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Assessment of Potential Wood Supply for Intermediate Scale Thermoconversion

Tasks I, II, III

November 1985

Prepared by PYROS, Inc.
for Pacific Northwest Laboratory
under Contract DE-AC06-76RLO 1830
with the U.S. Department of Energy

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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ASSESSMENT OF POTENTIAL WOOD SUPPLY FOR INTERMEDIATE SCALE THERMOCONVERSION FACILITIES

TASK I, II, III

November 1985

Prepared by Pyros, Inc.
for Pacific Northwest Laboratory
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

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INTRODUCTION AND SUMMARY

The Department of Energy's (DOE's) Biomass Thermochemical Conversion Program has been concerned with the potential of wood biomass to contribute to the Nation's energy supply. The basic technologies to utilize wood as an energy source, both in the residential and industrial sectors, are readily available and in the residential sector have been widely applied. Industrial use of wood energy by industries other than those in the forest products sector is occurring much more slowly. One of the factors inhibiting the selection of wood biomass for energy by non-forest industries, especially by those requiring large quantities (500-2,000 green tons per day), is concern with adequate fuel supply in terms of both a supply system and an adequate resource base. With respect to the latter, this report looks at the gross resource base as has been historically reported and also examines factors other than traditional product removals that could reduce to some degree the amount of resource that is available.

The study first examined the conversion of a New England utility from coal to wood chips. Selection was made on the basis that not only was the utility a non-forest associated industry and, therefore, faced with the problem of identifying a supply system and evaluating the potential resource base within a rather small regional area, but in addition was in the process of constructing a new generation facility to be fired by wood chips and requiring some 500,000 green tons annually.

Based upon the observations in the first phase, the study subsequently assessed the feasibility of industrial use of wood energy in intermediate-sized facilities (500-2,000 green tons per day) in each of the northeastern states and selected states of the southeast region.

In the initial phase of the study, the factors evaluated by the utility with respect to the potential fuel supply were examined, as was the subsequent experience in obtaining supplies when the converted facility became operational. The study process in reality evaluated two situations, the initial expectations of the utility with respect to fuel supplies for the conversion, the subsequent results, and the factors evaluated for the proposed new facility with its greatly increased fuel needs.

The characteristics of the supply region and the modest initial requirements (100,000 green tons per year) of the converted facility presented a somewhat straightforward evaluation with respect to the resource base. The estimated supply region was predominantly commercial forestland and contained numerous forest industries which supported many harvesting operations. An adequate highway system was in place providing access to a significant portion of the resource and permitting efficient delivery to the facility site. Despite the presence of numerous forest industries, resource inventory data for the region indicated a significant surplus of growth in relation to biomass removals.

Operationally, there was an early problem with respect to adequate fuel supply not due to any problem with the resource base but rather with an initial expectation that adequate supplies would be available from whole-tree chipping operations. When supplies did not meet expectations, sufficient mill residues were available to meet the need.

In the second and third phase of the study involving an assessment of the potential wood supply for use in intermediate-scale thermoconversion facilities, evaluations were made of factors identified in the first phase that could materially affect the supply potential. Several states in the northeast and southeast regions were examined.

Within the regions examined, there is a significant variation at a state level with respect to potential wood supply. This variation is most apparent in the northeast region where the resource base varies from a low of 395,000 acres of commercial forestland in Rhode Island to over 17,000,000 acres in Pennsylvania. Thus, from the standpoint of a state's resource base, it is apparent that the potential in Rhode Island is extremely limited. The fact that other states in the region have a larger resource base is no indication that the potential is significantly greater. Examination of landownership patterns indicates that in several states of the northeast the urbanization process has resulted in a fracturing of the commercial forest into smaller and smaller units. There is no concensus as to what constitutes an uneconomical harvesting unit and although there is increasing reference made to this factor, very little research has been undertaken. Current opinion ranges from 50 acres to 100 acres as the minimum unit. Applying such criteria to the resources of Connecticut and Massachusetts for example, each with a resource base over five times that of Rhode Island, one finds that surveys indicate that in each state over one-third of the resource is now in units less than 50 acres and over one-half are in units less than 100 acres. Since it is highly unlikely that the urbanization process will stabilize, it is reasonable to expect that in these and other urban states the creation of smaller units will continue.

Another factor that will serve to reduce availability of the resource is terrain limitations. At present, it is a factor difficult to quantify although in the process of assessing the four southeastern states it was found that most recent forest surveys of three of the states, Alabama, Florida, and South Carolina, now contain estimates as to how much of the commercial forestland is adversely affected by terrain conditions. In these states, the significance of this factor was minor, ranging from 3 to 7 percent. One difficulty in attempting to evaluate the significance of terrain is again the lack of concensus among researchers as to what constitutes adverse terrain.

In general, the study found that there were various factors that influence eventual biomass availability. In any site planning process, these factors need both a near-term and long-term assessment; some factors will change over time.

"ASSESSMENT OF POTENTIAL WOOD SUPPLY FOR
INTERMEDIATE SCALE THERMOCONVERSION FACILITIES"

TASK I

"FEEDSTOCK SUPPLY INFRASTRUCTURE FOR THE
BURLINGTON ELECTRIC DEPARTMENT, BURLINGTON, VERMONT"

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1.0 Summary

The Burlington Electric Department's 50 MW wood-fired generation plant, presently under construction, will require approximately 500,000 green tons of wood chips annually. There appears to be an adequate resource base to support fuel requirements. Based upon current experience in securing wood chips for the existing facility, the BED is structuring a supply system that will include brokers and individual suppliers of both whole tree chips and mill residues.

The transportation system will include truck and rail deliveries, the latter being a requirement contained in the Vermont Public Service Board (VPSB) construction permit.

Forestry resources within a 50 mile area of the site are predominantly in private ownership characterized by numerous individuals and organizations who own forest land for a variety of reasons.

2.0 Background

The Burlington Electric Department (BED) is a municipal utility owned by the City of Burlington, Vermont. Burlington is located on the eastern shore of Lake Champlain and is the largest municipality in the State with a population of about 38,000.

In 1954, the city constructed the present facility, a three unit, coal-fired steam plant, each unit rated at 10,000 KW. At the time of construction, provision was made for the future addition of oil or gas guns. In 1971, a natural gas burning capability was added and oil guns were installed in 1975.

Faced with the need for more energy, BED commissioned a study in 1977 to determine the feasibility of constructing a 50 megawatt wood-fired generation plant. Also in 1977, as a pilot project, the BED converted one of the existing units to burn wood chips. The resultant success of the conversion, coupled with an encouraging report on the feasibility of constructing a 50 MW wood-fired plant, led to voter approval in 1978 of a bond issue for construction. In September 1981, the State of Vermont Public Service Board (VPSB), after extensive public hearings, issued a Certificate of Public Good (Appendix A) authorizing construction of the facility. Following PSB approval, construction began in late 1981 on a site previously purchased by BED.

As proposed, the new facility will be designed to allow conversion to other fuels with a minimum of effort. The boiler will be designed to allow coal firing and gun ports will be installed to allow increased firing of oil or gas. However, the plant initially is licensed to be fueled with wood.

2.1 Special Considerations

In view of the fact that the intent of this report is to describe the fuel supply infrastructure for the BED facility, it is pertinent to document those conditions imposed by the VPSB in the issuance of the Certificate of Public Good that affect the wood supply system.

Order and Condition of Public Good
Pursuant to 30 V.S.A. Section 248

7. Not less than 75% of all wood fuel to be consumed by the facility shall be delivered to the plant site by railway.

8. All agreements between the Petitioner and other parties for the delivery of wood fuel by truck shall be in writing and shall provide that no fuel trucks may enter or utilize the five-corners intersection, so called, in Essex Junction, Vermont between the hours of 7:00 A.M. and 8:30 A.M. nor between the hours of 4:00 P.M. and 5:30 P.M., Mondays through Fridays, inclusive, holidays excepted, and that no such trucks may enter or utilize streets or highways within the Cities of Burlington or Winooski on Sundays or before 6:30 A.M. or after 9:30 P.M. on any other day. Violation of any such provision shall expressly be made a cause for cancellation of such agreements, and in the case of any such violation, then, at the discretion of the Petitioner or upon order of this Board, such termination shall be effected. The Petitioner shall promptly notify the Board of any violation of such provisions of which it becomes aware. Copies of all agreements for delivery of wood fuel by truck shall be furnished to the Board promptly upon the execution thereof.

10. All agreements between the Petitioner and other parties for the harvesting of woodchip fuel shall be in writing and shall provide that the harvester shall (a) advise the Vermont Department of Fish and Game in advance of the location of harvesting operations; (b) adhere to the recommendations of the Vermont Department of Fish and Game regarding cutting near deer yards, wetlands or the habitat of any endangered species; (c) comply with all applicable environmental protection standards established under state or federal law; (d) limit clear cutting to 25 acres or less except in genuine cases of land use *conversion, and in all such cases, the harvester shall advise the Petitioner sufficiently far in advance to permit the Petitioner to verify that the conversion is in fact genuine; and (e) comply with all terms and conditions of "Harvesting Policy for Whole Tree Chipping Operations in Vermont (Second Revised Draft)" as set forth in Petitioner's Exhibit No. 101. Violation of any such provision shall expressly be made a cause for cancellation of such agreements and, in the case of any such violation, then, at the discretion of the Petitioner or upon order of this Board, such termination shall be effected. The Petitioner shall promptly notify the Board of any violation of such provisions of which it becomes aware. Copies of all agreements for harvesting of woodchip fuel shall be furnished to the Board promptly upon the execution thereof. Not later than the first day upon which woodchip harvesting commences, the Petitioner shall have and maintain a staff of not less than 11 professional foresters to monitor the provisions of this paragraph.*

3.0 Current Supply

The present facility is being used as an intermediate power generation plant[a] with an approximate need of 100,000 green tons of wood chips for the units capable of firing with wood. In essence the present supply system can be viewed as a microcosm of the eventual system for the new plant.

(a) Intermediate Power - That portion of the power which is in demand for long periods of time but not continuously.

3.1 Number of Suppliers

At present, current wood fuel needs are being furnished by three suppliers. One is essentially a broker furnishing mill residues from a variety of sources. The other two suppliers are harvesters (loggers) furnishing whole tree chips from logging operations.

Mill residues comprise about 20 percent of the supply and in view of the fact that the present facility lacks chipping equipment, mill residues procurement is limited to those industries with on-site chipping systems.

The bulk of the supply comes from whole tree chips produced within the supply area. Currently one producer supplies about 60 percent of the whole tree chip fuel.

When the new facility comes on line, BED procurement staff anticipate that there will be no significant change in the ratio of mill residue to whole tree chips (20-80). As a matter of policy, the BED will contract directly with a number of whole tree chip producers and not rely to any great extent on brokers. The number of mobile chipping operations is on the increase within the state. From a reported two operations in 1979,[1] state personnel indicate ten operations currently.[(a)]

The current price of delivered chips to the Burlington plant is approximately $17.50/green ton.

(a) Information from N. Hudson, Vermont State Energy Office, April 21, 1982.

3.2 Contract Terms

Present contract terms with suppliers are extremely simple and are for one-year periods. According to BED officials, the only requirements are that the feedstock as delivered contain no excessive quantities of oversize material. However no specific designation is now made to what constitutes oversize material.

When the new facility becomes operational contracts will, of necessity, have to contain more conditions than are now felt necessary. First of all, the new facility will not have the multi-fuel flexibility that the current plant has; thus, the dependence upon an adequate wood supply becomes more critical especially when viewed in terms of the quantities required. In addition, there are specific restrictions or limitations affecting the supply system that were imposed by the Vermont Public Service Board (VPSB) in the issuance of the Certificate of Public Good (Section 1.2) and, it is clear that the intent of the VPSB was that all such conditions be part of supplier contracts.

Although no firm decision has yet been made, BED officials are considering long-term supplier contracts extending as long as 5 years.

3.3 Supply Area

Vermont is predominantly a rural State. Seventy-five percent of the State is classified as commercial forest land. Chittenden County, site of the BED, is considered the most densely populated area. This is indicated in Figure 1 which compares households to total land area. As the data shows, on a statistical basis, Chittenden County has a density factor of 8 acres per household. This density is relative since the population is concentrated in Burlington and the immediate area and as the data indicates, the county is 57 percent commercial forest land. One does not travel far from Burlington to find a rural, farming environment. Dairying

Figure 1

Total Households 1980

County	Households[a]	Land Area[b]	Density (Acres/Household)	% Commercial Forest Land[b]
Addison	12,002	501,500	41.7	57
Bennington	15,597	430,200	27.5	86
Caledonia	11,611	391,900	33.6	74
Chittenden	41,347	341,000	8.2	57
Essex	3,704	424,500	114.6	93
Franklin	14,460	422,700	29.2	56
Grand Isle	3,556	53,300	14.9	-
Lamoille	7,537	303,600	40.2	83
Orange	10,483	441,700	42.1	76
Orleans	11,175	457,400	40.9	74
Rutland	25,778	593,300	23.0	75
Washington	22,113	452,800	20.4	80
Windham	19,961	503,600	25.2	85
Windsor	24,275	617,800	25.4	80

a) Information from B. Johnson, Vermont State Planning Office, April 30, 1982.

b) Source: The Forest Resources of Vermont, USDA Forest Service Resource Bulletin NE-46, 1977, Northeast Forest Experiment Station.

is the predominant form of agriculture. The recreation industry is significant throughout the State and especially so within the supply area with Lake Champlain providing numerous opportunities for water oriented recreation while almost to the immediate east of Burlington, the Green Mountains provide some of the finest skiing facilities in the country.

The Green Mountain Range can be looked at as more or less bisecting the BED supply area, thus traveling east from the flat to rolling terrain in the vicinity of the lake, the land rises rather abruptly to the Green Mountain peaks, ranging from 3,000 to 4,300 feet, then dropping again rather steeply down the easterly side.

Within a 50 mile supply area there are some 1.6 million acres of commercial forest land, approximately 68 percent of the total land within the supply zone. Although there are large blocks of public forest land within the area, the bulk of the commercial forest land is in private ownership. The extent of private ownership can be evaluated by data in Figure 2 which indicates the number of private owners and the acreage of commercial forest land for those counties within the 50 mile zone. There are an estimated 24,535 owners of 1.1 million acres of commercial forest land (89 percent of the total commercial forest land in those counties).

Generally, the entire area is serviced by an extensive network of roads. Interstate-89 originates at the Canadian border about 40 miles north of Burlington and proceeds south paralleling the lake to Burlington where it swings southeasterly to New Hampshire.

There are several major state highways, usually located in the valleys. There is no county road system in the State, local roads are the responsibility of the towns. At the town level, there are a variety of roads ranging from paved to gravel to dirt. Many are remnants of the "hill-farm" era. It is not unusual to find some town roads or at least sections

Figure 2

Private Commercial Forest Land Ownership

County	No. of Private Forest[a] Land Owners	Acres of Commercial[a] Forest Land Owned	Total Commercial Forest Land	Percent of Private Ownership
Addison	3,095	199,000	286,000	70
Chittenden	1,412	185,100	196,000	94
Franklin	2,898	235,100	237,000	99
Lamoille	1,393	237,400	251,000	95
Washington	15,737	324,000	361,000	90
	24,535	1,180,600	1,331,000	89

a) Source: Unpublished Data, USDA Forest Service, Northeast Forest Experiment Station.

of some roads impassable in winter especially in areas where there are scattered seasonal homes unoccupied in winter months. In the spring, many dirt roads become impassable as thaws turn sections into deep mud. Thus accessibility to the resource in some localities may be limited because of seasonal road conditions. In other situations, insofar as whole tree chipping technology is concerned, the inability of van trucks to maneuver on some roads may be a limiting factor. There is no indication that these factors will have a significant affect on resource accessibility at this time.

Various studies have indicated that within the supply area the resource base is more than adequate to meet supply needs. In addition there is a well developed forest industry and an active, widespread supply infrastructure engaged in harvesting and transporting traditional raw material to the forest industries. Within the area there are some 55 major sawmills,[a] 18 equipped with chippers.[2]

With respect to suppliers, State personnel estimate there are approximately 570 logging operators working throughout the State.[b]

The distribution of primary wood-using industries is widespread. Commercial sawmills are located in every county except Grand Isle.

It should be pointed out that the 50 mile supply area discussed in this report is to some extent arbitrary (Appendix B). It is being used because it is an area analyzed by the BED and appears to be a reasonable economic area to investigate. It also is appropriate at this point to

(a) Mills producing over 100,000 board feet/year.
(b) Information from W. Grove, Wood Utilization Forester, Vermont Department of Forests, Parks and Recreation, April 30, 1982.

refer back to Section 2.1, Special Considerations, and discuss the ramifications of Condition #7 in the VPSB's Order of Certificate and Public Good. In essence, Condition #7 imposes a severe limitation on both the BED and suppliers in electing the transportation mode. Thus, regardless of transportation economies, only 125,000 tons (25%) can be delivered to the facility by truck.

Under normal conditions, a potential supply zone would be delineated around a proposed site and the resources within that area analyzed including a transportation network. This was done in the initial BED studies and it was assumed that truck transport would predominate. Because of its location, the BED supply zone included significant areas across the lake in New York State. Again, under a normal condition, it could be assumed that given a favorable market, truck delivered supplies would be readily obtained from the New York area since Burlington can be accessed via several ferries, and bridges north and south of the city.

The mandated transportation mode has altered the configuration of the supply area insofar as transportation is concerned and BED officials now do not anticipate significant supplies from the New York area.

3.4 Collection and Transportation

As now structured, the supply system is composed of whole tree chips from harvesting operations and chipped mill residues from forest industries. The bulk of the current fuel supply comes from the production of whole tree chips furnished by two operators.

