a commercial firewood collection operation, this method could facilitate 100% recovery of

the measured hardwood residue within each forest type. For example, in the Aspen-Birch type, 42% of the measured volume could be recovered. (Figure 3). As much as 96% of the residue could be recovered if aspen was also removed. (Aspen can be burned as firewood but is currently not a preferred species on the market).

FIGURE 3. SPECIES COMPOSITION OF ANNUAL RESIDUE BY FOREST TYPE



Mechanical Chipping of Residues

The process of mechanically chipping residue or relogging a harvested area involves heavy equipment developed for this purpose. Although much less labor intensive than manual recovery, this process is still fairly costly.

This method of recovering logged area residue has been used on an experimental basis only. Studies conducted in Michigan by the United States Forest Service, although not conclusive, indicate it may be possible to economically produce chips for fuel at least in the Northern Hardwoods forest type where large volumes of residue are generated following harvest. A careful cost analysis followed by a sound market for woodchips as fuel is necessary for wide spread use of this method of recovery.

Although, the processing of shorter-length pieces is limited by existing equipment, relogging slash is still largely experimental and there is much opportunity for development of more efficient machines.

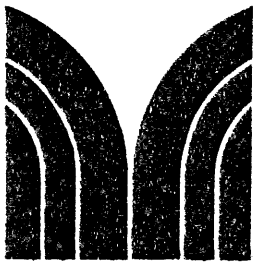
It is estimated that 100% of the residue volume per acre could be recovered by mechanical chipping. This is based on the assumption that an additional 10 to 15% volume could be recovered from wood less than 2.6 inches in diameter. Species would not be a factor once a particular site was in the process of being chipped.

MINNESOTA PRIMARY AND SECONDARY WOOD PROCESSORS RESIDUE SURVEY

- 1979 -

Projects #3A and #3B

November 1980



minnesota energy agency

ABSTRACT

This report summarizes the results of surveys conducted of Minnesota's primary and secondary wood processing industries to determine the location, volume, and type of residue material available for wood fuel following roundwood and lumber processing. Contact with over 600 primary processors found that over one-third of the residue generated - 290,000 cord equivalents in 1979 - is unused and available for energy. A phone survey of over 800 secondary processors found that 14,000 cord equivalents of wood residue is unused and available for energy, the majority of which is located in the Twin City area.

3A PRIMARY WOOD PROCESSORS RESIDUE SURVEY

3A.A INTRODUCTION

Primary Wood Processors Definition

Primary wood processors are those industries which receive and utilize roundwood or chips from roundwood. They manufacture products such as lumber, poles and posts, chips, waferboard, and chipboard. The wood residues generated by these industries grouped in three categories include bark, coarse residues such as slabs, edgings and veneer cores, and fine residues such as sawdust and shavings. The wood used by these industries is received in a raw form, therefore, residue volumes are reported in green tons.

Study Objectives

The objectives of this study were to: (1) identify the primary wood product manufacturers; (2) determine the volumes and types of residues being generated; and (3) determine the current methods of utilization or disposal of the residues. All the calculations to determine residue volumes are based on 1979 production figures for each processor.

Study Methods

Data collection for the 1979 primary processor survey began in April, 1980, and was completed in four months. A survey form adaptable for data processing and computer programming was developed by DNR-Forestry in cooperation with and input from the United States Forest Service and the University of Minnesota. A list of current primary wood processing industries was developed using a number of different sources and previous directories. Most of the processors were contacted by DNR Regional Forest Products Utilization (FPU) Specialists. Data from several primary processors was obtained from the University of Minnesota study by David O'Brien and Steve Sinclair (1980).

Contacts were made with 698 primary wood processors in Minnesota, 606 of which operated and were considered active in 1979 and supplied residue data for this report. This represents approximately 90% of the primary processors in Minnesota. Approximately 95% of the primary wood processor residue generated in Minnesota in 1979 is accounted for by these active mills. A survey of residue generated by tree removal services is not included in this report. It is possible that up to 250,000 green tons of residue was generated in 1979 by tree service companies.

The residue data, for bark, coarse, and fine residues, was directly derived from using previously developed conversion factors applied to the primary processors 1979 production figures. These conversion factors are presented in Appendix C.

Additional data collected which was used to derive residue figures included: type of plant and mill equipment, production figures by conifers, hardwoods, and aspen, radius of operation, years of accumulation of residues, and the disposition of the residue. The survey form is presented in Appendix C.

3A.B SUMMARY OF FINDINGS

The 1979 residue survey results show that 1.4 million green tons of residue were generated by 606 active mills of which 535,000 green tons or 38% was not used.

Residue Generated By County

Figures 1 and 2 show the amount of residue generated by county and the amount of residue not used by county, respectively.

Eighty-five percent of the residue is generated in Units 1 and 2, the primary timber producing regions of Minnesota. Unit 2, the Northern Pine Unit, generates over half of the total residue statewide. Itasca County in Unit 2 generates the most residue, with 310,793 green tons.

The four largest timber processing counties, Itasca, Cass, Carlton, and Koochiching together generate 57% of the total wood residue in the State.

As expected, the largest volumes of non-used residues are also concentrated in Survey Units I and II, with 64% of the unused residues of the State concentrated in the four largest timber processing counties.

Residue Production by Survey Unit and Type of Use

Table 1 shows the total residue production by survey unit and type of use. Statewide, 36% of the residue is currently used as fuel, either within the industry or is provided by them for domestic (residential) use, twenty-five per cent is used for manufacturing fiber products and other non-fuel

FIGURE 1

PRIMARY WOOD PROCESSORS RESIDUE

TOTAL AMOUNT OF RESIDUE GENERATED

(green tons)

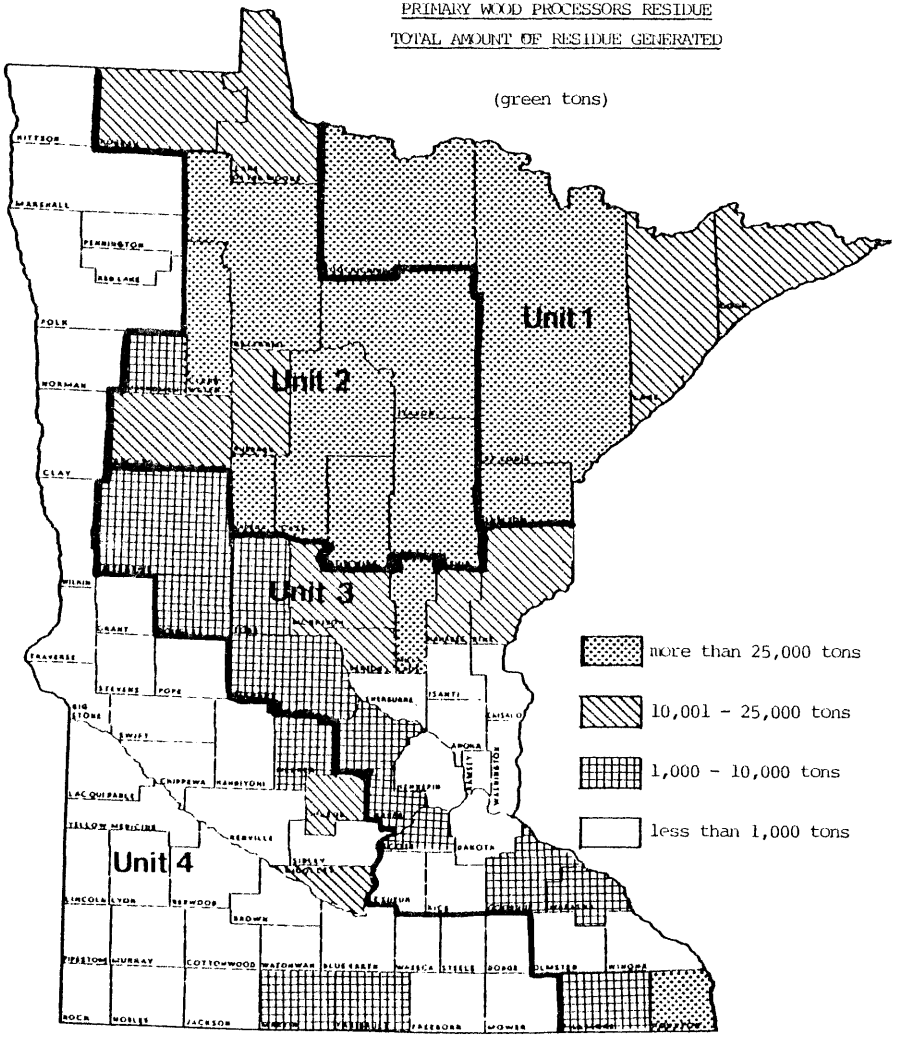


FIGURE 2

PRIMARY WOOD PROCESSORS RESIDUE

AMOUNT OF RESIDUE NOT USED

(green tons)

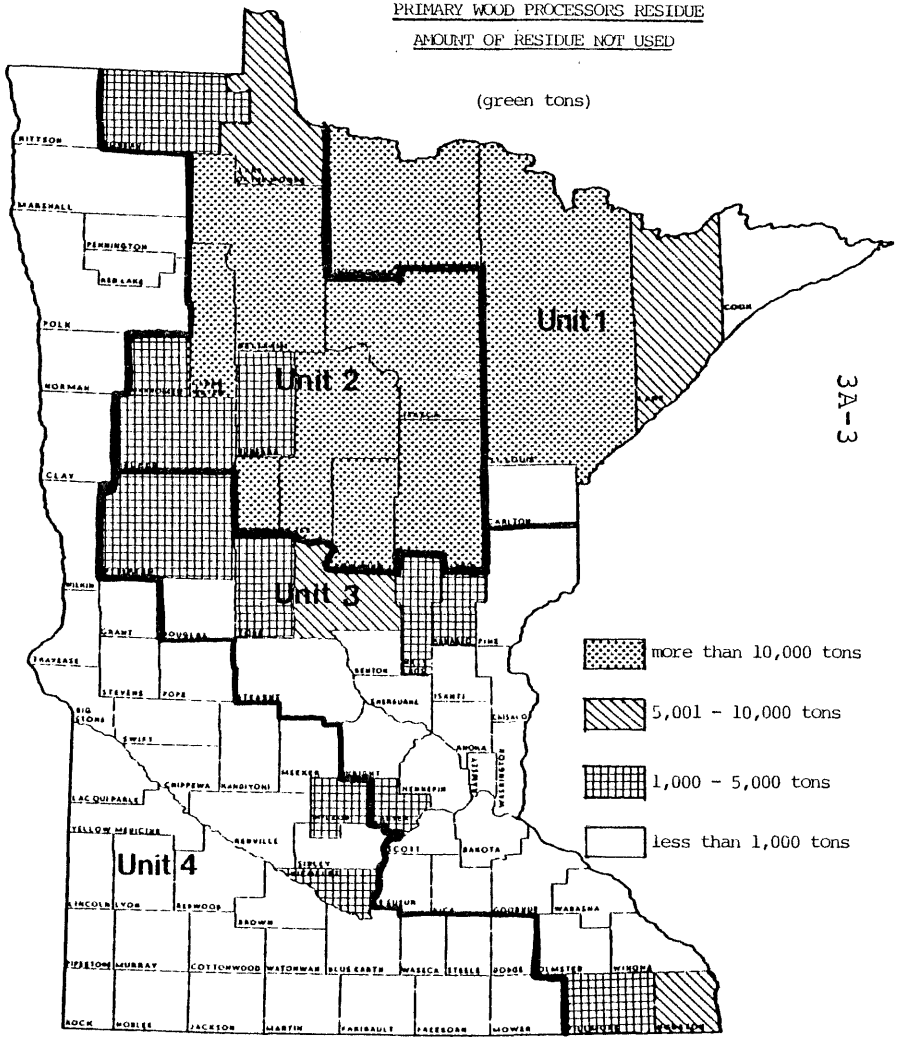
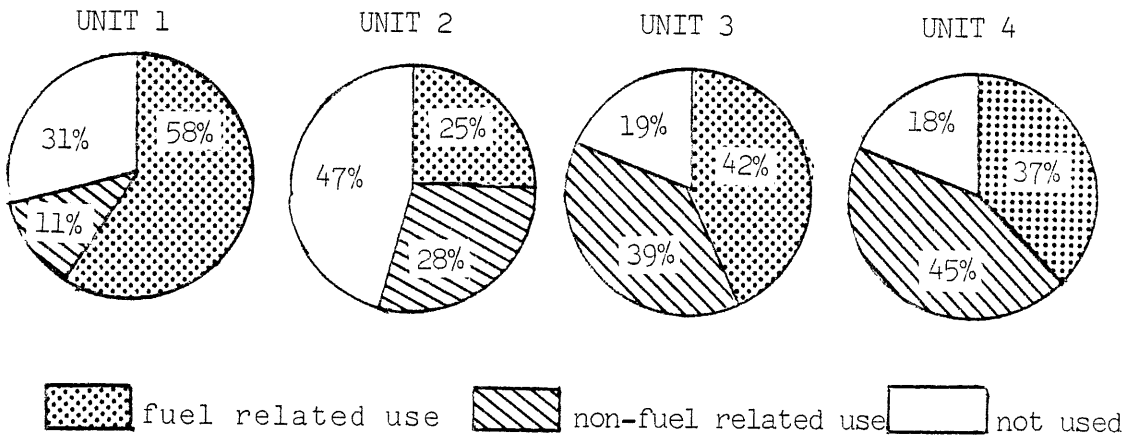


TABLE 1
PRIMARY WOOD PROCESSORS
TOTAL RESIDUE PRODUCTION
By SURVEY UNIT and TYPE OF USE
MINNESOTA - 1979
(green tons)

TYPE OF USE		SURVEY UNIT I	II	III	IV	TOTAL
FUEL Related Uses	This plant	193,621	33,522	15,942	971	244,056
	%	50.6	4.2	8.8	3.1	17.5
	Other plants	11,876	35,074	10,925	27	57,902
	%	3.1	4.4	6.1	.1	4.1
	Domestic use	15,395	129,644	50,390	10,676	206,105
	%	4.0	16.1	27.9	33.9	14.7
TOTAL (fuel)		220,892	198,240	77,257	11,674	508,063
% of Total Residue		57.8	24.7	42.8	37.0	36.3
NON-FUEL Related Uses	Fiber Prod.	40,922	190,783	48,988	3,743	284,436
	%	10.7	23.7	27.2	11.9	20.3
	Other uses	3,118	37,032	20,099	10,452	70,701
	%	.8	4.6	11.1	33.1	5.1
TOTAL (non-fuel)		44,040	227,815	69,087	14,195	355,137
% of Total Residue		11.5	28.3	38.3	45.0	25.4
TOTAL (not used)		117,453	377,756	34,018	5,667	534,894
% of Total Residue		30.7	47.0	18.9	18.0	38.3
ALL USES	TOTAL	382,385	803,811	180,364	31,538	1,398,098
	%	100%	100%	100%	100%	100%

related uses, and 38% is unused. There is a wide range of use patterns between units, as illustrated below.

Figure 3 Percentage of Residue Utilization by Survey Unit and Type of Use



Current Uses of Residue by Type of Residue

Table 2 shows the current uses of residues by type of residue, and type of use statewide. Hardwoods make up nearly 3/4 of the total residues generated. They also account for 68% of the unused residues.

Unused Residue Volumes (from table 2)

Hardwood slabs and edgings	27%
Hardwood sawdust and shavings	22%
Hardwood bark	19%
Conifer slabs and edgings	16%
Conifer sawdust and shavings	8%
Conifer bark	8%
	100%

(534,892 green tons)

Coarse materials make up 56% of the total residues, but 43% of the unused residues. Much of the slabs and cutoffs are currently being sold or given away for domestic use.

Currently in Minnesota, the bark, sawdust, and some slabs and edgings has little or no dollar value and the processors are disposing of these by any means possible. As the demand and associated value for residue increases, the specific use of residue will change also.

TABLE 2
PRIMARY WOOD PROCESSORS
CURRENT USES OF RESIDUES
By TYPE OF RESIDUE AND TYPE OF USE
MINNESOTA - 1979
(green tons)

RESIDUE USE	RESIDUE TYPES						TOTAL		
	BARK		COARSE[1]		FINE		ALL TYPES		
	Conifer	Hdwd	Conifer	Hdwd	Conifer	Hdwd	Conifer	Hdwd	All Species
Fuel This Plant	53,627	125,319	35,983	4,110	22,181	2,836	111,791	132,265	244,056
Fuel Other Plant	2,571	17,916	4,677	13,070	6,441	13,226	13,689	44,212	57,901
Domestic Fuel	0	0	54,907	151,202	0	0	54,907	151,202	206,109
Manufacture of Fiber Products	0	571	34,718	242,008	0	7,139	34,718	249,718	284,436
Other Uses	100	23,698	786	8,285	4,944	32,887	5,830	64,870	70,700
Not Used	43,668	101,553	86,427	143,698	40,485	119,061	170,580	364,312	534,892
TOTAL	99,965	269,057	217,498	562,372	74,051	175,149	391,514	1006,580	1,398,094

1. Includes bark, unless bark is separated from roundwood by debarking process.

Residue Used for Fuel

Table 3 contains information on the residue currently used for fuel by survey unit and type of residue.

TABLE 3
PRIMARY WOOD PROCESSORS
RESIDUE CURRENTLY USED FOR FUEL
By SURVEY UNIT and TYPE OF RESIDUE
MINNESOTA - 1979
(green tons)

Survey Unit, Type and Use of Residue	# Mills	BARK		COARSE		FINE		TOTAL
		Conifer	Hdwd	Conifer	Hdwd	Conifer	Hdwd	
UNIT I								
Industrial fuel	9	39,051	93,744	38,675	5,088	25,696	3,242	205,497
Domestic fuel	139	0	0	7,163	8,234	0	0	15,396
TOTAL	-	39,051	93,744	45,838	13,322	25,696	3,242	220,893
UNIT II								
Industrial fuel	11	3,805	42,456	1,985	9,128	2,925	8,296	68,595
Domestic fuel	203	0	0	43,289	86,356	0	0	129,645
TOTAL	-	3,805	42,456	45,274	95,484	2,925	8,296	198,240
UNIT III								
Industrial fuel	8	13,340	7,036	0	1,967	0	4,524	26,867
Domestic fuel	167	0	0	4,416	45,974	0	0	50,390
TOTAL	-	13,340	7,036	4,416	47,941	0	4,524	77,257
UNIT IV								
Industrial fuel	4	0	0	0	998	0	0	998
Domestic fuel	28	0	0	40	10,636	0	0	10,676
TOTAL	-	0	0	40	11,634	0	0	11,674
ALL UNITS								
Industrial fuel	32	56,197	143,236	40,660	17,180	28,622	16,062	301,957
Domestic fuel	537	0	0	54,908	151,200	0	0	206,107
TOTAL	-	56,197	143,236	95,568	168,380	28,622	16,062	508,064

Ninety-one percent of the primary processors either sell or give residue away for domestic (residential) use. Over 206,000 green tons of residue is utilized in this manner.

Statewide, only 5% of the processors currently use wood residues for industrial fuel. The volume of residues used by these processors, however, is substantial. Fifty-nine percent of the total residue volume used for fuel is generated by 31 companies. Industrial fuel includes both the residue used at the site where it was generated, and the residue sold to other wood products industries.

There are several large industies in Minnesota that are presently contracting or indicating an interest in bark and fine residues for energy consumption. This expanded use of bark and fine residues will consume approximately 150,000 green tons annually. In addition to the expected expansion in use of residues, the waferboard industry currently being developed in Minnesota will generate additional residues. These surpluses, however, will be utilized within the new expanding industry.

In 1975, in a study of Minnesota fuelwood production, 25% of the primary processors wood residue generated was consumed for fuel (Blyth and Wilhelm, 1980) as compared with 37% in 1979. Of this 37%, industrial residue consumption is 22% and domestic use is 15%. The trend has been toward greater use of residues for fuel, and a greater utilization of the residues within the wood products industry. This trend is likely to continue as the costs of fossil fuels rise and as economically feasible ways to utilize wood residues for fuel are developed and perfected.

Minnesota's Pulp and Paper Industry

Residues from Minnesota's eight pulp and paper industries account for 15% of the total residue generated by primary processors in the State. Two-thirds of the residues generated by this industry are used for fuel at the processing sites, and one-third of the residues are not used. This represents 58% of the total State's residue used for fuel at the site of processing. Only 13% of the total non-used residues are generated by the pulp and paper industry.

Unused Residues - Annual and Accumulated Volumes

In order to get an accurate inventory of the primary wood residues available for fuel the volume of unused residues accumulated and stored at the site of processing prior to 1979 was also surveyed.

Table 4 shows the annual residue production that is not used and the volumes of residue accumulated at the site of processing over the last one to five years by survey unit and type of residue. Approximately 978,000 green tons of additional residue could be available for fuel use from accumulated stockpiles at primary processing plants. The accumulated residue will not provide a continuous supply of fuel, but is available on a one-time use basis.

TABLE 4
PRIMARY WOOD PROCESSORS
ANNUAL RESIDUE PRODUCTION NOT USED and RESIDUE ACCUMULATED
By SURVEY UNIT and TYPE OF RESIDUE
MINNESOTA - 1979
(green tons)

Unit, Type of Residue	BARK		COARSE		FINE		TOTAL
	Conifer	Hdwd	Conifer	Hdwd	Conifer	Hdwd	
UNIT I							
Annual	16,079	21,470	34,632	10,482	15,868	18,922	117,453
Accumulated	17,773	18,257	35,112	27,437	32,344	45,153	176,076
UNIT II							
Annual	8,206	100,034	50,697	128,013	23,184	67,622	377,756
Accumulated	23,221	164,652	23,976	80,688	82,568	308,560	683,665
UNIT III							
Annual	5,632	11,946	976	1,770	1,375	12,319	34,018
Accumulated	28,162	38,703	270	1,292	2,838	27,627	98,892
UNIT IV							
Annual	0	1,054	123	3,433	58	1,000	5,667
Accumulated	0	5,271	161	11,565	120	2,525	19,643
ALL UNITS							
Annual	29,917	134,504	86,428	143,698	40,485	99,863	534,894
Accumulated	69,156	226,883	59,519	120,982	117,370	383,865	978,276
TOTAL	99,073	361,387	145,947	264,680	158,355	483,728	1,513,170

Fine materials consisting of sawdust and shavings account for over one-half of the accumulated residues. In contrast approximately one-fourth of the fine residues produced annually are not used. This accumulated total of fine residue reflects that over the past few years, this is often the only unmarketable residue remaining at the site of processing.

There are proportionately more coarse residues consisting of slabs and edgings generated each year than are shown as accumulated. This would indicate that seasoned slabs and edgings are being utilized, most likely for household fuel use.

Percent of Non-used Residue by Type

	Bark	Coarse	Fine	Total
Annual Production	31%	43%	26%	100%
Accumulated Production	30%	19%	51%	100%

A number of opportunities exist for expanded use of residues. Compressing bark and fine residues into pellets or briquets for industrial or household fuel is feasible. Also these residues may be considered for charcoal production through pyrolysis, hydrogeneration to produce oil from wood chips, or liquification to produce methanol and ethanol. Cogeneration to produce steam and then electricity on a small scale is currently being developed in Minnesota, and could be expanded. As economical ways of handling, storage, and transporting wood residues are developed, new ways of utilizing wood residues will be developed.

Heating Values of Residues

In Table 5, all residue types have been grouped together and an approximate heating value has been calculated for each type of residue use and for each survey unit. The total potential energy contribution from primary processors is the sum of the residue volumes currently used for fuel, the annual residue production not used, and the accumulated residue volumes.

The energy potential from unused residues is greater than the energy derived from residues currently used for fuel. Wood residues generated by primary wood processors currently used for energy was estimated to be 5.5 trillion BTU's from 508,062 green tons of residue. An additional 5.8 trillion BTU's from 534,894 green tons of residue is potentially available for energy production from the unused residues generated in 1979. There is also an estimated 10.5 trillion BTU's from accumulated residue at the site of primary processing which would be available for a one time use.

The total consumption for residential space heating in 1980 was projected at 225.9 trillion BTU's. All of the residues generated by primary processors which are currently used, or available for fuel on an annual basis potentially could provide 5% of the total energy supply for residential space heating in Minnesota. Five percent of Minnesota homes could be heated for one year using accumulated residues generated by primary processors.

TABLE 5
PRIMARY WOOD PROCESSORS
FUEL VALUES OF RESIDUES
By SURVEY UNIT and TYPE OF USE
MINNESOTA - 1979
(green tons and billion BTU)[1]

ANNUAL RESIDUE PRODUCTION, CURRENTLY USED FOR ENERGY

Residue Use	SURVEY UNIT								TOTAL	
	I		II		III		IV			
	Tons	10^9 BTU	Tons	10^9 BTU	Tons	10^9 BTU	Tons	10 BTU	Tons	10^9 BTU
Plant Fuel	193,620	2,089	33,522	362	15,942	172	971	10	244,056	2,633
Fuel for other Plants	11,876	128	35,074	378	10,925	118	27	0.3	57,902	625
Domestic Fuel	15,395	166	129,644	1,399	50,390	544	10,676	115	206,105	2,223
Residue currently used for energy	220,891	2,383	198,240	2,139	77,257	833	11,674	126	508,062	5,481

ANNUAL RESIDUE PRODUCTION CURRENTLY NOT USED
AVAILABLE FOR ENERGY

Residue Not Used Annual Prod.	117,453	1,267	377,756	4,075	34,018	367	5,667	61	534,894	5,770

ACCUMULATED RESIDUE PRODUCTION, NOT USED
AVAILABLE FOR ENERGY[2]

Accumulated Residue Not Used	176,076	1,900	683,665	7,375	98,892	1,067	19,643	212	978,276	10,554

1 - Assumes residue is at 47% moisture content, therefore, containing 5,394 BTU/Pound.

2 - Totals based on from one to five years accumulated residue, prior to 1979, at site of primary wood processors.

3A.C CONCLUSIONS

- Currently wood residues for fuel are divided into two separate markets. Domestic users are generally limited to slabs and edgings, while industrial users may be able to utilize bark and fine residues (sawdust and shavings).

- A directory which describes the wood residue available from individual processors is being developed by DNR. Such a directory could significantly aid in the marketing of wood residues for fuel.

- Unused wood residues generated by primary processors have the potential of reducing the dependence on fossil fuels near wood processing plants. Transportation of residues for energy purposes over long distances is currently not feasible.

- Primary wood residues offer the advantage of being stockpiled at the processing site, allowing for efficient handling. They also are a relatively inexpensive source of energy material. However, to efficiently use these residues for energy in their present forms, specialized equipment may be required. The use of currently surplus residues will increase as technology is developed which can effectively utilize residues in their present or altered forms.

- As demand for residue increases, the price structure will increase also. This may lead to alteration of the present residue use.

- Projects which would demonstrate the use of residues in their present or altered form should be supported. This may be in the form of grants or incentives which would lead to increased utilization of residues for fuel.

- At 1980 prices and gross BTU values, the amount of residues which currently go unused have the equivalent dollar value of $35.5 million of fuel oil, $15.1 million of natural gas, or $53.5 million of electricity. These values do not include any costs associated with converting wood residues into energy. When an economical method is developed to convert certain types of wood residues to usable fuel, Minnesota will reclaim a valuable resource.

3B SECONDARY WOOD PROCESSORS RESIDUE SURVEY

3B.A INTRODUCTION

Secondary Wood Processors Definition

Secondary wood processors are those industries which utilize lumber or other materials produced by the primary wood processing industries. The products which are manufactured by secondary processors include furniture, pallets, boxes, millwork, doors and windows, homes, etc. The wood residues generated by these industries can be grouped into three categories: coarse residues including cutoffs, edgings and other solid pieces; shavings; and fine residues such as sawdust and sander-dust. The wood materials used by these industries are generally in a dry condition and so the residue volumes are reported in dry tons, assuming 10% moisture content.

Study Objectives

The objectives of this study are to: (1) identify the secondary wood products manufacturers; (2) determine the types and volumes of residue being generated; and (3) determine the current methods of utilization or disposal of these residues. From this information, the possible impact these materials could have on the State's energy needs can be determined.