One contractor is totally mechanized, producing primarily tree chips. Equipment consists of a feller-buncher, grapple skidder and a 22-inch mobile chipper.

The other contractor has similar equipment but, in addition, utilizes chain saws in the felling process and the production of round wood products.

One operation is approximately 48 miles from Burlington, the other operation is 20 miles away.

Mill residues come from a variety of sources. Supplies have been obtained as close as 5 miles and, because of attractive prices, from over 100 miles.

All material is transported directly to the BED in van trucks.

Current delivered prices are approximately $17.50 per green ton.

It is anticipated that the major difference in the system for the new facility will be in the transportation area. Obviously more suppliers will be involved, however, the major change will be in the transportation system. As has been documented, at least 75 percent of the supply must be rail transported. This poses no site problems since the site acquired by the BED is bounded by tracks of the Central Vermont Railroad (Appendix C). Currently, the BED is considering the establishment of one or more chip satellite yards in Vermont, readily accessible to a railroad and the interstate highway. A primary site would be located in or near St. Albans, approximately 25 miles north of Burlington. The Central Vermont Railroad goes through St. Albans and Interstate-89 is nearby. The location of a site in this area would increase accessibility to the heavily forested counties of Orleans and Lamoille located in the north central portion of the state. In addition, potential supplies might be available from southern Quebec. In addition to being a transfer point from trucks to rail, such a facility could provide additional storage capacity. Another site under investigation is in the area of Waterbury, Vt., approximately 25 miles southeasterly of Burlington, also on the Central Vermont Railroad and adjacent to I-89. The Vermont Railway runs south from Burlington linking at Rutland with the Delaware and Hudson which then runs westerly into New York State.

3.5 Wood Storage Facilities

The present wood storage system utilizes open storage (photos #1 & #2). Each unit is equipped with overhead bunkers but capacity is only about 8,620 cubic feet and are more properly part of the feed system.

Storage capacity is limited at the present site and appears to occupy slightly more than an acre. The BED attempts to keep a 30-day supply (10,000 tons) on hand.

In light of the experience gained in the operation of the existing system, the proposed storage system, while greatly expanded, will not differ significantly since outdoor storage will continue to be utilized. In operation, chips will be received both by van trucks and rail. Trucks will be unloaded by hydraulic dumper. Deliveries will either be transported directly to chip bunkers similar to the present system or to the chip storage area where storage will be in steeply sloped piles, 40 feet high. A reclaim system will transport fuel from storage to the boiler.

Thirty day storage on-site is planned with possible additional storage at satellite yards if such plans now under consideration are implemented.

The wood storage and handling area at the new facility will occupy an estimated 10 acres.

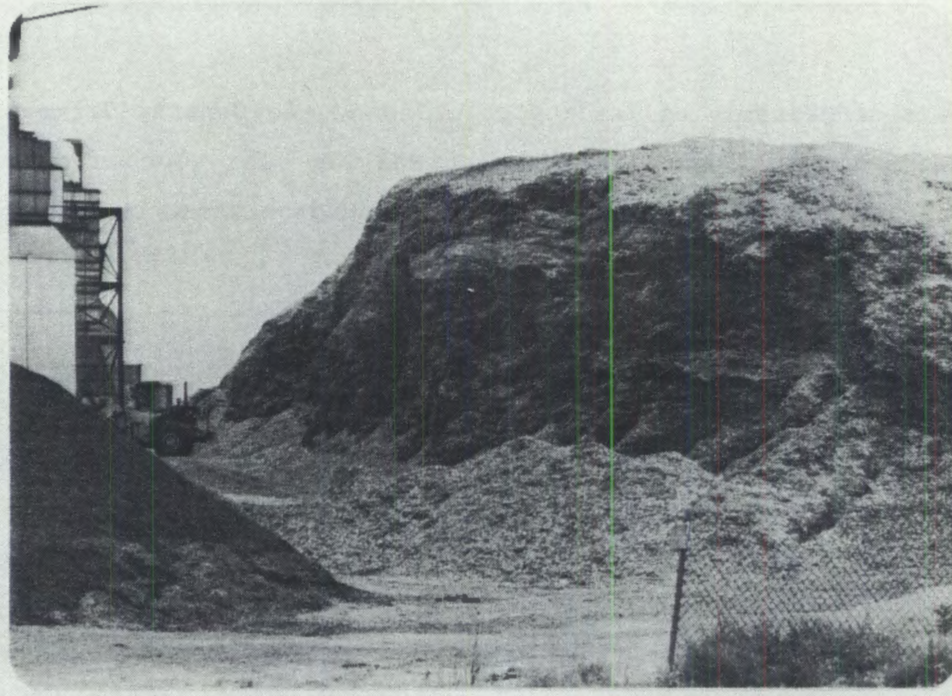


Photo #1 - BED Fuel Storage and Dumpster Loader

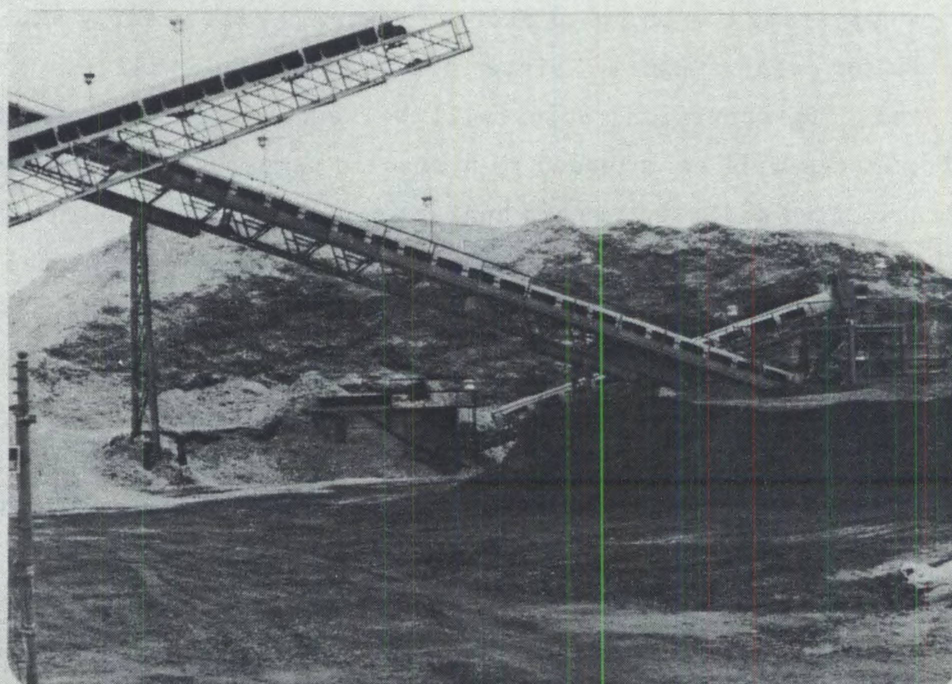


Photo #2 - BED Fuel Storage and Fuel Conveyor System to Boilers

3.6 Wood Preparation

Neither the present system nor the proposed system incorporates wood preparation processes. The procurement policy will purchase green chips suitable for direct utilization.

4.0 Characteristics of Forest Land Owners

Studies conducted for the BED have established that within a reasonable supply zone (50-75 miles), there is sufficient biomass growing to provide for the estimated needs of the new Burlington facility. However, ultimate availability is dependent upon many factors, one of which is land ownership. The BED does not now own forest land and is not considering purchasing any at this time[a]

Approximately 90 percent of the commercial forest land in Vermont is privately owned. When compared with the rest of New England, there is nothing unique about this large amount of private ownership. Figure 3 indicates that private ownership of commercial forest land predominates throughout the region.

A study by the Northeast Forest Experiment Station[8] (NFES) of private forest land owners indicates that the ownership is composed of many owners, estimated to be over 77,000 in Vermont. Thus, the eventual availability of adequate quantities of wood biomass, regardless of whether it is for energy use or the production of traditional forest products, is dependent upon the decision of numerous individuals as to whether they will allow harvesting and, if so, under what conditions.

(a) Information from T. Cronin, BED, April 26, 1982.

Figure 3

Ownership of Commercial Forestland

New England Region

(Thousands of Acres)

State	Total[1]	Federal	%	State/ Local	%	Forest Industry	%	Other Private	%	Total Private	%
Connecticut	1805.6	2.4	--	144.2	8	0.0	0	1659.0	92	1659.0	92
Maine	16864.0	73.3	--	467.7	3	8082.8	48	8240.2	49	16323.0	97
Massachusetts	2797.7	9.6	--	355.8	13	30.1	1	2402.2	86	2432.3	87
New Hampshire	4692.0	471.6	10	108.1	2	946.9	20	3165.4	67	4112.3	88
Rhode Island	395.3	0.0	0	32.1	8	0.0	0	363.2	92	363.2	92
Vermont	4429.9	212.8	5	209.2	5	666.3	15	3341.6	75	4007.9	90

[1] Commercial forestland.

Source: An Analysis of the Timber Situation in the United States 1952-2130, USDA/FS, Review Draft.

One of the most significant findings in the NFES study of Vermont forest land owners is the fact that owners of 88 percent of the private commercial forest land expressed a willingness to harvest timber. In view of the large number of owners and the expressed diversity of reasons for forest land ownership, this statistic is most encouraging not only to BED but also to other potential industrial wood energy users not allied with the forest products industry. It indicates no widespread antipathy on the part of the large segment of landowners who indicated reasons for forest land ownership other than for timber production (Figure 4).

The importance of this finding is further documented by data in Figure 5 which indicates the forest land acreage in various land ownership categories. Eighty percent of private ownership is for reasons other than timber production, and while the acreage devoted primarily to timber production is respectable (almost 20%), most of this land is owned by forest industries and it is presumed that most of the production will be utilized by those industries.

Thus, within the Vermont portion of the supply area, studies indicate that there is a significant resource base owned by numerous individuals for a variety of reasons. Although a vast majority of the owners indicate a willingness to consider harvesting their woodlands, the fact that timber production is of secondary interest to so many owners suggests that harvesting programs need to be tailored to reflect the interests of the landowner.

A forest ownership study was conducted for New York in the late 60's,[4] and although more dated than the Vermont study, the basic findings are believed to be still valid. As is the case in Vermont, private forest

Figure 4

Reason For Owning Commercial Forest,
By Number Of Owners, Vermont, 1973[a]

Reason	Vermont	
	Number	Percent
	OWNERS	
Land Investment	10,000	13
Recreation	17,900	23
Timber Production	5,400	7
General Farm Use	6,600	9
Place Of Residence	25,900	33
Other	11,500	15
Total	77,300	100

[a]Based on a pooling of the first four reasons given.

Figure 5

Reason For Owning Commercial Forest,
By Number Of Acres Owned, Vermont, 1973[a]

Reason	Vermont	
	Number	Percent
	ACRES OWNED	
Land Investment	548,600	14
Recreation	873,900	22
Timber Production	760,700	19
General Farm Use	479,900	12
Place Of Residence	824,400	21
Other	500,800	12
Total	3,988,300	100

[a]Based on a pooling of the first four reasons given.

ownership predominates. An estimated 94 percent of the commercial forest land in New York is in private ownership, with 84 percent being private non-industrial holdings.

Fundamentally, although the two studies are not entirely comparable, the New York study indicates a pattern of private land ownership quite similar to the Vermont findings in that the primary reason for forest ownership is other than timber production.

One significant difference between the two States is the larger percentage of private commercial forest land in New York State held by owners indicating opposition to any future timber harvest. An estimated 27 percent of the commercial forest land in the State is in this category, a figure slightly more than double the situation in Vermont. However, there is no evidence that this owner attitude is any more prevalent within the BED New York supply area than in other portions of the State.

According to the findings of the NFES study, the profile of the Vermont forest landowner indicates that the owner has an education that goes beyond high school, is over 45 years of age, is a skilled laborer with an income of $10,000 - $15,000, and has owned the land less than 10 years. The size tract is from 10 to 14 acres and the major reason for ownership is that the forested land is part of the residence.

Another significant finding of the study is that the non-resident or absentee owner is a minor factor. In the past, it was widely perceived that such absentee ownership was a significant factor. The study indicates that this factor, at least for the recent time frame, is not a critical segment of the landowner population and accounts for only 12 percent of the land.

5.0 Procurement Program

The BED is cognizant of the fact that in order to ensure adequate fuel supplies for the new facility, actions are necessary other than simply going to the marketplace. One important factor has been the concern about the possible adverse effect of whole tree chipping technology. Coupled with this is the fact that much of the resource base is owned by many individuals not primarily concerned with timber production. The significant market that will be created by the new facility has caused concern over the potential for large scale overcutting of forest land.

Although the VPSB placed certain restrictions on clearcutting of forest land when the material is destined for the Burlington facility (Section 2.1, Item 10), it should be noted that the BED recognized the concern before the formal public review and as early as 1979 indicated that a Woodlands Department would be created to, among other things, ".... design and implement a landowners' assistance program."

Burlington has in place a forester responsible for wood procurement and the provision of assistance to private woodland owners. It is expected that this staff will be increased as the new facility comes on line. Materials designed to encourage forest management have been created for the use of private landowners (Appendix D).

The BED landowners assistance program will complement professional assistance now available to landowners from private consulting foresters and county foresters of the Vermont Department of Forests, Parks and Recreation.

6.0 Resource Base

While an extensive investigation of the resource base is beyond the scope of this report, PYROS has analyzed information applicable to the supply zone envisioned by the BED.

The initial Burlington report[1] stated that research carried out for BED indicated that within a 75 mile radius the average quantity of wood fiber per harvested acre in the 6-20 inch (DBH)[a] size classes on commercial forest land was approximately 75 tons, composed of the following:

Hardwoods			
Growing Stock	36.112	green	tons
Rough and Rotten	17.838	"	"
Total:	53.950	"	"
Softwoods			
Growing Stock	16.947	green	tons
Rough and Rotten	3.785	"	"
Total:	20.732	"	"
TOTAL	74.682	green	tons

A recent publication of the USDA/FS[5] indicates that for Vermont, the per acre green weight of aboveground tree biomass on commercial forest land is approximately 82.6 green tons. However, 9.8 green tons of this total is in small trees (less than 5.0 inches DBH), Appendix E, a category not included in the BED study.

(a) Diameter Breast High.

Using a different methodology, PYROS estimated an approximate green tonnage of 78 tons per acre.

Given the empirical nature of current tree biomass computations, the various estimates appear close enough to accept the premise that with present information there appears to be a sufficient resource base to meet the BED supply need.

It should be noted that in 1977, the Vermont Department of Forests, Parks and Recreation, in cooperation with the USDA/FS, conducted a study of whole tree chipping operations in Central Vermont (within the estimated BED supply area).[6] On a site composed of mixed hardwood and softwood, a clearcutting operation involving approximately 10 acres of land yielded an average of 110 tons per acre.[(a)]

Within a 50 mile area, there are approximately 1.6 million acres of commercial forest land. Assuming 70 green tons per acre average, the resource base would appear to be some 112 million green tons. However, there are factors that serve to reduce the gross estimates. First, it has been noted that there is a significant established forest industry both within the area and externally that draws upon the resource base. A rough estimate based upon published roundwood harvest data indicate that some 200,000 tons are being removed for traditional forest products.

(a) Information from David C. Stevens, Utilization Specialist, Department of Forests, Parks, and Recreation, Morrisville, Vermont, March 31, 1981.

A second factor is the pattern of land ownership and the probability that significant holdings are too small to warrant economic chipping operations with currently available equipment. A third factor is the growing use of fuelwood in the residential sector. A report by the Vermont State Energy Office[15] estimates that some 451,000 cords of fuelwood were consumed in 1980. On a tonnage basis, this would equate to approximately 1 million tons for the entire State. It is somewhat problematic how much of this was removed from the supply zone. When placed in perspective, however, current drain data for the region as a whole are modest compared to the estimated resource base.

A survey done for the BED within the supply area indicated that the major proportion of residential firewood is cut on forest lands of less than 100 acres. The BED report also indicated that holdings of less than 100 acres were least desirable for whole tree chipping operations. The economics of whole tree chipping, and especially those operations involving material for fuel use, is an area still under investigation, and much work needs to be done. Studies done to date are few and tend to be site specific.

However, for the purposes of this report, if one accepts a 100 acre unit as a limit below which whole tree chipping operations will not normally operate, then some analysis can be made with respect to the resource base in terms of whole tree chipping operations. Figure 6 indicates the size class of private landowners in Vermont. Assuming that the supply area ownership pattern is similar to that of the State as a whole, then the bulk of the ownership is in units of 100 acres or over. This would indicate a resource base in terms of commercial forest land of around 1 million acres. Using the recently published data of the USFS[1] of 22 green tons per acre of rough and rotten material gives an indication as to the supply potential of normally unutilized material.

Figure 6

Estimated Number of Private Owners of Commercial Forest Land and Acreage Owned By Size Class and Form of Ownership - Vermont 1973

Size Class	Individual[a]	Corporation	Other[b]	Total	
Acres	Number	Number	Number	Number	Percent
			OWNERS		
1-9	33,500	-	-	33,500	43
10-19	8,600	-	1,100	9,700	12
20-49	13,800	300	700	14,800	20
50-99	7,700	-	100	7,800	10
100-199	6,200	200	400	6,800	9
200-499	3,500	100	300	3,900	5
500+	600	100	100	800	1
Total	73,900	700	2,700	77,300	100
			ACRES OWNED		
1-9	57,900	-	-	57,900	1
10-19	96,500	-	9,700	106,200	3
20-49	357,200	9,700	19,300	386,200	10
50-99	444,200	-	9,700	453,900	11
100-199	695,300	19,300	57,900	772,500	19
200-499	859,400	38,600	48,300	946,300	24
500+	425,100	791,900	48,300	1,226,300	32
Total	2,935,600	859,500	193,200	3,988,300	100

a) Includes joint ownership.

b) Includes parternships, undivided estates, clubs, association, etc.

Source: See Footnote 8.

Analysis of the most recent roundwood removals data (1980), Appendix F, indicates that the harvesting of forest products has increased 48 percent over that reported by the USFS in the last resource survey.[8] However, the total roundwood cubic foot volume removed in the five counties, within a 50 mile radius, remained proportionately the same in 1980 when compared to the total State removal, as in 1972 (Figure 7).

At this point, it is premature to draw any conclusions from the recent data indicating increased harvesting activities with respect to the effect on the resource base and its ability to meet the demands for traditional products and wood energy. If one examines the historical data (Appendix G), for example, the data indicates that for sawlogs, the annual harvests, while showing an almost steady increase for the past ten years, do not exceed, and for most of the years, do not approach the volumes harvested in the late forties and early fifties.

The pulpwood/boltwood category, when viewed historically, exhibits wide fluctuations in terms of cords harvested. Although the years 1979 and 1980 set new highs for the period (1945-1980), the average for the years 1971-1980 is 176.3 thousand cords, slightly less than the average for the ten year period 1945-1954.

Figure 7

Industrial Roundwood Harvest, Vermont - 1972, 1980

(Thousands of Cubic Feet)

County	1972[a]	1980[b]
Addison	2,435	1,658
Chittenden	754	1,171
Franklin	1,413	2,699
Lamoille	2,390	2,969
Washington	1,714	3,196
Total:	8,706	11,693
State Total:	36,071	53,406
Percent of State Total:	24	22

a) Source: The Timber Industries fo New Hampshire and Vermont, USDA Forest Service Resource Bulletin NE-35.1974. J. T. Bones, N. Engalichev, W. G. Gove. Northeast Forest Experiment Station.

b) Source: Vermont Forest Resource Cut Summary - 1980. W. G. Gove, Wood Utilization Forester. Department of Forests, Parks and Recreation. Agency of Environmental Conservation. (Appendix F)

7.0 CONCLUSION

As the new BED 50 MW wood chip fired generation facility becomes operational, the required 500,000 tons of wood fuel annually should have no substantial effect, in the near future, on the total resource base within the estimated supply region. Various studies have indicated that the average per acre green weight of above ground tree biomass on commercial forest land is approximated 70 tons per acre in trees larger than 5.0 inches Dbh.

In a 50 mile radius, there are an estimated 1.6 million acres of commercial forest land within Vermont. The bulk of the land is controlled by many private owners, most of whom have expressed reasons other than timber production for ownership. Studies indicate, however, that there are no significant objections to timber harvesting operations. Despite the size of the resource base, some units of land are too small to support the efficient use of equipment now being utilized in whole tree chipping operation. Other areas may have physical limitations that restrict the use of current equipment.

There are numerous primary wood using industries within the area supported by a well established wood supply infrastructure. The use of whole tree chipping technology while not yet widely employed, has been increasing. Additional investments will have to be made by the existing supply system to meet the expected demand of the new facility.

Although the harvesting of traditional roundwood products has been increasing in recent years, historical information indicates present quantities are below earlier time periods.

Addenda

On-site visits were made to the Burlington facility to examine aspects of the fuel on site.

- The species composition of the fuel comprise a mixture of most of the species growing in the supply area. Since, for energy purposes, procurement policies consider all wood as having equal value, no specific data are available regarding species composition. Assuming that the fuel supply is representative of general forest types found in the area then the fuel would be predominantly hardwood and contain such species as maple, birch, beech, oak and other species common to northern hardwood forests. Softwood components would contain spruce, pines, and hemlock.

- Bark content would be highly variable due not only to the fact that some fuel is obtained from mill residues and is relatively bark free, but also due to the fact that in forest biomass, the amount of bark varies by species. Studies indicate that the proportion of bark to total cubic volume can vary from a low of 8 percent in beech to a high of 17 percent in hemlock, both common species in Vermont.

- Chip size in storage piles is quite variable with the predominant size being about 1" x 1". However, the range included "fines" (1/4") to an occasional large (3" x 6") fragment.

- Burlington has done no monitoring or sampling of fuel supplies to determine such factors as ash (dirt) content or moisture content. Again both factors would be variable, especially with respect to extraneous foreign matter such as dirt. Not only would there be a seasonal factor (harvesting on snow covered terrain will result in less dirt) but also the bark characteristics will be a factor with a relatively smooth-barked species as beech containing less dirt than a rough-barked species such as hemlock or maple. Burlington does not consider moisture content to be a significant factor and indeed the moisture content would be variable given the range of factors that will affect moisture content at a specific point in time.

Forest biomass that is chipped soon after harvesting can be expected to have a higher moisture content than biomass that is stored on-site for a period of time before being chipped. In addition, many manufacturing plants either store logs in ponds or spray log piles during summer months to reduce "checking." Thus, the bark of many species will contain a very high moisture content. Thus, at the BED site, biomass is continually being delivered that is highly variable with respect to such factors as species, moisture content, and ash content.

- Studies have not been conducted at the site as to the effect of open storage on moisture content. BED personnel believe that there is a drying effect on the wood fuel in the interior of the storage pile. Precipitation apparently increases moisture content only in the "outer shell" of the stored fuel, possibly to a depth of 1-2 feet. Despite the severity of the winter climate, ice,and snow have had no appreciable effect on the ability to retrieve fuel from storage. During combustion, any adjustments necessary because of moisture content are made by the boiler operator.

- The delivered cost of fuel to the BED site is not tied to a rigid price schedule. Procurement policies are flexible to permit acquisition of supplies from various sources when opportunities arise to secure fuel at an advantageous price. It is not unusual for a mill with markets for its residue to have those markets temporarily disrupted. When this occurs, the residues become surplus. At times, the BED has secured supplies outside of the normal supply area at favorable prices.

- Very few improvements were needed to the present site and it is anticipated that the site for the new facility will be somewhat more sophisticated but in essence will handle the fuel in much the same manner as the current facility. The estimated cost of the new wood storage yard is $4,300,000.

TASK I REFERENCES

1. Wood Fired Electric Power Generation - A New England Alternative. The Joseph C. McNeil Station. Burlington Electric Department, 1979.

2. Directory of Primary Wood-Using Industries in Vermont -- Vermont Agency of Environmental Conservation, Department of Forests, Parks and Recreation, July 1981.

3. The Forestland Owners of New Hampshire and Vermont, Neal P. Kingsley and Thomas W. Birch, USDA Forest Service Resource Bulletin NE-51, 1977.

4. Forest Ownership and Timber Supply, Hugh O. Canham, School of Environmental and Resource Management, State University College of Environmental Science and Forestry, Syracuse, New York 13210, 1973.

5. Tree Biomass - A State-of-the-Art Compilation, United States Department of Agriculture, Forest Service, General Technical Report WO-33, November 1981.

6. Wood For Energy - An Interim Report On the Whole-Tree Harvesting Experiment, South Duxbury, Vermont, March 1, 1978, Department of Forests, Parks and Recreation. Vermont Agency of Environmental Conservation, Montpelier, Vermont. Vermont Natural Resources Council, 26 State Street, Montpelier, Vermont.

7. Vermont Energy Section Data, 1980. State Energy Office, November 1981.

8. The Forest Resources of Vermont, USDA Forest Service Resource Bulletin NE-46, 1977, Northeastern Forest Experiment Station.

APPENDIX A

Vermont Public Service Board Certificate of Public Good

STATE OF VERMONT
PUBLIC SERVICE BOARD

Docket No. 4450

Petition of the City of Burlington Electric Department requesting a certificate of public good pursuant to 30 V.S.A. Section 248 to construct and operate a 50 MW wood-fired electric generating station to be known as the Joseph C. McNeil Station --	)	Order Entered: 9/14/81

INTRODUCTION

On March 14, 1980 the City of Burlington Electric Department (BED or the Petitioner) filed a petition pursuant to 30 V.S.A. §248 seeking a certificate of public good for the construction of an electric generating facility to be known as the Joseph C. McNeil Station.

Plans for the proposed facility were submitted by the Petitioner to the City of Burlington Planning Commission and the Chittenden County Regional Planning Commission. By resolution of August 27, 1979, the Chittenden County Regional Planning Commission waived its right to receive said plans 45 days prior to the submission of the application for a certificate of public good; and by resolution of September 4, 1979, the City of Burlington Planning Commission did likewise.

Pursuant to Section 248(a), notice of the hearing on this petition was properly given to the Vermont Attorney General, the Department of Health, the Agency of Environmental Conservation, the Historic Sites Board, the Scenery Preservation Council, the State Planning office, the Agency of Transportation, the Chairman of the Burlington Planning Commission, the Executive

Director of the Chittenden County Regional Planning Commission and the Board of Aldermen of the City of Burlington. On August 19, 1980 and August 26, 1980, notice was published in the Burlington Free Press, a newspaper of general circulation in the county in which the facility is proposed to be located.

The City of Winooski, the State of Vermont, the Vermont Public Power Supply Authority, the Chittenden County Regional Planning Commission, the Vermont Natural Resources Council and the New England Regional Energy Project have intervened in the proceedings. Hearings were held in Burlington commencing on September 8, 1980 and on various dates through April 6, 1981. In addition to the technical hearings, public hearings were held in Burlington on June 18, 1980 and April 6, 1981 and in Winooski on July 30, 1980. The parties have briefed various issues of law and have submitted proposed findings of fact and conclusions of law and proposed orders.

FINDINGS OF FACT

I. THE PETITIONER AND THE PROJECT.

1. The Petitioner is a municipal electric utility owned and operated by the City of Burlington, Vermont. (Tr., 9/8/80, pg. 62.)

2. The Petitioner owns and operates electric generating, transmission and distribution facilities with which it serves approximately 16,000 customers within the City of Burlington and, in addition, the Burlington International Airport. (Ibid.)

3. The proposed facility will be located entirely within the limits of the City of Burlington. (Pet's Exs. Nos. 2,3,36.)

4. The plant will burn wood chips as its primary fuel source but may utilize fuel oil as an ignition fuel. (Pet's Ex. No. 77.)

5. With a design capacity of 50 megawatts, it is intended to operate as a base load/intermediate unit and to be dispatched at a 70 percent load factor. (Pet's Ex. No. 11A, pg. 1-1; Tr., 10/22/80, pp. 55-56.)

6. The plant will also produce excess steam to be used by the University of Vermont and the Medical Center Hospital. (Pet's Ex. No. 71.)

7. The Petitioner proposes to retain ownership of 50% of the proposed facility. (Pet's Ex. No. 31-A.)

8. The Petitioner has contracted to sell an additional 30% to the Vermont Public Power Supply Authority (VPPSA) and is seeking purchasers for the remaining 20%. (VPPSA, Ex. No. 1, pg. 7; Tr., 10/28/80, pg. 29.)

9. The estimated cost of construction, as of September 9, 1980 is $73,658,500.

II. NEED FOR THE FACILITY

10. Using a variety of methodologies, four witnesses gave a total of six projections of peak demand growth ranging from less than 2 percent per year to 4.2 percent per year to the year 2000. (Tr., 10/24/80, pp. 38-39; Tr. 10/30/80, pg. 169; Pet's Ex. No. 31-A, pg. 5; States Exs. Nos. 37, 40.)

11. All witnesses, including those called by parties opposed to the petition were of the opinion that BED's system will experience positive growth in peak demand for the forseeable future. (Ibid.)

12. The analyses and conclusions of the Petitioner's witness, John Perkins and the state's witness, Byron McCoy, are the most credible and persuasive, and the Board finds that the most reasonable assumption is that BED will experience growth in peak demand of not less than 3 percent per year until the year 2000.

13. On the basis of the foregoing conclusion, beginning with the 1981 peak of 68.9 megawatts (Tr., 3/17/81, pg. 49) and postulating the need for a 15 percent reserve, which the Board finds to be the minimum reserve required, BED's growth for the 10 years beginning with a hypothetical on-line date of 1984 will be as follows:

Year	Peak Demand (MW)	Peak Demand Plus 15% Reserve (MW)
1984	75.3	86.6
1985	77.6	89.2
1986	79.9	91.9
1987	82.3	94.6
1988	84.8	97.5
1989	87.3	100.4
1990	89.9	103.4
1991	92.6	106.5
1992	95.4	109.7
1993	98.3	113.0

14. If service is to be provided in the most economical manner, approximately 58% of a utility's power sources should be of the base load type, and 67% to 73% should consist of a combination of base load and intermediate facilities. (Tr., 10/22/80, pg. 54; Pet's Ex. No. 31-A, pg. 3-8.)

15. Until 1984, without taking the proposed facility into account, BED will have both adequate capacity and an appropriate mix of sources by type. (Tr., 9/8/80, pp. 62-65; Pet's Exs. Nos 28, 29, 31-A, 73.)

16. BED will require no more than one-half of its full share of 25 megawatts in the proposed facility until after 1984. (Tr., 10/28/80, pg. 23; Pet's Ex. No. 73.)

17. BED's second largest, and its least expensive base load source, PASNY hydro, expires in 1985, and there is no assurance of renewal. (Tr., 9/8/80, pp. 65, 70; Tr., 3/17/81, pp. 24-25; Pet's Ex. No. 31-A, pg. 3-6.)

18. Two of BED's smaller intermediate sources, New Brunswick and Middletown, will no longer be available to it by the winter season of 1986-87. (Pet's Ex. No. 31-A, pg. 3-6.)

19. BED's future entitlements to small amounts of base load power from Millstone Unit #3 and Pilgrim Unit #II may not be available before 1990. (Tr., 3/17/81, pg. 86.)

20. By 1986, if PASNY is not extended, and if the Millstone and Pilgrim nuclear facilities are not on line, BED will have only 34% of its capacity in base load facilities. (Pet's Ex. No. 31-A, pp. 3-6, 3-7; Table 3-3.)

21. If PASNY is extended, BED will have only 43% of its capacity in base load facilities by 1986. (Ibid.)

22. Either projected baseload capacity amount is substantially below the 58% which BED requires in order to operate most economically.

23. Not only will BED be unable to operate most economically by 1986, but if PASNY is not renewed, it will not have sufficient capacity of any kind to meet its projected peak demand plus a 15% reserve. (Ibid; Finding No. 13.)

24. If PASNY is not renewed, and if other sources are not obtained, BED will not have sufficient capacity to meet actual demand by 1990, even assuming a zero reserve requirement. (Ibid.)

25. BED's need for the facility will continue to grow, and BED will require its full entitlement by the early 1990's. (Pet's Ex. No. 31-A, pg. 3-1.)

26. Assuming a 10% escalation in construction costs, an assumption which the Board finds to be reasonable, a two year delay in construction would add approximately $15,000,000 to the cost of the project, or 6.5 mills per kilowatt hour for all energy produced over the estimated 30 year useful life of the facility. (Tr., 3/17/81, pp. 64-65, 71; State's Ex. No. 40.)

27. BED proposes to arrange both a firm sale of the 20% of the plant capacity which is as yet unsold as well as temporary short term sales of its own excess capacity until it requires its full 25 megawatt share for its own purposes. (Tr. 10/28/80, pp. 24, 29.)

28. Based upon its knowledge of the market for base load-intermediate power in New England, as well as the testimony and exhibits of witness McCoy, the Board concludes that it is reasonable to assume that BED will sell the presently uncommitted 20% share before the plant goes on line and that it will be able to arrange short term sales of its own, unused capacity.

29. Construction of the proposed facility will significantly contribute to the reliability of BED's power supply by increasing its diversity of generating sources, by maintaining its commendable diversity of generating fuels, by increasing its control over the

operation of its generating sources and, because it will reduce the average age of its sources, by increasing the integrity of its generating plant overall.

30. With regard to the member utilities of VPPSA who have agreed to take and finance 30% or 15 megawatts of the proposed facility, the Board finds that it is probable that they will require additional base load capacity by 1984 and that they will require substantially more base load capacity by 1986.

31. In addition to needing additional base load capacity, VPPSA members, who are heavily reliant upon nuclear generation for their present base load capacity, and will be even more so if PASNY is not renewed after 1985, would benefit substantially from having a greater diversity of sources of supply and of fuel. (VPPSA Ex. No. 1, pg. 9; VPPSA Ex. No. 2.)

32. The evidence fails to establish that any new nuclear plant will be more economic than the McNeil station or even that any such plant will ever be built. Moreover, changes in design and in operating procedures for existing as well as new nuclear generating facilities may be imposed by the Nuclear Regulatory Commission. (Pet's Ex. No. 25A, pp. 8-9.)

33. Sears Island, the only coal fired plant planned for New England, will not be available until 1989 at the earliest. It has once been rejected by the state regulatory agency having jurisdiction and, although a modified proposal has been presented, the agency has not yet given its approval to the plan. (VPPSA Ex. No. 1, pg. 4.)

34. The evidence fails to establish with reasonable certainty that Canadian hydro power can be imported in amounts and at prices which would render McNeil unncessary. Transmission plans have not been completed, nor have they received regulatory approval. Availability, interruptibility and prices for such power are unknown. (Tr., 9/8/80, pg. 71; Tr., 10/30/80, pp. 179-181.)

35. The proposed McNeil station is required to meet present and future demand for service.

III. SYSTEM STABILITY, RELIABILITY AND ECONOMIC FACTORS

36. Pursuant to procedures adopted by agreement of the members of the New England Power Pool (NEPOOL), the proposed facility was studied by NEPOOL engineers as to its effect upon the pool transmission system and the systems of utilities adjacent to the proposed facility. (Pet's Ex. No. 82.)

37. That review resulted in the conclusion that no stability problems would be presented because of the construction and operation of the proposed facility. No evidence was presented to the contrary. (Ibid.)