Study Methods

Data collection for the secondary survey began in April, 1980. Wood manufacturers were identified using several sources; Manufacturer's directories, United States Department of Agriculture Extension lists, Department of Natural Resources information, and the Telephone Company Yellow Pages. Lists of secondary processors by county were then compiled. Each processor was contacted by telephone and information about their wood purchases, production, and residues was obtained. All the necessary conversions of residue volumes were recorded on survey forms adaptable for computer programming for ease of data processing and retrieval.

Eight hundred thirty-two secondary wood processors throughout the State were surveyed, yielding 348 completed interviews. Additional information was obtained from the University of Minnesota study by David O'Brien and Steve Sinclair (1980), bring the total number of completed survey forms to 356. This represents 43% of the processors contacted.

An estimate of 25,000 tons of additional residue was made from the secondary processors that were not identified in the initial survey. An analysis of the survey indicated that 80% to 85% of the residue generated by secondary wood processing in Minnesota is accounted for in this survey.

Volume estimates of residues were converted to dry tons using factors published by Perry and Gregory (1976), and other sources. The conversion factors used, and a copy of the survey form are presented in Appendix C.

3B.B SUMMARY OF FINDINGS

The 1979 residue survey results show that approximately 171,000 dry tons of residue were generated by 356 secondary wood processors of which nearly 32,000 tons or 19% was not used.

RESIDUE TOTAL BY SURVEY UNIT - 1979

SECONDARY PROCESSORS
(dry tons-approximately 10% MC)

Unit	#Processors Reporting	Total Residue	Residue Not Used
I	10	1,804	424
II	36	26,737	9,715
III	225	133,750	17,259
IV	85	8,588	4,476
STATE TOTALS	356	170,879	31,874

The majority of the residue is generated by a very small percentage of the secondary processors in the state, as illustrated below.

CUMULATIVE RESIDUE PRODUCTION - 1979
SECONDARY PROCESSORS

dry tons	cumulative # of processors	cumulative % of processors	cumulative % of residue
more than 10,000	1	.3	43.3
5,001 - 10,000	3	.8	50.1
1,001 - 5,000	26	7.3	78.4
501 - 1,000	49	13.8	87.1
251 - 500	73	20.5	92.4
101 - 250	123	34.6	97.1
51 - 100	161	45.2	98.6
0 - 50	356	100.0	100.0

Fifty-five percent of the mills sampled generated a total of 2,375 dry tons of residue, or just 1.4% of the total residue. Seven percent of the mills sampled generated 78% of the total residue in 1979. Thirty-five percent of the mills were responsible for 97% of the residue production.

Residue Generated by County

Figures 4 and 5 show the total amount of residue generated by county and the amount of residue not used by county respectively.

Unlike the primary wood processing industries which usually are located close to their raw materials and concentrated in the northern half of the State, the secondary industries tend to be located nearer their market and are primarily located near population centers in the southern half of the State. In fact, 43% of the 356 secondary producers responding to the survey were located within the seven county metropolitan area. In addition, 66% of the total residue volume produced in the State came from this area. The remaining processors tend to be located near the other urban areas throughout the State.

FIGURE 4

SECONDARY WOOD PROCESSORS RESIDUE

TOTAL AMOUNT OF RESIDUES GENERATED

(dry tons)

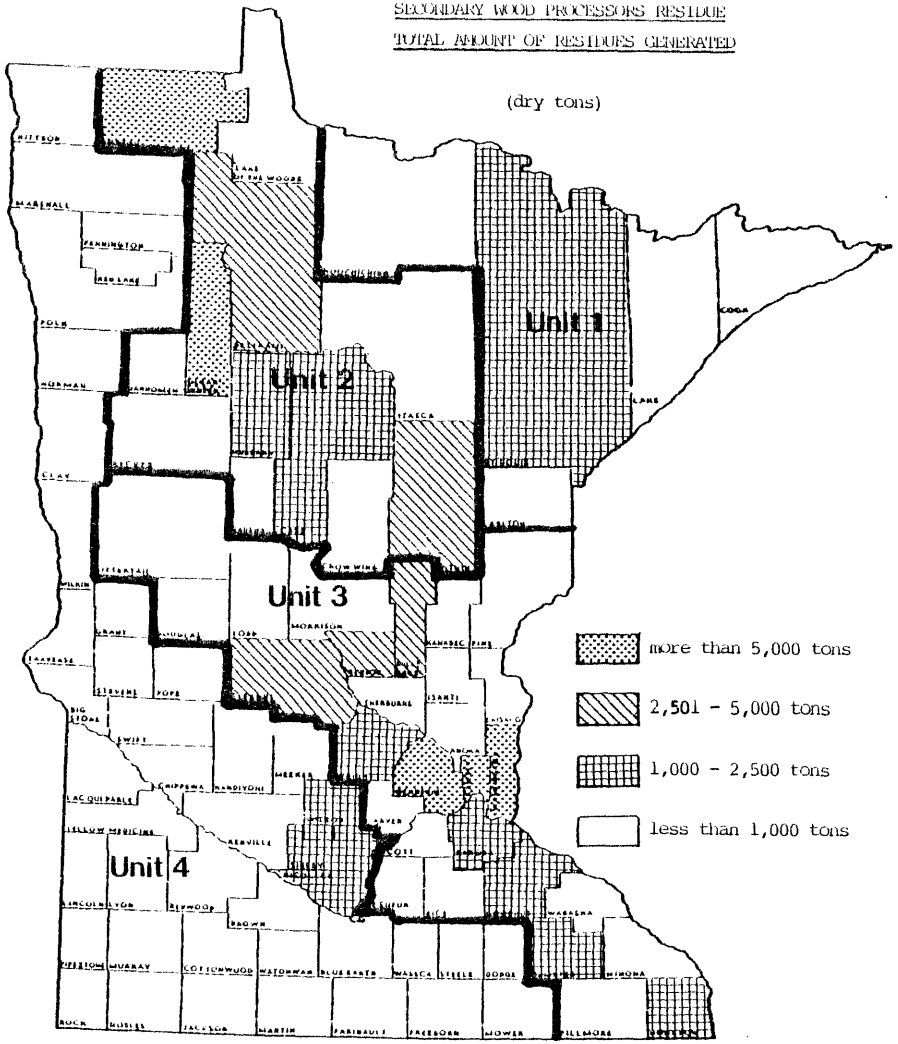
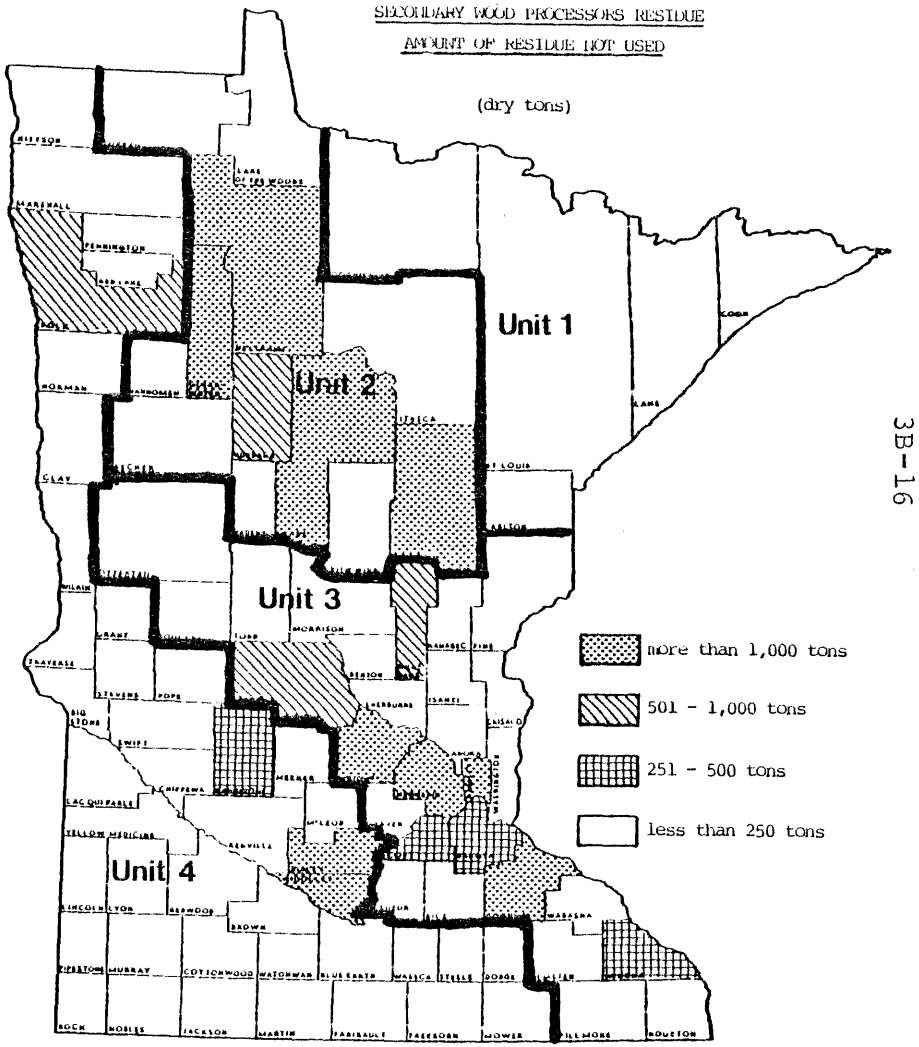


FIGURE 5

SECONDARY WOOD PROCESSORS RESIDUE

AMOUNT OF RESIDUE NOT USED

(dry tons)



Current Uses of Residues Produced

Table 6 shows the different ways the production residues are currently being used. For the State as a whole, over 81% of the total 170,879 dry tons produced by these industries is used in some way and less than 19% actually ends up as waste. Thirty-seven percent is currently used as fuel either by the industry itself or is provided by them for domestic (private household) use. The largest percentage of the State's total residue is used as animal bedding with about 29% of the total volume produced sold or given away for this purpose.

TABLE 6
SECONDARY WOOD PROCESSORS
TOTAL RESIDUE PRODUCTION
By SURVEY UNIT and TYPE OF USE
MINNESOTA - 1979
(dry tons)

Type of Use		SURVEY UNIT I	II	III	IV	TOTAL
FUEL RELATED USES	This plant	5	4,986	42,056	125	47,172
	%	.3	18.6	31.4	1.5	27.6
	Other plants	0	603	34	6	643
	%		2.3	.0	.1	.4
	Domestic use	68	6,056	6,072	3,187	15,383
	%	3.8	22.6	4.5	37.1	9.0
TOTAL (fuel)		73	11,645	48,162	3,318	63,198
% of total residue		4.1	43.6	36.0	38.6	37.0
NON-FUEL RELATED USES	Fiber prod.	0	0	189	0	189
	%			.1		.1
	Bedding	0	4,881	43,735	652	49,269
	%		18.2	32.7	7.6	28.8
	Other uses	1,307	495	24,405	141	26,347
	%	72.4	20.1	18.2	1.6	15.4
TOTAL (non-fuel)		1,307	5,376	68,329	793	75,805
% of total residue		72.4	20.1	51.1	9.2	44.4
TOTAL (Not Used)		424	9,715	17,259	4,477	31,875
% of Total Residue		23.5	36.3	12.9	52.1	18.6
ALL USES	TOTAL	1,804	26,737	133,750	8,588	170,879
	%	100%	100%	100%	100%	100%

The forms in which the residues are generated are the most important factors in determining their value for a particular use. Table 7 divides the total residue volumes into their different residue type categories and shows the volume of each type within the different use categories.

Conifer type residues comprise 63% of the total residue generated by the processors in 1979, but only 45% of the unused residues. Currently, conifer residues are utilized to a greater extent than hardwood type residues.

TABLE 7
SECONDARY WOOD PROCESSORS
CURRENT USES OF RESIDUES
By TYPE OF RESIDUE and TYPE OF USE
MINNESOTA - 1979
(dry tons)

RESIDUE USE	RESIDUE TYPES								
	COARSE		SHAVINGS		SAWDUST		ALL TYPES		
	Hdwd	Conifer	Hdwd	Conifer	Hdwd	Conifer	Hdwd	Conifer	ALL SPECIES
FUEL This Plant	3,861	28,439	9,961	1,443	2,817	652	16,639	30,534	47,172
FUEL Other Plant	0	7	227	91	227	91	454	189	643
DOMESTIC FUEL	6,288	6,281	407	1,694	96	616	6,791	8,591	15,383
MANUFACTURE OF FIBER PRODUCTS	0	0	14	9	100	66	115	75	189
BEDDING	404	39	8,450	2,746	11,391	26,239	20,245	29,024	49,269
OTHER USE	1,145	4,095	62	179	173	20,424	1,650	24,698	26,347
NOT USED	8,568	7,427	4,519	2,307	4,495	4,559	17,582	14,293	31,875
TOTAL	20,536	46,288	23,640	8,469	19,299	52,647	63,475	107,404	170,879

Volume of Residues Available for Energy

Table 8 shows the volumes of residue by unit and type of residue currently used for energy production.

TABLE 8
SECONDARY WOOD PROCESSORS
RESIDUE CURRENTLY USED FOR FUEL
By SURVEY UNIT and TYPE OF RESIDUE
MINNESOTA - 1979
(dry tons)

Survey Unit, Type and Use of Residue	# Mills	Coarse		Shavings		Sawdust		TOTAL
		Hdwd	Conifer	Hdwd	Conifer	Hdwd	Conifer	
Unit I								
Industrial fuel	1	4	1	-	-	-	-	5
Domestic fuel	5	48	20	-	-	-	-	68
TOTAL	-	52	21	-	-	-	-	73
Unit II								
Industrial fuel	13	36	1,557	1,693	1,480	211	613	
Domestic fuel	19	1,519	2,805	-	1,242	-	490	5,589
TOTAL	-	1,555	4,362	1,693	2,722	211	1,103	11,645
Unit III								
Industrial fuel	100	3,799	26,791	8,495	54	2,832	120	42,091
Domestic fuel	106	3,980	1,851	107	31	39	64	6,072
TOTAL	-	7,779	28,642	8,602	85	2,871	184	48,163
Unit IV								
Industrial fuel	17	22	99	-	-	1	10	132
Domestic fuel	40	742	1,605	300	421	57	62	3,187
TOTAL	-	764	1,704	300	421	58	72	3,319
All Units								
Industrial fuel	131	3,861	28,448	10,188	1,534	3,044	743	47,817
Domestic fuel	170	6,289	6,281	407	1,694	96	616	15,383
TOTAL	-	10,150	34,729	10,595	3,228	3,140	1,359	63,200

Thirty-seven percent of the secondary mills surveyed statewide use wood residues to support their own heating systems, and nearly half of the processors currently sell or give away residues for private household use.

The potential for additional energy sources from secondary wood processing residue is considered to be that volume currently unused. Table 9 shows the annual

production which is not currently used and also the volume of any accumulated residue at the plant site. Unlike the annual volume of unused residue, the accumulated residue is not a continuous supply and can be used only once.

TABLE 9
SECONDARY WOOD PROCESSORS
ANNUAL RESIDUE PRODUCTION NOT USED and RESIDUE ACCUMULATED
By SURVEY UNIT and TYPE OF RESIDUE
MINNESOTA - 1979
(dry tons)

Unit, Type of Residue	Coarse		Shavings		Sawdust		TOTAL
	Conifer	Hdwd	Conifer	Hdwd	Conifer	Hdwd	
Unit I							
Annual	46	10	7	19	61	282	425
Accumulated	0	0	0	0	0	0	0
Unit II							
Annual	55	5,878	495	1,328	340	1,619	9,715
Accumulated	0	5,025	0	2,775	0	5,117	12,917
Unit III							
Annual	6,492	2,356	1,043	1,650	3,575	2,143	17,259
Accumulated	917	570	0	0	3	105	1,595
Unit IV							
Annual	835	324	762	1,522	583	451	4,477
Accumulated	0	0.3	0	0.5	0	188	189
All Units							
Annual	7,428	8,568	2,307	4,519	4,559	4,495	31,876
Accumulated	917	5,595	0	2,775	3	5,410	14,701
TOTAL	8,345	14,163	2,307	7,294	4,562	9,905	46,577

The volume of the accumulated residues at each mill was calculated using 1979 production figures and the number of years residue had accumulated at the production site. Less than 5% of the processors had residues stored for more than a year, but those plants have 14,700 dry tons of residue which potentially could be used for fuel on a one-time basis. There are 6,500 tons of cutoffs and edgings, or the equivalent of 2,950 cords of wood stored at these processing plants.

Heating Values from Residue Supply

Table 10 combines all residue types for each use category and gives the corresponding energy potential. The total energy contribution from secondary processors is then equal to that volume currently used for fuel plus the volume which is currently unused with an additional one-time potential from the accumulated residue volume. At an average burning efficiency, the amount of residue currently used for fuel has the equivalent energy content of 6.3 million gallons of fuel oil, or the amount used to heat 6,300 homes. Assuming that the average annual consumption of fuel oil is 1,000 gallons per home. The annual residue production that is currently unused has the equivalent energy content of 3.2 million gallons of fuel oil or the potential to heat 3,200 homes. The accumulated residue volumes are equivalent to 1.6 million gallons of fuel oil or could heat 1,600 homes for one year.

The total consumption for residential space heating in 1980 was projected at 225.9 trillion BTU's. All the residues which are currently used or available for fuel, including the accumulated volumes, provide less than 1% of the total energy supply for Minnesota in 1980.

TABLE 10
SECONDARY WOOD PROCESSORS
FUEL VALUES OF RESIDUES
By SURVEY UNIT and TYPE OF USE
MINNESOTA - 1979
(dry tons and 10^9 BTU)

	SURVEY UNIT								TOTAL	
	I		II		III		IV			
	Tons	10^9BTU	Tons	10^9BTU	Tons	10^9BTU	Tons	10^9BTU	Tons	10^9BTU
Plant fuel	5	0.1	4,986	76	42,056	641	125	2	47,122	718
Fuel for other Plants	0	0	603	9	34	0.5	6	0.1	643	10
Domestic Fuel	68	1	6,056	92	6,072	93	3,187	49	15,383	234
Residue Currently Used for Energy	73	1	11,645	177	48,162	734	3,318	51	63,198	963

ANNUAL RESIDUE PRODUCTION CURRENTLY NOT USED,

AVAILABLE FOR ENERGY

Residue Not Used Annual Prod.	424	6	9,715	148	17,259	263	4,477	68	31,875	486

ACCUMULATED RESIDUE PRODUCTION NOT USED

AVAILABLE FOR ENERGY

Accumulated Residue Not Used	0	0	12,916	197	1,596	24	1,881	29	16,393	249

- Assumes Residue is at 10% moisture content, therefore containing 7617 BTU/Pound.
- Totals based on from one to five years accumulated residue, prior to 1979, at site of secondary wood processors.

3B.C CONCLUSIONS

- It is difficult to predict trends in residue use among secondary processors because the nature of their locations may prohibit any storage of the residues and inconsistent production levels in some industries make it difficult to insure a steady supply of materials.

- Although the State's secondary wood processing residue is a relatively small amount by volume, it makes an excellent fuel since it is already dry. It is also important because the industries themselves tend to be located near population centers and areas of high energy demand.

- The vast majority of these manufacturers generate too small an amount or are too uncertain of a steady supply to justify a wood burning system using their own residues alone. However, such businesses may be an ideal customer for pelletized wood materials which can supplement their own residue supply.

- Another possibility for such smaller businesses within a small area is to pool their residues together in order to obtain a quantity more attractive to a buyer. Several survey participants mentioned this as a possibility they were exploring.

- Regardless of efforts to imporve utilization, several industries have intrinsic obstacles to the collection of their residues. In on-site homebuilding, for example, it is extremely difficult and time consuming to keep wood residues separate from other residues. It would also be very costly to transport the relatively small amounts generated in the construction of an average home. In addition, smaller residues, like sawdust, simply blow away and are lost completely.

- In some industries, residues become contaminated with other materials such as paint, formica, etc. as a result of the manufacturing process itself and their usefulness for energy production is lessened.

- There seems to be a great interest within industries for some sort of utilization of residues since the costs of disposing of unused residues can be very high in some instances.

- Several areas which were not surveyed but may yield amounts of residue include:

1) Building demolition which, by some estimates, may yield up to 67,000 tons of additional wood wastes annually.

2) The packaging industry is one of the largest consumers of wood products and there is evidence that large amounts of cardboard and pallet material end up as waste at the freight receiving end.

3) Unrepairable pallets may provide a great amount of unused material.

Literature Cited

Blyth, James E. and Steven Wilhelm. 1980. Fuelwood Production in Rural Minnesota, 1975. U.S.D.A. Forest Service Research Bulletin NC-47, North Central Forest Experiment Station, St. Paul, Minnesota. 6 pp.

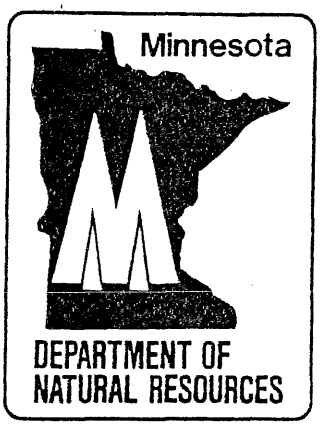
O'Brien, David and Steven Sinclair. 1980. The Near-Term Potential and Present Utilization of Forest Products Manufacturing Residues as an Energy Source in Minnesota. Preliminary Draft, Department of Forest Products, University of Minnesota. 98 pp.

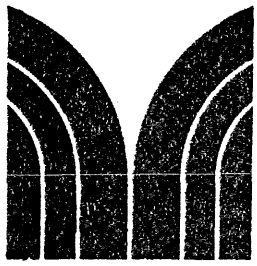
Perry, Joe D. and Robert T. Gregory. 1976. A Guide to 1975 Wood Residue Volumes in 125 Tennessee Valley Counties. Tennessee Valley Authority. Division of Forestry, Fisheries, and Wildlife Development, Technical Note BZO. 55 pp.

COSTS OF LOGGING AND TRANSPORTATION IN MINNESOTA

Project #4

November 1980





minnesota energy agency

ABSTRACT

This report contains the results of an investigation into the costs of harvesting and transporting fuelwood both on a large-scale basis and for the individual wood user. The report also compares the costs of wood with those of other fuels. Although, in many situations, wood fuel is now cost effective compared to alternative fuels, the accelerating costs of logging and transportation will have a determining effect whether or not wood fuel will be feasible in future years.

4. COSTS OF LOGGING AND TRANSPORTATION

4.A INTRODUCTION

The most important factor in the feasibility of any wood energy system is its economic costs, and especially how these costs compare with those of other fuels. The total cost involved can be made up of a variety of components. The first step may be the actual harvest or collection of the material, whether it is live biomass, logging slash, or mill residues. The costs of transporting these materials to the points where they are utilized makes up the second component of total costs. A third component may be the actual conversion of the materials into usable energy. A variety of costs may be included in this portion, such as the costs of storage and handling, drying or processing, as well as equipment and operating costs, etc.

Study Objectives

Although every situation requires its own analysis, it is possible to make general statements on the feasibility of using wood materials for energy. When determining the practicality of an individual project, many other factors must be considered, such as the local supply and availability of materials, actual equipment and operating costs, etc. This section will attempt to identify some of the important factors to consider and some of the average costs to expect in determining the feasibility of using wood materials for energy.

4.B SUMMARY OF FINDINGS

4.B.1 Costs of Harvesting

Although harvest costs are highly variable under different situations, some estimate of average costs is both useful and possible to obtain. However, any discussion of economic costs, it is necessary to realize the limitations of the figures obtained.

The harvest costs presented here reflect the annual operating cost of the machines which is based on their purchase price, finance rates, depreciation, maintenance, fuel consumption, etc. This annual operating cost is then refined to an hourly basis and, when combined with the machine's cord production rates under various stand conditions, gives the average cost per cord.

Two types of harvest methods which lie more or less at the extremes of those commonly used in Minnesota in terms of degree of mechanization were surveyed. The first is the shortwood method, (bucking and transporting roundwood in designated lengths) and the second is whole-tree chipping (complete utilization by chipping the entire tree). Cost averages were also determined for the process of relogging in which the slash remaining on a site after conventional harvesting is collected.

It should be noted that these harvest costs reflect only the harvest operation itself and do not include the actual cost of the trees or stumpage fee.

Shortwood Harvesting (Table 1)

Shortwood harvesting is largely nonmechanized and highly labor-intensive. Although the types of equipment combinations and methods can vary greatly, it would commonly consist of manual felling with chainsaws, delimbing the tree at the stump, skidding the tree-length logs to the landing with a conventional skidder, and finally cutting it into logs at the landing. Costs for harvesting by this method are shown in Table 1.

Although cost per cord is relatively high for this method, it is the most commonly used in Minnesota. It requires a relatively low capital investment to begin with and allows more flexibility to the operator.

TABLE 1: ESTIMATED HARVEST COSTS FOR SHORTWOOD LOGGING METHOD (NON-MECHANICAL FELLING)[a] IN $/CORD

DBH[b]	5 CORDS/ACRE	12 CORDS/ACRE	20 CORDS/ACRE
6"			
FELLING, LIMBING	13.92	12.48	12.24
SKIDDING, TREE LENGTH	10.87	10.27	9.55
LANDING, CUT-UP	5.78	5.16	4.56
	30.57	27.91	26.35
9"			
FELLING, LIMBING	11.14	9.98	9.79
SKIDDING, TREE LENGTH	10.08	9.48	9.26
LANDING, CUT-UP	4.78	4.56	4.46
	26.00	24.02	23.51
12"			
FELLING, LIMBING	8.16	7.58	7.39
SKIDDING, TREE LENGTH	12.38	11.38	11.04
LANDING, CUT-UP	4.44	4.44	4.44
	24.98	23.40	22.87

a - *Operation uses workers felling and delimbing trees with chainsaws at the stump. Tree length logs are then dragged to the landing by skidders, at 24.96/hour, where they are cut up into logs.*

b - *Diameter at breast height, or 4.5 feet above the ground.*

Whole-Tree Chipping (Table 2)

In contrast to the shortwood harvest system, whole-tree chipping is highly mechanized and requires only a small number of machine operators. A common example of such a system would consist of a feller-buncher which cuts the trees and lays them in bunches to be picked up by grapple skidders which drag the trees to the landing where a chipper reduces the entire tree to chips. Costs for whole-tree chipping are shown in Table 2.

Cost per cord by this method is considerably lower than if harvest is by the shortwood method because of the high production rates and low labor cost. However, the system has a high initial cost and there are currently few such systems in the State.

TABLE 2: ESTIMATED HARVEST COSTS FOR WHOLE-TREE CHIPPING OPERATION IN $/CORDS [a]

DBH[b]	5 CORDS/ACRE	12 CORDS/ACRE	16 CORDS/ACRE	20 CORDS/ACRE
3"				
FELLER-BUNCHER	19.69	18.85	18.40	
SKIDDER, CHIPPER	33.83	33.69	32.87	
	53.52	52.54	50.27	
6"				
FELLER-BUNCHER	5.63	4.95	3.56	3.45
SKIDDER, CHIPPER	10.62	10.41	10.20	9.92
	16.25	15.36	13.76	13.37
9"				
FELLER-BUNCHER	2.84	2.46	1.63	1.54
SKIDDER, CHIPPER	6.12	6.05	6.00	5.89
	8.96	8.51	7.63	7.43
12"				
FELLER-BUNCHER	1.87	1.15	1.01	.91
SKIDDER, CHIPPER	4.37	4.31	2.57	3.94
	6.24	5.46	3.58	4.85
15"				
FELLER-BUNCHER	1.13	.76	.70	.63
SKIDDER, CHIPPER	3.17	3.08	2.98	2.83
	4.30	3.84	3.68	3.46

a - *Operation uses one rubber-tired feller-buncher which has hourly operating cost of $30.72, Two Grapple Skidders at $24.96/hour each, and one large Chipper (22") at $31.27/hour.*

b - *Diameter at breast height or 4.5 feet above the ground.*

Relogging (Table 3)

In addition to the harvesting of roundwood, the process of relogging a harvested area to recover the material left at the site is an important possible component to a program of utilizing wood materials for energy. An example of this system might include a topwood processor which compacts and accumulates logging slash into bundles which are picked up by grapple skidders and reduced to chips at the landing. Costs for collecting slash in this manner are shown in Table 3.

Although the costs of harvesting logging slash are relatively high, the process is still largely experimental and the costs will probably begin to decrease as relogging comes into wider use and more experience is gained. Even so, it may be more feasible to use a slash chipping process on the landing site of a conventional harvest operation to collect the residue during the harvest and avoid the high costs of returning to the area to relog.

TABLE 3: ESTIMATED HARVEST COSTS FOR RELOGGING SLASH AND LOGGING DEBRIS[a] IN $/CORD

	CORDS/ACRE[c]		
DBH[b]	8 CORDS	12 CORDS	15 CORDS
9"			
SLASH ACCUMULATION PROCESS	22.30	20.88	19.32
SKIDDING, CHIPPING	24.06	23.64	22.44
	46.36	44.52	41.76
12"			
SLASH ACCUMULATION PROCESS	17.88	17.16	16.56
SKIDDING, CHIPPING	28.08	26.94	25.98
	45.96	44.10	42.54
15"			
SLASH ACCUMULATION PROCESS	16.44	15.61	14.53
SKIDDING, CHIPPING	26.16	24.84	23.64
	42.60	40.45	38.17

a - Operation uses a Topwood Processor which prepares residual trees and slash for skidding at $36.00/hour, three Grapple Skidders at $24.96/hour each, and a large chipper (22") at $31.27/hour.

b - Diameter at breast height or 4.5 feet above the ground of stand before original harvest.

c - Refers to stand before original harvest.

4.B.2 Costs of Transportation

The costs of transporting wood materials long distances can easily make up the largest component of the final price and be the most important limiting factor in the use of wood for energy. Wood materials are transported primarily by truck and by railroad in Minnesota, and cost figures for these two methods have been determined. There is also information on transporting smaller quantities of fuelwood for home heating.

All rates given are average commercial rates using conventional equipment, but more specialized and efficient equipment and methods would probably be available for longer term contracts involving a predictable volume, and, therefore, would greatly effect costs per volume and loading and unloading costs. Other variables which may affect prices in the future include: the fluctuation of interest rates and its effects on equipment purchases, the deregulation of the trucking industry, the viability of the railroad industry in the future, the rising costs of fuel, the quality of maintenance of road and track systems, etc.

Transporting Materials by Truck (Table 4)

The most common means of moving wood materials is by truck. This method is well-suited for shorter hauls and the convenience of a complex road network makes routing much more flexible than with fixed rail systems. There is also a great variety of equipment available which can lend itself to different situations.

Table 4 shows the average commercial rates for hauling wood materials with conventional equipment. None of these rates consider loading and unloading costs. As a rough average, the costs are usually about $1.00/load/mile for any length of trip.

TABLE 4: AVERAGE COMMERCIAL FREIGHT RATES BY TRUCK AND RAIL FOR ROUNDWOOD [a] IN $/TON

MILES OF HAUL	TRUCK[b] 50,000	RAIL[c] 60,000	RAIL[c] 80,000	RAIL[c] 100,000
0- 20	1.71	5.40	4.80	4.40
20- 40	1.94	8.80	8.00	7.20
40- 60	2.57	10.20	9.00	8.50
60- 80	3.43	10.80	9.20	8.70
80-100	4.29	9.00	8.00	7.50
100-120	5.14	9.60	9.00	8.40
120-140	6.00	10.50	9.80	9.10
140-160	6.86	11.20	10.40	9.60
160-180	7.71	11.70	10.80	9.90
180-200	8.57	12.00	11.00	10.00
200-220	9.43	12.10	11.00	9.99
220-240	10.29	12.00	10.80	9.60

a - *Average rates obtained from a number of commercial haulers and other sources. Some variation can be found due to types of roads or tracks, tax structures, discounts, fuel surcharges, equipment used, contract specifications, etc.*

b - *Based on standard 40 foot trailer with 50000# maximum payload.*

c - *Weights given are minimum load size. Other sizes at different rates are also available.*

Transporting Materials by Railroad (Table 4)

Table 4 also shows average rates for moving materials by train. Transport of materials by rail is usually limited to longer hauls because of the higher cost of railroad transportation. Also, it is usually necessary to haul materials by truck to the siding and this adds further to the costs involved—on the average about $3.00/ton. However, if the situation involves a large amount of material and covers a rather long distance, moving by railroad may be more attractive than by truck.

Transporting Materials for Home Heating Use (Tables 5A-B, 6, 7)

With the increasing cost of heating fuels in recent years, there has also been an increase in the numbers of people who use wood for home heating. Although some are supplied directly by local commercial vendors, the vast majority apparently purchase or cut their own further away from home and haul it themselves. It is important in these situations, that the energy expended in traveling does not exceed that contained in the wood. Tables 5A and 5B show the maximum driving distance a person should travel for wood before more energy is spent than is obtained. Table 5A shows information on seasoned wood at 20% moisture content as would, for example, commonly be found in wood that has been stacked and air-dryed for six months. Table 5B shows information on green wood at average moisture content as would be found in wood from freshly cut trees. While Tables 5A and 5B provide information on specific volumes of wood, Table 6 deals with a single weight of wood and, as an example, uses a standard, three-quarter ton pickup truck fully loaded with 1500 pounds of wood.

In addition to the problem of maintaining a favorable energy balance when transporting wood it is also necessary to be aware of the costs involved. Table 7 attempts to identify some of the costs involved in a situation where a wood user who owns his own pickup truck would use it to haul wood. If the assumed values are correct, the cost of driving this vehicle, for any purpose, would be about 23 cents per mile. Therefore, if, for instance, a 100-mile trip to pick up wood is made, $23.00 should be added to the cost of the wood.

When a home wood user actually harvests his own wood, he also has an investment in equipment. The most important of these may be a chainsaw. Table 7 also shows some of the costs involved in operating a chainsaw. If the assumed values are correct, the costs of operating the saw would be about $3.33 per face cord. Since a face cord is usually the maximum amount of wood which can be hauled in a pickup truck, this cost should be added to the transportation costs to determine the total cost of wood.

4.B.3 COSTS OF CONVERSION (Table 8A-B, 9, Figure 1)

Once the cost and supply of wood have been determined it is necessary to compare them with those of other fuels. Table 8A shows the cost per million BTU for a number of fuels including wood. Table 8B shows projected prices for 1985-86. All of these prices are for the delivered

TABLE 5A - ENERGY EFFICIENCY OF TRANSPORTING FUELWOOD FOR HOME USE[1]

SEASONED WOOD

	% Moisture Content (Dry Weight Basis)	LB/FT³	BTU/LB	1/3 STANDARD CORD[2]			½ STANDARD CORD			1 STANDARD CORD		
				LB/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to dirve for wood	LB/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood	LB/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ironwood	20	50	6880	1313	5.0	460	1975	7.5	690	3950	14.9	1380
White Oak	20	47	6880	1240	4.7	435	1855	7.0	650	3715	14.1	1300
Sugar Maple	20	44	6880	1160	4.4	405	1740	6.6	610	3475	13.1	1210
Red Oak	20	44	6880	1160	4.4	405	1740	6.6	610	3475	13.1	1210
Green Ash	20	43	6880	1130	4.3	395	1700	6.4	590	3395	12.8	1190
Tamarack	20	38	6880	1000	3.8	350	1500	5.7	520	3000	11.4	1050
Paper Birch	20	37	6880	975	3.7	340	1460	5.5	510	2925	11.1	1020
American Elm	20	36	6880	950	3.6	330	1420	5.4	500	2845	10.8	990
Black Ash	20	35	6880	920	3.5	320	1385	5.2	480	2765	10.5	970
Red Maple	20	34	6880	895	3.4	315	1345	5.1	470	2685	10.2	940
Jack Pine	20	31	6880	815	3.1	285	1225	4.6	430	2450	9.3	860
Norway Pine	20	31	6880	815	3.1	285	1225	4.6	430	2450	9.3	860
Black Spruce	20	29	6880	765	2.9	265	1145	4.3	400	2290	8.7	800
Aspen	20	27	6880	710	2.7	250	1065	4.0	390	2135	8.1	750
White Pine	20	26	6880	685	2.6	240	1025	3.9	360	2055	7.8	720
Basswood	20	25	6880	660	2.5	230	990	3.7	350	1975	7.5	690
N. White Cedar	20	23	6880	605	2.3	210	910	3.4	320	1815	6.9	630
AVERAGE	20	35	6880	930	3.5	325	1395	5.3	490	2790	10.6	975

[1]ASSUMES 79 FT³ OF SOLID WOOD/STANDARD CORD AND VEHICLE AVERAGES 12 MILES/GALLON OF GASOLINE THROUGHOUT TRIP.

[2]1/3 STANDARD CORD IS COMMONLY REFERRED TO AS A FIREPLACE CORD, FACE CORD, STOVE CORD, OR RICK.

TABLE 5B - ENERGY EFFICIENCY OF TRANSPORTING FUELWOOD FOR HOME USE [1]

GREEN WOOD

	% Moisture Content (Dry Weight Basis)	LB/Ft.³	BTU/LB	1/3 STANDARD CORD [2]			½ STANDARD CORD			1 STANDARD CORD		
				LB/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood	LB/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood	LB/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ironwood	44	60	5580	1580	4.8	450	2370	7.3	670	4740	14.6	1340
White Oak	60	63	4860	1660	4.4	410	2490	6.7	610	4980	13.3	1230
Sugar Maple	44	53	5580	1395	4.3	400	2090	6.4	590	4185	12.8	1190
Red Oak	68	62	4570	1635	4.1	380	2450	6.2	570	4900	12.3	1140
Green Ash	58	57	5370	1500	4.4	410	2250	6.6	610	4505	13.3	1230
Tamarack	42	45	5630	1185	3.7	340	1780	5.5	510	3555	11.0	1020
Paper Birch	47	46	5390	1210	3.6	330	1820	5.4	500	3635	10.8	990
American Elm	74	52	4370	1370	3.3	300	2050	4.9	460	4110	9.9	910
Black Ash	77	52	4270	1370	3.2	300	2050	4.8	440	4110	9.7	890
Red Maple	47	42	5390	1105	3.3	300	1660	4.9	460	3320	9.8	910
Jack Pine	48	39	5350	1025	3.0	280	1540	4.5	420	3080	9.1	840
Norway Pine	81	47	4150	1240	2.8	260	1860	4.3	390	3715	8.5	780
Black Spruce	50	37	5260	975	2.8	260	1460	4.2	390	2925	8.5	780
Aspen	87	42	3980	1105	2.4	220	1660	3.6	340	3320	7.3	670
White Pine	64	36	4710	950	2.5	230	1420	3.7	340	2845	7.4	680
Basswood	83	38	4090	1000	2.3	210	1500	3.4	310	3000	6.8	620
N. White Cedar	40	26	5720	685	2.2	200	1030	3.2	300	2055	6.5	600
AVERAGE	60	47	4957	1235	3.2	310	1852	5.0	465	3705	10.1	930

[1]ASSUMES 79 FT³ OF SOLID WOOD/STANDARD CORD AND VEHICLE AVERAGES 12 MILES/GALLON OF GASOLINE THROUGHOUT TRIP.

[2]1/3 STANDARD CORD IS COMMONLY REFERRED TO AS A FIREPLACE CORD, FACE CORD, STOVE CORD, OR RICK.

TABLE 6 - ENERGY EFFICIENCY OF TRANSPORTING FUELWOOD IN A FULLY-LOADED THREE QUARTER TON PICKUP TRUCK (1500 LBS/LOAD) [1]

	Seasoned Wood						Green Wood					
	% Moisture Content	LB/Ft^3	BTU/LB	Cords/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood	% Moisture Content	LB/Ft^3	BTU/LB	Cords/Load	Million BTU/Load @ 55% Stove Efficiency	Maximum mile distance to drive for wood
Ironwood	20	50	6880	.38	5.7	520	44	60	5580	.32	4.6	420
White Oak	20	47	6880	.40	5.7	520	60	63	4860	.30	4.0	370
Sugar Maple	20	44	6880	.43	5.7	520	44	53	5580	.36	4.6	420
Red Oak	20	44	6880	.43	5.7	520	68	62	4570	.31	3.8	350
Green Ash	20	43	6880	.44	5.7	520	58	57	5370	.33	4.4	410
Tamarack	20	38	6880	.50	5.7	520	42	45	5630	.42	4.6	430
Paper Birch	20	37	6880	.51	5.7	520	47	46	5390	.41	4.5	410
American Elm	20	36	6880	.53	5.7	520	74	52	4370	.36	3.6	330
Black Ash	20	35	6880	.54	5.7	520	77	52	4270	.36	3.5	330
Red Maple	20	34	6880	.55	5.7	520	47	42	5390	.45	4.5	410
Jack Pine	20	31	6880	.60	5.7	520	48	39	5350	.49	4.4	410
Norway Pine	20	31	6880	.60	5.7	520	81	47	4150	.40	3.4	320
Black Spruce	20	29	6880	.65	5.7	520	50	37	5260	.52	4.3	400
Aspen	20	27	6880	.70	5.7	520	87	42	3980	.45	3.3	300
White Pine	20	26	6880	.72	5.7	520	64	36	4710	.45	3.9	360
Basswood	20	25	6880	.77	5.7	520	83	38	4090	.50	3.4	310
N. White Cedar	20	23	6880	.84	5.7	520	40	26	5720	.72	4.7	440
AVERAGE	20	35	6880	.56	5.7	520	60	47	4957	.42	4.1	365

[1] ASSUMES 79 FT^3 OF SOLID WOOD/STANDARD CORD AND VEHICLE AVERAGES 12 MILES/GALLON OF GASOLINE THROUGHOUT TRIP

TABLE 7 - ESTIMATING COSTS OF HARVEST AND TRANSPORTATION FOR THE SMALL WOOD USER

COST OF OPERATING A STANDARD THREE QUARTER TON PICKUP TRUCK

ASSUME:

Initial cost of vehicle - $8,000

Expected life of vehicle - 10 years

Expected salvage value of vehicle at end of expected life - $1,000

Average annual driving distance - 12,000 miles

Average fuel consumption - 12 miles/gallon

Cost of fuel - $1.25/gallon

Annual maintenance costs - $600

Annual insurance costs - $200

Annual vehicle depreciation - $\left(\frac{\$8,000 - \$1,000}{10 \text{ years}}\right) = \$700$

Annual fuel cost = (12,000 mile/12MPG) X $1.25 = $1,250

Average vehicle cost = $\left(\frac{\$1,250+\$700+\$600+\$200}{12,000 \text{ miles}}\right) = \underline{\$.23/\text{mile}}$

COST OF OPERATING A CHAINSAW

ASSUME:

Initial cost of saw = $250

Expected life of saw = 10 years

Expected salvage value of saw at end of expected life = $25

Expected production/year = 5 standard cords

Average fuel consumption = 1 GAL of gas-oil mixture/cord or $1.50/cord

Annual maintenance costs = $20

1 cord (standard) = 3 face or fireplace cords

Annual saw depreciation = $\left(\frac{\$250 - \$25}{10 \text{ year}}\right) = \$22.50$

Annual fuel cost = 5 cords x 1 GAL. fuel = 5 GAL. or $7.50

Average cost/cord = $\left(\frac{\$22.50+\$20+\$7.50}{5 \text{ cords/year}}\right) = \$10.00$

Cost/face cord - $10.00 ÷ 3 = $3.33

TABLE 8A - 1980 FUEL PRICES COMPARISON

FUEL	UNIT	Heating efficiency (percent)	Heating Values (1,000's of BTU/Unit)		Units needed to give one million BTU of available heat	COST/UNIT[1]	COST/ MILLION BTU
			Total BTU content	Avail. BTU at heating efficiency			
NATURAL GAS[2]	MCF	70	1,000	700	1.43	3.32	4.75
#2 FUEL OIL	GAL	65	141	91.7	10.91	1.10	12.00
LIQUID PROPANE	GAL	70	91	63.7	15.70	0.73	11.46
ELECTRICITY[3]	KWH	100	3.4	3.4	29.30	0.04	11.72
WOOD							
ASPEN	CORD[4]	55	14,700	8,085	0.12	60.00	7.20
PAPER BIRCH	CORD[4]	55	20,300	11,165	0.09	65.00	5.85
RED OAK	CORD[4]	55	25,000	13,750	0.07	70.00	4.90
WOOD PELLETS	TON	70	15,600	10,920	0.08	60.00	4.80
WOOD CHIPS (GREEN)[5]	TON	65	10,800	7,015	0.14	16.00	2.24

1) SOURCE: FOSSIL FUEL PRICES ARE MINNESOTA ENERGY AGENCY (MEA) COST PROJECTIONS FOR THE 1980-81 HEATING SEASON; ELECTRICITY PRICE IS MEA PROJECTION FOR 1981; WOOD PRICES ARE THE RESULT OF A FUEL-WOOD MARKET SURVEY CONDUCTED BY THE MEA IN SPRING, 1980; THE PRICE OF WOOD PELLETS AND WOOD CHIPS ARE FROM CURRENT DNR MARKET PRICE REPORTS

2) SOME PARTS OF THE STATE RECEIVE CANADIAN NATURAL GAS. PROJECTED PRICE FOR THIS FUEL IS $6.62/MCF.

3) THE PRICE SHOWN FOR ELECTRICITY REFLECTS THE UPPER END OF THE RANGE OF AVERAGE REGIONAL PRICES OF ELECTRICITY FOR SPACE HEATING PURPOSES. SOME VARIATION WILL OCCUR BETWEEN DIFFERENT ELECTRIC SUPPLIERS.

4) ASSUMES 79 FT^3 OF SOLID WOOD/STANDARD CORD AT 20% MOISTURE CONTENT. PRICES SHOWN REFLECT AVERAGE COMMERCIAL RATES IN AREAS OUTSIDE THE METRO AREA FOR WOOD WHICH IS CUT TO 16" LENGTHS, SPLIT AND SEASONED. PRICES WITHIN THE METRO AREA WOULD BE ABOUT TWICE AS MUCH.

5) WHOLE TREE CHIPS AT 47% MOISTURE CONTENT.

TABLE 8B - 1985 PROJECTED FUEL PRICES COMPARISON

FUEL	UNIT	Heating efficiency (percent)	Heating Values (1,000's of BTU/unit)		Units needed to give one million BTU of available heat	COST/UNIT[1]	COST/ MILLION BTU
			Total BTU content	Avail. BTU at heating efficiency			
NATURAL GAS[2]	MCF	70	1,000	700	1.43	5.94	8.49
#2 FUEL OIL	GAL	65	141	91.7	10.91	2.06	22.47
LIQUID PROPANE	GAL	70	91	63.7	15.70	1.37	21.51
ELECTRICITY[3]	KWH	100	3.4	3.4	293.0	0.07	20.80
WOOD							
ASPEN	CORD[4]	55	14,700	8,085	0.12	65.00	7.80
PAPER BIRCH	CORD[4]	55	20,300	11,165	0.09	85.00	7.65
RED OAK	CORD[4]	55	25,000	13,750	0.07	95.00	6.65
WOOD PELLETS	TON	70	15,600	10,920	0.08	80.00	6.40
WOOD CHIPS (GREEN)[5]	TON	65	10,800	7,015	0.14	22.00	3.08

1) SOURCE: FOSSIL FUEL PRICES ARE MINNESOTA ENERGY AGENCY COST PROJECTIONS FOR THE 1985-86 HEATING SEASON; ELECTRICITY PRICE IS MEA PROJECTION FOR 1986; PRICES FOR WOOD, WOOD PELLETS AND, WOOD CHIPS ARE PREDICTIONS BY THE MINNESOTA DNR.

2) SOME PARTS OF THE STATE RECEIVE CANADIAN NATURAL GAS. PROJECTED PRICE FOR THIS FUEL IS $10.34/MCF.

3) THE PRICE SHOWN FOR ELECTRICITY REFLECTS THE UPPER END OF THE RANGE OF AVERAGE REGIONAL PRICES OF ELECTRICITY FOR SPACE HEATING PURPOSES. SOME VARIATION OCCURS BETWEEN DIFFERENT ELECTRIC UTILITIES.

4) ASSUMES 79 FT^3 OF SOLID WOOD/STANDARD CORD AT 20% MOISTURE CONTENT. PRICES SHOWN REFLECT AVERAGE COMMERCIAL RATES IN AREAS OUTSIDE THE METRO AREA FOR WOOD WHICH IS CUT TO 16" LENGTHS, SPLIT, AND SEASONED. PRICES WITHIN THE METRO AREA WOULD BE ABOUT TWICE AS MUCH.

5) WHOLE TREE CHIPS AT 47% MOISTURE CONTENT.

fuel alone and do not consider equipment cost, storage cost, etc. The prices for wood reflect commercial rates for cut, split, and seasoned wood.

When wood is obtained from other than commercial sources, the cost may be different. Perhaps a more useful way of comparing prices in these situations is shown in Table 9. Table 9 shows the maximum price to pay for wood as compared to other common home heating fuels and average burning efficiencies. The prices shown reflect the point at which the costs per heating value of the two fuels compared are equal. Below this point it is less expensive to use wood and above this point it is less expensive to use the alternate fuel. In this way, the total cost of obtaining and using wood, including harvest, transportation, storage and handling, etc., can be compared.

TABLE 9 - MAXIMUM TOTAL COST TO PAY FOR WOOD (PER STANDARD CORD) WHEN COMPARED TO OTHER FUELS*

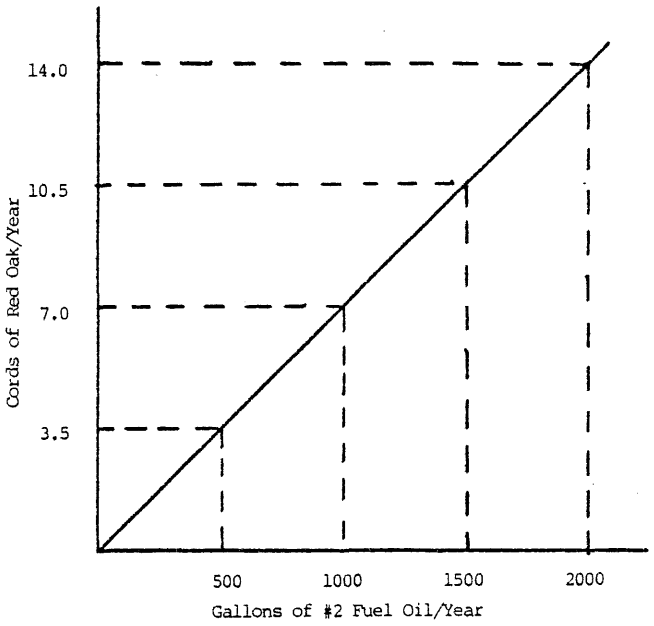
WOOD SPECIES	When #2 FUEL OIL costs $1.10/ gallon and is used with 65% efficiency, wood is less expensive for heating until its costs reaches:	When NATURAL GAS costs $3.32/MCF and is used with 70% efficiency, wood is less expensive for heating until its cost reaches:	When ELECTRICITY costs $.04/KWH and is used with 100% efficiency, wood is less expensive for heating until its cost reaches:	When LIQUID PROPANE costs $.73/gallon and is used with 70% efficiency, wood is less expensive for heating until its cost reaches:
IRONWOOD	178.75	70.75	174.75	170.75
WHITE OAK	169.25	67.00	165.25	161.50
SUGAR MAPLE	157.25	62.25	153.50	150.25
RED OAK	157.25	62.25	153.50	150.25
GREEN ASH	153.50	60.75	150.00	146.75
TAMARACK	136.75	54.25	133.50	130.75
PAPER BIRCH	133.25	52.75	130.00	127.25
AMERICAN ELM	129.50	51.25	126.50	123.75
BLACK ASH	126.00	50.00	123.00	120.25
RED MAPLE	122.50	48.50	119.50	117.00
JACK PINE	111.50	44.25	109.00	106.50
NORWAY PINE	111.50	44.25	109.00	106.50
BLACK SPRUCE	104.50	41.25	102.00	99.75
ASPEN	97.25	38.50	95.00	92.75
WHITE PINE	93.50	37.00	91.50	89.50
BASSWOOD	90.00	35.75	88.00	86.00
N. WHITE CEDAR	82.75	32.75	80.75	79.00
AVERAGE	126.75	50.25	123.75	121.00

*WOOD IS AT 20% MOISTURE CONTENT WHEN BURNED AND HEATING EFFICIENCY IS 55%

In addition to the costs of the fuel itself, there are a number of other possible costs associated with the use of wood for energy:

- Because of the lower BTU content/volume in wood as compared to other fuels, the storage of wood materials can present problems. For the home wood user the volume of wood needed to provide the equivalent heat value of the home's current annual consumption of fuel oil, as shown in Figure 1, can be much larger and require much more storage space. On the average, the volume of wood required will be about 6.5 times the volume of fuel oil used.

FIGURE 1 - CORD EQUIVALENT OF YEAR'S SUPPLY OF #2 FUEL OIL*



* 55% Wood burner efficiency and 65% Oil burner efficiency

- In addition to the problem of space, when large quantities of chipped materials or sawdust are stored improperly they can become highly volatile and such materials must be closely monitored to prevent their igniting spontaneously.

- When chipped material is stored in the green condition it must be protected from severe cold or it can freeze into a solid mass that is difficult to use.

- Dry chipped material and roundwood should be protected from precipitation to prevent the loss of heat value through absorption of water.

- In some situations, the costs of conversion from conventional energy systems to wood-powered systems can be very high.

- The use of wood also requires more time and attention than more convenient fuels such as oil and natural gas.

4.C CONCLUSIONS

- Although the cost of wood fuel itself is, in many cases, less than that of other fuels, the costs of equipment conversion, the inconvenience of storage and handling,etc. are among the prohibitive factors preventing its greater use at this time.

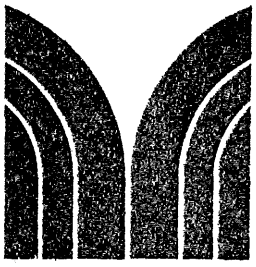
- In many situations where the use of wood is prohibited by storage and handling problems, the process of pelletizing the wood material into a dry, densified particle of uniform size may provide a more acceptable fuel. Pelletizing is also a good way to utilize logging slash and mill residues.

- In the future, the difference between the costs of wood fuel and fossil fuels will increase, and a corresponding increase in demand for the lower priced wood fuel will occur.

MINNESOTA FUELWOOD
MARKET SURVEY

Project #5

November 1980



minnesota energy agency

ABSTRACT

This report summarizes the results of a telephone survey of 376 fuelwood vendors throughout the State which was designed to coordinate the needs of wood users with the fuelwood suppliers. A directory of 115 fuelwood vendors was compiled as a result of this survey. The survey results indicate that due to a current slump in the wood products industry, many loggers have entered the fuelwood supply market as a means of supplementing their business. However, the majority of fuelwood consumed in Minnesota is harvested by individuals for their own use.

5. FUELWOOD MARKET SURVEY

5.A INTRODUCTION

A large portion of the firewood consumed in Minnesota is obtained by users through commercial fuelwood vendors. For the most part, these vendors operate within urban areas and can provide an economical supply of fuelwood to areas outside the forested regions of the State.

Objectives of the Fuelwood Market Survey

The objective of the fuelwood market survey was to provide a tool to coordinate the needs of wood users with the source and type of supply available. In addition, a directory of the larger fuelwood vendors was prepared.

Study Methods

Various methods of data gathering were used to compile a list of wood suppliers and potential suppliers in Minnesota. The suppliers, (hereafter called vendors), were identified in the metropolitan area through the yellow pages, key resource people and the classified ads. In the non-metropolitan area, the district foresters were asked to compile a list of the fuelwood producers known to them. The original list compiled from this method contained 376 names.

The telephone interview was used for verification. Several calling attempts were made during the day and evening to reach all persons who advertised and/or were on the original list. A large number could not be reached: residents had moved, phones were disconnected or went unanswered, or the person spoken to was unwilling to answer the questions. The final results and conclusions are based on telephone interviews with 115 vendors in 25 counties (see Tables 1 in Appendix E).