38. The construction and operation of the proposed facility will not adversely affect system stability.

39. Because of its location in Vermont, which as a whole is heavily dependent upon out of state sources of power, the proposed facility will improve, and will not adversely affect, the reliability of the entire state system.

40. To substitute oil fired sources for the McNeil facility would be substantially more costly owing to the greater cost of oil. (Tr., 9/8/80, pg. 69; Tr., 10/22/80, pp. 54-55; Tr., 3/17/81, pg. 74; State's Ex. No. 40, pp. 15-16; State's Exs. Nos. 41, 42.)

41. To substitute an oil fired source for the McNeil facility would also entail substantially more risk as to fuel availability because the continued availability of petroleum is subject to forces beyond the ability of this nation to control, whereas adequate sources of wood fuel exist wholly within the State of Vermont. (Tr., 1/22/81, pp. 5-9; Tr., 2/5/81, pp. 75-78; Pet's Ex. No. 98, VNRC Ex. No. 3.)

42. The proposed facility is more economic than any other new generating source reasonably certain to be available during the facility's lifetime.

43. The proposed facility will not adversely affect system economic factors.

IV. EFFECT ON ESTHETICS

44. The proposed facility will be visible from a relatively limited number of locations in its general vicinity. (Tr., 11/20/80, pp. 42-44.)

45. It will not be a dominant visual feature from any locations which are peculiarly sensitive because of their historic or scenic nature. (Ibid.)

46. Substantial fogging and the creation of a large plume by the cooling tower will occur infrequently. (Tr., 11/12/80, pp. 15-18; Pet's Ex. No. 74, pp. 34-39.)

47. Fugitive dust from construction and from the ash landfill will be adequately controlled by measures which the Petitioner will be required to undertake, in accordance with the conditions of the certificate and the conditions of the air quality certificate issued by the Vermont Agency of Environmental Conservation.

48. Because of the conditions imposed by this certificate, clearcutting for fuel will be limited to areas of 25 acres or less in general. The proposed facility will not, therefore, result in major esthetic degradation of forests.

49. The proposed facility will have no undue adverse effect on esthetics.

V. EFFECT ON HISTORIC SITES

50. Under the sponsorship of the Petitioner, studies were conducted to determine whether the proposed plant location contained sites of historic significance. (Tr., 11/12/80, pp. 64-72.)

51. Those studies disclosed several such sites and, as a result, the plant design was modified so that the sites would remain undisturbed. (Tr., 11/12/80, pp. 72-74, 83-84; Pet's Ex. No. 78.)

52. A substantial portion of fuel truck traffic will utilize the principal streets of the City of Winooski, some of which pass through historic districts. Because of the conditions of the certificate limiting the use of trucks for fuel transportation, and because of the projected use of such streets by other traffic, the effect will be minimal. (Tr., 1/13/81, pp. 38-44; Tr., 1/14/81, pp. 17-18.)

53. The proposed facility will have no undue adverse effect upon historic sites.

VI. EFFECT ON AIR PURITY

54. Through legislation (10 V.S.A. Ch.23) and regulations issued thereunder, the State of Vermont has adopted "a coordinated statewide program of air pollution prevention and control ... [within] a framework within which all values may be balanced in the public interest." 10 V.S.A. §551(c).

55. The purpose of that program is "to achieve and maintain such levels of air quality as will protect human health and safety and to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state and facilitate the enjoyment of the natural attractions of this state." 10 V.S.A. §551(a).

56. Under such legislation and regulations, the Agency of Environmental Conservation has the authority to approve or prohibit the construction of new air contaminant sources. 10 V.S.A. §551(a).

57. Because the proposed facility would, if built, constitute a new air contaminant source, the Petitioner applied to the Agency of Environmental Conservation for approval of its construction. (Pet's Ex. No. 77.)

58. The Agency of Environmental Conservation found that the proposed facility had the potential to emit in significant quantities the following pollutants: particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide and volatile organic compounds. (Ibid.)

59. The Agency of Environmental Conservation issued the permit after having found that, with respect to those pollutants and if all of the conditions of the permit were fulfilled, the facility would (a) satisfy all existing and applicable emission standards; (b) satisfy all existing and applicable ambient air quality standards; (c) achieve all existing and applicable most stringent emission rates; (d) not violate any existing and applicable prevention of significant deterioration increments; and (e) not affect any Class I area. (Ibid.)

60. Provided that the facility and the Petitioner fulfill conditions 1 through 9 of the Air Quality Permit issued by the Agency of Environmental Conservation on May 2, 1980, which conditions are also made a condition of this certificate, the facility will have no undue adverse effect on air purity.

VII. EFFECT ON WATER PURITY

61. The proposed facility will require up to 1,500 gallons of water per minute. (Tr., 11/19/80, pg. 20; Pet's Ex. No. 85.)

62. It is proposed that this water be drawn from four wells on the property, each with an estimated capacity of 500 gallons per minute. (Ibid.)

63. There is an adequate supply of sub-surface water to meet the facility's demand on a continuous basis, utilizing the four wells as proposed, without permanent depletion of the supply. (Tr., 11/19/80, pp. 13,19-20,23.)

64. There will be two kinds of discharge of water from the plant: (a) heated water from the cooling tower (Tr., 11/19/80, pg. 6; Tr., 3/5/81, pp. 34-35) and (b) storm water runoff. (State's Ex. No. 26, pg. 1; Tr., 3/5/81, pp. 34-35.)

65. The State of Vermont has adopted a comprehensive water pollution control program administered by the Vermont Water Resources Board. The program utilizes a permit system to control the discharge of wastes into state waters. 10 V.S.A. Ch. 47.

66. A permit has been issued for the discharge of heated water from the facility into the Winooski River. (Tr., 3/5/81, pp. 33-34.)

67. Such a permit constitutes a certification that discharges made in conformance with its conditions will not violate any applicable provisions of state or federal laws or regulations. 10 V.S.A. §1263(c).

68. In addition to obtaining a discharge permit for heated waste water, the Petitioner caused a study to be made as to the effect of such water on the temperature of the Winooski River. (Tr., 11/19/80, pp. 5-6.)

69. The study found, and the Board finds as fact, that such discharge will raise the temperature of the waters in the Winooski River not more than 0.02° Farenheit under average flow conditions and not more than 0.5° Farenheit under minimum flow conditions and that it will have no adverse effect on the river system. (Tr., 11/19/80, pp. 7-8.)

70. In addition to the certification implicit in the discharge permit, the Chief of the Permit Section of the Department of Water Resources concluded, and the Board finds as a fact, that the heated water will not affect the wasteload allocations or the assimilative capacity of the Winooski River. (Tr., 3/5/81, pg. 45.)

71. A temporary pollution permit has been issued for storm water runoff from the facility. (Tr., 3/5/81, pg. 35.)

72. A temporary pollution permit was utilized in this instance because standards for treatment and discharge for storm water have not yet been finalized by the State of Vermont. (State's Ex. No. 26, pg. 2.)

73. The temporary pollution permit constitutes a certification that discharges made in conformance with its conditions will not be unreasonably destructive to the quality of the receiving waters and will not violate any applicable provisions of state or federal laws or regulations. 10 V.S.A. §1265(c)(7) and (8).

74. The proposed facility will generate 16,000 tons of wood ash per year. (Pet's Ex. No. 88, pg. 2.)

75. For the first six years of plant operation, this ash is proposed to be deposited at a location near the plant site. (Tr., 3/5/81, pg. 9; Tr., 11/20/80, pg. 6.)

76. This location will first be covered with a five foot blanket of soil (Tr., 11/20/80, pg. 11) which is intended to protect sub-surface waters. (Tr., 3/4/81, pp. 175-176.)

77. Each day's deposit of ash will also be covered with a synthetic liner in order to minimize fugitive dust and to prevent rainwater percolation. (Tr., 11/20/80, pp.12,16.)

78. Wood ash is not classified as a hazardous substance by either state or federal authorities. (Tr., 3/4/81, pg. 173.)

79. The proposed location of the ash disposal facility is within the Vermont Agency of Environmental Conservation guidelines regarding distance from lakes (Champlain) and rivers (the Winooski). (Tr., 3/4/81, pg. 174.)

80. The petitioner's plans include provisions for protection of adjacent surface waters by means of a sand filter berm. (Tr., 3/4/81, pp. 174-175.)

81. The petitioner's plans include provisions for the protection of the ash disposal facility against a 100 year flood by means of a flood berm inside of the sand filter berm. (Tr., 3/4/81, pg. 175.)

82. The ash disposal facility will have no impact or minimal impact on the wetlands and the local environment generally. (Tr., 11/20/80, pg. 12; Tr. 3/4/81, pg. 174.)

83. The State of Vermont has adopted a comprehensive statewide program for the control of solid waste materials such as wood ash. The program utilizes a permit system as its principal means of control. 10 V.S.A. Ch. 159.

84. A disposal facility certification has been issued by the Agency of Environmental Conservation for the proposed ash disposal facility. (State's Ex. No. 25.)

85. Such a certification for the type of disposal facility proposed by petitioner is required by law to contain such "conditions, requirements, and restrictions as the secretary of the [Agency of Environmental Conservation] may deem necessary to preserve and protect the ground and surface water quality in the vicinity of the [facility]." 10 V.S.A. §6605.

86. The proposed facility will have no undue adverse effect on water purity.

87. Harvesting of fuel will be accomplished by a technique known as whole tree chipping. After they are cut and brought to a central location, trees which can be utilized for lumber are separated and delimbed. The remaining trees are fed into a chipper which reduces them to one inch by two inch chips. The chips are then blown into a tractor trailer van for direct delivery to the site at which they are to be burned or to a transfer site. (Tr., 1/23/81, pp. 5-11; Pet's Ex. No. 100.)

88. The forests of Vermont in which woodchip harvesting will be performed contain an overabundance of low quality timber which presently has no substantial market and which takes growing space from more valuable timber. (Tr., 2/24/81, pp. 140-141; Tr., 3/4/81, pp. 34-35; State's Ex. No. 18.)

89. Harvesting the quantity of woodchips required for operation of the proposed facility provides an opportunity to improve the management of a substantial portion of Vermont's forests. (Tr., 1/22/81, pg. 156; Tr., 3/4/81, pp. 34-35; State's Ex. No. 18.)

90. Although harvesting performed in an improper manner can cause soil erosion, stream sedimentation, needless destruction of wildlife habitat and esthetic degradation, (Tr., 3/4/81, pp. 92-95) the conditions imposed by this certificate will require woodchip suppliers to adhere to procedures which will protect against such effects.

91. The proposed location of the plant itself is a 46 acre portion of a 400 acre parcel owned by the City of Burlington within an area known as the Intervale. (Pet's Ex. No. 96.)

92. Studies were made of the potential effects on the soils, water sources, flora and fauna at the site. (Tr., 11/19/81, pp. 11-12, 28-29; Pet's Exs. Nos. 85,86.)

93. Construction of the proposed facility will unavoidably destroy vegetation and wildlife habitat and will disturb surface and sub-surface soils within the construction area itself, but no evidence was presented which would warrant a conclusion that such effects would be greater than would be caused by many other kinds of industrial development permitted by applicable land use laws and regulations.

94. Construction of the proposed facility will not significantly disturb soils, water sources, flora or fauna in areas beyond the immediate construction area. (Tr., 11/19/80, pp. 8, 31, 38, 49, 52, 63; Pet's Ex. No. 86; State's Ex. No. 21.)

95. Construction of the proposed facility will have no undue adverse effect upon the natural environment.

IX. EFFECT ON PUBLIC HEALTH AND SAFETY

96. The proposed facility will consume up to 500,000 tons of woodchips per year, (Pet's Ex. No. 94, pg. 8.), not more than 25% of which may, under the conditions of the certificate, be delivered to the site by truck.

97. Assuming an average payload of 22 tons for trucks making deliveries, and assuming a minimum of 300 delivery days per year, which assumptions the Board finds to be reasonable (Pet's Ex. No. 94, pp. 8-9) there will be an average of not more than 20 trucks arriving and 20 trucks leaving each delivery day.

98. The routes used by trucks will be generally uncontrolled, although it is probable that a majority will travel from Exit 15 or 16 of Interstate 89 through the principal streets (Main Street and East Allen Street) of the City of Winooski to Riverside Avenue in Burlington. (Pet's Ex. No. 94, pp. 5-6.)

99. Under the sponsorship of the Petitioner, a traffic study was conducted to analyze the effect on major intersection traffic in Winooski. (Tr., 1/13/81, pg. 37; Pet's Ex. No. 93.)

100. The study assumed that 100% of the fuel for the proposed facility would be delivered by truck through Winooski. (Pet's Ex. No. 93, pg. 10; Pet's Ex. No. 94, pg. 8.)

101. The study concluded that such truck traffic would not constitute more than 1% of the increase expected from all sources by the year 2000 and that this increase would not cause a significant level of congestion at any major intersection. (Tr., 1/13/81, pp. 38-44, 81-82; Pet's Ex. No. 93, pp. i-ii, 26-27.)

102. The study was realistic in its assumptions and was, if anything, biased in the direction of assuming greater impacts upon the City of Winooski.

103. Under the conditions of the certificate, the fuel truck traffic volume associated with the proposed facility will be reduced below the levels assumed in the study by 75%.

104. Both the Petitioner and the City of Winooski presented evidence regarding noise studies. (Pet's Ex. No. 94, pp. 18-24; Winooski's Ex. No. 4, pp. 6-7; Pet's Exs. Nos. 80, 81.)

105. The Petitioner's study concluded that the incremental noise increase that would be produced by trucks servicing the McNeil facility would be less than 5dBA, which is imperceptible in an urban environment. (Pet's Ex. No. 94, pg. 24.)

106. Winooski's study concluded that the incremental noise increase would be 6 dBA. (Winooski's Ex. No. 4, pg. 7.)

107. Winooski's study is less credible and precise because it was not a site specific study, (ibid.) and the Board finds that the incremental highway noise increase will be indistinguishable from background noise in the urban environment.

108. Fuel truck traffic noise in rural areas will not exceed generally accepted criteria. (Pet's Ex. No. 94, pp. 21-22.)

109. Site generated noise, resulting from a combination of plant operations and fuel delivery and handling, may have a significant impact on a number of residences nearest the southern and eastern boundaries of the site. (Pet's Ex. No. 94, pp. 15-18.)

110. A study sponsored by the Petitioner, which study is found to be credible and persuasive, found that, assuming all fuel to be delivered by truck between 6:00 a.m. and 10:00 p.m., the average level of site generated noise alone would be 64 dBA. (Pet's Ex. No. 80, pg. 12.)

111. 64 dBA is within the existing daytime ambient noise levels on residential streets adjacent to the proposed site. (Pet's Ex. No. 94, pg. 6.)

112. Noise levels will remain below the threshhold of pain or damage to the human ear of 120-130 dBA and will not be hazardous to physical or psychological health in the long term. (Tr., 11/12/80, pp. 114, 129.)

113. The proposed facility will not have an undue adverse impact on the public health and safety.

X. ORDERLY DEVELOPMENT OF THE REGION

114. The municipal and regional planning commissions and the municipal legislative bodies specified in 30 V.S.A. §248(a) have made recommendations relating to the proposed facility as follows:

A. The Regional Plan for Chittenden County adopted by the Chittenden County Regional Planning Commission on April 26, 1976 identifies Burlington as the core of the region; specifies as a major goal the availability of electric energy with a high degree of availability at reasonable cost; recognizes that additional generating facilities may be required in the region; and proposes that the core of the region should absorb the greatest intensity of development. (Pet's Ex. No. 96.) The Chittenden County Regional Planning Commission, as a party to this proceeding, has submitted proposed findings of fact urging approval of the proposed facility.

B. The Comprehensive Municipal Development Plan readopted by the City of Burlington in 1979 designates the proposed site as an industrial use area and specifically anticipates that an electric generating facility will be located there. (Ibid.)

C. By unanimously placing the bond issue for the proposed facility before the voters of the city in 1978, the Board of Aldermen of the City of Burlington approved the facility contingent upon the approval of voters which was subsequently given. (Ibid.)

115. Having given due consideration to the foregoing recommendations, and in view of the findings of fact set forth above, it is found that the proposed facility will not unduly interfere with the orderly development of the region.

XI. THE GENERAL GOOD OF THE STATE

116. In view of the findings of fact previously set forth, it is found that the proposed facility will promote the general good of the State of Vermont.

OPINION

By the certificate hereinafter granted, the Board authorizes the construction of a 50 MW wood-fired generating facility in the City of Burlington. As a prerequisite to such authorization, the Board is required to find that the project will promote the general good of the state and that it will not have undue adverse effects as measured by various criteria. 30 V.S.A. §248.

I. NEED FOR THE FACILITY

The first consideration in determining whether a major generating facility will promote the public good is the question of its need. The financial costs, the consumption of resources and the inevitable burdens upon the human and natural environment can be justified only to the extent that the facility is necessary to satisfy the legitimate demands of consumers for its power.

A utility's need for a particular facility must be determined by reference to a set of interrelated factors: (a) the need for adequate capacity, including reserve capacity, to meet the system's projected load or demand, (b) the need for an appropriate mix of base load, intermediate and peaking sources so that demand can be satisfied in the most economical manner; (c) the need for reliability, which is a function of diversity and integrity of sources, diversity of fuels and the degree of control which the utility can exercise over the availability and operation of its sources; and (d) the availability of alternatives.

The difficulty of this issue lies in the fact that it is largely a question of judgment. Available facts are often incomplete. Most are subject to rapid change, and reasonable people can differ as to the significance of even those facts that are clear and likely to remain unchanged. Further, the most important considerations often are not facts in any real sense - they are only predictions or forecasts. Such forecasts ultimately depend upon variables which are themselves impossible to predict with precision including, among others, changes in demographics, economic conditions, the price of electricity, the elasticity of demand at various prices, the availability and price of substitutes and the degree and effects of conservation programs.