There are limitations to this study because not all fuelwood suppliers could be included in the survey. Due to the ease of entering the fuelwood business, there are a large number of small operators; locating all of them was virtually an impossible task. For this reason, a 10 cord minimum limit was set for a person to be called a vendor. Also, those who did not advertise, and were not well-known in their area were obviously not included. This would include vendors who serve steady customers year after year, making advertising unnecessary. Individuals who obtained more wood then they needed for the upcoming year often sold surpluses to a neighbor. In some areas there is

an exchange of an "in kind" basis - "you cut the wood you want, but leave me one-third for my use". These types of arrangements are fairly common. Thus, in consideration of these limitations, this is a sample rather than a census study.

Some of the information obtained and a list of the vendors responding is contained in Appendix E.

5.B SUMMARY OF FINDINGS

Recent Expansion

The firewood industry has grown considerably within the past few years. Sixty-three percent of the vendors surveyed have been selling wood for three years or less. This includes those who said they had been selling for a "few years" or the past "couple years". For twenty-one percent, it was their first year selling firewood. Only twelve percent of those selling have been in the firewood business for more than five years. Of the vendors surveyed in the out-state regions of Minnesota, fifty-nine percent said they were also loggers.

Prices

Of the 115 vendors surveyed, only 14 vendors said they sold cords of aspen (although others sold some aspen when selling mixed hardwoods). The price of aspen in 9 out of 14 cases sells for at least $5.00 less than the price of birch and as much as $10.00-12.00 less than the price of oak, a very general price analysis would be that an 8' cord of wood in the out-state region sells between $30.00 to $40.00 and can go as high as $45.00, and a cord of 16" wood sells between $60.00 to $70.00.

The average prices received per cord for 8', 4' and 16" lengths are $38.00, $48.00 and $64.00, respectively, for out-state fuelwood vendors.

In the Twin Cities area, the fuelwood sold is almost exclusively oak, birch, and maple. The price ranges from $90.00 to $140.00 per cord. There is no difference in price whether purchased from a retail vendor or an individual vendor.

Transportation and Prices

There does not appear to be any correlation between the miles delivered and the price charged by retailers. Some retailers charge $100.00 for wood delivered 130 miles while other charge $115.00 for the same type of wood delivered 75 miles.

Of the vendors surveyed, the wood sold by individuals is generally cut by the individual and is trucked less than 100 miles. In quantity and is trucked between 100 and 200 miles.

Most of the wood is being sold locally (within a 20 mile radius). The remaining fifteen percent of the vendors sold some, if not all, of their wood to the Twin Cities. The local wood being sold excludes people who drive up north and get a pick-up load or those who stop on the way back from a fishing trip, vacation, etc.

One reason vendors sell their wood locally, is that they do not have trucks equipped to travel long distances frequently. Unless a trip, it is not financially remunerative. However, some of the vendors selling in quantity to the Twin Cities area have the retailers pick up the wood.

Size - Length of Wood

Of the vendors selling wood in the out-state regions of Minnesota, fifty-six percent sell it in 8' or 100" lengths. Thirty-three percent of the vendors sell it in 16" lengths and of this, forty percent of the wood comes to the Twin Cities. Often the 16" wood not sold to the Twin Cities, is sold in Duluth, Mankato, St. Cloud, and other larger communities. Retail vendors in the Twin Cities area all sell 16" lengths and eighty-three percent purchase the wood split and cut to 16" lengths.

When not dealing in large volumes of fuelwood, the vendor is likely to spend more time cutting and splitting the wood. For vendors selling less than 50 cords per year, 70% sold their wood in 16 - 18" lengths, including two vendors selling less than 100 cords sold some or all wood in 16" lengths. of those selling over 100 cords per year, 16% sold the wood already split into 16" lengths. (see Table 2, in Appendix E for the number of cords sold by vendors)

Advertising

Of the out-state vendors surveyed, 68% said they did not advertise. Many said they advertised when first starting out but after building up their business, they now have regular customers or they rely on word-of-mouth advertising. In some cases, a dealer will advertise for a week or two in the spring or fall to take orders. The advertising depended on how well the wood was moving, how much wood a vendor had for sale, whether or not he had regular customers, etc.

For the most part, vendors selling less than 50 cords did not advertise. Usually they sold to friends or relatives and any excess is sold by word-of-mouth. However, if it is their first year selling, a dealer will probably advertise.

Resource Location

Sixty percent of the vendors surveyed cut some or all of their wood on State land, 41% cut on county land and 33% on private land, including 9% that cut on their own property. Ten percent said they cut from land owned by forest industries. Another 10% of the vendors cut wood on federal land. This does not include the wood sold in the Metro area by retailers since this wood is purchased from loggers in the northern part of the State and the retailers do not know the land source.

There appears to be no correlation between the number of cords sold and the resource location. Where the wood is obtained is dependent upon the make-up of the county. Some counties have more State land, others have more county or federal land. Some of the vendors selling only 50 cords yearly as well as those that sell over 500 cords get their wood from two to three sources. In contrast, some dealers who sell a couple hundred cords yearly, get their wood from only one land source. For the most part, the dealers get the wood from wherever permits are available and thus the land source could change from year to year. Many of the vendors are also in the pulpwood business and will also take the hardwood when clear-cutting an area.

Observations

The loggers, in general, feel that due to the recession people cannot afford to purchase firewood so they are cutting their own. At the same time, the loggers felt that as the pulp market slumps, more loggers will be getting into firewood and the market is becoming saturated.

There have been many ads in the newspaper already in 1980 but the loggers are complaining that they have less than half the orders they had last year at this time. As a result of this, more advertising than last year is necessary.

Those vendors that deal strictly on a wholesale level sell for less money, but there are fewer problems. One vendor, for example, said he got tired of delivering to people who weren't home when they were supposed to be, or buyers who said "that's five times more than I thought it would be, I only want half that amount". There is also the problem of checks being returned for insufficient funds.

5.C CONCLUSIONS

- Most of the firewood sold outside of the metropolitan area of Minneapolis-St. Paul in 1979 was sold in 8-foot lengths at a price of $30.00 to $40.00 per cord. When sold in 16-inch lenghts, the price was $60.00 to $70.00 per cord.

- Most of the firewood sold was oak, birch, and maple.

- The amount of firewood sold through vendors in the metropolitan area was quite small.

- Virtually all the firewood sold by vendors in the metropolitan area was in 16-inch lengths at a price of $90.00 to $140.00 per cord.

- Apparently, most firewood cut in the State is cut by individuals for their own use.

- Professional loggers have entered the firewood market due to the current slump in the forest products industry. As a result, the firewood market appears to have become saturated with a supply of wood and vendors.

- The 115 vendors surveyed collectively sold 34,653 cords in 1979. Because this is a small fraction of the estimated 1,300,000 cords consumed in 1979, either most people cut their own firewood or the market was supplied by very small or part-time vendors who could not be identified by this study.

APPENDIX A

RESOURCE ANALYSIS (BIOMASS ASSESSMENT)

Calculation of Minnesota's Total Timber Resource (Worksheets 1-5)

Determination of Harvest Residue Volume (Worksheets 6-11)

Determination of Volume from Low Productivity Forests (Worksheets 12-23)

Determination of Volume Removed Annually but Unused (Worksheet 24)

Determination of Volume from Annual Mortality (Worksheet 25)

Determination of Volume Available from Non-Commercial Forest Land (Worksheet 26)

Summary of Total Volume Available for Wood Fuel (Worksheets 27-30)

WORKSHEET 1
UNIT 1

TIMBER RESOURCE FROM 1977 INVENTORY

Forest Type	THOUSAND CUBIC FEET				GREEN TONS		
	1. All live volume (NCFES BIV5)	2. Growing stock volume (NCFES VL16)	3. Growing stock volume & bark (col.2xl.14)	4. Residual volume (col.1-col.3)	5. All live biomass (NCFES BIO5)	6. Growing stock biomass & bark (calculated)	7. Residual biomass (col.5-col.6)
Jack Pine	307,779	130,022	148,225	159,554	2,013,555	3,412,631	3,600,923
Red Pine	383,894	183,003	207,483	176,411	8,041,691	4,341,053	3,700,638
White Pine	107,560	46,905	53,472	54,088	2,154,590	1,050,739	1,103,851
Balsam Fir	1,311,084	465,570	530,750	780,334	27,795,914	11,068,131	16,727,783
White Spruce	103,546	38,466	43,851	59,695	2,133,484	867,407	1,266,077
Black Spruce	1,417,109	436,840	497,998	919,111	28,194,147	8,860,320	19,333,827
Cedar	728,529	252,042	287,328	441,201	13,460,907	4,857,292	8,603,615
Tamarack	189,591	54,170	61,754	127,837	4,162,354	1,326,690	2,835,664
Oak	14,190	5,726	6,528	7,662	372,325	182,356	189,969
Elm-Ash	462,184	169,734	193,497	268,687	10,343,081	4,399,749	5,943,332
N. Hdwds	531,018	190,604	217,289	313,729	12,303,711	5,091,533	7,212,178
Aspen	4,436,340	1,719,215	1,959,905	2,476,435	95,064,778	41,997,529	53,067,249
Birch	1,307,415	515,809	588,022	719,393	29,490,251	13,414,726	16,075,525
Balm	469,847	182,787	214,077	255,770	9,849,921	4,467,108	5,382,813
Non-Forest	18,963	3,033	3,458	15,505	410,269	72,851	337,418
All Types	11,789,049	4,397,926	5,013,636	6,775,412	250,790,978	105,410,116	145,380,862

WORKSHEET 2
UNIT 2

TIMBER RESOURCE FROM 1977 INVENTORY

Forest Type	THOUSAND CUBIC FEET				GREEN TONS		
	1. All live volume (NCFES BIV5)	2. Growing stock volume (NCFES VL16)	3. Growing stock volume & bark (col.2x1.14)	4. Residual volume (col.1-col.3)	5. All live biomass (NCFES BIU5)	6. Growing stock biomass & bark (calculated)	7. Residual biomass (col.5-col.6)
Jack Pine	739,635	301,512	343,724	395,911	17,065,243	7,969,112	9,096,131
Red Pine	198,313	90,506	103,177	95,136	4,177,830	2,174,089	2,003,741
White Pine	69,344	30,570	34,850	34,494	1,403,203	659,472	743,731
Balsam Fir	401,867	145,943	166,375	235,492	8,603,218	4,186,840	4,416,378
White Spruce	32,319	10,858	12,378	19,941	679,280	252,045	427,235
Black Spruce	378,348	83,834	95,571	282,777	7,794,549	1,699,064	6,095,485
Cedar	354,845	114,673	130,727	224,118	6,501,962	2,179,934	4,322,028
Tamarack	366,110	128,271	146,229	219,881	8,104,735	3,606,979	4,497,756
Oak	487,553	192,962	219,977	267,576	12,254,865	7,321,848	4,933,017
Elm-Ash	608,590	225,721	257,322	351,268	13,801,723	6,043,678	7,758,045
N. Hdwds	1,144,374	425,446	485,008	659,366	26,570,378	11,544,478	15,025,900
Aspen	5,719,086	2,112,336	2,408,063	3,311,022	124,895,201	53,140,034	71,755,167
Birch	810,440	317,828	362,324	448,116	18,552,614	8,455,817	10,096,797
Balm	540,007	199,665	227,618	312,389	11,412,751	4,768,902	6,643,849
Non-Forest	33,660	2,159	2,461	31,199	728,284	51,477	676,837
All Types	11,884,491	4,382,284	4,995,804	6,888,687	262,545,836	114,053,739	148,492,097
Total (Includes Chippewa Nat'l Forest)	13,717,242	8,764,568	5,725,972	7,991,270	302,149,008	129,831,643	172,317,365

WORKSHEET 3
UNIT 3

TIMBER RESOURCE FROM 1977 INVENTORY

Forest Type	THOUSAND CUBIC FEET				GREEN TONS		
	1. All live volume (NCFES BIV5)	2. Growing stock volume (NCFES VL16)	3. Growing stock volume & bark (col.2xl.14)	4. Residual volume (col.1-col.3)	5. All live biomass (NCFES B1U5)	6. Growing stock biomass & bark (calculated)	7. Residual biomass (col.5-col.6)
Jack Pine	26,064	9,152	10,433	15,631	591,881	240,139	351,742
Red Pine	29,323	9,315	10,619	18,704	629,884	225,775	404,109
White Pine	16,929	8,229	9,381	7,548	338,279	184,999	153,280
Balsam Fir	11,289	3,992	4,551	6,738	234,825	92,593	142,232
White Spruce	0	0	0	0	0	0	0
Black Spruce	26,100	4,689	5,345	20,755	553,641	106,513	447,128
Cedar	0	0	0	0	0	0	0
Tamarack	47,956	18,878	21,521	26,435	1,067,160	483,312	583,848
Oak	1,281,078	519,662	592,415	688,663	33,880,817	16,401,020	17,479,797
Elm-Ash	243,257	90,053	102,660	140,597	5,713,745	2,129,197	3,584,548
H. Hdwds	1,105,472	435,896	496,921	608,551	26,482,687	12,172,925	14,309,762
Aspen	1,058,492	373,682	425,997	632,495	23,650,975	9,627,255	14,023,720
Birch	163,758	64,577	73,618	90,140	3,858,265	1,770,191	2,088,074
Balm	18,974	6,838	7,795	11,179	398,169	164,616	233,553
Non-Forest	16,291	1,854	2,114	14,177	383,762	50,289	333,473
All Types	4,044,982	1,546,817	1,763,371	2,281,611	97,784,090	43,648,824	54,135,266

WORKSHEET 4
UNIT 4

TIMBER RESOURCE FROM 1977 INVENTORY

Forest Type	THOUSAND CUBIC FEET				GREEN TONS		
	1. All live volume (NCFES BIV5)	2. Growing stock volume (NCFES VL16)	3. Growing stock volume & bark (col.2xl.14)	4. Residual volume (col.1-col.3)	5. All live biomass (NCFES B1U5)	6. Growing stock biomass & bark (calculated)	7. Residual biomass (col.5-col.6)
Jack Pine	0	0	0	0	0	0	0
Red Pine	0	0	0	0	0	0	0
White Pine	0	0	0	0	0	0	0
Balsam Fir	0	0	0	0	0	0	0
White Spruce	0	0	0	0	0	0	0
Black Spruce	0	0	0	0	0	0	0
Cedar	0	0	0	0	0	0	0
Tamarack	460	130	148	312	10,701	2,872	7,829
Oak	142,049	57,248	65,262	76,787	3,738,909	1,795,207	1,943,702
Elm-Ash	124,144	44,512	50,744	73,400	2,930,566	1,212,726	1,717,840
H. Hdwds	312,016	123,991	141,351	170,665	7,514,723	3,507,459	4,007,264
Aspen	404,526	122,477	139,625	264,901	8,801,068	3,023,173	5,777,895
Birch	0	0	0	0	0	0	0
Balm	40,464	13,303	15,164	25,300	848,618	310,658	537,960
Non-Forest	5,341	551	628	4,713	126,994	14,508	112,486
All Types	1,028,998	362,211	412,922	616,076	23,971,579	9,866,603	14,104,976

WORKSHEET 5
UNIT ALL

TIMBER RESOURCE FROM 1977 INVENTORY

FOREST TYPE	THOUSAND CUBIC FEET				GREEN TONS		
	1. All Live Volume (NCFES BIV5)	2. Growing Stock Volume (NCFES VL16)	3. Growing Stock Volume & bark (Col.2xl.14)	4. Residual Volume (Col.1-Col.3)	5. All Live Biomass (NCFES BIO5)	6. Growing Stock Biomass & bark (Calculated)	7. Residual Biomass (Col.5-Col.6)
JACK PINE	1,073,478	440,686	502,382	571,096	24,670,679	11,621,883	13,048,796
RED PINE	611,530	282,824	321,279	290,251	12,849,405	6,740,917	6,108,488
WHITE PINE	193,823	85,704	97,703	96,130	3,896,072	1,895,210	2,000,862
BALSAM FIR	1,724,240	615,505	701,676	1,022,564	36,633,957	15,347,564	21,286,393
WHITE SPRUCE	135,865	49,324	56,229	79,636	2,812,764	1,119,452	1,693,312
BLACK SPRUCE	1,821,557	525,363	598,914	1,222,643	36,542,337	10,665,897	25,876,440
CEDAR	1,083,374	366,715	418,055	665,319	19,962,369	7,037,226	12,925,643
TAMARACK	604,117	201,449	229,652	374,465	13,344,950	5,419,853	7,925,097
OAK	1,924,870	775,598	291,767	378,460	50,246,916	25,700,431	24,546,485
ELM-ASH	1,438,175	530,020	604,223	833,952	32,789,115	13,785,350	19,003,765
N. HARDWOODS	3,092,880	1,175,937	1,340,569	1,752,311	72,871,499	32,316,395	40,555,104
ASPEN	11,618,444	4,327,710	4,933,590	6,684,853	252,412,022	113,565,886	144,624,031
BIRCH	2,281,613	898,214	1,023,964	1,257,649	51,901,130	23,640,734	28,260,396
BALM	1,069,292	407,593	464,654	604,638	22,509,459	9,711,284	12,798,175
NON-FOREST	74,255	7,597	8,661	65,594	1,649,309	189,125	1,460,214
ALL TYPES	28,747,620	10,689,238	12,185,733	17,664,369	635,092,483	272,979,282	362,113,201
All (With Chip. N.F.)	30,580,371	15,071,522	12,915,901	18,766,952	674,695,655	288,757,186	385,938,469

WORKSHEET 6
UNIT 1

RESIDUE VOLUME ABOVE ECONOMIC ROTATION AGE BY FOREST TYPE
(thousand cubic feet)

Forest Type	All Live Biomass Volume Above Economic Rotation Age	Merchantible Volume Including Bark Above Economic Rotation Age	Residue Volume	% - Residue
Jack Pine	103,241	50,321	52,920	51.3
Red Pine	3,065	1,585	1,480	48.3
White Pine	3,468	1,368	2,100	60.6
Balsam Fir	399,405	304,302	95,103	23,8
White Spruce	11,912	6,924	4,988	41.9
Black Spruce	107,816	44,621	63,195	58.6
Cedar	203,587	97,221	106,366	52.2
Tamarack	32,282	14,630	17,652	54.7
Softwood Totals	864,776	520,972	343,804	48.9
Oak				
Elm-Ash	98,986	43,374	55,612	56.2
Northern Hdwds.	104,095	43,648	60,447	58.1
Aspen	2,180,305	1,009,772	1,170,533	53.7
Birch	792,979	129,780	663,119	83.6
Balm	339,356	160,505	178,851	52.7
Hardwood Totals	3,515,721	1,387,079	2,128,562	60.9
Non-Forest				
ALL TYPES	4,380,497	1,908,051	2,472,367	53.5

WORKSHEET 7

UNIT 2

RESIDUE VOLUME ABOVE ECONOMIC ROTATION AGE BY FOREST TYPE
(thousand cubic feet)

Forest Type	All Live Biomass Volume Above Economic Rotation Age	Merchantible Volume Including Bark Above Economic Rotation Age	Residue Volume	% - Residue
Jack Pine	257,107	133,166	123,941	48.2
Red Pine	4,451	1,805	2,646	59.5
White Pine				
Balsam Fir	191,865	90,592	101,273	52.8
White Spruce	11,762	5,586	6,176	52.5
Black Spruce	34,757	6,474	18,283	73.8
Cedar	122,702	49,809	72,893	59.4
Tamarack	91,435	43,227	48,208	52.7
Softwood Totals	714,079	330,659	373,420	57.0
Oak	42,721	20,186	22,535	52.7
Elm-Ash	108,944	48,963	59,981	55.1
Northern Hdwds.	195,368	8,836	107,007	54.8
Aspen	3,721,503	1,668,840	2,052,663	55.2
Birch	671,305	305,966	365,339	54.4
Balm	336,301	162,347	173,954	51.7
Hardwood Totals	5,076,142	2,215,138	2,781,479	54.0
Non-Forest				
ALL TYPES	5,790,221	2,545,797	3,154,899	55.6

WORKSHEET 8

UNIT 3

RESIDUE VOLUME ABOVE ECONOMIC ROTATION AGE BY FOREST TYPE
(thousand cubic feet)

Forest Type	All Live Biomass Volume Above Economic Rotation Age	Merchantible Volume Including Bark Above Economic Rotation Age	Residue Volume	% - Residue
Jack Pine	3,697	1,842	1,855	50.2
Red Pine				
White Pine				
Balsam Fir	1,312	383	929	70.8
White Spruce				
Black Spruce				
Cedar				
Tamarack	8,243	3,386	4,857	58.9
Softwood Totals	13,252	5,611	7,641	60.0
Oak	395,172	186,639	208,533	52.8
Elm-Ash	26,146	13,662	12,484	47.7
Northern Hdwds.	233,685	109,970	123,715	52.9
Aspen	601,548	256,244	345,305	57.4
Birch	120,185	56,598	63,587	52.9
Balm	14,128	7,207	6,921	49.0
Hardwood Totals	1,390,864	630,320	760,545	52.1
Non-Forest				
ALL TYPES	1,404,116	635,931	768,186	54.7

WORKSHEET 9

UNIT 4

RESIDUE VOLUME ABOVE ECONOMIC ROTATION AGE BY FOREST TYPE
(thousand cubic feet)

Forest Type	All Live Biomass Volume Above Economic Rotation Age	Merchantible Volume Including Bark Above Economic Rotation Age	Residue Volume	% - Residue
Jack Pine				
Red Pine				
White Pine				
Balsam Fir				
White Spruce				
Black Spruce				
Cedar				
Tamarack				
Softwood Totals				
Oak	70,236	33,845	36,391	51.8
Elm-Ash	21,249	19,294	11,955	56.3
Northern Hdwds.	93,074	44,776	48,298	51.9
Aspen	169,562	68,444	101,118	59.6
Birch				
Balm	16,141	7,499	8,642	53.5
Hardwood Totals	370,262	173,858	206,404	54.6
Non-Forest				
ALL TYPES	370,262	173,858	206,404	54.6

WORKSHEET 10

UNIT TOTAL

RESIDUE VOLUME ABOVE ECONOMIC ROTATION AGE BY FOREST TYPE
(thousand cubic feet)

Forest Type	All Live Biomass Volume Above Economic Rotation Age	Merchantible Volume Including Bark Above Economic Rotation Age	Residue Volume	% - Residue
Jack Pine	364,045	185,329	178,716	49.1
Red Pine	7,516	3,390	4,126	54.9
White Pine	3,468	1,368	2,100	60.6
Balsam Fir	592,582	395,277	197,305	33.3
White Spruce	23,674	12,510	11,164	47.2
Black Spruce	142,573	51,095	81,478	57.1
Cedar	326,289	147,030	179,259	54.9
Tamarack	131,960	61,243	70,717	53.6
Softwood Totals	1,592,107	857,242	724,865	45.5
Oak	508,129	240,670	267,459	52.6
Elm-Ash	255,325	125,293	144,867	56.7
Northern Hdwds.	626,222	207,230	339,467	54.2
Aspen	6,672,918	3,003,300	3,669,619	55.0
Birch	1,584,469	492,344	1,092,045	68.9
Balm	705,926	337,558	368,368	52.2
Hardwood Totals	10,352,989	4,406,395	5,876,990	56.8
Non-Forest				
ALL TYPES	11,945,096	5,263,637	6,601,856	55.3

WORKSHEET 11

DETERMINATION OF RESIDUE FROM RECOMMENDED
HARVEST OF MERCHANTABLE WOOD
(THOUSAND CUBIC FEET PER YEAR 1980)

Determination of Residue	Unit I	Unit II	Unit III	Unit IV	STATE TOTALS
Recommended Harvest of Merchantable Wood	140,692	148,044	33,700	7,324	329,760
Conifers	46,525	36,045	1,901	--	
Hardwoods	94.167	111,999	31,799	--	
Actual Harvest	66,480	54,402	12,055	2,098	135,035
Conifers	34,448	21,858	592	52	
Hardwoods	32,032	32,544	11,463	2,046	
Not Harvested	74,212	93,642	21,645	5,226	194,725
Conifers	12,077	14,187	1,309	--	
Hardwoods	62,135	79,455	20,336	--	
Residue from Actual Harvest	76,181	64,751	10,502	1,465	152,899
Conifers	36,868	28,331	933	--	
Hardwoods	39,313	36,420	9,569	--	
Residue from Wood Not Harvested	100,015	125,906	27,842	7,212	260,975
Conifers	13,647	19,436	2,422	--	
Hardwoods	86,368	106,470	25,420	--	

NOTE: The actual harvest volume for 1985 includes a projected increase in aspen harvests to 108.0 MCF in Unit 1,394.2 MCF in Unit 2, and 40.5 MCF in Unit 3 and also a 2% annual increase in the harvest of other hardwoods. Although harvest volumes will probably continue to increase beyond 1985, the forest products industry may well be utilizing the additional residue for products due to more complete harvest methods, changes in merchantibility standards, etc.

WORKSHEET 12

UNIT I

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
LESS THAN 50
(acres)

Forest Type	Site Index			
	11-20	21-30	31-40	41-50
Oak	0	0	0	1,200
Maple/ Basswood	0	0	14,200	75,000
Aspen/ Balsam Poplar	0	8,900	28,900	184,500
Paper Birch	0	1,400	36,700	112,100
Elm/Ash	0	0	57,600	97,300

WORKSHEET 13

UNIT I

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
MORE THAN 50
(acres)

Forest Type	Site Index			
	51-60	61-70	71-80	81-90
Oak	1,400	1,400	1,400	0
Maple/ Basswood	82,600	39,000	2,700	1,000
Aspen/ Balsam Poplar	583,000	762,400	425,300	136,900
Paper Birch	223,400	144,000	27,200	1,500
Elm/Ash	75,400	10,500	2,900	0

WORKSHEET 14

UNIT II

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
LESS THAN 50
(acres)

Forest Type	Site Index			
	11-20	21-30	31-40	41-50
Oak	0	4,600	34,900	92,800
Maple/ Basswood	0	0	21,700	100,200
Aspen/ Balsam Poplar	1,400	1,700	49,200	205,400
Paper Birch	0	0	4,900	54,900
Elm/Ash	0	0	2,700	5,800

WORKSHEET 15

UNIT II

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
MORE THAN 50
(acres)

Forest Type	Site Index			
	51-60	61-70	71-80	81-90
Oak	67,000	34,500	9,400	4,200
Maple/ Basswood	171,900	116,800	39,800	16,100
Aspen/ Balsam Poplar	508,600	906,600	781,900	345,600
Paper Birch	143,100	122,000	35,500	9,400
Elm/Ash	1,400	0	0	0

WORKSHEET 16

UNIT III

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
LESS THAN 50
(acres)

Forest Type	Site Index			
	11-20	21-30	31-40	41-50
Oak	0	1,700	98,200	195,200
Maple/ Basswood	0	0	20,500	105,200
Aspen/ Balsam Poplar	0	1,600	4,200	39,200
Paper Birch	0	1,600	5,500	20,000
Elm/Ash	0	0	100	100

WORKSHEET 17

UNIT III

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
MORE THAN 50
(acres)

Forest Type	Site Index			
	51-60	61-70	71-80	81-90
Oak	144,300	93,000	28,700	7,900
Maple/ Basswood	167,600	134,900	43,800	13,700
Aspen/ Balsam Poplar	156,100	225,400	130,300	14,200
Paper Birch	22,500	23,800	6,800	0
Elm/Ash	400	300	400	0

WORKSHEET 18

UNIT IV

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
LESS THAN 50
(acres)

Forest Type	Site Index			
	11-20	21-30	31-40	41-50
Oak	0	1,300	31,000	18,300
Maple/ Basswood	0	0	7,100	22,400
Aspen/ Balsam Poplar	0	0	16,400	79,700
Paper Birch	0	0	0	0
Elm/Ash	0	0	200	200

WORKSHEET 19

UNIT IV

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
MORE THAN 50
(acres)

Forest Type	Site Index			
	51-60	61-70	71-80	81-90
Oak	12,800	5,900	0	0
Maple/ Basswood	43,000	25,700	17,000	1,500
Aspen/ Balsam Poplar	111,300	55,800	22,500	0
Paper Birch	0	0	0	0
Elm/Ash	900	400	300	0

WORKSHEET 20

UNIT ALL

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
LESS THAN 50
(acres)

Forest Type	Site Index			
	11-20	21-30	31-40	41-50
Oak	0	7,600	164,100	307,500
Maple/ Basswood	0	0	63,500	302,800
Aspen/ Balsam Poplar	1,400	12,200	98,700	508,800
Paper Birch	0	3,000	47,100	187,000
Elm/Ash	0	0	60,600	108,400

WORKSHEET 21

UNIT ALL

AREA OF MINNESOTA COMMERCIAL FOREST LAND
BY FOREST TYPE AND SITE INDEX CLASS OF
MORE THAN 50
(acres)

Forest Type	Site Index			
	51-60	61-70	71-80	81-90
Oak	225,500	134,800	39,500	12,100
Maple/ Basswood	465,100	316,400	103,800	32,300
Aspen/ Balsam Poplar	1,359,000	1,950,200	1,360,000	469,700
Paper Birch	389,000	289,800	69,500	10,900
Elm/Ash	78,100	11,200	3,600	0

WORKSHEET 22

GROWING STOCK VOLUME[2] OF LOW PRODUCTIVITY LANDS POTENTIALLY AVAILABLE FOR FUEL (THOUSAND CUBIC FEET)

Forest Type	G.S. Volume[1] in Cubic Ft/acre	SURVEY UNIT				
		UNIT 1	UNIT 2	UNIT 3	UNIT 4	STATE
Oak	223	214	25,364	57,101	10,468	93,147
Maple-Basswood	585	58,464	84,384	86,280	20,528	249,656
Aspen-Balm	1,264	164,383	195,920	32,106	71,100	463,509
Paper Birch	832	124,966	49,754	22,547	0	197,267
Elm-Ash	106	61,056	2,862	106	212	64,236
TOTAL	----	409,083	358,284	198,140	102,308	1,067,815

1. Calculated as (total growing stock volume on site index < 50) ÷ (total acreage on site index < 50)

2. Calculated as (growing stock volume on site index < 50 in cubic ft/acre) x (acreage of low productivity lands as defined by DNR; usually acres on site index ≤ 40)

WORKSHEET 23

WOOD RECOVERABLE FROM LOW PRODUCTIVITY LANDS
(THOUSAND CUBIC FEET)

		SURVEY UNIT				
		UNIT 1	UNIT 2	UNIT 3	UNIT 4	STATE
Harvested by Mechanical Tree Chipping	If 100% of growing stock = fuel	409,100	358,300	198,100	102,300	1,067,800
	If 40% of residue = fuel	224,200	196,300	108,600	56,100	585,200
	Total wood for fuel	633,300	554,600	306,700	158,400	1,653,000
	Annual availability over 20 years	31,665	27,730	15,335	7,920	82,650
Harvested by Manual Roundwood Recovery	If 100% of growing stock = fuel	409,100	358,300	198,100	102,300	1,067,800
	If 25% of residue = fuel	140,100	122,700	67,800	35,100	365,700
	Total wood for fuel	549,200	481,000	265,900	137,400	1,433,500
	Annual availability over 20 years	27,460	24,050	13,295	6,870	71,675

WORKSHEET 24 - WOOD REMOVED ANNUALLY FROM COMMERCIAL FOREST LAND, BUT NOT USED BY SOURCE AND UNIT[1]
(THOUSAND CUBIC FEET PER YEAR)

SOURCE	UNIT I	UNIT II	UNIT III	UNIT IV	STATE
1. MERCHANTABLE RESIDUE RESULTING FROM LOGGING[2]	1,974	2,026	893	167	5,060
2. OTHER REMOVALS[3]					
a. Portion available from timber stand improvement, land clearing, etc.	(2,920)	(5,715)	(7,097)	(2,154)	(17,886)
b. Portion available from reclassification of commercial forest land.	(2,145)	(4,177)	(5,213)	(1,587)	(12,122)
TOTAL OTHER REMOVALS	5,065	9,892	12,310	3,741	30,978
TOTAL (1+2)	7,039	11,918	13,203	3,908	36,068

1) Growing stock volume only.
2) The unused merchantable volume of harvested trees left on the harvest site and/or the unintentional tree mortality resulting from damages sustained during harvest operations.
3) The merchantable portion of trees removed but not utilized for products and trees "removed" from commercial forest land status because of changes in land classification. The U.S. Forest Service estimated 1/3 of the total volume was generated by the former (2a) and all was recoverable while of the remaining two-thirds (2b) only one-third would be recoverable. This determination was based on the fact that roughly 24 percent of the volume lost to land reclassification changed to urban and 21 percent changed to cropland. It was then assumed that 66 percent of this volume on land reclassified as urban and 100 percent of the volume on land reclassified as cropland would be available for fuel.

NOTE: Although this total volume is considered to be sustainable through the future, only 70% will be available for fuel in 1985 due to increasing utilization for traditional wood products. This trend toward greater utilization will then continue beyond 1985.

WORKSHEET 25

MINNESOTA FOREST LAND SUMMARY - 1979

Type of Forest Land	Subtotal Acres	Total Acres
Commercial Forest Land		13,700,000
Unproductive Forest Land		1,835,100
Other Forest Land		608,000
a) Cropland with Trees	65,700	
b) Improved Pasture with Trees	90,100	
c) Wooded Strips	158,900	
d) Idle Farm with Trees	7,900	
e) Windbreaks	151,000	
f) Wooded Pasture	135,000	
Urban		1,200,000

WORKSHEET 26

ANNUAL MORTALITY OF GROWING STOCK BY UNIT AND CAUSE

(thousand cubic feet per year)

	UNIT 1[a]	UNIT 2[b]	UNIT 3	UNIT 4	STATE
INSECTS	5,483	1,284	---	---	6,767
DISEASE	32,841	34,785	8,833	4,417	80,876
FIRE	120	3,968	2,444	1,154	7,686
ANIMALS	2,046	1,461	---	---	3,507
WEATHER	6,343	12,582	4,595	342	23,862
LOGGING	333	240	214	---	787
TSI	703	---	---	---	703
LAND CLEARING	---	45	---	---	45
CONVERSION	---	---	---	---	---
OTHER	7,627	8,167	1,197	318	17,309
TOTAL	55,496	62,532	17,283	6,231	141,542

a. Includes Superior National Forest

b. Includes Chippewa National Forest

NOTE: Because annual mortality occurs at low rates over large areas, it is unlikely that such material can be recovered unless it occurs on sites which are conventionally harvested for merchantable live roundwood. In this way, 2.5% of the annual mortality is currently recoverable and 5% will be available in 1985 due to increased harvesting activities.

WORKSHEET 27

UNIT 1

MINNESOTA
WOOD RECOVERABLE ANNUALLY FOR ENERGY USE
(Thousand Cubic Feet)

SOURCE OF BIOMASS	YEAR & METHOD OF HARVEST			
	1980		1985	
	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING
Residue from actual and projected annual harvest	24,400	39,000	27,400	43,900
Harvest of low productivity forests	27,500	31,700	27,500	31,700
Volume from timber "removed", but not used				
- Merchantable timber	8,000	8,000	5,600	5,600
- Residue	2,400	3,900	2,400	3,900
Annual mortality	1,920	2,240	3,840	4,480
Volume available from noncommercial forest land				
- Urban	40	860	740	860
- Other	1,150	--	1,150	--
TOTAL	66,110	85,700	68,630	90,440

WORKSHEET 28

UNIT 2

MINNESOTA
WOOD RECOVERABLE ANNUALLY FOR ENERGY USE
(Thousand Cubic Feet)

SOURCE OF BIOMASS	YEAR & METHOD OF HARVEST			
	1980		1985	
	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING
Residue from actual and projected annual harvest	23,400	37,500	34,300	54,800
Harvest of low productivity forests	24,100	27,700	24,100	27,700
Volume from timber "removed", but not used				
- Merchantable timber	13,600	13,600	9,500	9,500
- Residue	4,100	6,500	4,100	6,500
Annual mortality	2,100	2,420	4,200	4,840
Volume available from noncommercial forest land				
- Urban	930	1,070	930	1,070
- Other	2,350	--	2,350	--
TOTAL	70,580	88,790	79,480	104,410

WORKSHEET 29

UNIT 3

MINNESOTA
WOOD RECOVERABLE ANNUALLY FOR ENERGY USE
(Thousand Cubic Feet)

SOURCE OF BIOMASS	YEAR & METHOD OF HARVEST			
	1980		1985	
	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING
Residue from actual and projected annual harvest	3,800	6,100	5,100	8,200
Harvest of low productivity forests	13,300	15,300	13,300	15,300
Volume from timber "removed", but not used				
- Merchantable timber	15,100	15,100	10,500	10,500
- Residue	4,500	7,200	4,500	7,200
Annual mortality	580	670	1,160	1,340
Volume available from noncommercial forest land				
- Urban	2,880	3,320	2,880	3,320
- Other	7,890	--	7,890	--
TOTAL	48,050	47,690	45,330	45,860

WORKSHEET 30

UNIT 4

MINNESOTA
WOOD RECOVERABLE ANNUALLY FOR ENERGY USE
(Thousand Cubic Feet)

SOURCE OF BIOMASS	YEAR & METHOD OF HARVEST			
	1980		1985	
	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING	MANUAL RECOVERY (Roundwood)	MECHANICAL CHIPPING
Residue from actual and projected annual harvest	1,200	2,000	1,400	2,200
Harvest of low productivity forests	6,900	7,900	6,900	7,900
Volume from timber "removed", but not used				
- Merchantable timber	4,500	4,500	3,100	3,100
- Residue	1,300	2,100	1,300	2,100
Annual mortality	210	240	420	480
Volume available from noncommercial forest land				
- Urban	1,820	2,090	1,820	2,090
- Other	1,530	--	1,530	--
TOTAL	17,460	18,830	16,470	17,870

APPENDIX B

LOGGED AREA ANALYSIS

Summary of Logged Area Residue Survey Sample and Results (Table 1)

Wood Residue Volumes by Sources and Sale Area Sampled (Worksheets 1-9)

Minnesota Timber Production by Product and Species (Table 2, Worksheets 10-13)

Logged Area Residue Volume by Product and Species (Worksheets 14-22)

Logged Area Residue Volume by Diameter Class and Species (Worksheets 23-31)

Volume of Residue as a Percent of Volume Harvested (Table 3)

Logged Area Residue by Forest Type, Logging Method, and Residue Class (Table 4)

Residue Volume per Acre by Species Group and Forest Type (Table 5)

Volume of Wood Residue 3 Inches or Greater in Diameter Available by Manual Recovery by Forest Type, Logging Method, and Species Group (Table 6)

Percent of Residue Volume that is 8 Feet or Greater in Length, Available by Mechanical Recovery, by Forest Type and Logging Method (Table 7)

TABLE 1 SUMMARY OF LOGGED AREA RESIDUE SURVEY SAMPLE AND RESULTS

(cubic feet and green tons)

FOREST TYPE	LOGGING METHOD	CHAINS OF SAMPLE	NUMBER OF SITES	SAMPLED AREA (acres)	HARVESTED VOLUME PER ACRE		RESIDUE VOLUME PER ACRE		
					cubic ft.	tons	cubic ft.	tons	Million BTU
PINE	Shortwood	297	7	130	1803.9	31.98	303.9	5.39	63.17
	Tree Length	307	10	110	3073.3	55.4	213.56	3.85	45.12
SPRUCE - BALSAM	Shortwood	250	8	128	959.8	16.09	267.14	4.48	52.51
	Tree Length	204	3	84	2193.8	42.60	98.38	1.91	22.39
ASPEN-BIRCH	Shortwood	322	9	163	1789.0	33.13	514.78	9.36	109.70
	Tree Length	364	11	168	1951.0	33.64	448.31	7.76	90.95
	Full Tree	339	6	150	1791.0	30.88	276.81	4.76	55.79
NORTHERN HARDWOODS	Clearcut	280	10	153	1284.1	29.95	995.55	23.22	272.14
	Partial cut	297	12	230	435.6	9.84	491.79	11.11	130.21

- *Used 91 cu. ft/cord to convert to cubic feet to include bark.*
- *Tons reported at 45% moisture content (dry weight basis). Heat value= 11.72 million BTU/Ton*
- *Residue volume to a minimum top diameter of 2.6 inches*
- *1 Chain = 66 feet.*
- *Used same ratio of cubic ft. to tons as given by type on logged area worksheets 1-9, appendix.*

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 1

27-L00 ___

Cover Type Pine

Logging Method Shortwood/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre			Landing Residue Volume (Estimated to a 2.6 minimum top diameter)			Total Standing and Landing	Total Logging Area Residue
					(Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Cords	Cubic Feet	Total Cubic Feet/Ac	Cu. Ft./Ac	Cu. Ft./Ac
C-0903	1	10	59	2.5	0.1	7.9	9.1	2.0	158.0	75.8	86.1	
C-0738	1	25	95	7	0	0	0	5.0	395.0	67.7	67.7	
C-0614	1	26	93	5	0	0	0	3.8	300.2	72.0	72.0	
C-8044	3	42	483	21	0	0	0	0	0	0	0	
(11 Sale Area)	3	142	1,168	71	0	0	0	14.0	1,106.0	18.7	18.7	
C-8146	3	16	53	8	2.1	165.9	190.8	0.2	15.8	2.4	218.1	
A-3648	2	36	626	15	0	0	0	0	0	0	0	
Total		297	2,577	129.5								213.6

PERCENT OF STANDING THAT IS MERCHANTABLE 0

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 2

27-L00 ___

Cover Type Pine

Logging Method Treelength/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre (Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Landing Residue Volume (Estimated to a 2.6 minimum top diameter) Cords	Cubic Feet	Total Cubic Feet/Ac	Total Standing and Landing Cu. Ft./Ac	Total Logging Area Residue Cu. Ft./Ac
C-3542	2	27	428	13	0	0	0	4	316	24.3	24.3	
C-5309	2	12	130	3.5	0	0	0	0.5	40	11.4	11.4	
C-5295	2	12	120	3.5	0	0	0	0	0	0	0	
A-2933	2	39	400	16	0	0	0	0	0	0	0	
C-3491	2	25	201	6	0	0	0	0	0	0	0	
A-3522	2	42	418	17	0	0	0	0	0	0	0	
A-3869	1	12	100	3.5	0	0	0	0	0	0	0	
A-3314	1	20	259	10	0	0	0	10	790	79.0	79.0	
A-3742	1	18	295	3	0	0	0	9	711	237.0	237.0	
A-3549	1	100	1,364	35	0	0	0	50	3,950	112.9	112.9	
Total		307	3,715	110.5				73.5	5,807	52.6		303.9

PERCENT OF STANDING THAT IS MERCHANTABLE ___

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 3

27-L00 ___

Cover Type Spruce-Balsam

Logging Method Shortwood/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre (Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Landing Residue Volume (Estimated to a 2.6 minimum top diameter) Cords	Cubic Feet	Total Cubic Feet/Ac	Total Standing and Landing Cu. Ft./Ac	Total Logging Area Residue Cu. Ft./Ac
C-2247	1	20	167	11	1.8	142.2	163.5	0	0	0	184.9	
C-0934	1	25	129	6	0	0	0	3.5	276.5	46.1	46.1	
C-3929	2	15	103	6.5	0.2	15.8	18.2	0	0	0	20.5	
B-0141	2	26	99	10	5.1	402.9	463.3	0	0	0	523.8	
C-3171	2	42	363	22	2.2	173.8	199.9	0	0	0	225.9	
B-0124	2	15	33	5	0	0	0	0	0	0	0	
C-4135	2	9	171	4.5	0.1	7.9	9.1	0	0	0	10.3	
C-3882	2	98	285	63	1.0	79.0	90.9	2.0	158.0	2.5	151.3	
Total		250	1,350	128								267.1

PERCENT OF STANDING THAT IS MERCHANTABLE 83

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 4

27-L00 ___

Cover Type Spruce-Balsam

Logging Method Tree Length/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre			Landing Residue Volume (Estimated to a 2.6 minimum top diameter)			Total Standing and Landing	Total Logging Area Residue
					(Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Cords	Cubic Feet	Total Cubic Feet/Ac	Cu. Ft./Ac	Cu. Ft./Ac
C-3917	2	15	216	7	0.4	31.6	36.3	0	0	0	41.1	
A-3402	2	159	1,477	62	0.8	63.2	72.7	0	0	0	82.2	
C-4203	2	30	332	15	0.8	63.2	72.7	5.0	395.0	31.6	113.8	
Total		204	2,025	84								98.4

PERCENT OF STANDING THAT IS MERCHANTABLE 100

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 5

27-L00 ___

Cover Type Aspen

Logging Method Shortwood/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre			Landing Residue Volume (Estimated to a 2.6 minimum top diameter)			Total Standing and Landing	Total Logging Area Residue
					(Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Cords	Cubic Feet	Total Cubic Feet/Ac	Cu. Ft./Ac	Cu. Ft./Ac
C-8284		75	547	38	0.1	7.9	10.3	0.7	55.3	1.5	11.8	
C-0908	1	40	575	16	0	0	0	5.8	458.2	28.6	28.6	
C-8344	3	22	105	11	0.7	55.3	71.9	3.7	292.3	26.6	98.5	
C-8365	3	20	206	10	0	0	0	0.9	71.1	7.1	7.1	
B-0159	2	35	741	20	0	0	0	0.1	7.9	0.4	0.4	
B-0149	2	34	133	18	1.3	102.7	133.5	0	0	0	133.5	
C-2771	1	20	273	15	3.7	292.3	380.0	0.8	63.2	4.2	384.2	
C-3051	2	36	223	18	2.7	213.3	277.3	1.6	126.4	7.0	284.3	
C-0761	1	40	402	17	0	0	0	26.0	2054	120.8	120.8	
Total		322	3,205	163								514.8

PERCENT OF STANDING THAT IS MERCHANTABLE 56

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 6

27-L00 ___

Cover Type Aspen

Logging Method Tree Length/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre			Landing Residue Volume (Estimated to a 2.6 minimum top diameter)			Total Standing and Landing	Total Logging Area Residue
					(Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Cords	Cubic Feet	Total Cubic Feet/Ac	Cu. Ft./Ac	Cu. Ft./Ac
C-1846	1	26	550	20	0.3	23.7	30.8	4	316	19.0	49.8	
C-1884	1	40	575	17	0.3	23.7	30.8	3.5	276.5	19.5	50.3	
C-2613	1	14	316	7	0	0	0	0	0	0	0	
B-6905	3	64	577	32	0	0	0	0	0	0	0	
B-6906	3	60	470	30	0	0	0	0	0	0	0	
C-3465	2	30	80	4	0	0	0	0	0	0	0	
C-4199	2	30	263	11	0	0	0	1	79	8.6	8.6	
C-3151	2	33	175	16	0	0	0	0	0	0	0	
C-4201	2	27	200	9	0	0	0	0	0	0	0	
B-9606	1	20	226	16	0	0	0	8	632	47.4	47.4	
C-1638	1	20	171	6	0	0	0	18	1,422	284.4	284.4	
Total		364	3,603	168								448.3

PERCENT OF STANDING THAT IS MERCHANTABLE 67

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 7

27-L00 ___

Cover Type Aspen

Logging Method Fulltree/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre (Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Landing Residue Volume (Estimated to a 2.6 minimum top diameter) Cords	Cubic Feet	Total Cubic Feet/Ac	Total Standing and Landing Cu. Ft./Ac	Total Logging Area Residue Cu. Ft./Ac
C-2492	1	40	305	16	0	0	0	2	158.0	11.9	11.9	
C-1806	1	20	270	9	0	0	0	2	158.0	21.1	21.1	
C-8126	3	76	753	38	1.0	79	102.7	1.8	142.2	4.5	107.2	
C-8136	3	80	518	40	0.3	23.7	30.8	10.3	813.7	24.4	55.2	
B-7529	2	81	546	30	0	0	0	0	0	0	0	
C-4242	2	42	560	17	0	0	0	0	0	0	0	
Total		339	2,952	150								276.8

PERCENT OF STANDING THAT IS MERCHANTABLE 31

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 8

27-L00 ___

Cover Type Northern Hardwoods

Logging Method Shortwood/Clearcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre			Landing Residue Volume (Estimated to a 2.6 minimum top diameter)			Total Standing and Landing	Total Logging Area Residue
					(Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Cords	Cubic Feet	Total Cubic Feet/Ac	Cu. Ft./Ac	Cu. Ft./Ac
C-9732	5	16	59	8	0.2	15.8	23.7	0	0	0	23.7	
C-4462	2	31	462	19	0.1	7.9	11.9	3.0	237.0	12.5	24.4	
B-6296	2	32	315	18	0.5	39.5	59.3	1.5	118.5	6.6	65.9	
C-8418	3	62	389	31	0	0	0	10.1	797.9	25.7	25.7	
C-9733	5	20	71	10	1.4	110.6	165.9	5.0	395.0	39.5	205.4	
C-9731	5	21	71	11	1.0	79.0	118.5	0	0	0	118.5	
Private	5	6	154	10	0.9	71.1	106.7	0	0	0	106.7	
Private	5	10	192	5	1.4	110.6	165.9	0	0	0	165.9	
Private	5	20	32	10	0.2	15.8	23.7	0	0	0	23.7	
Private	5	62	414	31	1.0	79.0	118.5	3.0	237.0	7.6	118.5	
Total		280	2,159	153								995.6

PERCENT OF STANDING THAT IS MERCHANTABLE 9

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

WOOD RESIDUE VOLUMES BY SOURCES[a] AND SALE AREA SAMPLED

Worksheet 9
27-L00

Cover Type Northern Hardwoods
Logging Method Shortwood/Partialcut

Sale #	Region	Chains	Recovered Volume (Cords)	Sale Area (Acres)	Standing Tree Volume[b]/Acre (Cords)	(Cubic[c] Feet)	Total[d] (Cubic Feet)	Landing Residue Volume (Estimated to a 2.6 minimum top diameter) Cords	Cubic Feet	Total Cubic Feet/Ac	Total Standing and Landing Cu. Ft./Ac	Total Logging Area Residue Cu. Ft./Ac
Private	5	20	64	10	1.1	86.9	130.4	0	0	0	130.4	
Erickson	1	35	201	58	1.1	86.9	130.4	10	790.0	13.6	144.0	
C-4645	2	30	54	14	0	0	0	6	474.0	33.9	33.9	
C-3220	2	29	151	15	0.1	7.9	11.9	2	158.0	10.5	22.4	
C-8211	3	40	61	20	0.2	15.8	23.7	7	553.0	27.7	51.4	
Schunaman	1	20	109	37	0.3	23.7	35.6	6	474.0	12.8	48.4	
Haagenson	1	20	16	30	0	0	0	0	0	0	0	
B-8894	1	15	107	6	2.6	205.4	308.1	5	395.0	65.8	373.9	
C-8455	3	14	188	7	0.3	23.7	35.6	0	0	0	35.6	
B-7529	2	13	52	3	0	0	0	0	0	0	0	
Private	5	28	35	14	0.3	23.7	35.6	3	237.0	16.9	52.5	
C-9759	5	33	63	16	2	158.0	237.0	3	237.0	14.8	251.8	
Total		297	1,101	230								491.8

PERCENT OF STANDING THAT IS MERCHANTABLE 5

a. Sources of residue include standing timber, wood volumes accumulated at the landing, and logged area residue on the site.
b. Standing trees remaining on the site following harvest that should have been removed.
c. Measured merchantable volume of trees according to inventory guides (based on 79 cubic feet per cord).
d. An estimate of the total volume to a 2.6 minimum top diameter (based on the relationship between the volume per acre harvested and the residue volume per acre).

TABLE 2
UNIT ALL

MINNESOTA TIMBER PRODUCTION BY PRODUCT and SPECIES
(In Thousand Standard Cords)
1979

Product	SPECIES									TOTAL
	J Pine	N & W Pine	Fir	Spruce	Tama-rack	Cedar	Aspen	Birch	Other Hdwds	
Pulp (roundwood & chips)	141.9	16.6	117.4	152.9	35.8		837.6	6.7	31.2	1,340.1
Sawmills (Lbr)	81.7	54.8	19.9	10.0	.4	12.0	195.6	7.2	143.1	524.7
Posts & Poles (commercial)	14.4	15.0				9.0				38.4
Logs (export)	1.0		.2						12.0	13.2
Lath							22.5			22.5
Shavings							7.7			7.7
Dowels								15.0		15.0
Veneer (export)									8.0	8.0
Veneer (local)	.2						4.0	3.5	.3	7.8
Posts (local)		.5			.5	5.4			1.0	7.6
Staves									1.0	1.0
Total Cords	239.2	86.9	137.5	162.9	36.7	26.4	1,067.4	32.4	196.6	1,986.0
Ave. Cords/Acre	18	25	16	18	18	14	16	16	10	xxx
#Acres Harvested * (thousand acres)	13.29	3.55	8.59	9.05	2.04	1.89	66.71	2.03	19.66	126.81
Projected Increase By 1985 (cords)							542.8	3.2	19.2	565.2
1985 Projected Total							1,610.2	35.6	215.8	2,551.2

* Presented with updated acreage figures. In the text, Table 1 acreage figures will vary slightly.