The process of predicting future demand generally begins with history, but the lessons may not be readily apparent. During the ten years prior to the 1973 OPEC oil embargo, for example, BED's peak demand grew at an average rate of more than

8% per year; for the next six years, it grew at an average rate of just over 2% per year; but between the last year of that period and the following year,it grew by more than 10%. We daresay it is unlikely that even the most able students of load forecasting would have accurately predicted all of this very far in advance. Perhaps it is not surprising, then, that the expert witnesses testifying in this case varied by more than 100% (from less than 2% per year to 4.2% per year to the year 2000) in their forecasts of the growth of BED's future peak demand.

Because of the imprecision of load forecasting, we consider it imprudent to attempt to determine future need by reliance upon only one witness's opinion, even though we might agree that his credentials and track record are the best and that his methodology seems the most rigorous. Candor requires us to acknowledge, therefore, that our finding of a 3% growth rate is only our best prediction based upon the evidence presented and our own knowledge and expertise in evaluating it. In reaching the conclusion we did, we were strongly influenced by the fact that all witnesses, including those called by parties opposed to the project, forecast a positive rate of growth for BED's system and that no witness challenged that contention that VPPSA's members would also experience positive growth.

Having determined what we believe to be the most probable course of future demand, we must also consider the availability of facilities currently used to meet it. It is clear that the McNeil Station is not required immediately, as BED has both adequate capacity and an appropriate mix of base, intermediate and peaking sources. Prudent utility planning, however, must look well into the future.

By 1985, BED's supply picture becomes uncertain. As set forth in our findings, various sources presently utilized by BED will definitely be unavailable, and others may become unavailable between 1985 and 1990. Depending on the course of events, there is a substantial risk that, without new capacity of the kind afforded by this project, BED will not be able to meet its demand in an efficient manner or may be unable to meet it at all.

The suggestion was made by one or more parties that because of disagreement about the issue of need, the better course would be to deny the petition at this time in contemplation of BED's returning with a renewed request at such time as the demand question becomes more clear. We think, however, that this would be acting exactly in reverse of the order of the risks involved. The cost attributable to delay must be compared to the cost to BED ratepayers in the event the plant is built as scheduled, but with some or all of its power not needed by BED. When that comparison is made, the decision to proceed now seems the clear choice. To fail to authorize construction at this time on the ground that sufficient demand will not materialize, will likely be very costly if that prediction of demand turns out to be wrong. It is probable that the cost of construction will continue to escalate very rapidly, so that delay of only a few years would be enormously expensive to the facility's users. On the other hand, if we are mistaken in our projection of demand over the next several years, so that the facility is not soon needed by BED or VPPSA, the financial costs, at least, are likely to be very low or non-existent because we believe that it is probable that the power could still be sold elsewhere. Even if some of the latter sales must be made at a discount, which we believe to be an unlikely eventuality, it is not reasonable to assume that the cost to BED ratepayers of having to make up for such discounting could remotely approach the cost which even a two year delay in construction would entail.

Having determined that a facility of this kind is needed to meet the demand for service, we have further considered whether a more attractive alternative exists. We conclude that it does not.

Evidence was presented as to three other choices: investment in one or more of several nuclear units planned in New England; investment in the proposed Sears Island coal unit in Maine; and importation of Canadian hydro power. Like the evidence regarding McNeil Station itself, the assessment of this evidence must be based upon informed judgment, as the facts are always subject to change.

Taken at face value, the evidence regarding nuclear plants would show that they will be less expensive than McNeil. The Board does not find that evidence to be persuasive, however. Historically, cost estimates for nuclear facilities have been understated, sometimes by enormous amounts. Furthermore, there are certain factors, in particular, the costs of spent fuel disposal and of decommissioning, which simply cannot be known at this time because requirements have not even been established. Moreover, changes may be mandated in nuclear plant design and operating procedures with unknown effects on costs. Finally, experience has taught that completion of any new nuclear facility is not assured and that, at the least, announced in-service dates are highly unreliable.

Prospects for other facilities cited as options are no more certain. Sears Island is the only new coal plant planned for New England; it has yet to receive regulatory approval and, in fact, has once been denied. Transmission facilities for the importation of Canadian hydro power have not even been formally proposed, let alone approved under applicable criteria regarding safety and environmental effects. Even if such approval could be presumed, the Board has been presented with no evidence as to price, availability and interruptibility of Canadian power. With respect to price, we must assume that suppliers will not sell for less than the highest figure that can be obtained.

Manifestly, the record contains insufficient evidence for us to conclude that any of the facilities or systems presented as a possible alternative to the McNeil Station is sufficiently certain as to either cost or availability to warrant denial of this petition.

II. SYSTEM STABILITY, RELIABILITY AND ECONOMIC FACTORS

The reasons for our conclusions regarding stability, reliability and economic factors are clear from the findings themselves. One matter, however, requires a brief exposition: The "system" referred to in 30 V.S.A. §248(b)(3) is not defined in the statute. We conclude that it means the bulk electrical transmission system of the State of Vermont as well as the transmission and distribution systems of those Vermont utilities (here BED and the members of VPPSA) which intend either to transmit or distribute power from the facility as proposed.

III. EFFECTS ON ESTHETICS, HISTORIC SITES, AIR AND WATER PURITY, THE NATURAL ENVIRONMENT, PUBLIC HEALTH AND SAFETY

It may be worth observing that any large, industrial project will have certain adverse impacts upon its environment and on those who live or work nearby. At the least, undeveloped land must be utilized, and resources must be consumed. Beyond that, each project will have its particularized impacts which, in the case of the McNeil Station, are described in our findings. Overall, however, the environmental, health and safety effects of this project impress us as being remarkably slight.

Among the more serious effects will be noise at the project site resulting from a combination of regular plant operations and fuel handling. While the Board concludes that from the point of view we are required by statute to adopt, that of the public good, this particular adverse effect will not be undue, it may very well be a serious problem to a small number of residents in the area. To a degree, this kind of problem is a risk assumed by those who elect to live adjacent to a zone reserved for industrial use. Indeed, if the market is functioning properly, this risk is reflected in property values and rental levels in this area, and the residents that stand to be affected will have paid and will be paying lower purchase prices and rents as a result.

Whether or not this is so, we are requiring as a condition of this certificate that BED utilize reasonable noise limitation procedures and technologies in the design and operation of the facility. We note also that BED is voluntarily considering more direct measures such as the furnishing of air conditioners to the affected homes, the negotiation of noise easements or the outright purchase of certain properties. Additional possibilities exist, and the Board would not consider other reasonable accommodations to be illegally preferential. Yet, if the measures adopted are insufficient, residents may have legal or equitable remedies, and BED must take account of this possibility in evaluating the question of whether and how to proceed with the project.

Other environmental effects will also be produced. Wildlife habitat will be destroyed or disrupted, both at the plant location and in the forests where fuel is to be harvested. There will be a certain amount of air pollution, and water quality may be affected, again both on site and off. As our findings show, however, these effects will not be severe.

The witnesses to this proceeding were in general agreement that the quality of the state's forests affected by fuel harvesting would actually be improved as a result. This conclusion, of course, is based upon the quantity of harvest, and the harvesting techniques to be employed, as required by the terms of this order. Needless to say, the conclusion would not necessarily be valid for substantially greater amounts of harvest, nor in the absence of controls on harvesting techniques.

Through other administrative processes, the facility has satisfied existing legal criteria regarding air and water quality. This does not mean that there will be no air or water pollution. It means only that such pollution will be kept within the limitations established by the state's legislative and administrative processes. Section 248 does not state whether the Board is bound to follow, or is limited by, the same criteria as are utilized in the air and water quality certificate processes. For purposes of this case, we do not find it necessary to rule on the question. What we do hold is that, in the absence of persuasive evidence that those criteria are inadequate to protect the public, we will not look beyond them. No such showing was made here.

Off-site water pollution is, again, a function of the procedures used in fuel harvesting. We believe that the requirements we have imposed, and our continuing authority to modify those requirements, are adequate to protect both surface and subsurface waters in our forests.

As first proposed by the petitioner, most of the fuel to be used by the plant would be delivered by truck. Among the principal reasons that the City of Winooski opposes the project is its claim that fuel truck traffic would add significantly to noise and congestion at its major downtown intersection. Winooski further claims that its effect would generally degrade the quality of the environment both in the downtown area and at other historic site locations. One difficulty with this position is that highways are public facilities. No community has the right to close its streets to traffic which serves another and, certainly in the absence of extraordinary circumstances not present here, neither should this Board attempt to do so. Nevertheless, we think it only equitable that those who receive the majority of the benefits from a project of this nature should also bear most of the burdens. We have, therefore, required that at least 75% of the fuel be delivered by rail, a scheme which will be more expensive than one which relies primarily upon truck deliveries.

We have made no findings regarding the effects of fuel truck traffic on highway stability and maintenance, in part because the volume of truck and traffic using particular routes is unknown and cannot be predicted. Beyond this, however, all vehicles must conform to local and state laws regarding usage and maximum weight. They must also pay road use and fuel taxes. If this is insufficient to pay their way, the problem should be remedied by the appropriate legislative authorities.

IV. EFFECT UPON THE ORDERLY DEVELOPMENT OF THE REGION

The effect of a project upon the orderly development of the region is the first of the public good criteria specified in the statute. We have treated it last, however, because whether the other criteria are satisfied will in many cases, including the instant one, determine whether this standard can be met. We have found that such other criteria are satisfied. Moreover, no evidence was presented which is beyond the scope of those criteria and which would tend to show an adverse impact upon orderly development. Additionally, since the project is consistent with the recommendations of the appropriate planning commissions and legislative bodies, we can come to no other conclusion than that the proposed facility will have no undue adverse effect upon the orderly development of the region.

As is the case with other words in the statute, the term "region" is not defined. We conclude that in this instance it means, primarily, the City of Burlington (in which the facility will be located); secondarily, those nearby communities which will be affected, although to a diminished degree, because of their proximity to the facility; and, lastly, those outlying areas which may be affected because of the harvesting and transportation of fuel.

V. CONCLUSION

We conclude with the following observations. Other than the effects of fuel truck traffic (a problem which has been very substantially reduced by the 75% rail delivery requirement) the most serious dispute involved in this proceeding has been over the question of need for the facility. We have already set forth at some length the reasons why inevitably there must be a degree of uncertainty surrounding the resolution of this issue, and we have emphasized that it is largely a question of judgment. This facility is to be built by a municipal utility. The officials of that utility, the board of aldermen of the city of Burlington and the ratepayers, themselves, have all expressed overwhelming support for the project. In addition, at least 60% of the output which will not be used by BED will be taken and paid for by other public power authorities which are likewise responsible directly to their ratepayers. The judgments of those who will ultimately bear the financial risks of the project merit serious consideration, and we have taken account of them in our deliberations.

We recognize, nevertheless, that it is our duty to exercise our independent judgment upon all those matters committed to our discretion. We have done so, and we find that all of the statutory criteria are met and that the project will promote the general good of the state.

ORDER AND CERTIFICATE OF PUBLIC GOOD
PURSUANT TO 30 V.S.A. SECTION 248

IT IS HEREBY ORDERED, ADJUDGED AND DECREED by the Public Service Board of the State of Vermont that the construction of a fifty megawatt wood-fired electric generating station as proposed by the Petitioner will promote the general good of the state, and it is further

ORDERED that the petition for a certificate of public good is granted subject to the following conditions, unless otherwise ordered by this Board:

1. The Petitioner shall commence construction of the facility within 12 months of the date of this order and shall complete construction within a reasonable time thereafter in accordance with the plans and specifications submitted to this Board, the Vermont Agency of Environmental Conservation and the Vermont Water Resources Board.

2. The Petitioner shall comply with conditions 1 through 9 of the air quality permit issued on May 2, 1980 by the Vermont Agency of Environmental Conservation and shall at all times during the construction and operation of the facility maintain in effect such permit or any similar permit required by law. The Petitioner shall notify the Board promptly of any further application with respect to such permit and of any further agency action upon any such application or permit.

3. The Petitioner shall comply with the terms and conditions of the discharge permit issued on November 5, 1979 by the Vermont Water Resources Board and shall at all times during the construction and operation of the facility maintain in effect

such permit or any similar permit required by law. The Petitioner shall notify the Board promptly of any further application with respect to such permit and of any further agency action upon any such application or permit.

4. The Petitioner shall comply with the terms and conditions of the temporary pollution permit issued on November 14, 1980 by the Vermont Water Resources Board and shall at all times during the construction and operation of the facility maintain in effect such permit or any similar permit required by law. The petitioner shall notify the Board promptly of any further application with respect to such permit and of any further agency action upon any such application or permit.

5. The Petitioner shall comply with the terms and conditions of the disposal facility certification issued on November 3, 1980 by the Vermont Agency of Environmental Conservation and shall at all times during the construction and operation of the facility maintain in effect such permit or any similar permit required by law. The Petitioner shall notify the Board promptly of any further application with respect to such permit and of any further agency action upon any such application or permit.

6. Within one year after the commencement of commercial operation of the facility, the Petitioner shall present to the Board for its approval a detailed plan for the disposal of wood ash for use after the on-site disposal facility has been fully utilized.

7. Not less than 75% of all wood fuel to be consumed by the facility shall be delivered to the plant site by railway.

8. All agreements between the Petitioner and other parties for the delivery of wood fuel by truck shall be in writing and shall provide that no fuel trucks may enter or utilize the five-corners intersection, so called, in Essex Junction, Vermont between the hours of 7:00 A.M. and 8:30 A.M. nor between the hours of 4:00 P.M. and 5:30 P.M., Mondays through Fridays, inclusive, holidays excepted, and that no such trucks may enter or utilize streets or highways within the Cities of Burlington or Winooski on Sundays or before 6:30 A.M. or after 9:30 P.M. on any other day. Violation of any such provision shall expressly be made a cause for cancellation of such agreements, and in the case of any such violation, then, at the discretion of the Petitioner or upon order of this Board, such termination shall be effected. The Petitioner shall promptly notify the Board of any violation of such provisions of which it becomes aware. Copies of all agreements for delivery of wood fuel by truck shall be furnished to the Board promptly upon the execution thereof.

9. No fuel shall be off-loaded at the facility from any truck or railway car on Sundays or before 7:00 A.M. or after 9:00 P.M. on any other day.

10. All agreements between the Petitioner and other parties for the harvesting of woodchip fuel shall be in writing and shall provide that the harvester shall (a) advise the Vermont Department of Fish and Game in advance of the location of harvesting operations; (b) adhere to the recommendations of the Vermont Department of Fish and Game regarding cutting near deer yards, wetlands or the habitat of any endangered species; (c) comply with all applicable environmental protection standards

established under state or federal law; (d) limit clear cutting to 25 acres or less except in genuine cases of land use conversion, and in all such cases, the harvester shall advise the Petitioner sufficiently far in advance to permit the Petitioner to verify that the conversion is in fact genuine; and (e) comply with all terms and conditions of "Harvesting Policy for Whole Tree Chipping Operations in Vermont (Second Revised Draft)" as set forth in Petitioner's Exhibit No. 101. Violation of any such provision shall expressly be made a cause for cancellation of such agreements and, in the case of any such violation, then, at the discretion of the Petitioner or upon order of this Board, such termination shall be effected. The Petitioner shall promptly notify the Board of any violation of such provisions of which it becomes aware. Copies of all agreements for harvesting of woodchip fuel shall be furnished to the Board promptly upon the execution thereof. Not later than the first day upon which woodchip harvesting commences, the Petitioner shall have and maintain a staff of not less than 11 professional foresters to monitor the provisions of this paragraph.

11. Acoustic louvers shall be installed on all plant building openings. All outdoor pumps shall be enclosed to minimize site noise. Wood fuel at the site shall be handled by a front end loader or other equipment having a maximum noise rating of 77 dBA at a distance of 50 feet. The acoustic noise levels of major pieces of plant equipment shall be given significant weight in evaluating their acceptibility for use at the plant.

12. The Board recommends that, with the permission of the property owners, the Petitioner purchase and install air conditioners for those residences on Manhattan Drive and Intervale Road

which are likely to be substantially affected by site generated noise. The Board further recommends that, in the case of any severely affected properties, the Petitioner investigate the desirability of the negotiation of noise easements or the purchase of the properties.

13. Within twelve months from the date of this certificate, the Petitioner shall file a petition under 30 V.S.A. §248 for a certificate of public good for transmission facilities to transmit power from the proposed facility to the VELCO transmission grid.

14. The Board shall retain continuous jurisdiction over plant construction, operation, emissions, discharges, shut down, decommissioning, fuel harvesting, fuel procurement and fuel delivery and may require any and all such changes as it may in its discretion determine to be necessary to protect the public health, safety and welfare or the natural environment.

Dated at Montpelier, Vermont this 14th day of September, 1981.

Rosalyn L. Hunneman

PUBLIC SERVICE BOARD OF VERMONT

OFFICE OF THE CLERK

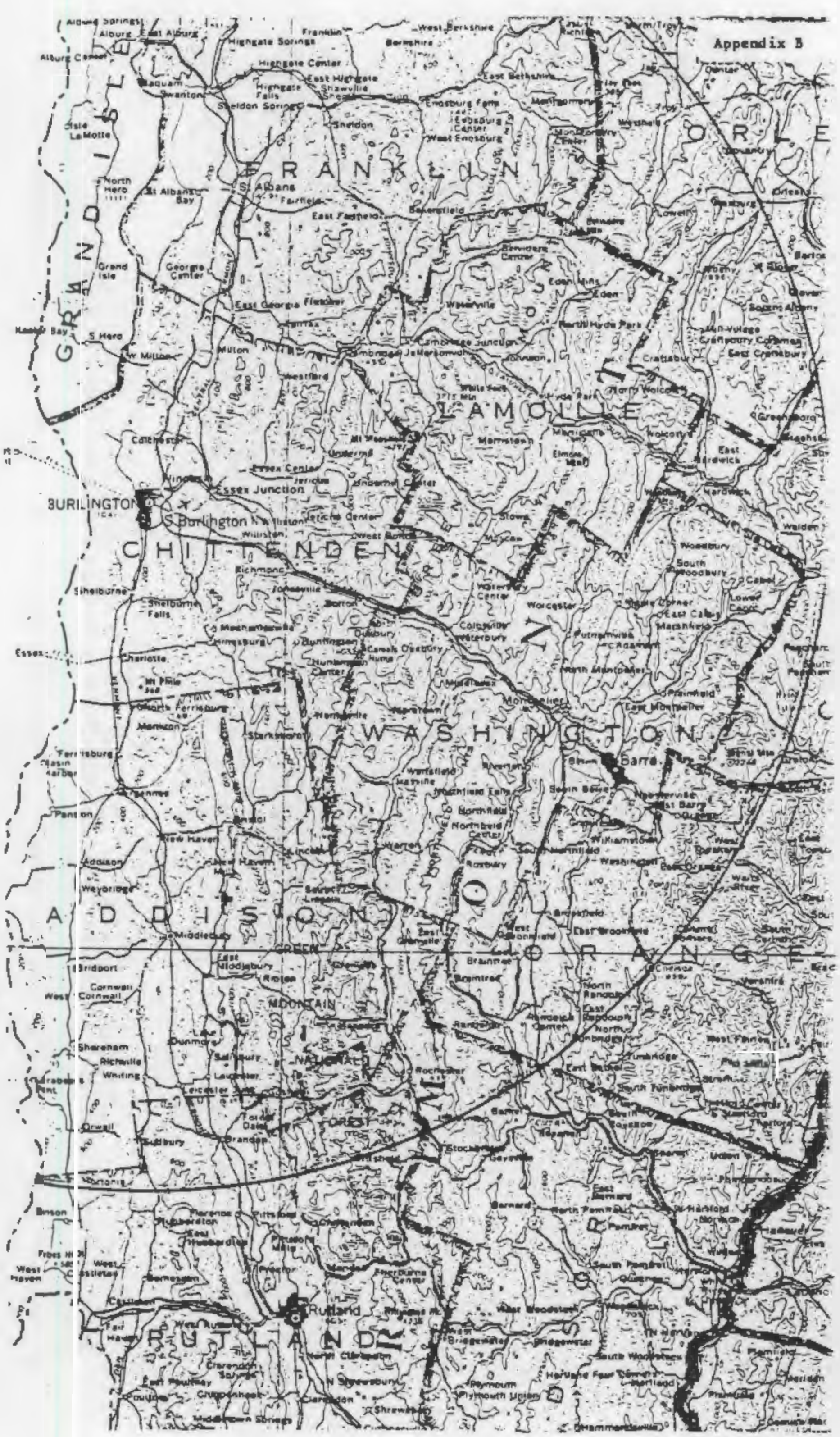
FILED: September 14, 1981

ATTEST: Susan M. Hudson
Clerk of the Board

APPENDIX B

Vermont Area Map

Appendix B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ORANGE
RUTLAND
BURLINGTON
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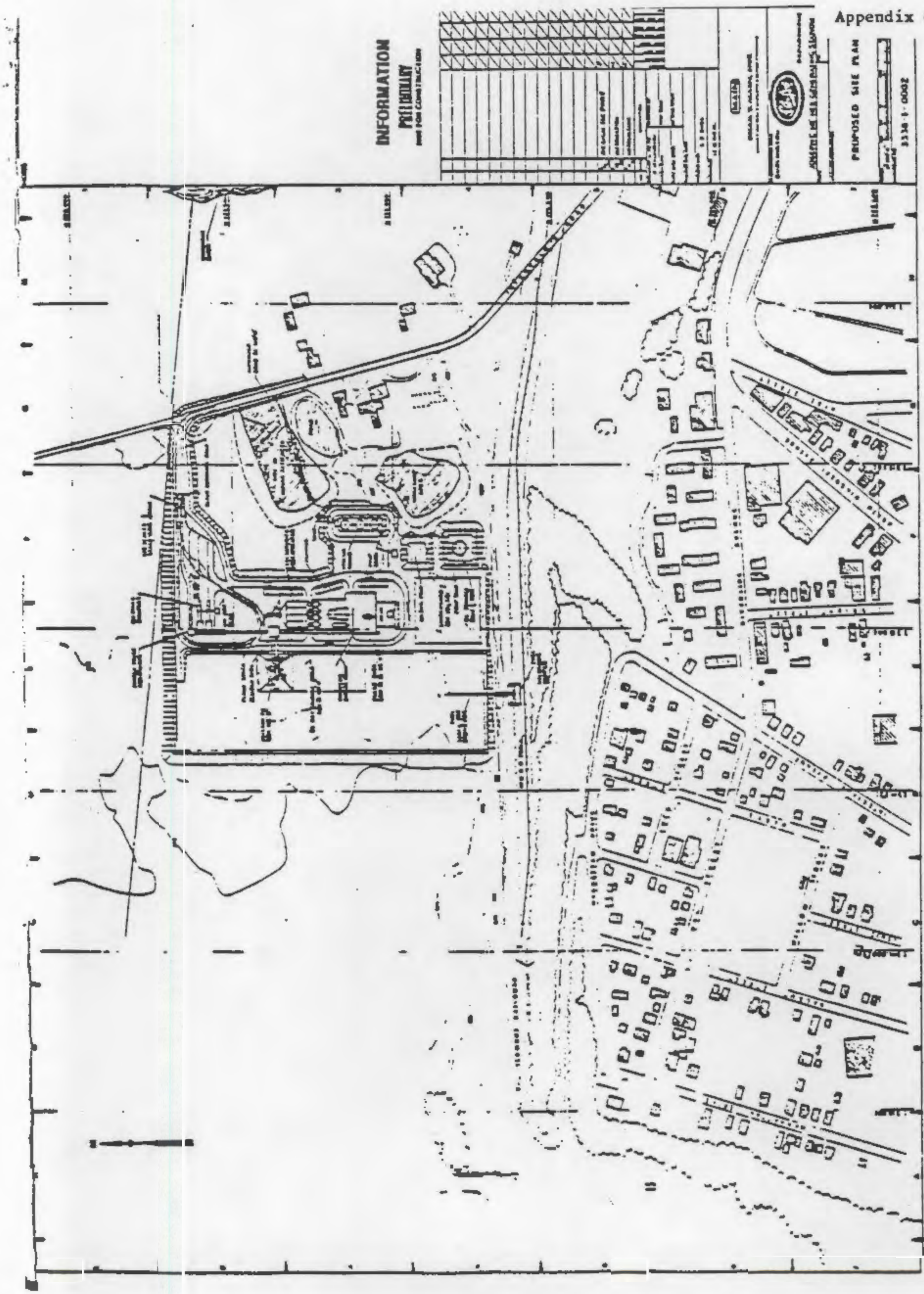
Essex Junction
St Albans
Swanton
Montpelier
Barre
Rutland
Middlebury
Stowe
Morrisville
Waterbury
Northfield
Brandon
Shelburne
Vergennes
Randolph

APPENDIX C

Burlington Electric Department Site Map

Appendix C



APPENDIX D

Burlington Electric Department Tree Farm Family Brochure

Who can join the Burlington Electric Department Tree Farm Family?

Forest landowners of 10 Vermont acres or more who want to improve their property by sound forest management practices.

What are "sound forest management practices?"

Each forest parcel has its own personality, problems, and potentials. The methods for keeping the forest healthy and vigorous can be as different as cutting trees down or planting them.

Why you should belong...
the Burlington Electric Department Tree Farm Family

Burlington Electric Department is the first utility in the United States to produce meaningful quantities of electricity using wood as a fuel. This is important to all Vermonters, and especially to Vermont forest landowners.

Energy Independence	Wood is Vermont's most abundant renewable, energy-producing resource that can be used now. Money spent on wood fuel stays in Vermont and creates jobs for Vermonters.
Timber Stand Improvement	Because Burlington Electric provides a market for whole-tree chips, timber stand improvement is possible for the first time at a profit to the landowner, rather than a cost.
Forest Management	With management, Vermont forests can produce more valuable timber, while improving the forest environment for wildlife and people.
Harvest Management	It is vital that harvest of forest products, including whole-tree chips, be managed so that forests are improved for productivity, quality, profit, and all other uses — wildlife habitat, aesthetics, recreation, water quality, hunting, fishing, or just walking around.

Improving Vermont's Forests for Vermonters

Burlington Electric Department
Tree Farm Family

APPENDIX E

USDA Forest Service Total Green Weight of Above Ground Tree Biomass on Commercial Forest Land in the New England States

Table 2.--Total green weight of aboveground tree biomass on commercial forest land in the North by class of timber, species group, section, and State
(Million green tons)

Section, region, and species group	Growing stock			Rough and rotten			Small trees	Total biomass
	Merchantable stem	Tops and branches	Total	Merchantable stem	Tops and branches	Total		
New England:								
Connecticut								
Softwoods	11.6	3.9	15.5	1.1	0.4	1.5	1.6	18.6
Hardwoods	51.6	13.2	64.8	4.9	1.3	6.2	10.9	81.9
Total	63.2	17.1	80.3	6.0	1.7	7.7	12.5	100.5
Maine								
Softwoods	437.3	175.6	612.9	74.7	26.2	100.9	134.1	847.9
Hardwoods	247.9	73.6	321.5	103.4	29.5	132.9	118.0	572.4
Total	685.2	249.2	934.4	178.1	55.7	233.8	252.1	1,420.3
Massachusetts								
Softwoods	43.7	15.2	58.9	4.6	1.6	6.2	5.3	70.4
Hardwoods	57.4	14.7	72.1	11.3	2.9	14.2	18.2	104.5
Total	101.1	29.9	131.0	15.9	4.5	20.4	23.5	174.9
New Hampshire								
Softwoods	95.2	34.6	129.8	11.5	4.0	15.5	22.2	167.5
Hardwoods	96.8	27.1	123.9	33.8	9.3	43.1	39.8	206.8
Total	192.0	61.7	253.7	45.3	13.3	58.6	62.0	374.3
Rhode Island								
Softwoods	2.5	0.9	3.4	1.4	0.6	2.0	0.6	6.0
Hardwoods	7.8	2.0	9.8	1.9	0.5	2.4	2.3	14.5
Total	10.3	2.9	13.2	3.3	1.1	4.4	2.9	20.5
Vermont								
Softwoods	59.5	19.9	79.4	12.9	4.8	17.7	14.1	111.2
Hardwoods	114.7	30.7	145.4	63.5	16.8	80.3	29.3	255.0
Total	174.2	50.6	224.8	76.4	21.6	98.0	43.4	366.2
Total, New England								
Softwoods	649.8	250.1	899.9	106.2	37.6	143.8	177.9	1,221.6
Hardwoods	576.2	161.3	737.5	218.8	60.3	279.1	218.5	1,235.1
Total	1,226.0	411.4	1,637.4	325.0	97.9	422.9	396.4	2,456.7

APPENDIX F

Vermont Forest Resource Cut Summary - 1980

Dept. of Forests, Parks & Recreation
Agency of Environmental Conservation
Montpelier, Vermont 05602

Compiled by: William G. Gove
Wood Utilization
Forester

VERMONT FOREST RESOURCE CUT SUMMARY - 1980

Figures in MBF - Does not include pulpwood or boltwood.

Sawlogs and Veneer Logs - Shows timber drainage by county where harvested.

	Addison	Bennington	Caledonia	Chittenden	Essex	Franklin	Lamoille	Orange	Orleans	Rutland	Washington	Windham	Windsor	Species Total MBF
No. of Mills	18	13	22	13	3	17	13	24	33	24	15	37	31	263
Ash	260	1,138	232	170	234	318	683	255	397	973	568	1,135	926	7,289
Poplar	126	217	621	128	62	129	279	120	243	359	449	174	284	3,191
Basswood	56	122	24	45	9	98	183	23	147	66	135	42	109	1,059
Beech	792	731	370	470	167	1,230	1,167	93	332	1,700	1,350	644	1,556	10,602
White Birch	214	1,331	194	150	646	93	519	473	208	828	518	573	956	6,703
Yellow Birch	954	1,546	645	270	2,377	396	836	247	938	758	1,222	1,122	1,555	12,866
Elm	87	85	67	63	20	57	124	6	76	120	88	20	61	874
Hard Maple	2,511	3,147	1,343	877	2,702	2,746	3,667	1,534	2,436	5,001	4,604	2,443	5,541	38,552
Soft Maple	312	966	627	221	465	737	999	20	490	597	551	1,028	922	7,935
~~Oak~~	571	2,091	70	235	76	223	301	264	57	1,247	417	2,313	1,621	9,486
Other Hdwds.	80	271	54	54	125	107	348	31	69	94	134	499	253	2,119
Total Hdwds.	5,963	11,645	4,247	2,683	6,883	6,134	9,106	3,066	5,393	11,743	10,036	9,993	13,784	100,676 MBF
Hemlock	1,047	368	1,119	1,179	64	4,967	1,740	1,503	1,793	967	1,844	4,931	4,964	26,486
White Pine	1,385	1,964	4,559	1,422	452	1,516	1,992	2,575	650	1,743	2,747	11,262	6,048	38,315
Red Pine	69	1	49	80	-	49	51	121	4	32	158	84	197	895
Spruce	500	420	6,530	207	4,391	3,070	3,174	1,662	3,981	891	2,096	1,449	2,396	30,677
Tamarack	-	-	207	-	4	15	65	11	57	14	15	-	7	395
Cedar	16	-	141	1	10	4	1	77	394	-	22	-	-	666
Total Sftwds.	3,017	2,753	12,605	2,889	4,921	9,621	7,023	5,949	6,879	3,647	6,792	17,726	13,612	97,434 MBF
County Totals	8,980	14,398	16,852	5,572	11,804	15,755	16,129	9,015	12,272	15,390	16,828	27,719	27,396	198,110 MBF

TOTAL CUT: VENEER LOGS = 16,037 MBF
SAWLOGS = 182,073 MBF

TOTAL = 198,110 MBF

F.1

Dept. of Forests, Parks & Recreation
Agency of Environmental Conservation
Montpelier, Vermont 05602

Compiled by: William G. Gove
Wood Utilization
Forester

VERMONT PULPWOOD AND BOLTWOOD CUT SUMMARY - 1980

Figures in cords - Shows drain by county where harvested.

	Addison	Bennington	Caledonia	Chittenden	Essex	Franklin	Lamoille	Orange	Orleans	Rutland	Washington	Windham	Windsor	Species Total
Ash	37	182	745	11	1,485	2	65	11	647	367	21	353	112	4,038
Poplar	109	440	2,416	122	7,263	54	67	232	2,228	615	126	204	335	14,211
Basswood	-	-	55	-	272	-	1	2	63	3	-	-	30	426
Beech	50	200	2,160	22	7,178	3	106	73	1,940	329	61	471	260	12,853
White Birch	70	270	1,387	23	3,591	4	122	40	1,115	454	38	647	836	8,597
Yellow Birch	74	310	3,658	37	13,469	4	170	93	3,545	523	61	707	324	22,975
Elm	-	-	216	-	797	-	3	13	188	-	14	-	-	1,231
Hard Maple	246	928	5,642	88	14,820	15	450	192	4,370	1,353	252	2,354	803	31,513
Soft Maple	100	392	2,878	38	8,610	6	191	98	2,477	634	98	942	379	16,843
Oak	25	85	174	7	371	1	41	4	114	106	14	236	75	1,253
Other Hdwds.	18	64	221	5	869	2	133	7	212	78	10	177	87	1,883
Total Hdwds.	729	2,871	19,552	353	58,725	91	1,349	765	16,899	4,462	695	6,091	3,241	115,823 Cords
Hemlock	244	231	2,510	317	2,638	53	625	231	2,489	1,675	1,295	289	103	12,700
White Pine	291	402	2,705	780	3,088	132	167	293	944	1,846	410	475	259	11,792
Red Pine	29	380	315	31	296	2	6	14	451	285	25	260	470	2,564
Spruce	505	2,327	27,724	1,371	28,809	552	1,143	1,405	16,829	1,905	2,148	1,322	2,771	88,811
Tamarack	-	-	5	-	-	-	-	-	10	-	-	-	-	15
Cedar	100	-	2,513	-	143	25	10	32	5,258	29	25	-	19	7,154
Total Sftwds.	1,169	3,340	35,772	2,499	34,974	764	1,951	1,975	25,981	5,740	3,903	2,346	3,622	124,036 Cords
County Totals	1,898	6,211	55,324	2,852	93,699	855	3,300	2,740	42,880	10,202	4,598	8,437	6,863	239,859 Cords

TOTAL CUT:	PULPWOOD	=	229,041 Cords
	PARTICLEBOARD WOOD	=	196 Cords
	BOLTWOOD	=	10,622 Cords
	TOTAL	=	239,859 Cords

APPENDIX G

Vermont Forest Resource Cut - 1945-1980

Compiled by: William G. Gove, Wood Utilization Forester
Vermont Department of Forests, Parks & Recreation