WORKSHEET 10
UNIT I

MINNESOTA TIMBER PRODUCTION BY PRODUCT and SPECIES
(In Thousand Standard Cords)

1979

Product	SPECIES									TOTAL
	J Pine	N & W Pine	Fir	Spruce	Tama-rack	Cedar	Aspen	Birch	Other Hdwds	
Pulp (roundwood & chips)	68.2	6.5	71.3	118.5	18.3		391.8	2.5	18.5	695.6
Sawmills	46.2	28.6	11.8	5.4	.1	10.2	39.9	3.5	7.8	153.5
Posts & Poles (commercial)	7.9	7.8				8.5				24.2
Logs (export)	1.0		.2							1.2
Lath							.2			.2
Shavings										
Dowels										
Veneer (export)								15.0		15.0
Veneer (local)							4.0	3.5		7.5
Posts (local)	.1	.2			.2	3.0				3.4
Staves										
TOTAL CORDS	123.4	43.1	83.3	123.9	18.6	21.7	435.9	24.5	26.3	900.7
PROJECTED INCREASE BY 1985							108.0	2.5	2.6	113.1
1985 PROJECTED TOTAL							543.9	27.0	28.9	1013.8

WORKSHEET 11
UNIT II

MINNESOTA TIMBER PRODUCTION BY PRODUCT and SPECIES
(In Thousand Standard Cords)

1979

Product	SPECIES									TOTAL
	J Pine	N & W Pine	Fir	Spruce	Tama-rack	Cedar	Aspen	Birch	Other Hdwds	
Pulp (roundwood & chips)	67.9	7.5	46.1	34.3	15.3		403.9		9.0	584.0
Sawmills	33.8	23.2	8.0	4.5	.2	1.8	140.4	3.2	54.3	269.4
Posts & Poles (commercial)	6.5	7.2				.5				14.2
Logs (export)										
Lath							20.8			20.8
Shavings							4.4			4.4
Dowels										
Veneer (export)										
Veneer (local)										
Posts (local)	.1	.3			.2	2.3				2.9
Staves									1.0	1.0
TOTAL CORDS	108.3	38.2	54.1	38.8	15.7	4.6	569.5	3.2	64.3	896.7
PROJECTED INCREASE 1985							394.2	.3	6.0	400.5
1985 PROJECTED TOTAL							963.7	3.5	70.3	1297.2

WORKSHEET 12

UNIT III

MINNESOTA TIMBER PRODUCTION BY PRODUCT and SPECIES

(In Thousand Standard Cords)

1979

Product	SPECIES									TOTAL
	J Pine	N & W Pine	Fir	Spruce	Tama-rack	Cedar	Aspen	Birch	Other Hdwds	
Pulp (roundwood & chips)	5.8	2.6			.2		41.1	3.2	3.7	56.6
Sawmills	1.7	2.8	.1	.1	.1		15.2	.5	58.9	79.4
Posts & Poles (commercial)										
Logs (export)										
Lath							1.5			1.5
Shavings							3.3			3.3
Dowels										
Veneer (export)										
Veneer (local)									.3	.3
Posts (local)					.1				.5	.6
Staves										
TOTAL CORDS	7.5	5.4	.1	.1	.4		61.1	3.7	63.4	141.7
PROJECTED INCREASE BY 1985							40.5	.4	6.3	47.2
1985 PROJECTED TOTAL							101.6	4.1	4.1	188.9

WORKSHEET 13

UNIT IV

MINNESOTA TIMBER PRODUCTION BY PRODUCT and SPECIES

(In Thousand Standard Cords)

1979

Product	SPECIES									TOTAL
	J Pine	N & W Pine	Fir	Spruce	Tama-rack	Cedar	Aspen	Birch	Other Hdwds	
Pulp (roundwood & chips)					2.0		.8			2.8
Sawmills		.2					.1		22.1	22.4
Posts & Poles (commercial)										
Logs (export)									12.0	12.0
Lath										
Shavings										
Dowels										
Veneer (export)									8.0	8.0
Veneer (local)										
Posts (local)						.1			.5	.6
Staves										
TOTAL CORDS		.2			2.0	.1	.9		42.6	45.8
PROJECTED INCREASE BY 1985							.1		4.3	4.4
1985 PROJECTED TOTAL							1.0		46.9	50.2

WORKSHEET 14 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Pine
Logging Method: Shortwood/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
105 Jack pine	cu-ft/AC	74.33	79.35	0	52.17	205.85
	Ton/AC	1.32	1.41		.93	3.66
	%	24	25		17	66
375 Paper birch	cu-ft/AC	13.21	0	0	0	13.21
	Ton/AC	.23				.23
	%	6				6
833 Oak	cu-ft/AC	0	1.65	0	0	1.65
	Ton/AC		.03			.03
	%					
746 Aspen	cu-ft/AC	15.62	59.34	0	5.42	80.38
	Ton/AC	.26	1.06		.10	1.42
	%	5	19		2	26
95 Black spruce	cu-ft/AC	2.81	0	0	0	2.81
	Ton/AC	.05				.05
	%	1				1
TOTAL	cu-ft/AC	105.97	140.34	0	57.59	303.90
	Ton/AC	1.86	2.50		1.03	5.39
	%	36	45		19	100

WORKSHEET 15 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Pine
Logging Method: Tree length/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
105 Jack pine	cu-ft	84.17	54.84	0	0	139.02
	Ton/AC	1.51	.98			2.49
	%	39	26			65
125 Red pine	cu-ft	1.57	0	0	0	1.57
	Tons/AC	.03				.03
	%	1				1
129 White pine	Cu-ft	3.39	4.61	0	0	8.00
	Tons/AC	.06	.08			.14
	%	2	2			4
375 Paper birch	cu-ft	9.37	11.13	0	0	20.50
	Tons/AC	.17	.20			.37
	%	4	5			9
746 Aspen	cu-ft	1.47	0	0	0	1.47
	Tons/AC	.03	0			.03
	%	1				1
12 Balsam fir	cu-ft	22.48	0	0	0	22.48
	Tons/AC	.40				.40
	%	10				10
94 White spruce	cu-ft	7.80	12.72	0	0	20.52
	Tons/AC	.14	.25			.39
	%	4	6			10
TOTAL	cu-ft	130.25	83.30	0	0	213.56
	Tons/AC	2.34	1.51			3.85
	%	61	39			100

WORKSHEET 16 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Spruce-Balsam
Logging Method: Shortwood/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
375 Paper birch	cu-ft/AC Tons/AC %	23.39 .40 9	35.71 .60 13	0	0	59.10 1.00 22
12 Balsam fir	cu-ft/AC Tons/AC %	62.87 1.05 24	30.49 .51 11	0	0	93.36 1.56 35
95 Black spruce	cu-ft Tons/AC %	1.57 .03 1	0	0	0	1.57 .03 1
746 Aspen	cu-ft/AC Tons/AC %	29.26 .49 11	39.28 .65 15	0	0	68.54 1.14 26
316 Maple	cu-ft/AC Tons/AC %	8.91 .15 3	0	0	0	8.91 .15 3
543 Ash	cu-ft/AC Tons/AC %	2.68 .04 1	0	0	0	2.68 .04 1
972 Elm	Cu-ft/AC Tons/AC %	8.67 .14 3	2.62 .04 1	0	0	11.29 .18 4
951 Basswood	cu-ft/AC Tons/AC %	6.72 .11 2	0	0	0	6.72 .11 2
241 N. white cedar	cu-ft/AC Tons/AC %	0	14.97 .27 6	0	0	14.97 .27 6
TOTAL	cu-ft/AC Tons/AC %	144.07 2.41 54	23.07 2.07 46	0	0	267.14 4.48 100

WORKSHEET 17 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Spruce-Balsam
Logging Method: Tree Length/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
95 Spruce	cu-ft/AC	7.78	0	0	0	7.78
	Tons/AC	.15				.15
	%	7				7
375 Paper birch	cu-ft/AC	13.67	7.38	0	13.54	34.59
	Tons/AC	.27	.14		.26	.67
	%	14	8		14	36
12 Balsam Fir	cu-ft/AC	11.56	2.45	0	3.77	17.78
	Tons/AC	.23	.05		.07	.35
	%	12	2		4	18
746 Aspen	cu-ft/AC	2.74	15.61	0	0	18.35
	Tons/AC	.05	.30			.35
	%	3	16			19
543 Ash	cu-ft/AC	3.21	0	0	0	3.21
	Tons/AC	.06				.06
	%	3				3
741 Balsam Poplar	cu-ft/AC	3.09	0	0	0	3.09
	Tons/AC	.06				.06
	%	3				3
316 Maple	cu-ft/AC	12.59	0	0	0	12.59
	Tons/AC	.25				.25
	%	13				13
972 Elm	cu-ft/AC	.99	0	0	0	.99
	Tons/AC	.02				.02
	%	1				1
TOTAL	cu-ft/AC	55.63	25.44	0	17.31	98.38
	Tons/AC	1.09	.49		.33	1.91
	%	56	26		18	100

WORKSHEET 18 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Aspen
Logging Method: Shortwood/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
746 Aspen	cu-ft/AC	58.30	86.35	0	75.63	220.28
	Ton/AC	1.06	1.57		1.38	4.01
	%	11	17		15	43
12 Balsam fir	cu-ft/AC	11.92	0	0	0	11.92
	Ton/AC	.22				.22
	%	2				2
375 Paper birch	cu-ft/AC	80.37	45.79	0	0	126.16
	Ton/AC	1.46	.83			2.29
	%	16	9			25
951 Basswood	cu-ft/AC	28.16	0	0	0	28.16
	Ton/AC	.51				.51
	%	5				5
543 Ash	cu-ft/AC	35.12	12.51	0	4.66	52.29
	Ton/AC	.64	.23		.09	.96
	%	7	2		1	10
833 Oak	cu-ft/AC	12.23	0	0	14.13	26.36
	Ton/AC	.22			.25	.47
	%	2			3	5
316 Maple	cu-ft/AC	30.83	2.38	0	0	33.21
	Ton/AC	.56	.04			.60
	%	6	.5			6.5
741 Balsam poplar	cu-ft/AC	13.91	0	0	0	13.91
	Ton/AC	.25				.25
	%	3				3
318 Sugar maple	cu-ft/AC	2.49	0	0	0	2.49
	Ton/AC	.05				.05
	%	.5				.5
TOTAL	cu-ft/AC	273.33	147.03	0	94.42	514.78
	Ton/AC	4.97	2.67		1.72	9.36
	%	52.5	28.5		19	100

WORKSHEET 19 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Aspen
Logging Method: Tree length/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
746 Aspen	cu-ft/AC	227.29	64.11	0	10.84	302.24
	Ton/AC	3.93	1.12		.19	5.24
	%	51	14		2	67
12 Balsam fir	cu-ft/AC	26.76	13.89	0	0	40.65
	Ton/AC	.46	.24			.70
	%	6	3			9
375 Paper birch	cu-ft/AC	19.08	9.32	0	0	28.40
	Ton/AC	.33	.16			.49
	%	4	2			6
972 Elm	cu-ft/AC	1.92	4.65	0	0	6.57
	Ton/AC	.03	.08			.11
	%	.5	1			1.5
544 Ash	cu-ft/AC	2.36	0	0	0	2.36
	Ton/AC	.04				.04
	%	1				1
316 Maple	cu-ft/AC	0	2.43	0	0	2.43
	Ton/AC		.04			.04
	%		1			1
833 Oak	cu-ft/AC	38.75	7.95	0	0	46.70
	Ton/AC	.67	.14			.81
	%	9	2			11
951 Basswood	cu-ft/AC	5.61	2.27	0	11.08	18.96
	Ton/AC	.10	.04		.19	.33
	%	1	.5		2	3.5
TOTAL	cu-ft/AC	321.77	104.62	0	21.92	448.31
	Ton/AC	5.56	1.82		.38	7.76
	%	72.5	23.5		4	100

WORKSHEET 20 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Aspen
Logging Method: Full tree/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
746 Aspen	cu-ft/AC	90.18	54.75	0	59.78	204.72
	Ton/AC	1.55	.94		1.03	3.52
	%	33	20		22	75
12 Balsam fir	cu-ft/AC	7.30	0	0	0	7.30
	Ton/AC	.13				.13
	%	3				3
741 Balsam poplar	cu-ft/AC	16.74	12.25	0	0	28.99
	Ton/AC	.29	.21			.50
	%	6	4		0	10
375 Paper birch	cu-ft/AC	13.61	0	0	0	13.61
	Ton/AC	.23				.23
	%	5				5
543 Ash	cu-ft/AC	1.70	0	0	0	1.70
	Ton/AC	.03				.03
	%	.5				. 5
94 Spruce	cu-ft/AC	2.28	0	0	0	2.28
	Ton/AC	.04				.04
	%	.5				.5
972 Elm	cu-ft/AC	3.62	0	0	0	3.62
	Ton/AC	.06				.06
	%	1				1
316 Red maple	cu-ft/AC	7.74	0	0	0	7.74
	Ton/AC	.13				.13
	%	3				3
318 Sugar maple	cu-ft/AC	1.08	0	0	0	1.08
	Ton/AC	.02				.02
	%	0				0
833 Oak	cu-ft/AC	5.77	0	0	0	5.77
	Ton/AC	.10				.10
	%	2	0		0	2
TOTAL	cu-ft/AC	149.49	67.00	0	59.78	276.81
	Ton/AC	2.58	1.15		1.03	4.76
	%	54	24		22	100

WORKSHEET 21 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Northern Hdwds.
Logging Method: Shortwood/ Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull Wood	
746 Aspen	cu-ft/AC	64.57	8.66	0	1.94	75.17
	Ton/AC	1.46	.20		.04	1.70
	%	6	1		.1	7.1
375 Paper birch	cu-ft/AC	24.64	0	0	0	24.64
	Ton/AC	.56				.56
	%	2				2
951 Basswood	cu-ft/AC	32.64	19.15	0	0	51.79
	Ton/AC	.74	.43			1.17
	%	3	2			5
972 Elm	cu-ft/AC	1.12	0	6.16	0	7.28
	Ton/AC	.03		.14		.17
	%	1		.5		1.5
823 White oak	cu-ft/AC	168.16	0	0	0	168.16
	Ton/AC	3.82				3.82
	%	16				16
833 Red oak	cu-ft/AC	471.93	48.48	0	2.14	522.55
	Ton/AC	11.30	1.16		.05	12.51
	%	49	5		.2	54.2
318 Sugar maple	cu—ft/AC	8.78	10.86	0	2.26	21.90
	Ton/AC	.20	.25		.05	.50
	%	1	1		.2	2.2
316 Red maple	cu-ft/AC	113.60	0	0	0	113.60
	Ton/AC	2.57				2.57
	%	11				11
543 Black ash	cu-ft/AC	0	10.47	0	0	10.47
	Ton/AC		.24			.24
	%		1			1
TOTAL	cu-ft/AC	885.44	97.62	6.16	6.33	995.55
	Ton/AC	20.67	2.27	.14	.14	23.22
	%	89	10	.5	.5	100

WORKSHEET 22 LOGGED AREA RESIDUE VOLUME BY PRODUCT AND SPECIES

Cover Type: Northern Hdwds.
Logging Method: Shortwood/ Partial cut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	PRODUCT				TOTAL
		Fuelwood	Pulpwood	Sawlog	Cull wood	
972 Elm	cu-ft/AC Ton/AC %	163.50 3.61 32	0	0	19.93 .43 4	183.43 4.04 36
12 Balsam fir	cu-ft/AC Ton/AC %	1.21 .03 .5	0	0	0	1.21 .03 .5
318 Sugar maple	cu-ft/AC Ton/AC %	13.67 .30 2.5	0	0	0	13.67 .30 3
541 White ash	cu-ft/AC Ton/AC %	15.57 .34 3	1.43 .03 .5	0	4.86 .11 1	21.86 .48 4
951 Basswood	cu-ft/AC Ton/AC %	9.40 .20 2	0	5.18 .11 1	0	14.58 .31 3
837 Red oak	cu-ft/AC Ton/AC %	5.17 .11 1	0	0	0	5.17 .11 1
746 Aspen	cu-ft/AC Ton/AC %	80.68 1.95 17.5	10.27 .22 2	0	0	90.95 2.17 20
375 Paper birch	cu-ft/AC Ton/AC %	1.99 .04 .5	3.95 .09 .5	0	0	5.94 .13 1
316 Red maple	cu-ft/AC Ton/AC %	12.21 .27 2	0	0	0	12.21 .27 2
823 White oak	cu-ft/AC Ton/AC %	104.05 2.43 22	0	38.72 .84 8	0	142.77 3.27 29.5
TOTAL	cu-ft/AC Ton/AC %	407.45 9.28 83	15.65 .34 3	43.90 .95 9	24.79 .54 5	491.79 11.11 100

WORKSHEET 23

LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Pine
Logging Method: Shortwood/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS *					TOTAL
		2"	4"	6"	8"	10"	
105 Jack Pine	cu-ft	89.13	76.84	30.00	9.88	0	205.85
	Tons/AC	1.58	1.38	.53	.17		3.66
	%	29.3	25.3	9.9	3.2		67.7
375 Paper Birch	cu-ft.	13.21	0	0	0	0	13.21
	Tons/AC	.23					.23
	%	4.3					4.3
833 Oak	cu-ft	0	1.65	0	0	0	1.65
	Tons/AC		.03				.03
	%		.5				.5
746 Aspen	cu-ft	63.31	11.65	5.42	0	0	80.38
	Tons/AC	1.13	.21	.09			1.43
	%	21	4	1.5			26.5
95 Black Spruce	cu-ft	2.81	0	0	0	0	2.81
	Tons/AC	.05					.05
	%	1					1
TOTAL	cu-ft	168.46	90.14	35.42	9.88	0	303.90
	Tons/AC	2.99	1.62	.62	.17		5.4
	%	55	30	12	3		100

*The diameter class intervals are as follows:
(2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches
(10) 9.0 inches and greater

WORKSHEET 24 LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Pine
Logging Method: Treelength/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS*					TOTAL
		2"	4"	6"	8"	10"	
105 Jack Pine	cu-ft	39.53	55.40	27.46	16.63	0	139.02
	Tons/AC	.71	.98	.50	.30		2.49
	%	18	26	13	8		65
125 Red Pine	cu-ft	1.57	0	0	0	0	1.57
	Tons/AC	.03					.03
	%	1					1
129 White pine	cu-ft	3.39	4.61	0	0	0	8.00
	Tons/AC	.06	.08				.14
	%	2	2				4
375 Paper birch	cu-ft	12.11	8.39	0	0	0	20.50
	Tons/AC	.22	.15				.37
	%	5	4				9
746 Aspen	cu-ft	1.47	0	0	0	0	1.47
	Tons/AC	.03					.03
	%	1					1
12 Balsam fir	cu-ft	17.12	5.36	0	0	0	22.48
	Tons/AC	.30	.10				.40
	%	8	2				10
94 White spruce	cu-ft	14.57	5.95	0	0	0	20.52
	Tons/AC	.27	.12				.39
	%	7	3				10
TOTAL	cu-ft	89.76	79.71	27.46	16.63	0	213.56
	Tons/AC	1.62	1.43	.50	.30		3.85
	%	42	37	13	8		100

*The diameter class intervals are as follows:
(2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches
(10) 9.0 inches and greater.

WORKSHEET 25 LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Spruce-Balsam
Logging Method: Shortwood/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS*					TOTAL
		2"	4"	6"	8"	10"	
375 Paper birch	cu-ft	59.13	0	0	0	0	59.13
	Tons/AC	1.00					1.00
	%	22					22
12 Balsam fir	cu-ft	64.90	24.01	4.45	0	0	93.36
	Tons/AC	1.08	.40	.07			1.55
	%	24	9	2			35
95 Black spruce	cu-ft	1.57	0	0	0	0	1.57
	Tons/AC	.02					.02
	%	1					1
746 Aspen	cu-ft	39.26	18.64	0	10.64	0	68.54
	Tons/AC	.65	.31		.18		1.14
	%	15	7		4		26
316 Maple	cu-ft	.94	7.97	0	0	0	8.91
	Tons/AC	.02	.13				.15
	%	.5	2.5				3
543 Ash	cu-ft	2.69	0	0	0	0	2.69
	Tons/AC	.05					.05
	%	1					1
972 Elm	cu-ft	7.98	3.31	0	0	0	11.29
	Tons/AC	.14	.06				.20
	%	3	1				4
951 Basswood	cu-ft	6.73	0	0	0	0	6.73
	Tons/AC	.11					.11
	%	2					2
241 N. White Cedar	cu-ft	14.97	0	0	0	0	14.97
	Tons/AC	.26					.26
	%	6					6
TOTAL	cu-ft	198.17	53.93	4.45	10.64	0	267.19
	Tons/AC	3.33	.90	.07	.18		4.48
	%	74.5	19.5	2	4		100

* The diameter class intervals are as follows:
(2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches
(10) 9.0 inches and greater.

WORKSHEET 26

LOGGED AREA RESIDUE VOLUME BY
DIAMETER CLASS AND SPECIES

Cover Type: Spruce-Balsam
Logging Method: Treelength/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS*					TOTAL
		2"	4"	6"	8"	10"	
95 Black spruce	cu-ft	5.51	2.27	0	0	0	7.78
	Tons/AC	.11	.04				.15
	%	6	2				8
375 Paper birch	cu-ft	17.87	0	7.38	9.33	0	34.58
	Tons/AC	.35		.14	.18		.67
	%	18		8	9		35
12 Balsam fir	cu-ft	5.04	12.75	0	0	0	17.79
	Tons/AC	.10	.25				.35
	%	5	13				18
746 Aspen	cu-ft	14.18	3.55	0	0	0	18.35
	Tons/AC	.29	.06				.35
	%	15	4				19
543 Ash	cu-ft	3.21	0	0	0	0	3.21
	Tons/AC	.06					.06
	%	3					3
741 Balsam poplar	cu-ft	3.09	0	0	0	0	3.09
	Tons/AC	.06					.06
	%	3					3
316 Maple	cu-ft	12.59	0	0	0	0	12.59
	Tons/AC	.25					.25
	%	13					13
972 Elm	cu-ft	.99	0	0	0	0	.99
	Tons/AC	.02					.02
	%	1					1
TOTAL	cu-ft	63.10	18.57	7.38	9.33	0	98.38
	Tons/AC	1.24	.35	.14	.18		1.91
	%	64	19	8	9		100

* *The diameter class intervals are as follows:*
(2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches
(10) 9.0 inches and greater

WORKSHEET 27

LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Aspen
Logging Method: Shortwood/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS*					TOTAL
		2"	4"	6"	8"	10"	
746 Aspen	cu-ft	80.50	69.65	59.14	0	10.99	220.28
	Tons/AC	1.46	1.27	1.08		.20	4.01
	%	16	14	11		2	43
12 Balsam fir	cu-ft	5.35	1.71	4.86	0	0	11.92
	Tons/AC	.10	.03	.09			.22
	%	1	.3	.7			2
375 Paper birch	cu-ft	57.08	38.28	19.07	11.73	0	126.16
	Tons/AC	1.03	.70	.35	.21		2.29
	%	11	8	4	2		25
951 Basswood	cu-ft	25.77	2.39	0	0	0	28.16
	Tons/AC	.46	.05				.51
	%	4.5	.5				5
543 Ash	cu-ft	22.85	6.87	0	22.57	0	52.29
	Tons/AC	.42	.12		.42		.96
	%	5	1		4		10
833 Oak	cu-ft	3.54	8.68	0	0	14.14	26.36
	Tons/AC	.07	.15			.25	
	%	.5	1.5			3	5
316 Maple	cu-ft	28.52	4.69	0	0	0	33.21
	Tons/AC	.52	.08				.60
	%	5.5	1				6.5
741 Balsam poplar	cu-ft	13.91	0	0	0	0	13.91
	Tons/AC	.25					.25
	%	3					3
318 Sugar maple	cu-ft	2.49	0	0	0	0	2.49
	Tons/AC	.05					.05
	%	.5					.5
TOTAL	cu-ft	240.01	132.27	83.07	34.30	25.13	514.78
	Tons/AC	4.36	2.40	1.52	.63	.45	9.36
	%	47	26.3	15.7	6	5	100

* *The diameter class intervals are as follows: (2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches (10) 9.0 inches and greater.*

WORKSHEET 28 LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Aspen
Logging Method: Treelength/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS *					TOTAL
		2"	4"	6"	8"	10"	
746 Aspen	cu-ft	156.28	104.10	34.99	0	6.87	302.24
	Tons/Ac	2.71	1.81	.60		.12	5.24
	%	35	22	8		2	67
12 Balsam fir	cu-ft	25.64	10.49	4.52	0	0	40.65
	Tons/AC	.44	.18	.08			.70
	%	6	2	1			9
375 Paper birch	cu-ft	18.84	9.56	0	0	0	28.40
	Tons/AC	.33	.16				.49
	%	4	2				6
972 Elm	cu-ft	5.39	1.18	0	0	0	6.57
	Tons/AC	.09	.02				.11
	%	1	.5				1.5
544 Ash	cu-ft	0	2.36	0	0	0	2.36
	Tons/AC		.04				.04
	%		1				1
316 Maple	cu-ft	2.43	0	0	0	0	2.43
	Tons/AC	.04					.04
	%	1					1
833 Oak	cu-ft	29.19	17.51	0	0	0	46.70
	Tons/AC	.51	.30				.81
	%	7	4				11
951 Basswood	cu-ft	16.68	2.28	0	0	0	18.96
	Tons/AC	.29	.04				.33
	%	3	.5				3.5
TOTAL	cu-ft	254.45	147.48	39.51	0	6.87	448.31
	Tons/AC	4.41	2.55	.68		.12	7.76
	%	57	32	9		2	100

* *The diameter class intervals are as follows: (2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches (10) 9.0 inches and greater.*

WORKSHEET 29

LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Aspen
Logging Method: Fulltree/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS*					TOTAL
		2"	4"	6"	8"	10"	
746 Aspen	cu-ft	44.51	99.45	27.13	11.65	21.98	204.72
	Tons/AC	.76	1.71	.47	.20	.38	3.52
	%	16	37	10	4	8	75
12 Balsam fir	cu-ft	2.56	4.74	0	0	0	7.30
	Tons/AC	.05	.08				.13
	%	1	2				3
741 Balsam poplar	cu-ft	22.11	6.88	0	0	0	28.99
	Tons/AC	.38	.12				.50
	%	8	2				10
375 Paper birch	cu-ft	8.06	1.86	3.69	0	0	13.61
	Tons/AC	.14	.03	.06			.23
	%	3	.5	1.5			5
543 Ash	cu-ft	1.70	0	0	0	0	1.70
	Tons/AC	.03					.03
	%	5					5
94 White spruce	cu-ft	2.28	0	0	0	0	2.28
	Tons/AC	.04					.04
	%	.5					.5
972 Elm	cu-ft	3.62	0	0	0	0	3.62
	Tons/AC	.06					.06
	%	1					1
316 Maple	cu-ft	7.74	0	0	0	0	7.74
	Tons/AC	.13					.13
	%	3					3
318 Sugar maple	cu-ft	1.08	0	0	0	0	1.08
	Tons/AC	.02					.02
	%	0					0
833 Oak	cu-ft	3.81	1.96	0	0	0	5.77
	Tons/AC	.07	.03				.03
	%	1.4	.6				2
TOTAL	cu-ft	97.47	114.89	30.82	11.65	21.98	276.81
	Tons/AC	1.68	1.97	.53	.20	.38	4.76
	%	34.4	42.1	11.5	4	8	100

*The diameter class intervals are as follows: (2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches (10) 9.0 inches and greater.

WORKSHEET 30

LOGGED AREA RESIDUE VOLUME BY DIAMETER CLASS AND SPECIES

Cover Type: Northern Hardwoods
Logging Method: Shortwood/Clearcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS*					TOTAL
		2"	4"	6"	8"	10"	
746 Aspen	cu-ft	46.29	7.00	0	0	21.88	75.17
	Tons/AC	1.05	.16			.49	1.70
	%	4.5	.6			2	7.1
375 Paper birch	cu-ft	16.13	8.51	0	0	0	24.64
	Tons/AC	.37	.19				.56
	%	1.5	.5				2
951 Basswood	cu-ft	20.24	27.63	3.92	0	0	51.79
	Tons/AC	.46	.62	.09			1.17
	%	2	2.8	.2			5
972 Elm	cu-ft	7.28	0	0	0	0	7.28
	Tons/AC	.17					.17
	%	1.5					1.5
823 White oak	cu-ft	136.15	32.01	0	0	0	168.16
	Tons/AC	3.09	.73				3.82
	%	13.7	2.3				16
833 Oak	cu-ft	377.93	42.21	26.25	0	76.16	522.55
	Tons/AC	9.08	.96	.58		1.89	12.51
	%	39	4.2	3		8	54.2
318 Sugar maple	cu-ft	19.64	2.26	0	0	0	21.90
	Tons/AC	.44	.06				.50
	%	2	.2				2.2
316 Maple	cu-ft	109.07	0	4.53	0	0	113.60
	Tons/AC	2.47		.10			2.57
	%	10.7		.3			11
543 Ash		3.24	7.23				10.47
		.07	.17				.24
		.3	.7				1
TOTAL	cu-ft	735.97	126.85	34.70	0	98.04	995.56
	Tons/AC	17.20	2.89	.77		2.38	23.24
	%	75.2	11.3	3.5		10	100

*The diameter class intervals are as follows:
(2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches
(10) 9.0 inches and greater.

WORKSHEET 31

LOGGED AREA RESIDUE VOLUME BY
DIAMETER CLASS AND SPECIES

Cover Type: Northern Hardwoods
Logging Method: Shortwood/Partialcut

SPECIES WITHIN COVERTYPE	UNIT OF MEASURE	DIAMETER CLASS *					TOTAL
		2"	4"	6"	8"	10"	
972 Elm	cu-ft	111.93	17.91	15.85	6.51	31.23	183.43
	Tons/AC	2.49	.39	.34	.14	.68	4.04
	%	24	3	3	1	6	37
12 Balsam fir	cu-ft	1.21	0	0	0	1.21	1.21
	Tons/AC	.03					.03
	%	.5					.5
318 Sugar maple	cu-ft	11.67	2.00	0	0	0	13.67
	Tons/AC	.03	.04				.04
	%	2	1				3
541 White ash	cu-ft	6.06	0	15.80	0	0	21.86
	Tons/AC	.13		.35			.48
	%	1		3			4
951 Basswood	cu-ft	13.39	1.19	0	0	0	14.58
	Tons/AC	.28	.03				.31
	%	2.5	.5				3
837 Red oak	cu-ft	2.26	2.91	0	0	0	5.17
	Tons/AC	.05	.06				.11
	%	.5	.5				1
746 Aspen	cu-ft	80.68	4.53	5.74	0	0	90.95
	Tons/AC	1.94	.10	.13			2.17
	%	17	1	1			19
375 Paper birch	cu-ft	4.96	.98	0	0	0	5.94
	Tons/AC	.11	.02				.13
	%	.8	.2				1
316 Maple	cu-ft	7.73	4.48	0	0	0	12.21
	Tons/AC	.18	.09				.27
	%	1.5	.5				2
823 White oak	cu-ft	129.45	0	13.32	0	0	142.77
	Tons/AC	2.98		.29			3.27
	%	26.5		3			29.5
TOTAL	cu-ft	369.34	34.00	50.71	6.51	31.23	491.79
	Tons/AC	8.45	.73	1.11	.14	.68	11.11
	%	76.3	6.7	10	1	6	100

*The diameter class intervals are as follows:
(2) 2.6-2.9 inches (4) 3.0-4.9 inches (6) 5.0-6.9 inches (8) 7.0-8.9 inches
(10) 9.0 inches and greater.