VERMONT FOREST RESOURCE CUT - PULPWOOD & BOLTWOOD

VOLUMES IN THOUSANDS OF CORDS

YEAR	POPLAR	OAK	OTHER HARDWOODS	TOTAL HARDWOODS	SPRUCE & FIR	HEMLOCK & TAMARACK	PINE	TOTAL SOFTWOODS	YEARLY SUMMARY: TOTAL CORDWOOD	YEARLY SUMMARY: PULPWOOD ONLY	WHOLE TREE CHIPS	SAWMILL RESIDUE CHIPS
1945									157.2			
1946									165.4			
1947									197.2			
1948	5.3	.3	31.3	36.9	152.7	7.4	1.3	161.4	198.3			
1949	5.9	.2	16.4	22.5	120.5	2.9	2.2	125.6	148.1			
1950	7.2	.3	20.7	28.2	118.6	2.0	.6	121.2	149.4			
1951	8.8	.2	42.4	51.4	145.3	5.3	7.9	158.5	209.9			
1952	8.2	.4	36.3	44.9	156.6	7.7	5.2	169.5	214.4			
1953	7.2	.8	34.5	42.5	132.0	6.7	4.4	143.1	185.6	160.3		
1954	6.9	.1	29.5	36.5	117.0	4.6	3.0	124.6	161.1	157.8		
1955	9.1	2.2	46.2	57.5	120.3	3.9	4.8	129.0	186.5	182.6		
1956	8.2	2.8	48.9	59.9	125.8	2.4	4.0	132.2	192.1	186.5		
1957	8.1	1.2	47.5	56.8	141.4	4.1	4.7	150.2	207.0	200.3		
1958	7.0	.2	45.2	52.4	107.1	2.6	2.7	112.4	164.8	156.2		
1959	9.0	.5	48.0	57.5	114.9	2.4	3.2	120.5	178.0	174.7		
1960	8.8	1.9	50.4	61.1	138.9	3.5	5.0	147.4	208.5	196.8		
1961	6.7	1.7	49.8	58.2	116.0	2.3	4.0	122.3	180.5	174.0		
1962	5.1	1.5	52.9	59.5	115.0	3.0	4.0	122.0	182.3	176.3		21.6
1963	6.4	2.2	43.0	51.6	105.5	3.2	2.4	111.1	162.7	155.6		23.1
1964	7.7	2.0	31.8	41.5	112.3	4.1	2.9	119.2	160.7	149.0		27.1
1965	4.4	1.3	24.3	30.0	86.4	3.8	2.8	93.0	123.0	118.8		26.7
1966	3.0	1.5	27.1	31.5	86.9	2.6	3.3	92.8	123.8	120.0		31.7
1967	3.6	1.9	34.4	39.9	85.1	2.8	3.7	91.6	130.9	126.2		36.5
1968	3.9	.7	36.6	41.2	76.6	2.2	3.4	82.2	123.4	120.0		40.8
1969	2.1	.8	45.6	48.5	60.7	2.1	3.7	66.5	115.0	111.0		40.6
1970	.9	1.1	48.9	50.9	68.6	3.0	4.2	75.8	126.7	124.9		30.4
1971	2.2	1.1	57.6	60.9	53.3	2.5	6.5	62.3	123.2	121.5		26.4
1972	2.7	1.4	75.5	79.6	51.0	3.3	7.2	61.5	141.1	137.8		43.7
1973	7.6	1.2	70.1	78.9	54.7	3.2	5.3	63.2	142.1	140.8		54.4
1974	8.4	1.2	85.3	94.9	92.6	3.1	8.9	104.6	199.5	197.8	11.8	68.8
1975	8.0	1.0	70.9	79.9	56.2	3.1	8.9	68.2	148.1	146.8	27.3	57.4
1976	9.1	1.7	53.5	64.3	74.3	3.0	7.1	84.4	148.7	146.0	30.8	70.3
1977	9.1	1.8	83.2	94.1	73.9	7.5	9.1	93.8	187.9	182.2	24.6	112.3
1978	9.2	1.3	80.6	91.1	94.7	5.1	8.0	107.8	198.9	197.2	17.6	120.5
1979	13.0	1.9	100.2	115.1	96.2	8.0	13.2	117.4	234.5	230.5	56.1	110.9
1980	14.2	1.3	100.3	115.8	88.8	12.7	14.4	124.0	239.9	229.0	87.7	110.9

Compiled by: William G. Gove, Wood Utilization Forester
Vermont Department of Forests, Parks & Recreation

VERMONT FOREST RESOURCE CUT - SAWLOGS

VOLUMES IN MILLION BOARD FEET

YEARLY SUMMARY

YEAR	ASH	POPLAR	BASS-WOOD	BEECH	WHITE BIRCH	YELLOW BIRCH	ELM	HARD MAPLE	SOFT MAPLE	OAK	OTHER HDWD	TOTAL HDWD	HEMLOCK	WHITE PINE	RED PINE	SPRUCE & FIR	CEDAR	TAMA-RACK	TOTAL SFTWD	TOTAL
1945																				215.4
1946																				252.3
1947	5.2	1.8	3.1	15.0	36.4		.7	50.1		3.7	.4	116.4	41.2	59.8		51.5	.1	.0	152.6	269.0
1948	5.2	1.0	2.7	16.2	34.6		.5	43.9		3.4	.5	108.0	40.2	57.6		55.6	.7	.3	154.4	262.4
1949	5.3	.6	2.7	10.3	25.7		.4	41.3		4.4	.3	91.0	36.0	47.2		51.4	.5	.2	135.3	226.3
1950	5.6	.7	3.2	13.2	28.1		.8	40.7		3.5	.7	96.5	37.3	51.5		54.7	1.0	.8	145.3	241.8
1951	6.2	1.2	3.1	14.7	29.2		.7	51.4		4.0	.9	111.4	35.5	62.2		63.4	.8	.1	162.0	273.4
1952	6.6	1.1	2.5	13.4	31.0		.5	45.7		5.5	1.3	107.6	41.7	54.8		62.0	.9	.8	160.2	267.8
1953	5.1	.9	3.1	12.3	42.0		1.0	49.5		4.2	.9	119.0	39.5	50.5		61.2	1.3	.8	153.3	272.3
1954	4.0	.9	2.8	9.0	23.8		.7	43.6		5.5	1.2	91.5	33.0	41.7		55.3	2.5	.6	133.1	224.6
1955	4.4	.9	2.6	11.0	27.1		1.1	51.8		6.3	1.4	106.6	41.4	43.1		51.4	2.4	1.2	139.7	246.3
1956	5.6	.9	3.0	13.1	28.1		1.7	55.8		8.3	1.4	117.9	33.3	37.3		57.0	3.4	.9	131.9	249.8
1957	3.3	1.1	2.7	13.6	28.1		.8	52.6		6.0	1.7	113.3	36.6	37.3		42.9	4.7	1.8	123.3	236.6
1958	3.1	.7	2.7	10.8	22.1		.7	44.0		6.4	1.3	91.8	28.6	30.0		38.9	4.3	.3	102.1	193.9
1959	6.0	.8	2.6	13.9	27.1		1.1	48.9		6.5	1.2	108.1	27.6	29.6		39.5	5.4	1.1	103.2	211.3
1960	5.3	.8	2.5	12.7	30.3		1.0	47.3		7.2	1.3	108.9	25.9	29.8		37.5	4.9	.3	98.4	207.3
1961	4.3	.5	1.7	11.9	26.7		1.1	44.8		5.0	1.1	97.1	18.8	23.1		30.3	4.5	.2	76.9	174.0
1962	4.8	.6	2.6	12.7	30.0		1.3	43.5		5.5	1.3	102.3	15.9	21.4		26.1	4.8	.3	68.5	170.8
1963	5.2	.7	1.6	12.7	26.5		1.5	42.6		5.1	1.6	97.5	13.3	24.6		22.4	6.8	.4	67.5	165.0
1964	6.3	.6	1.9	14.7	32.8		2.4	45.5		5.0	2.2	111.4	14.7	21.4		17.1	6.9	.1	60.2	171.6
1965	7.2	.7	1.7	15.1	29.8		2.3	42.5		4.8	2.8	106.9	8.1	18.6		17.5	6.8	.9	51.9	158.8
1966	7.1	1.1	1.6	13.7	35.5		1.6	47.6		5.5	2.8	116.5	10.7	21.1		19.3	9.8	.3	61.2	177.7
1967	6.3	1.2	1.9	11.6	7.5	22.8	1.4	42.0	5.3	5.2	1.3	107.3	10.3	20.8	.6	18.0	5.7	.1	55.5	162.8
1968	6.1	1.0	1.4	11.9	7.6	19.7	1.3	40.0	5.3	3.2	1.4	98.9	11.1	19.0	.9	19.0	5.2	.1	56.4	155.3
1969	5.8	1.1	1.1	10.1	6.1	24.3	1.1	47.4	6.1	3.6	.7	107.4	11.3	25.1	.6	17.1	4.6	.1	58.8	166.2
1970	5.2	.8	.9	10.8	5.5	15.4	1.2	37.6	5.2	2.9	.9	86.4	10.2	22.5	1.5	19.8	7.0	.1	61.1	147.5
1971	6.1	.8	.9	9.5	6.5	11.3	.7	34.0	4.1	2.9	.8	75.5	10.5	21.5	1.0	15.7	4.2	.1	52.0	127.5
1972	5.9	.7	.8	11.2	5.4	13.4	1.2	37.6	5.7	3.7	1.2	86.8	10.3	29.6	1.4	17.2	7.3	.1	65.9	152.7
1973	6.4	1.5	1.0	14.2	6.1	16.5	1.2	38.1	7.6	4.4	1.1	98.1	16.4	46.5	1.6	21.0	4.0	.1	89.5	187.6
1974	8.2	2.2	1.2	13.1	8.4	14.7	1.4	40.1	8.7	6.6	2.5	107.1	17.8	45.9	1.9	17.0	5.1	.2	88.6	195.7
1975	7.1	.9	.8	9.8	6.7	11.1	.8	33.1	5.7	5.5	3.5	85.0	16.5	40.6	1.3	18.0	3.1	.5	80.0	165.0
1976	6.8	2.0	1.2	11.3	9.4	13.3	.8	34.1	6.6	9.7	3.3	98.5	19.8	52.5	1.2	20.4	3.6	.5	98.0	196.5
1977	10.5	2.4	1.3	11.4	11.1	11.4	1.1	38.4	7.3	8.3	1.3	104.4	20.7	52.9	.9	20.4	2.8	.2	98.0	202.4
1978	9.7	3.2	1.5	12.1	7.6	12.8	1.1	39.2	8.1	8.6	1.9	105.9	22.6	55.9	1.3	26.8	5.1	.5	112.2	218.1
1979	10.4	2.4	1.2	11.0	8.0	12.9	1.1	38.7	9.0	8.9	4.7	108.4	26.0	56.6	1.6	31.9	5.1	.4	121.6	230.0
1980	7.3	3.2	1.1	10.6	6.7	12.9	0.9	38.6	7.9	9.5	2.1	100.7	26.5	30.3	0.9	30.7	8.6	.4	97.4	198.1

G.2

"ASSESSMENT OF POTENTIAL WOOD SUPPLY FOR INTERMEDIATE SCALE THERMOCONVERSION FACILITIES"

TASK II

"ASSESSMENT OF POTENTIAL WOOD SUPPLY FOR INTERMEDIATE SCALE THERMOCONVERSION FACILITIES IN THE NORTHEAST"

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1.0 Summary

When viewed in totality, the states in the northeast region contain an impressive amount of commercial forestland, estimated at some 63 million acres, approximately 13 percent of the national total. On the forestland, surveys indicate there is an estimated 76 billion cubic feet of growing stock.

The current resource provides supplies of timber products for a variety of forest industries and supports a well established and experienced timber supply infrastructure.

In addition to the large quantities of commercial timber, a large portion of which is not being utilized, the forestland contains some 9 billion cubic feet of low quality, low value biomass categorized as rough and rotten. This category of material is ideally suited for fuel purposes since it has little market demand and its removal would greatly benefit the growing environment for more desirable timber. Thus, there is an incentive to harvest such material.

Using recent USDA Forest Service estimates of above ground tree biomass on the commercial forestland of the region, the above data converts to some 5 billion green tons, ranging from 1.4 billion tons in Pennsylvania to 20.5 million tons in Rhode Island. Of the regional total, 16 percent or approximately 803 million green tons is in the rough and rotten category.

However, despite the physical presence of large quantities of wood biomass, quantities over and above that needed to meet current and expanded demands of forest industries, several factors have been identified that will reduce, to some extent, the availability of the resource for use as an industrial fuel.

These factors, while found in each state in the region, have varying degrees of importance with respect to the potential effect on resource supply and for the most part will have varying degrees of importance within a state.

In only one state, Rhode Island, will the size of the resource base, in this case less than one-half million acres, have a significant effect in limiting the capability of the resource to support significant use of biomass as an industrial fuel for intermediate size facilities. In other states where the resource is not distributed uniformly, the size of the resource base within a local supply area will impose limitations given that the transport economics of low value wood limit the effective transport distance.

Another major factor in the northeast, varying in importance among the states but showing significance in all urban areas, is the fracturing of the commercial forestland into small parcels many of which will be uneconomical to harvest with current systems. Although the sheer number of private landowners, almost one and one-half million, who own 90 percent of the resource, could eventually present organizational problems if large quantities of biomass are needed, various attitude surveys indicate that a vast majority of the owners are not opposed to harvesting.

In view of the fact that transport economics have been identified as a significant factor in limiting the supply area of a facility, this factor was found to be potentially important only in localized regions of some states.

Of all the factors affecting supply, the factor of terrain emerges as the one having the potential to limit potential supply in many localized areas of those states with significant resources. Although very little effective research has been undertaken in this subject area, a review of what has been done indicates that terrain conditions can limit the application of whole tree chipping systems in several ways.

- In an absolute sense, at some point, steep terrain will prohibit the use of totally mechanized systems.
- Weather conditions can limit the use of transport vehicles.
- Terrain conditions can limit the use of transport vehicles.

Although chipping technology is being utilized to a minor degree in various areas of the region sufficient experience and investigation is lacking at this time to reasonably assess how much of a limitation this factor will place on supply availability.

Generally, throughout the region, none of the factors discussed in this report preclude the initial establishment of an intermediate scale wood fueled industrial facility. However, as additional decisions are made and implemented to utilize wood as an industrial fuel, then one or more factors will operate to constrain supplies.

2.0 Purpose of Study

The purpose of this study is to assess the potential for siting intermediate size facilities (500-2000 green tons per day) based upon potential resource availability. The study draws upon data evaluated in Task I, which examined various factors effecting the supply of biomass for the existing Burlington Electric Department's municipal generation plant which utilizes approximately 100,000 green tons of wood chips annually in two 10 MW units and the expected supply system for a new 50 MW generation facility, now under construction, and which is expected to require approximately 500,000 green tons of wood chips annually.

The assessment does not attempt to quantify the amount of biomass potentially available for wood energy purposes except that in each state assessment the size of the resource base is analyzed as is the latest data on the demand for industrial and non-industrial products from the resource. This initial analysis, assuming that industrial wood energy will not compete with existing uses, serves as a base from which to evaluate other factors that will effect availability. Thus, in the case of Rhode Island, the fact that the resource base is limited to some 395 thousand acres of commercial forestland clearly indicates that without quantification it is evident that the supplies of wood energy for intermediate size facilities will be limited.

The study is not site specific but does attempt to describe and evaluate those significant factors that emerged from the Task I study that will effect the availability of the resource for energy purposes.

The study is not concerned with the technology for combustion. Information on combustion technology is readily available from numerous sources.

The investigation focuses on the resource base within each state in the region, the extent of the resource and those major factors that appear, at this time, to have significance with respect to supply.

2.1 Scope and Methodology

The study encompassed those states generally described as comprising the northeast region, consisting of the six New England States: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont, plus the States of New Jersey, New York, and Pennsylvania.

In each state, the basic timber resources were analyzed utilizing the most recent USDA Forest Service data available and incorporating, where available, supplemental information provided by state forestry officials and other appropriate sources. To the extent that information was available, the forest industry was analyzed both in terms of the type of industry and the distribution.

Most, but not all of the states, have had studies conducted on the attitudes and patterns of commercial forestland ownership and this information has been analyzed with respect to the potential effect on wood energy supply.

Many of the individual state resource surveys are somewhat dated and are currently undergoing a resurvey. In light of the significant increase in residential fuelwood use, recent information was analyzed and used in the evaluation of the resource base rather than utilizing the earlier survey data which generally indicates small quantities of fuelwood use.

In general terms, both transportation networks and terrain conditions were examined, and where conditions indicated a potential adverse effect on supply the situation was noted.

Finally, the state forestry officials were visited in each state to obtain their observations and appropriate data on factors effecting the use of wood for industrial energy purposes.

3.0 Background

The sudden and somewhat dramatic change in the price and supply situation of oil and natural gas, in the post-embargo period, brought to an end an era of almost casual disregard about energy. The most immediate response by industry and other users was conservation to reduce consumption of increasingly expensive fossil fuels. Along with conservation actions, there was generated a widespread interest in alternative energy sources. In forested regions, especially the northeast with a heavy dependence on petroleum fuels, the residential sector registered an explosive growth in the use of wood for home heating. In the industrial sector, as one would expect, the forest products industries, especially the pulp and paper segment, greatly expanded use of plant residues as an inexpensive energy source.

Industrial interest in the non-forest industry sector has grown slowly. Lack of knowledge about the combustion technology and the inability to perceive or identify a reliable supply structure served to inhibit significant interest in wood as an alternative energy source. There have been notable exceptions and one project that has received considerable attention is the current construction by the Burlington Electric Department, Burlington, Vermont, of a 50 megawatt electric generation facility to be fueled with wood chips.

In 1977, the utility, a municipal facility, made a decision to convert one of the existing 10 MW coal-fired units to burn wood chips. The conversion was highly successful and commercial operation began in late 1977. In July 1979, a second 10 MW unit was converted to wood chip fuels as part of a program to establish a reliable fuel supply infrastructure that would be the basis of greatly expanded system for the proposed new 50 MW facility.