TABLE 3 VOLUME OF RESIDUE AS A PERCENT OF VOLUME HARVESTED

(Cubic feet/Acre)

FOREST TYPE	LOGGING METHOD[a]	VOLUME HARVESTED[c]	VOLUME RESIDUE[b]	PERCENT RESIDUE PER VOLUME HARVESTED
PINE	Shortwood	1803.9	303.9	16.8%
	Tree Length	3073.3	213.5	6.9%
SPRUCE-BALSAM	Shortwood	959.8	276.2	27.8%
	Tree Length	2193.8	98.4	4.5%
ASPEN - BIRCH	Shortwood	1789.0	514.8	28.8%
	Tree Length	1951.0	448.3	23.0%
	Full Tree	1791.0	276.8	15.5%
NORTHERN HARDWOODS	Clearcut	1284,1	995.6	77.5%
	Partial cut	435.6	491.8	112.9%

a - *All logging methods are clearcut except in Northern Hardwood types. In Northern Hardwood type, clearcut and partial cut use shortwood logging method.*

b - *Measured residue vol. down to 2.6" diameter only.*

c - *Used 91 cubic feet/cord in conversion.*

TABLE 4

LOGGED AREA RESIDUE BY FOREST TYPE, LOGGING METHOD, AND RESIDUE CLASS

(Cubic Feet and Green Tons)

FOREST TYPE	LOGGING METHOD	MERCHANTABLE RESIDUE PER ACRE [a]		WOOD FUEL RESIDUE PER ACRE		TOTAL RESIDUE PER ACRE [c]	
		Cubic Feet	Green Tons	Cubic Feet	Green Tons	Cubic Feet	Green Tons
PINE	Shortwood	140.3	2.50	163.6	2.89	303.9	5.39
	Tree Length	83.3	1.51	130.2	2.34	213.5	3.85
SPRUCE BALSAM	Shortwood	123.1	2.07	144.1	2.41	267.2	4.48
	Tree Length	25.4	.49	55.6	1.09	98.4	1.91
ASPEN-BIRCH	Shortwood	147.0	2.67	367.8	6.69	514.8	9.36
	Tree Length	104.6	1.82	343.7	5.94	448.3	7.76
	Full Tree	67.0	1.15	209.8	3.61	276.8	4.76
NORTHERN HARDWOODS	Clearcut	103.8	2.41	891.7	20.81	995.5	23.22
	Partial Cut	59.6	1.29	432.2	9.82	491.8	11.11

a - *This volume could have been removed at the time of harvest.*

b - *Residue weight determined at 45% MC (dry weight basis).*

c - *Includes volume to a minimum diameter of 2.6 inches.*

TABLE 5 RESIDUE VOLUME PER ACRE BY SPECIES GROUP AND FOREST TYPE

Forest Type	Logging Method	Unit of Measure	SPECIES GROUP			TOTAL
			Hardwoods	Aspen	Softwoods	
PINE	Shortwood	cu-ft	14.86	80.38	208.66	303.9
		Tons/AC	.26	1.42	3.71	5.39
		%	5%	26%	69%	100%
	Tree Length	cu-ft	20.50	1.47	191.59	213.56
		Tons/AC	.37	.03	3.45	3.85
		%	9%	1%	90%	100%
SPRUCE-BALSAM	Shortwood	cu-ft	88.70	68.54	109.90	267.14
		Tons/AC	1.48	1.14	1.86	4.48
		%	33%	26%	41%	100%
	Tree Length	cu-ft	51.38	21.44	25.56	98.38
		Tons/AC	1.00	.41	.50	1.91
		%	52%	22%	26%	100%
ASPEN BIRCH	Shortwood	cu-ft	268.67	234.19	11.91	514.78
		Tons/AC	4.88	4.26	.22	9.36
		%	52%	46%	2%	100%
	Tree Length	cu-ft	105.42	302.24	40.65	448.31
		Tons/AC	1.81	5.24	.70	7.76
		%	24%	67%	9%	100%
	Full Tree	cu-ft	32.99	233.71	9.58	276.81
		Tons/AC	.57	4.02	.17	4.76
		%	12%	83%	3%	100%
NORTHERN HARDWOODS	Clearcut	cu-ft	920.38	75.17	0	995.55
		Tons/AC	21.52	1.70		23.22
		%	93%	7%		100%
	Partial Cut	cu-ft	399.63	90.95	1.21	491.79
		Tons/AC	8.91	2.17	.03	11.11
		%	79.5%	20%	5%	100%

TABLE 6

VOLUME OF WOOD RESIDUE 3 INCHES OR GREATER IN DIAMETER AVAILABLE BY MANUAL RECOVERY BY FOREST TYPE, LOGGING METHOD AND SPECIES GROUP

FOREST TYPE	LOGGING METHOD	SPECIES GROUPS			TOTAL	
		HARDWOODS	ASPEN	SOFTWOODS		
		Cu-ft/Acre	Cu-ft/Acre	Cu-ft/Acre	Cu-ft/Acre	*Cords/Acre
PINE	Shortwood	1.65 (1 %)	17.07 (13%)	116.72 (86%)	135.44 (100%)	1.49
	Tree Length	8.39 (7%)	-	115.41 (93%)	123.8 (100%)	1.36
SPRUCE-BALSAM	Shortwood	11.28 (16%)	29.28 (43%)	28.46 (41%)	69.02 (100%)	.76
	Tree Length	16.71 (47%)	3.55 (10%)	15.03 (43%)	35.28 (100%)	.39
ASPEN-BIRCH	Shortwood	128.42 (47%)	139.78 (51%)	6.57 (2%)	274.77 (100%)	3.02
	Tree Length	32.89 (17%)	145.96 (75%)	15.01 (8%)	193.86 (100%)	2.13
	Full Tree	7.51 (4%)	167.09 (93%)	4.74 (3%)	179.34 (100%)	1.97
NORTHERN - HARDWOOD	Clearcut	112.18 (92%)	10.27 (8%)	-	122.45 (100%)	1.35
	Partial cut	230.71 (89%)	28.88 (11%)	-	259.59 (100%)	2.85

* Cubic feet converted to cords using 91 cu. ft. per cord.

TABLE 7

PERCENT OF RESIDUE VOLUME THAT IS 8 FEET OR GREATER IN LENGTH, AVAILABLE BY MECHANICAL RECOVERY BY FOREST TYPE AND LOGGING METHOD

FOREST TYPE	LOGGING METHOD	PERCENT OF RESIDUE VOLUME - 8 FEET OR MORE IN LENGTH
PINE	Shortwood	84%
	Tree Length	93%
SPRUCE-BALSAM	Shortwood	- *
	Tree Length	98%
ASPEN-BIRCH	Shortwood	94%
	Tree Length	82%
	Full Tree	88%
NORTHERN HARDWOODS	Clearcut	90%
	Partial Cut	96%

* Information not available at this time due to computer malfunction.

APPENDIX C

PRIMARY AND SECONDARY

WOOD PROCESSING RESIDUE SURVEY

PRIMARY RESIDUE SURVEY CONVERSION FACTORS

CONVERSION FACTORS*

Tons of Residue

Bark = .57 gr. tons/1,000 bd. ft. In't Rule
Coarse = 1.34 gr. tons/1,000 bd. ft. In't Rule
Fine = .78 gr. tons/1,000 bd. ft. In't Rule

Cubic Feet Residue*

Bark = 31 ft^3/1,000 bd. ft. In't Rule
Coarse = 48 ft^3/1,000 bd. ft. In't Rule
Fine = 28 ft^3/1,000 bd. ft. In't Fule

To Convert Cubic Feet to Green Tons

Bark = $\frac{.57 \text{ gr. tons/M}}{31 \text{ ft}^3\text{/M}}$ = .018 gr. tons/ft^3 and 54.4 ft^3/gr. tc

Coarse = $\frac{1.34 \text{ gr. tons/M}}{48 \text{ ft}^3\text{/M}}$ = .028 gr. tons/ft^3 and 38.8 ft^3/gr. tc

Fine = $\frac{.78 \text{ gr. tons/M}}{28 \text{ ft}^3\text{/M}}$ = .028 gr. tons/ft^3 and 35.9 ft^3/gr. tc

THEREFORE

Bark = 1 cu. ft. = .018 tons and 36 lbs/ft^3
Coarse = 1 cu. ft. = .028 tons and 56 lbs/ft^3
Fine = 1 cu. ft. = .028 tons and 56 lbs/ft^3

} or on an average for total residue can use 38.5 ft^3/ton

RESIDUE SURVEY
MINNESOTA PRIMARY WOOD USERS

RECORD #1

DIRECTIONS: Place only one digit number in each space

MILL#: Leave blank

CARD# COUNTY MILL#

Col# 1-5 | 1 | | | | |

This survey form is designed for determining the types, amount, and use of wood residues generated by your mills in 1979. The information obtained from this survey will be used in publishing a directory of Minnesota wood users.

A) COMPANY NAME : _____

B) MAILING ADDRESS: _____

C) TELEPHONE : _____

D) CONTACT PERSON : _____

E) PLANT LOCATION : COUNTY _____

TOWNSHIP RANGE SECTION

(i.e. Range W=9) Col# 6-13 | | | | | | 9 | | |

F) TYPE OF PLANT: Col# 14-15 | | |

Code		Code		Code	
01	SAWMILL	06	WAFERBOARD	11	SHAVING
02	VENEER	07	PARTICLEBOARD	12	CHARCOAL
03	POLES, PILING, POSTS	08	SHAKES & SHINGLES	13	BUILDING LOGS
04	PULP	09	FENCE	14	ENERGY
05	CHIPPER	10	LATH	15	OTHER _____

G) MEASUREMENT

Code		Code	
1	LUMBER TALLY	4	INTERNATIONAL ¼-inch
2	DOYLE LOG RULE	5	DOYLE-SCRIBNER RULE
3	SCRIBNER DECIMAL C	6	Std. CORD (4'x4'x96")
		7	CORD (4'x4'x100")

bd.ft. Col# 16 | |

Cords Co.# 17 | |

H) VOLUME PROCESSED FOR PRODUCTS PRODUCED IN 1979;

1 Active in 1979 2 Inactive in 1979. Col# 18 | |

If inactive, indicate processing potential when active.

		M bd.ft.	Cords
HARDWOODS	Col# 19-29		
CONIFERS	Col# 30-40		

I) RADIUS of OPERATION (miles)

Col# 41-43 | | | |

J) MILL CLASSIFICATION: (Volume in M bd.ft.)

Col# 44 [ ]

Code		Code		Code	
1	0-50	4	251-500	7	5,001-10,000
2	51-100	5	501-1,000	8	10,000+
3	101-250	6	1,001-5,000		

K) SPECIES USED (percentage; %)

If inactive, indicate % when active.

Col# 45-53

CONIFER			HARDWOOD			ASPEN		

L) PRIMARY PRODUCTS (choose three by most important first):

choice

Col# 54-59

#1	#2	#3

Code		Code		Code		Code	
01	LUMBER (green or air dry)	05	LATH	11	WAFERBOARD	17	VENEER
02	LUMBER (kiln dry)	06	PULP	12	EXCELSIOR	18	STAVES
03	CANTS	07	CHIPS	13	SHINGLES & SHAKES	19	OTHER _____
04	TIES & TIMBER	08	POLES, PILING	14	BUILDING LOGS		
		09	POSTS	15	RUSTIC PRODUCTS		
		10	SHAVINGS	16	FUELWOOD		

M) PRIMARY EQUIPMENT (choose two by most important first):

choice

Col# 60-63

#1	#2

Code		Code		Code	
01	CIRCLE SAW	05	SCRAGG SAW	09	SHAVER
02	BAND SAW	06	CHIP & SAW	10	FUELWOOD PROCESSOR
03	BOLTER SAW	07	BARREL SAW	11	OTHER _____
04	SASH GANG	08	CHIPPER		

N) MILL EQUIPMENT (check those that apply; Yes-Code 1, No-leave blank):

Col# 64-71

KILN	EDGER	PLANER	RESAW	TRIM SAW	DEBARKER	REFUSE BURNER	RESIDUE PROCESSOR

O) WOOD TREATING: (indicate main process)

Col# 72-73

	Method (M)		Chemical (C)
1	COLD SOAK	1	CREOSOTE
2	HOT SOAK	2	PENTA
3	PRESSURE	3	SALTS

M	C

P) YEAR of SURVEY

COL# 74 - 75 [ ]

NOTE: END OF RECORD #1

RECORD #2

	CARD	COUNTY		MILL#	
Col# 1-5	2				

Q) PLANT RESIDUES (enter by percentage, if 100%, code to 99%)
(Code only if active during year of survey; if inactive, leave blank)

DISPOSAL	BARK				COURSE RESIDUES (slabs, edgings)				FINE RESIDUES (sawdust)			
	% Con.		% Hdwd.		% Con.		% Hdwd.		% Con.		% Hdwd.	
USED FOR:												
a) Manufacture of Fiber Prod. Col#(6-17)												
b) Indust. Fuel this Plant Col#(18-29)												
c) Indust. Fuel Other Plants Col#(30-41)												
d) Domestic Household Fuel Col#(42-53) ---sold or given away---												
e) Other Uses_____ Col#(54-65)												
NOT USED: (waste, landfill, etc.) Col#(66-77)												
TOTAL % (do not punch) ----------	9	9	9	9	9	9	9	9	9	9	9	9

Q) RESIDUE ACCUMULATION
(enter number of years of accumulation)
(code for active or inactive)

	BARK	SLABS	SAWDUST
Col# 79-80)			

RESIDUE TOTALS BY SURVEY UNIT AND COUNTY - 1979

PRIMARY PROCESSORS

(green tons)

Unit	County Code	County	# Processors Reporting (active)	Total Residue	Residue Not Used
I	9	CARLTON	20	156,104	726
	16	COOK	9	22,282	956
	36	KOOCHICHING	29	154,926	94,180
	38	LAKE	6	15,154	7,235
	69	ST. LOUIS	54	33,919	14,356
		UNIT TOTALS	118	382,385	117,453
II	1	AITKIN	48	52,789	20,667
	3	BECKER	19	14,382	3,004
	4	BELTRAMI	18	86,266	35,072
	11	CASS	49	178,208	153,236
	15	CLEARWATER	11	52,558	29,483
	18	CROW WING	32	37,053	10,608
	29	HUBBARD	10	13,365	3,823
	31	ITASCA	46	310,793	95,423
	39	LAKE of the WOODS	8	10,929	8,863
	44	MAHNOMEN	8	3,762	1,665
	68	ROSEAU	11	11,209	4,039
	80	WADENA	25	32,498	11,873
		UNIT TOTALS	285	803,812	377,756

Unit	County Code	County	# Processors Reporting (active)	Total Residue	Residue Not Used
III	2	ANOKA	3	1,487	30
	5	BENTON	3	15,121	0
	10	CARVER	3	1,926	1,122
	13	CHISAGO	0	0	0
	19	DAKOTA	2	372	0
	21	DOUGLAS	5	1,314	260
	23	FILLMORE	9	3,067	1,366
	25	GOODHUE	2	2,842	12
	27	HENNEPIN	1	1,492	0
	28	HOUSTON	7	26,337	5,869
	30	ISANTI	6	702	91
	33	KANABEC	5	10,122	3,579
	40	LE SUEUR	0	0	0
	48	MILLE LACS	12	55,358	3,398
	49	MORRISON	28	13,512	9,929
	55	OLMSTEAD	3	201	0
	56	OTTER TAIL	8	4,568	842
	58	PINE	16	17,452	4,154
	62	RAMSEY	0	0	0
	66	RICE	1	60	4
	70	SCOTT	1	1,493	390
	71	SHERBURNE	3	176	12
	73	STEARNS	10	8,420	802
	77	TODD	28	9,865	2,061
	79	WABASHA	5	2,929	57
	82	WASHINGTON	0	0	0
	85	WINONA	3	328	42
	86	WRIGHT	5	1,220	0
		UNIT TOTALS	169	180,364	34,020

Unit	County Code	County	# Processors Reporting (active)	Total Residue	Residue Not Used
IV	6	BIG STONE	1	36	2
	7	BLUE EARTH	0	0	0
	8	BROWN	0	0	0
	12	CHIPPEWA	0	0	0
	14	CLAY	2	230	60
	17	COTTONWOOD	0	0	0
	20	DODGE	0	0	0
	22	FARIBAULT	0	0	0
	24	FREEBORN	1	60	0
	32	JACKSON	1	60	16
	34	KANDIYOHI	4	281	38
	35	KITTSON	0	0	0
	37	LAC QUI PARLE	0	0	0
	41	LINCOLN	0	0	0
	42	LYON	1	15	4
	43	MC LEOD	4	10,310	1,336
	45	MARSHALL	0	0	0
	46	MARTIN	1	2,389	181
	47	MEEKER	6	1,182	250
	50	MOWER	0	0	0
	51	MURRAY	0	0	0
	52	NICOLLET	3	13,907	2,595
	53	NOBLES	0	0	0
	54	NORMAN	1	896	459
	57	PENNINGTON	0	0	0
	59	PIPESTONE	0	0	0
	60	POLK	1	194	122
	61	POPE	1	523	233
	63	RED LAKE	1	164	30
	64	REDWOOD	2	456	282
	65	RENVILLE	1	90	0
	67	ROCK	0	0	0
	72	SIBLEY	0	0	0
	75	STEVENS	1	75	0
	78	TRAVERSE	0	0	0
	81	WASECA	0	0	0
	83	WATONWAN	2	672	59
	84	WILKIN	0	0	0
	87	YELLOW MEDICINE	0	0	0
		UNIT TOTALS	34	31,538	5,667
		STATE TOTALS	606	1,398,098	534,896

CONVERSION FACTORS FOR ESTIMATING TONS AND CUBIC FOOT VOLUMES OF WOOD RESIDUES PRODUCED BY SECONDARY WOOD PROCESSORS.

CUBIC FEET OF RESIDUE TO DRY TONS:

Coarse	= 15 pounds/ft.^{3} or .0075 ton/ft.^{3}
Shavings	= 20 pounds/ft.^{3} or .01 ton/ft.^{3}
Sawdust and sanderdust	= 20 pounds/ft.^{3} or .01 ton/ft.^{3}

From: reprint by Massey Ferguson, Inc. (1967)

CUBIC FOOT VOLUMES OF RESIDUE CONTAINERS:

55 gallon drum	= 88 ft.^{3}
one gallon	= .625 ft.^{3}
one cubic yard	= 27 ft.^{3}
one bushel	= 15 ft.^{3}
large commercial dumpster	= 810 ft.^{3}
regular commercial dumpster	= 96 ft.^{3}
garbage can	= 9 ft.^{3}
silo (20x20x50')	= 16,200 ft.^{3}
"pick-up" load	= 130 ft.^{3}

From: various sources.

WEIGHT ESTIMATES OF RESIDUE CONTAINERS:

Dump Truck	= 10 ton
Semi-load	= 20 ton
Rail-box car	=100 ton

From: various sources

TO CONVERT BOARD FEET TO TONS:

This conversion was used when the residues were given as a percent of the purchased board foot volume.

One Board foot= 5.5 pounds

One MBF = 2.75 tons

From: reprint by Massey-Ferguson, Inc. (1967)

CONVERSION FACTORS FOR ESTIMATING TONS OF WOOD RESIDUE PER THOUSAND BOARD FEET (MBF) OF WOOD USED FOR WOOD PRODUCTS.

Type of Plant	Softwood								Hard Hardwood								Soft Hardwood							
	Bark	% MC	Chip-[2] pable	% MC	Shav- ings	% MC	Fine[3]	% MC	Bark	% MC	Chip- pable	% MC	Shav- ings	% MC	Fine	% MC	Bark	% MC	Chip- pable	% MC	Shav- ings	% MC	Fine	% MC
Planing Mill[4]	-	-	0.04	19	0.38	19	-	-	-	-	0.04	19	0.49	19	-	-	-	-	0.02	19	0.35	19	-	-
Wood Chip Mill	0.46	50	-	-	-	-	-	-	0.90	60	-	-	-	-	-	-	0.62	88	-	-	-	-	-	-
Hardwood Flooring	-	-	-	-	-	-	-	-	-	-	0.15	6	0.73	6	0.30	6	-	-	-	-	-	-	-	-
Hardwood Dimension (Cutstock)[5]	-	-	0.11	7	0.53	7	0.22	7	-	-	0.15	7	0.73	7	0.30	7	-	-	0.10	7	0.50	7	0.21	7
Handle Blanks[6]	-	-	-	-	-	-	-	-	0.67	60	2.65	65	-	-	1.27	65	-	-	-	-	-	-	-	-
Wooden Furniture Frames	-	-	0.45	12	0.79	12	0.14	12	-	-	0.37	9	0.80	9	0.15	9	-	-	0.25	9	0.55	9	0.10	9
Shingles and Cooperage Stock	0.46	50	2.66	100	-	-	0.47	100	0.63	60	2.66	65	-	-	0.47	65	-	-	-	-	-	-	-	-
Mill Work	-	-	0.45	12	0.79	12	0.14	12	-	-	0.37	9	0.74	9	0.14	9	-	-	0.26	9	0.52	9	0.12	9
Kitchen Cabinets	-	-	0.19	12	-	-	0.17	12	-	-	0.25	9	-	-	0.10	9	-	-	0.18	9	-	-	0.07	9
Hardwood Veneer and Plywood	-	-	-	-	-	-	-	-	0.63	60	2.63	65	-	-	1.10	9	0.44	88	1.83	65	-	-	0.76	9
Softwood Veneer and Plywood	0.44	50	1.83	100	-	-	0.76	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Structural Parts N.E.C.	-	-	0.05	12	0.02	12	0.01	12	-	-	0.06	9	0.02	9	0.01	9	-	-	0.04	9	0.01	9	0.01	9
Boxes and Shook	-	-	0.19	100	0.09	100	0.28	100	-	-	0.18	65	0.09	65	0.27	65	-	-	0.12	65	0.06	65	0.18	65
Pallets and Skids	-	-	0.49	60	0.24	60	0.08	60	-	-	0.58	60	0.29	60	0.10	60	-	-	0.40	60	0.20	60	0.07	60
Wirebound Boxes	-	-	-	-	-	-	-	-	0.63	60	2.63	65	-	-	1.10	65	0.44	88	1.83	65	-	-	0.76	65
Veneer and Plywood Containers	-	-	-	-	-	-	-	-	0.63	60	2.53	65	-	-	1.10	65	0.44	88	1.83	65	-	-	0.76	65
Cooperage	-	-	-	-	-	-	-	-	-	-	-	-	0.50	19	0.12	19	-	-	-	-	-	-	-	-
Mobile Homes	-	-	0.04	12	-	-	0.01	12	-	-	0.08	9	-	-	0.02	9	-	-	0.06	9	-	-	0.01	9
Prefabricated Buildings	-	-	0.05	12	-	-	0.02	12	-	-	0.29	9	-	-	0.01	9	-	-	0.21	9	-	-	0.01	9
Log Homes	0.42	50	2.21	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Preservative Treating Plants	0.67	50	0.40	100	0.65	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Particleboard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21	6
Other Wood Products	-	-	0.45	12	-	-	0.93	12	-	-	0.37	9	-	-	0.95	9	-	-	0.25	9	-	-	0.65	9
Wooden Handles[7]	-	-	-	-	-	-	-	-	-	-	0.02	12	1.56	12	0.01	12	-	-	-	-	-	-	-	-
Furniture	-	-	0.45	12	0.79	12	0.14	12	-	-	0.37	9	0.80	9	0.15	9	-	-	0.25	9	0.55	9	0.10	9
Pulp and Paper	0.60	70	-	-	-	-	-	-	0.90	60	-	-	-	-	-	-	0.62	88	-	-	-	-	-	-
Gum and Wood Chemicals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boot and Shoe Cut Stock	-	-	0.45	12	0.79	12	0.14	12	-	-	0.37	9	0.80	9	0.15	9	-	-	0.25	9	0.55	9	0.10	9
Farm Machines and Textile Machines	-	-	0.03	12	0.54	12	0.14	12	-	-	0.03	9	0.49	9	0.15	9	-	-	0.02	9	0.35	9	0.10	9
Industrial Patterns	-	-	0.15	12	0.73	12	0.30	12	-	-	0.15	9	0.73	9	0.30	9	-	-	0.10	9	0.50	9	0.20	9
Transportation Equipment	-	-	0.45	12	0.79	12	0.14	12	-	-	0.37	9	0.80	9	0.15	9	-	-	0.25	9	0.55	9	0.10	9
Musical Instruments	-	-	0.45	12	0.79	12	0.14	12	-	-	0.37	9	0.80	9	0.15	9	-	-	0.25	9	0.55	9	0.10	9
Games and Toys	-	-	0.11	9	0.50	9	0.21	9	-	-	0.15	9	0.73	9	0.30	9	-	-	0.11	9	0.50	9	0.21	9

CONVERSION FACTORS FOR ESTIMATING TONS OF WOOD RESIDUE PER THOUSAND BOARD FEET (MBF) OF WOOD USED FOR WOOD PRODUCTS.

Type of Plant	Softwood								Hard Hardwood								Soft Hardwood							
	Bark	% MC	Chippable[2]	% MC	Shavings	% MC	Fine[3]	% MC	Bark	% MC	Chippable	% MC	Shavings	% MC	Fine	% MC	Bark	% MC	Chippable	% MC	Shavings	% MC	Fine	% MC
Sporting Goods	-	-	0.08	9	0.50	9	0.08	9	-	-	0.12	9	0.73	9	0.12	9	-	-	0.08	9	0.50	9	0.01	9
Pencils	-	-	0.09	8	0.54	8	0.63	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artists' Materials	-	-	0.03	8	0.54	8	0.02	8	-	-	0.03	8	0.49	8	0.02	8	-	-	0.02	8	0.35	8	0.02	8
Brooms and Brushes	-	-	0.03	12	0.54	12	0.04	12	-	-	0.25	12	0.49	12	0.05	12	-	-	0.20	12	0.35	12	0.03	12
Signs and Advertising Displays	-	-	0.03	12	-	-	0.01	12	-	-	0.01	12	-	-	0.01	12	-	-	0.01	12	-	-	0.01	12
Burial Caskets and Coffins	-	-	0.20	6	0.10	6	0.10	6	-	-	0.30	6	0.12	6	0.15	6	-	-	0.20	6	0.08	6	0.09	6
Wood Manufactures N.E.C.	-	-	0.03	12	0.54	12	0.04	12	-	-	0.25	12	0.49	12	0.05	12	-	-	0.20	12	0.35	12	0.03	12

1. For shingles and cooperage stock the table indicates that for every MBF of softwood logs used you could expect 2.66 tons of chippable material, with an average moisture content (MC) of 100 percent, based on oven-dry weight. If the average MC of lumber is greater or less than 100 percent, you could expect a proportionally greater or lesser weight of material.

2. Chippable is material large enough to warrant size reduction before being used by the paper, particleboard, or metallurgical industry.

3. Fines are considered to be sawdust or sanderdust.

4. For chipping mills, with debarkers only.

5. Some softwood cut stock is produced.

6. From roundwood only.

7. Factors are for handles from blanks. Residue for finished handles from roundwood is the sum of the residues produced when converting from roundwood to blanks plus the residues produced converting blanks to handles.

FRO : Perry, Joe D. and Robert T. Gregory (1976).

DEPARTMENT OF NATURAL RESOURCES - FORESTRY

RESIDUE SURVEY

MN. SECONDARY WOOD MANUFACTURES SPRING 1980

DIRECTIONS: Place only one digit in each space. Complete all questions unless company contacted 1) is not, by your determination, a secondary wood user or manufacturer, or 2) firm is not able to give specific answers. In the later case make notations of information acquired.

RECORD #1

MILL # Col.# 1-8

Card# Year County Mill#

1							

The following questions have been designed for determining the types, amount, and use of wood residues generated by your company in 1979. The information obtained will be helpful in assessing the potential for greater utilization of wood residues for energy. A directory of primary and secondary wood users in Minnesota will also be published as a result of this survey.

A. Company Name: _____

B. Mailing Address: _____

C. Telephone: _____

D. Contact Person: _____

E. Plant Location: COUNTY _____

F. Legal Description:

(9 = West Range) Col# 9-16

Township Range Section

					9		

G. What was the average number of employees in the plant in 1979?

Col# 17-20 | | | | |

H. How many months per year is your plant in operation?

Col# 21-22 | |

I. What major wood products were manufactured in 1979?
(List by order of importance)

CODE

01 Cabinets (cupboards & similar)
02 Case Goods (dressers, hutches, nite stands)
03 Composition Board (particle board)
04 Cut/dimension stock (glued panels, squares for turning)
05 Doors (windows)
06 Fixtures (mantles, bookcases)
07 Furniture (upholstered & wooden)
08 Laminated Products (glued)
09 Millwork (mouldings, facing)
10 Novelties (toys, nick-nacks, trophies)
11 Plywood panels/ Panels
12 Signs
13 Stairs
14 Siding
15 Handles
16 Pre-fab buildings
17 Landscape materials (timbers)
18 Pallets, Skids
19 Turnings
20 Boxes, crates
21 Pulp, paper
22 Buildings, Homes
23 Treated wood
30 OTHER_____(Specify).

1. _____
2. _____
3. _____
4. _____
5. _____

COL# 23 - 32

# 1		# 2		# 3		# 4		# 5	

J. What form of wood materials did you acquire in 1979 for use in the manufacture of those products?

CODE

01 Lumber - Green (M bd ft.)
02 Lumber - air dry (M bd ft.)
03 Lumber - kiln dry (M bd ft.)
04 Posts, Poles (M bd ft.)
05 Blanks (M bd ft.)
06 Cut or dimension stock (M bd.ft.)
07 Chips (M Tons)
08 Pulp (M Tons)
09 Veneer 1/32" (M sq. ft.)
10 Waferboard/Particleboard (M sq. ft.)
11 Plywood (M sq. ft.)
12 Hardboard (M sq. ft.)
13 Roundwood (Cords)
14 Sawdust/Shavings (M Tons)
15 OTHER_____
Specify

1)_____
2)_____
3)_____
4)_____

Col# 33-40

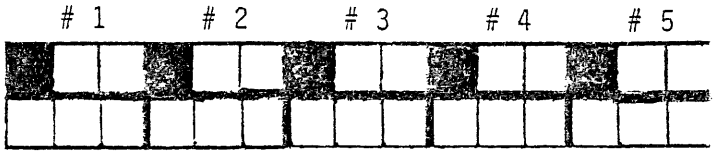
# 1		# 2		# 3		# 4	

K. What species of wood materials did you purchase in 1979 and how much?

CODE	SPECIES	VOLUME
01 Yellow Birch	1)	
02 Hard Maple		
03 Soft Maple	2)	
04 Basswood		
05 P. Birch	3)	
06 Aspen		
07 Elm	4)	
08 Ash		
09 Walnut	5)	
10 Cherry		
11 W. Oak	6)	
12 R. Oak		
13 Cottonwood		
14 Other Hardwood (Specify)		
15 W. Pine		
16 R. Pine		
17 J. Pine		
18 W. Spruce		
19 B. Spruce		
20 Balsam		
21 Tamarack		
22 White Cedar		
23 Western Lumber _____ Species		
24 Southern Yellow Pine		

Species Col# 41-50

Volume Col# 51- 65 (MBF)



L. Do you buy Minnesota wood? (Yes - 1, No- leave blank) Col# 66 ☐

M. Is lumber grade specification required? (Yes - 1, No - leave blank) Col#67 ☐

N. Are there any contaminents such as plastic, glass, metal, abrasives or paint in your residues? (Yes - 1, No - leave blank)

Col# 68-70

O. What did it cost in 1979 to dispose of unused residue?

Hundred dollars

Col# 71-73 ☐☐☐

RECORD #2

Card Year County Mill#

Col.# 1-8 2 ☐☐☐☐☐☐☐

RESIDUES

P. How much wood residue was generated in 1979? If possible, break this down by hardwoods and conifers and in catagories of fine and course residues. (Describe measure if tons are not known) (For "% conifers" code 100% as 99%).

P. Residues - continued.

			TONS				%
							Conif
FINE	Sawdust & Sanderdust	Col.# 9 - 14					
FINE	Shavings	Col.# 15-20					
COURSE	Solid Lumber (edgings, trimmings, etc.)	Col.# 21-26					
COURSE	Plywood (" " " ")	Col.# 27-32					
COURSE	Particle board (" " " ")	Col.# 33-38					
COURSE	OTHER _____ (Specify)	Col.# 39-44					

Q. How did you dispose of or use your wood residues in 1979?
(Express as a percent. Code 100% as 99%)

USED FOR:		Cutoffs Edgings		Shavings		Sawdust Sanderdust	
		Hdwd	Conif	Hdwd	Conif	Hdwd	Conif
a)	Manufacture of fiber products. Col# 45-56						
b)	Industrial fuel this plant. Col# 57-68						
c)	Industrial fuel other plant. Col# 69-80						

RECORD #3 Col# 1-8 | Card# | Year | CO. | Mill# | | | | | | 3 | | | | | | | |

d)	Domestic household fuel. (sold or given away)	Col# 9-20
e)	Bedding	Col# 21-32
f)	Other uses_____	Col# 33-44
g)	Not used (waste, Landfill)	Col# 45-56
	TOTAL	9 9 9 9 9 9 9 9 9 9 9 9

R. By what percent has utilization of wood residues increased over the last three years? Col# 57-59

S. How many years has residue accumulated in yard?

Col# 60-62 | Cutoffs | Shavings | Sawdu |

T. Are you interested in greater utilization of your wood residues either in your own company or in some other capacity?
(Yes - 1, No - leave blank) Col# 63

U. Please give me your correct mailing address and we will send you a directory of wood manufacturers when completed.

APPENDIX D

COSTS OF LOGGING AND TRANSPORTATION

WORKSHEET 1 CALCULATIONS USED IN TABLES 5A AND 5B

COL (1) ASSUMED

COL (2) ASSUMED

COL (3) $\frac{100-(MC/7)}{100+MC}$ x 8500 BTU/OVEN-DRY LB = BTU/LB

WHERE MC = PERCENT MOISTURE CONTENT (DRY BASIS)

1/3 STANDARD CORD (FIREPLACE CORD)

COL (4) 79 Ft^3 of SOLID WOOD/CORD ÷ 3 = 26.3 Ft^3 of SOLID WOOD/FACE CORD

26.3 Ft^3 x $LB/Ft.^3$ (2) = LB/LOAD

COL (5) LB/LOAD (4) x BTU/LB (3) = TOTAL BTU/LOAD

TOTAL BTU/LOAD x 55% STOVE BURNING EFFICIENCY ÷ 1,000,000 = MILLION BTU AVAILABLE/LOAD

COL (6) 130,000 BTU/GAL GASOLINE ÷ 12 MILES/GALLON = 10,833 BTU EXPENDED/MILE

(MILLION BTU/LOAD (5) X 1,000,000) ÷ 10,833 BTU EXPENDED/MILE = MAXIMUM MILE DISTANCE TO DRIVE FOR WOOD

½ STANDARD CORD

COL (7) 79 Ft^3 OF SOLID WOOD/CORD ÷ 2= 39.5 Ft^3 OF SOLID WOOD/½ CORD

39.5 Ft^3 x $LB/Ft.^3$ (2) = LB/LOAD

COL (8) LB/LOAD (7) x BTU/LB (3) = TOTAL BTU/LOAD

TOTAL BTU/LOAD x 55% STOVE HEATING EFFICIENCY ÷ 1,000,000 = MILLION BTU AVAILABLE/LOAD

COL (9) (MILLION BTU/LOAD (8) x 1,000,000) ÷ 10,833 BTU EXPENDED/MILE = MAXIMUM MILE DISTANCE TO DRIVE FOR WOOD

1 STANDARD CORD

COL (10) 79 Ft^3 OF SOLID WOOD/CORD x LB/FT (2) = LB/LOAD

COL (11) LB/LOAD (10) x BTU/LB (3) = TOTAL BTU/LOAD

TOTAL BTU/LOAD x 55% STOVE BURNING EFFICIENCY ÷ 1,000,000 = MILLION BTU AVAILABLE/LOAD

WORKSHEET 2 CALCULATIONS USED IN TABLES 8A AND 8B

UNIT - assumed

HEATING EFFICIENCY (PERCENT) - assumed

TOTAL BTU CONTENT - assumed

AVAILABLE BTU AT HEATING EFFICIENCY

TOTAL BTU CONTENT x HEATING EFFICIENCY (PERCENT)

UNITS NEEDED TO GIVE ONE MILLION BTU OF AVAILABLE HEAT

1,000,000 ÷ (AVAILABLE BTU AT HEATING EFFICIENCY x 1000)

COST/UNIT - assumed

COST PER MILLION BTU

COST/UNIT x UNITS NEEDED TO GIVE ONE MILLION BTU OF AVAILABLE HEAT

WORKSHEET 3 CALCULATIONS USED IN TABLE 8

1 MILLION BTU ÷ MILLION BTU/LOAD @ 55% STOVE EFFICIENCY (FROM TABLE 5A COL 11) = CORDS/MILLION BTU

COST/MILLION BTU OF ALTERNATE FUEL FROM TABLE 7 ÷ CORDS/MILLION BTU = MAXIMUM COST/CORD

APPENDIX E

FUELWOOD VENDOR SURVEY

TABLE 1 FUELWOOD VENDORS SURVEYED BY SURVEY UNIT AND COUNTY

UNIT	COUNTY	NUMBER OF VENDORS
I	Carlton	5
	Cook	2
	Koochiching	8
	Lake	3
	St. Louis	15
Unit Total		33
II	Aitkin	8
	Beltrami	5
	Cass	9
	Crow Wing	6
	Hubbard	8
	Itasca	10
	Lake of the Woods	2
Unit Total		48
III	Anoka	4
	Benton	3
	Hennepin	4
	Kanabec	1
	Mille Lacs	4
	Morrison	3
	Olmstead	1
	Pine	4
	Ramsey	4
	Washington	2
	Winona	1
	Wright	1
Unit Total		32
IV	Nicollet	2
Unit Total		2
	State Totals	115

TABLE 2 NUMBER OF CORDS SOLD IN 1979

No. of Cords Sold	No. of Vendors	Percent of Vendors
Less than 50 cords	29	25.2%
50 – 100 cords	24	20.9%
101 – 500 cords	43	37.4%
501 – 1000 cords	19	16.5%
TOTAL	115	100.0%

MINNESOTA FUELWOOD VENDORS
by COUNTY

AITKIN COUNTY

Michael L. Ashton
South Star Route
Box 409
Hill City, MN 55748

Burton Anderson
Tamarack, MN 55787
218-426-3055

David A. Danielson
Route 2
McGrath, MN 56350
612-592-3533

Leo A. Genz
McGrath, MN 56350
612-592-3292

Robert or Henry Johansen
McGrath, MN 56350
612-592-3402

John J. Owens Sr.
Route 2 Box 78
McGrath, MN 56350
612-592-3330

Martin Stolle
Route 2
McGrath, MN 56350
612-592-3536

Dana Thomsen
Box 30
McGrath, MN 56350
612-592-3147

Ralph Thomsen
McGrath, MN 56350
612-592-3266

Dick Zortman
McGrath, MN 56350
612-592-3345

George Bottila
Route 2 Box 101
McGregor, MN 55760
218-768-2325

Loren Erpelding
Box 329A Route 3
McGregor, MN 55760
218-426-3967 or
218-426-3306

Henry Hammond
RR 3 Box 290
McGregor, MN 55760
218-426-3630

Raymond E. Hurd
Route 4
McGregor, MN 55760
218-768-2795

Jack Maki
McGregor, MN 55760
218-768-4567

Chuck Schubring
Route 3, Box 458
McGregor, MN 55760
218-426-3625

Bert E. Wold
Route 3
McGregor, MN 55760
218-426-3998

BECKER COUNTY

Willy's Wood Sales
C. W. "Bill" Crowell
Star Route
Detroit Lakes, MN 56501
218-573-3704

BELTRAMI COUNTY

Richard J. Abbott
RR 4
Bemidji, MN
218-751-1144

David Horn
Route 2, Box 232A
Bemidji, MN 56601
218-751-6527

Joel A. Johnson Forest Products
506 - 21st Street
Bemidji, MN 56601
218-751-3535

Robert Wm. Lieske
Route 5, Box 204
Bemidji, MN 56601
218-586-2415

John A. Speck
1500 - 3rd St. So.
Bemidji, MN 56601
218-751-5045

Ken Bauer
Bauer Logging
Box 150
Blackduck, MN 56630
218-835-6455

George Bowman
Rt. 1, Box 91
Blackduck, MN 56630
218-835-6478

Clarence O. Johnson Logging
East Star Route, Box 10
Blackduck, MN 56630
218-835-6695

Daniel J. Rockensock
Pennington Star Rt., Box 132
Blackduck, MN 56630
218-835-4657

Donald Gross & Sons
Box 103
Hines, MN 56647
218-243-2318

Ernest N. Wentworth
Hines, MN 56647
218-835-4781

George H. Hasler
Box 64
Kelliher, MN 56650
218-647-8683

Glen Lorshbough
Pinewood, MN 56664
218-228-2341

William C. Raiter
Solway, MN 56678
218-467-3335

BENTON COUNTY

Ray's Fireplace Wood
Route 2, Box 237
Foley, MN 56329
612-968-7829

Doug Huehn
RR 1
Sauk Rapids, MN 56379
612-252-0316

CARLTON COUNTY

Palmer Logging
Route 2, Box 215A
Barnum, MN 55707
218-389-6189

Jim Abramowski
520 Anderson Road
Cloquet, MN 55720
218-879-8220

Richard Berthiaume
194 Reponen Road
Cloquet, MN 55720
218-879-4766

Donald M. Clark Sr.
Cromwell, MN 55726
218-644-3417

Clyde Homstad
Route 1, Box 163
Cromwell, MN 55726
218-644-3675

Roger Lund
Route 1, Box 150
Cromwell, MN 55726
218-644-3735

Thomas J. Peterson
Route 1, Box 95
Cromwell, MN 55726
218-644-3943

K.L.H. Firewood Sales
Ken L. Himango
198 Korby Road
Esko, MN 55733
218-879-3518

Paul Fish
Mahtowa, MN 55762
218-389-6167

Dewey Anderson
Route 1, Box 25
Moose Lake, MN 55767
218-485-4218

Floyd Weske
Weske Timber Products
Route 1
Moose Lake, MN 55767
218-485-4179

Willow River Lumber Company
Sue or Dick Delducco
Route 1
Moose Lake, MN 55767
218-485-4582

CASS COUNTY

Raymond Large
Star Route
Backus, MN 56435
218-947-3370

William Sawyer
PO Box 13
Backus, MN 56435
218-947-3892

Louis Fournier
Route 1
Cass Lake, MN 56633
218-335-8763

Leech Lake Firewood Company Inc.
P.O. Box 514
Cass Lake, MN 56633
218-335-2207 ext. 332 (Office)
218-665-2246 (Plant)

Richard Wittner
Route 1, Box 84
Cass Lake, MN 56633
218-335-6656

B. J. Logging
Kline Jordan
Longville, MN 56655
218-363-2377

Cantleberry Sawmill
Henry Cantleberry
Motley, MN 56466
218-575-2217

John Welk
Longville, MN 56655
218-836-2465

Floyd W. Griffith
Box 203
Motley, MN 56466
218-352-6406

Roger Smith
RR 1
Motley, MN 56466
218-894-2863

Dwayne & Dwight Johnson
Route 2
Pequot Lakes, MN 56472
218-568-5127

Larry Parker
RR 2
Pequot Lakes, MN 56472
218-568-8374

Charles Disterhaupt
Route 1
Pillager, MN 56473
218-746-3580

Albert & Lester Anderson
Star Route 60
Pine River, MN 56474
218-587-4771

CHIPPEWA COUNTY

Richard Handeen & Kurt Arner
Route 5, Box 43
Montevideo, MN 56265
612-269-8971

CLEARWATER COUNTY

Carter Knutson Logging
Route 3, Box 38
Bagley, MN 56621
218-694-6605

Troy Shegrud
Route 3, Box 74A
Bagley, MN 56621
218-657-2277

Gerald K. Smith
Route 3, Box 178
Bagley, MN 56621
218-694-2390

Ben J. Vorderbruggen
Clearbrook, MN 56634
218-776-3898

CROW WING

George Brancato
RR 11, Box 281-B
Brainerd, MN 56401
218-829-8617

Ervin A. Hoffman
723 - 12th Ave. NE
Brainerd, MN 56401
218-829-1525

Paul's Wood Pile
Paul Belgum
Route 1, Box 30A
Brainerd, MN 56401

Ellis R. Hite
Box 317
Emily, MN 56447
218-763-2270

Gordon Wynn
Wynn Logging
Emily, MN 56447
218-763-2160

Traynor the Tree Trimmer
Box 512
Nisswa, MN 56473

Roy Trowbridge
Merrifield, MN 56465
218-765-3319

HUBBARD COUNTY

David Duncan
Box 131
Nevis, MN 56467
218-652-4648

Jim's Wood Service
Jim King
Box 253
Nevis, MN 56467
218-652-4351

Melvin F. Hooker
Niawa Star Route, Box 97
Park Rapids, MN 56470
218-732-4974

Rich's Firewood
517 N. Central
Park Rapids, MN 56470
218-732-3949

Michael N. Thelen
Itasca Star Route
Park Rapids, MN 56470
218-732-8714

Thomas M. Thelen
Itasca Star Route
Park Rapids, MN 56470
218-732-5542

Dick Walsh Forest Products
Itasca Star Route
Park Rapids, MN 56470
218-732-5665

Charles M. Wilkins
Route 2
Park Rapids, MN 56470
218-732-3230 or
218-732-3217

ITASCA COUNTY

Mike Robertson
Big Fork, MN 56628
218-743-3394

Ted Baier
Route 1, Box 98A
Bovey, MN 55709
218-247-7762

C&M Logging
Clarence Callen 427-2595 Meadowland
Mark Cochran 885-1895 Nashwauk
15 First Street
Nashwauk, MN 55769

Lazy T Ranch
Bruce Tillotson & Sons
Route 1, Box 139
Nashwauk, MN 55769
218-885-2550

Larry Fisher
Route 1, Box 31A
Pengilly, MN 55775

Kenneth Nelson
Squaw Lake, MN 56681
218-659-4401

Thistledew Camp
Star Route
Togo, MN 55788
218-376-3811

KOOCHICHING COUNTY

Mike Johnson
Route 9, Box 285
International Falls, MN 56649
218-283-8079

William L. Karstens
Box 505
Northome, MN 56661
218-897-5687

Greg House
Ray, MN 56669
218-875-3275

LAKE COUNTY

Opsal Forest Products
Star Route, Box 87
Silver Bay, MN 55614
218-353-7388

Chester A. Tonnar Sr.
E. Star Route, Box 89
Silver Bay, MN 55614
218-353-7321

LAKE OF THE WOODS COUNTY

Tony Erickson
Route 3, Box 102
Baudette, MN 56623
218-634-2773

Maus Sales
Route 1
Baudette, MN 56623
218-634-1639

Grayceton Northland Firewood Service
Gordon Asmus
Grayceton, MN
218-783-2375

David J. Bridges
Williams, MN 56686
218-783-3282

MAHNOMEN COUNTY

Don Maruska
Lengby, MN 56651
218-668-2551

James R. Stockbridge
The Grunt & Groan Firewood Co.
Box 546
Naytahwaush, MN 56566
218-935-5967

MILLE LACS COUNTY

Mike Conner
Route 1, Box 81
Isle, MN 56342
612-676-3538

Venhuizen Brothers
Route 1
Isle, MN 56342
612-679-4790 or 679-4376
or 679-4061

Lloyd Olson
Star Route
Onamia, MN 56359
612-532-3247

Michael Schneppenheim
Route 1
Onamia, MN 56359
612-532-3702

Wm. A. Nelson's Timber Products
and Custom Sawing
Route 1, Box 94
Wahkon, MN 56386
612-495-3406

NICOLLET COUNTY

Minnesota Valley Forest Products
Box 35
Courtland, MN 56021
507-359-2705

PINE COUNTY

Kerrick Wood Company
Star Route
Bruno, MN 55712
218-496-4315

Lawrence Wermerskirchen
Bruno, MN 55712
612-838-3261

Stanley Schoett
Finlayson, MN 55735
612-233-7752

Richard Currie
RR 3
Hinckley, MN 55037
218-384-6898

Ed Washtock
Hinckley, MN 55037
612-629-6521

Horton Sawmill, Inc.
Route 1
Willow River, MN 55795
218-658-4312

ST. LOUIS COUNTY

The Firewood Merchant
Roger Abramowski
Star Route, Box 560
Brookston, MN 55711
218-879-4092

Anthony Rutar
Buyck, MN 55771
218-993-2280

Firewood Logging
707 NE 3rd Avenue
Chisholm, MN 55719
218-254-5527

Larry Nosie
Route 1, Box 118
Chisholm, MN 55719
218-254-5313

Fred Bagley
Route 1
Cook, MN 55723
218-666-2073

Dale Gustafson
Route 1
Cook, MN 55723
218-666-5870

Bob Johnson Logging
Star Route, Box 154
Cook, MN 55723
Phone - Bear River, MN
218-376-2135 or 376-3552

Pappas Fuel Woods
George & Jim Pappas
2741 Morris Thomas Road
Duluth, MN 55811
218-722-1526

Mike McCarty
Route 1
Embarrass, MN 55732
218-984-3981

Skibo Timbers, Inc.
% Stanley W. Erickson
Route 1, Box 309A
Embarrass, MN 55732
218-984-2493

Tim Aho
Box 392
Floodwood, MN 55736
218-476-2236

Melvin Sandstrom
Route 3, Box 28
Floodwood, MN 55736
218-476-2825

Jerry Shuster Logging
Box 141
Gheen, MN 55740
218-787-2264

Northern Natural Products
4026 Stuntz Drive
Hibbing, MN 55746
218-263-8400

Clusian Bros. Forest Products Inc.
Route 3, Box 82B
Hibbing, Minnesota 55746
218-885-1420

Thorne Timber Products
Hubert L. Thorne
P.O. Box 211 - Wade Road
Kinney, MN 55758
218-258-3550

Northern Natural Products
Nett Lake, MN 55772
218-757-3421

Julian Brzoznowski
Orr, MN 55771
218-757-3452

Jackopich Logging
Orr, MN 55771
218-757-3152

STEARNS COUNTY

J. L. Ergen Landscaping
Route 4
St. Cloud, MN 56301
612-255-0770

Dale Dhein
3119 - 15th St. N.
St. Cloud, MN 56301
612-252-6735

WADENA COUNTY

Minnesota Forest Products Coop
Menahga, MN 56464
218-564-4135

Northstar Lumber & Supply
Hwy. 71 So.
Menahga, MN 56464
218-564-4123

WINONA COUNTY

Richard J. Huelskamp
Box 218
Rollingstone, MN 55969
507-689-2305

METRO AREA

Clifford C. Imus
3309 Cedar Creek Dr.
Cedar, MN 55011
612-753-3433

J. L. Graham
525 - 108th Lane NW
Coon Rapids, MN 55433
612-757-3327

Minnesota Tree, Inc.
13000 W. 78th St.
Eden Prairie, MN 55344

44th St. Nursery & Flower Shop
4355 Nicollet Avenue So.
Minneapolis, MN 55409
612-823-6888

The Wood Shed
2919 Nevada Ave. No.
New Hope, MN 55427
612-545-9455

Farmer Seed & Nursery
Hwy 61 at Glen Road
Newport, MN 55055
612-459-2502

Forest Products Supply Co.
Hwy. 36 and White Bear Ave.
North St. Paul, MN 55109
612-770-2834

Cut Rate Fireplace Wood
10400 Bass Lake Road
Plymouth, MN 55442
612-559-0311

Richfield Floral & Nursery
66th St. at Chicago Ave. So.
Richfield, MN 55423
612-869-0666

Leitner Company
945 Randolph Ave.
St. Paul, MN 55102
612-291-2655

Neil Cosgrove
1520 W. Linden
Stillwater, MN 55082

Southview Garden Center
50 Crusader Avenue
West St. Paul, MN 55118
612-455-6669

Bever Brothers
3555 Hwy. 61
White Bear Lake, MN 55110
612-482-7760

GLOSSARY

Biomass: The volume of living matter above ground in a tree or stand of trees expressed as a weight.

BTU (British Thermal Unit): A measure of heat energy, specifically the approximate amount of heat energy required to raise one pound mass of water one degree fahrenheit. This report assumes ovendry wood contains 8500 BTU/pound. At moisture contents other than ovendry, this BTU value decreases according to the following formula:

$$\text{Actual BTU/pound} = 8500 \times \left[\frac{100 \times (MC/7)}{100 + MC}\right]$$

Where MC = Moisture Content

(source: Panshin, A. J. and de Zeeuw, Carl, Textbook of Wood Technology, Vol 1, 3rd Edition. New York: McGraw-Hill, 1970. p. 215.)

Burning Efficiency: The efficiency of a combustion system, expressed as the percent of a fuel's total heat value the system actually makes available.

Clearcut: Ideally, the total removal of all trees in a particular stand of timber. In practice, the total removal is usually somewhat less.

Commercial Forest Land: Forested land which is producing or capable of producing timber crops, generally with a site quality capable of producing more than 20 cubic feet per acre of annual growth.

Cord (standard): A unit of measurement for a 4'x 4'x 8' volume of stacked wood. Volume of solid wood in a standard cord is approximately 79 cubic feet and the volume of solid wood plus bark is 91 cubic feet per cord.

Dry Tons: Refers to the weight of wood at approximately 10% moisture content.

Forest Type: A classification of forest land based upon the species forming a plurality of live-tree stocking.

Fulltree Harvest: Harvest method in which the entire tree is removed and reduced to chips.

Green Tons: Refers to the weight of wood at 45-50 percent moisture content, when water and wood are present in approximately equal weights.

Growing Stock: All live trees of commercial species except rough and rotten trees.

Logged Area Residue: Wood material remaining on a site after harvesting the merchantable timber. Such materials include tops, branches, and leaves of harvested trees, unrecovered merchantable material, whole trees too small to be harvested, wood species which are not marketable, and wood with defects, poor form or decay.

Merchantable Wood: Includes wood from all growing stock trees 5 inches dbh or larger to a minimum top diameter established by current merchantability standards.

Moisture Content: The weight of moisture in wood expressed as a percent of oven-dry weight.

$$MC(\%) = \frac{(\text{Weight of Wood with Moisture}) - (\text{Oven-dry Weight})}{\text{Oven-dry Weight}}$$

Non-Commercial Forest Land: Land where timber use is precluded by development for non-forest use, such as cropland, pasture land, windbreaks, and urban areas.

Partial Cut: Harvest method in which some portion of the stand is left unharvested to satisfy silvicultural objectives or because of poor quality.

Primary Wood Processors: Industries which receive and utilize roundwood or chips from roundwood, and manufacture such products as lumber, poles , posts, waferboard, chips, and chipboard.

Residue: Wood remaining after the process of harvesting or milling.

Roundwood: Unprocessed wood in rough, round form including sawlogs, posts, and bolts.

Secondary Wood Processors: Industries which utilize lumber or other materials produced by primary processors, manufacturing such products as furniture, pallets, boxes, cabinets, millwork, window and doors, homes.

Shortwood Harvest: Harvest method in which trees are removed and transported in designated lenghts, e.g. 100 inch logs.

Survey Units: The survey units used in these studies have have been delineated by the United States Forest Service for the purpose of grouping counties of homogeneous cover types and market areas. (see map)

Timber Stand Improvement (TSI): Silvicultural techniques which improve the density and quality of forest stands. Examples of these techniques include thinning and pruning.

Treelength Harvest: Harvest method in which trees are removed and delimbed and the resulting treelength logs are transported in this form.

Minnesota Forest Survey Units

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