For the purposes of this report, Task I investigated, in detail, the existing wood supply system for the present facility and the projected system for the new facility. The Task I study furnished criteria to be used in assessing biomass availability in the region for industrial energy use. It is important to note that apart from the fact that the new Burlington facility will be the largest wood-fired utility yet constructed, the main focus of Task I was the decision by Burlington to obtain the fuel supply primarily from whole tree chipping operations and not mill residues. The vast majority of projects involving industrial use of wood energy have utilized mill wastes. This is understandable in economic terms since mill residues still represent a waste product that must be disposed of. While it is true that chipped mill residues are being increasingly used by the pulp and paper and particle board industries, there can be significant quantities of unutilized and, therefore, inexpensive supplies of mill wood wastes at times. However, if past trends continue, most analysts predict that mill residues will continue to be utilized in increasing amounts for pulp and other product feedstocks and as such will command a higher value than for the energy purposes. Thus, if industrial use of wood for energy continues to increase, potential users should generally discount mill residues as a significant fuel source and look to whole tree chips.

4.0 Factors Affecting Supply

There are many factors that will affect, on a regional basis, the potential available supply of wood for industrial energy use. Some factors may be short-term such as the current lack of appropriate harvesting equipment for small woodlot units. Other factors such as urbanization may, in the long term, significantly reduce the size of the resource base both quantitatively and economically. Factors may be minor when viewed at a state or regional perspective but significant at a local level.

At the present time, whole tree chipping technology is not widely utilized in the northeast nor is the industrial use of wood energy by non-forest industries. The major use of industrial wood energy is still to be found in the forest products industry but the fuel supply is primarily mill residues.

If interest in wood energy use continues on the part of industries and institutions,[1] then at some point mill residues will cease to be a reliable source of supply since these residues are increasingly being utilized both for energy and other, often higher valued, products. Potential large industrial users[2] must expect that increasingly, wood energy supplies will come from forest biomass.

The factors affecting supplies from mill residues are vastly different from those affecting forest biomass. Mill residues are basically a function of the market demand for the primary products produced by the mill, thus, residues are by-products and, in the absence of a market or use, are waste products that must be disposed of. Technological improvements to mill equipment in order to increase yields of primary products have served to reduce residues and further improvements can be expected.

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[1]Vermont State Hospital, Waterbury, Vermont; State Building, Montpelier, Vermont, are current examples of institutional use.

[2]Defined in this report as 500+ green tons/day.

Where appropriate, mill residues are discussed in this report; however, little attempt has been made to quantify potential supplies. In some states, available data on mill residues are obsolete due to the infrequency of surveys. Quantities are transitory because production of primary products can fluctuate widely in response to market conditions. Supplies must eventually be evaluated at a local level due to the fact that the primary industries may be concentrated in a particular region, a situation found in some states, or a significant market exists locally that has or is absorbing much of the residue. In addition, some residues may not be in a usable form for industrial use. Not all primary industries are equipped to produce chipped material. This situation is prevalent among smaller primary industries where the annual production capacity does not warrant the investment in chipping equipment.

In turning to forest biomass as a fuel supply, other factors come into play. However, forest biomass must, to a degree, be classified since various factors will affect categories of forest biomass differently. For example, with respect to logging wastes, the supply is a function of market demand by primary industries for roundwood. Without forest industries, there are no logging wastes. Depressed market conditions for forest products results in diminished industry activity and generally means less logging residues. The term "generally" is used since in certain local conditions a depressed market situation can actually result in an increase in logging wastes if primary industries raise roundwood specifications and become more selective in the material they purchase. Thus, lower grade material, ordinarily considered merchantable, will not be removed in the harvesting operation and becomes logging waste.

Other forest biomass comprise such categories as dead and dying trees, surplus growth, and rough and rotten timber. The general category is that material not normally or currently being utilized by forest products industries. While quantity wise, there is a large amount of this material, the potential availability will be influenced by various factors. The most significant component of the various forest categories is surplus growth. It comprises by far the largest volume of any category and is the component most widely and uniformly distributed. It is the primary focus of analysis with respect to discussions on the resource base. While it is certainly true that for industrial wood energy purposes such material as rough and rotten, dead and dying trees can and will be utilized, such material is generally found as scattered components of a normal forest stand and in the practical world of harvesting it will be uneconomical to attempt to concentrate on such material as a supply source except in local situations where due to a severe outbreak of insects or disease or past management practices concentrations of the material will be found.

From Task I, a number of significant factors have been identified and these are discussed in the state-by-state analysis. Categorically these factors are:

- Amount of Commercial Forestland
- Trends in Growing Stock Volume
- Distribution of Volume
- Land Ownership - Public, Private
- Number of Owners and Patterns of Ownership
- Timber Utilization and Growth
    - Number of Primary Industries and Type
    - Distribution of Industries
    - Loggers
    - Roundwood Harvest Data - Industrial Products
    - Fuelwood Utilization
    - Growth Data
- Use of Whole Tree Chipping Technology
- Transportation Networks

- General Terrain Conditions
- Special Factors

4.1 Resource Base

The forest resources of a region, and for the purposes of this report a region is primarily defined as a state, are the ultimate limiting factor with respect to supply. The resource base can be described in terms of the amount of commercial forestland available but this quantification by itself is not adequate since it is the biomass produced on that land that is utilized. But the quantity of commercial forestland available is valuable in an initial assessment of potential supply. Table 1 indicates the amount of commercial forestland in each of the northeastern states, and it is obvious that there is significant variation among the states. While the amount of land in and by itself is not the sole consideration, it is logical to assume that a potential large-scale user, with some degree of flexibility with respect to location, would view the potential in Rhode Island with less optimism than that of most of the other states. For example, in the initial feasibility report for the Burlington Electric Department facility, it was estimated that the annual requirement of 500,000 green tons of wood fuel would involve a land base commitment of approximately 125,000 acres. In Rhode Island, this amounts to almost one-third of the total commercial forestland. In New York State, it means approximately 1 percent.

The amount of commercial forestland within a region, is an important criteria when viewed in a long-term context. This is a critical factor from an industrial users standpoint given the expected longevity of the investment. It is not sufficient to take at face value the present size of the resource base especially in the populated northeastern area. It is necessary to look at what has been happening over time to the amount of

Table 1

Northeast Region 1977 Commercial Forestland
(Thousand Acres)

State	Total	Federal	%	State/ Local	%	Forest Industry	%	Other Private	%
Connecticut	1,805.6	2.4	--	144.2	8	0.0	0	1,659.0	92
Maine	16,894.0	73.3	--	238.2	3	8,255.0	48	8,327.8	49
Massachusetts	2,797.7	9.6	--	355.8	13	30.1	1	2,402.2	86
New Hampshire	4,692.0	471.6	10	108.1	2	946.9	20	3,165.4	67
Rhode Island	395.3	0.0	0	32.1	8	0.0	0	363.2	92
Vermont	4,429.9	212.8	5	209.2	5	666.3	15	3,341.6	75
New Jersey	1,856.8	27.7	1	291.2	16	16.3	1	1,521.6	82
New York(1)	15,405.8	--	--	979.0	6	1,034.7	8	13,392.1	85
Pennsylvania	17,478.0	515.0	3	2,888.0	19	610.0	6	13,465.0	72
Totals:	65,755.1	1,312.4	2	5,245.8	9	11,559.3	19	47,637.9	70

(1) Corrected to 1980 survey.

Source: Forest Statistics of the U.S. 1977. USDA Forest Service - Review Draft.

commercial forestland. A decreasing trend is of more importance in those states with a limited base. However, in those states with an apparent significant base, a local trend assumes importance given that the economies of low value wood energy limit transportation distances.

The other measurement of the resource base is the amount of biomass on the commercial forestland. Traditionally, the measurement of wood biomass has been restricted to a portion of the biomass, not total biomass. For example, the data for a typical state report of the forest resources includes the net volume of components of the survey. These include: Growing Stock, Rough and Rotten. However, the net volume expressed in cubic feet excludes trees less than 5-inches dbh[a] and only includes those species regarded as commercial. In addition, the net volume includes only live growing stock trees and the measurement is to a minimum 4.0-inch top diameter outside the bark of the central stem or to the point where the central stem breaks into limbs; thus, as much as one-third of the total volume may not be reported.

Unfortunately, this historical approach, which has been geared more towards forest management needs and the specific informational needs of the forest products industry creates problems for the non-forest industrialist investigating the potential use of wood for energy purposes since the basic interest, insofar as energy is concerned, is adequate quantities of fuel. As an industrial fuel, the basic unit of measurement is tons and this unit has not normally been utilized in resource surveys. Only recently has data based on resource surveys begun to appear in tonnage units.[1,2] The tonnage data currently available is considered preliminary and, while useful in initial planning activities, does not preclude the

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(a) dbh = Diameter, Breast Height (4-1/2 feet above the ground).

necessity for a more thorough examination of the resource characteristics within a proposed supply area. Table 2 indicates the large variation that can occur among the components of the resource when compared at state levels. For example, the per acre green weight of tree biomass for the Rough and Rotten timber class in Vermont is almost twice that of New Hampshire and three times that of Massachusetts.

However, the traditional data format is adequate for evaluating the significance of the resource base, long-term trends, growth in comparison with removals, and the components of removals. Traditional unit measurements (cubic feet) enable the researcher to determine the extent that the resource is being utilized. Underutilization results in surplus material and a reasonable commodity value. Overutilization means not only increased competition and higher prices but also eventual depletion of the resource.

Since for energy purposes, wood is wood, analysis of the resource data in this report ignores the mass of information that describes in detail such characteristics as species, timber types, and quality.

4.2 Land Ownership

The factor of land ownership, insofar as the northeast is concerned, has several facets. On one hand, the lack of significant Federal ownership throughout the region eliminates the problem of uncertainties about long range public policy, an issue of intense concern in many areas of the west where Federal land ownership predominates. On the other hand, the fact that private ownership is dispersed among numerous individual results in a different set of concerns.

Table 2

Per Acre Green Weight of Aboveground Tree Biomass on Commercial Forestland by Class of Timber, Species Group and State (Green Tons)[3]

State and Species Group	Growing Stock	Rough and Rotten	Small Trees	Total
Connecticut				
Softwoods	8.6	0.8	0.9	10.3
Hardwoods	35.9	3.4	6.0	45.3
Total:	44.5	4.2	6.9	55.6
Maine				
Softwoods	36.3	6.0	7.9	50.2
Hardwoods	19.0	7.9	7.0	33.9
Total:	55.3	13.9	14.9	84.1
Massachusetts				
Softwoods	21.1	2.2	1.9	25.2
Hardwoods	25.8	5.1	6.5	37.4
Total:	46.9	7.3	8.4	62.6
New Hampshire				
Softwoods	27.7	3.3	4.7	35.7
Hardwoods	26.4	9.2	8.5	44.1
Total:	54.1	12.5	13.2	79.8
New Jersey				
Softwoods	7.6	0.9	2.2	10.7
Hardwoods	41.9	5.3	10.8	58.0
Total:	49.5	6.2	13.0	68.7
New York				
Softwoods	9.5	2.8	1.9	14.2
Hardwoods	29.0	14.5	11.3	54.8
Total:	38.5	17.3	13.2	69.0
Pennsylvania				
Softwoods	5.5	0.5	0.9	6.9
Hardwoods	68.7	6.9	11.5	87.1
Total:	74.2	7.4	12.4	94.0
Rhode Island				
Softwoods	8.6	5.1	1.5	15.2
Hardwoods	24.8	6.1	5.8	36.7
Total:	33.4	11.2	7.3	51.9
Vermont				
Softwoods	17.9	4.0	3.2	25.1
Hardwoods	32.8	18.1	6.6	57.5
Total:	50.7	22.1	9.8	82.6

4.2.1 Private Non-Industry Landowners

The dominance of private non-industrial forestland ownership in the northeast has already been documented (Table 1). In many of the states, the USDA Forest Service, in conjunction with the periodic state resource surveys, has undertaken surveys of the forestland owners to determine trends in forestland ownership and the attitudes and intentions of owners regarding timber harvesting, management, and reasons for owning forestland. From these various surveys, certain general findings emerge:

- The majority of private forestland owners indicate they are not opposed to harvesting.
- The majority of landowners do not own forestland for timber production purposes.

The first finding, with respect to harvesting attitudes, is encouraging, not only to the area of wood energy supply but to the forest industry as a whole. There has been a long-standing belief that growing numbers of landowners were hostile to harvesting operations and the consistency in the reports, which indicate this is a minor item among landowners, should remove this as an item of significant concern when evaluating potential supply.

However, the second finding which indicates that large numbers of landowners attach values other than timber production to their lands indicates a need to be aware of such values and take such action as is necessary to maintain such values. While some may argue that the industrial wood fuel user, as a fuel purchaser, is somewhat removed from harvesting operations and, therefore, divorced from landowner attitudes, the adoption of a passive role by users may well be shortsighted. Given that wood energy supply economics dictate that the supply area will be localized, it is conceivable that a few poorly managed whole tree chipping operations could become a media event and significantly change landowner attitudes. Carried to the extreme, the eventual result could be public pressure to regulate harvesting operations. To a degree, public regulation was imposed in the issuance of the Certificate of Public Good for the construction of the Burlington facility (Task I, Section 2.1).

At the present time, in the northeast region, there are few state-level regulations that impose significant restrictions on how a private landowner may harvest the resource.

One factor of private ownership that appears to be highly significant, primarily in the more urbanized states of the region, is the problem of many small ownerships that result in uneconomical operating units especially with respect to mechanized whole tree chipping operations. In some states, over 60 percent of the commercial forestland is now in units smaller than 100 acres.

4.2.2 Forest Industry Ownership

In general, the primary forest products industries[a] in the northeast are not self-contained. Very few own or control enough of the resource to be independent with respect to supply. The fact is documented by Table 3, which indicates the amount of commercial forestland owned by forest industries in each of the northeast states and the relationship to total commercial forestland.

With one exception, the State of Maine, forest industry ownership of land is not a significant factor. While some of the literature on biomass advances the proposition the supplies of biomass from industrial lands may not be available especially for non-forest industry fuel users, this report does not concur. In general, industry

(a) Those industries that process, to some degree, the raw material harvested from forestland.

Table 3

1977 Commercial Forestland in Forest
Industry Ownership - Northeast (Thousand Acres)

State	Forest Industry Ownership	% of Total
Connecticut	0.0	0
Maine	8,082.8	48*
Massachusetts	30.1	1
New Hampshire	946.9	20
New Jersey	16.3	1
New York	1,177.0	8
Pennsylvania	964.1	6
Rhode Island	0.0	0
Vermont	666.3	15
Total:	11,883.5	19

Source: USDA Forest Service. Analysis of the Timber Situation in the U.S., 1952-2030.

*The data for Maine reflect the strong presence of the pulp industry in that state.

lands are managed for production. Unwanted or unusable material growing on industry lands represent a cost, and management would prefer to have its land growing desirable trees; hence, it is highly unlikely that industrial forestland managers will forego opportunities to market surplus or otherwise unusable products.

4.3 Utilization and Growth

Utilization data, in combination with information on growth, indicates to what extent the resource is being utilized. As analyzed in this report, utilization relates to the roundwood products harvested from a state's resource. The closer that utilization approaches growth, the less likely will be opportunities to utilize surplus growth for industrial wood energy. In addition, a high degree of utilization could undoubtedly bring forth public expressions of concern over any proposals that might stress the resource. Thus, utilization over the long term is a significant factor to be evaluated.

In the process of evaluating production data, the nature of the forest products industry was examined. The type of industry within a supply region can give an indication as to possible competition for supply, the presence of numerous industries can also mean potential sources of industrial fuel. However, a significant forest industry also indicates a significant supply system albeit in terms of traditional roundwood products.

Various assessments have been made of the potential for wood energy use by industries. One of the most consistent problems identified is the difficulty or inability to identify a reliable supply system capable of delivering required quantities over a long time period. This problem is particularly acute for non-forest product industries since there is generally little knowledge by such industries of the existing supply system that harvests and delivers traditional raw material to forest industries.

One factor, of course, is that few industries other than the forest industry sector are currently using wood energy and of those who are, many are utilizing mill residues. In some areas, the growth in demand for mill residues had produced "brokers" who now provide a critical link between users and producers. However, at present, a prospective industrial user of wood chips for energy-seeking supplies based upon chips from forest residues would, almost without exception, have difficulty in identifying an established system.

Whole tree chipping operations are not yet extensive in the northeast. Those that exist have been established in response to limited local markets. In some areas, recent technological improvements to chipping equipment that make it possible to produce pulp quality chips has created a market for whole tree chips. Some operators are associated with land clearing activities and in other situations a local, specialized fiber market (i.e., roofing material) is the market supporting the investment in chipping equipment. But, in general, operations are so few that in some areas, state forestry officials could not furnish information as to whether whole tree chipping technology was being utilized.

Investment in whole tree chipping equipment is expensive and can exceed $700,000, and has raised questions to the ability of many logging operators to secure financing.

When logging or harvesting is looked at as a business venture, one finds a wide variety of individuals with investments in equipment that range from little more than a truck and a chainsaw to highly sophisticated mechanized systems involving feller-bunchers and skidders. Some loggers are part-time, others specialize in the production of specific timber products. There are company or industrial loggers whose operations are performed solely to supply a specific facility. The majority of loggers in the northeast are so-called "independent" operators. Given the significant investment required in whole tree chipping systems (Section 4.4), it is not surprising that some operators would find it difficult to secure financing. We do not, however, concur with those opinions that suggest that such financing difficulties will materially affect the eventual establishment of supply systems if markets develop. Current evidence suggests otherwise. For example, in Vermont, whole tree chipping technology was first introduced in 1974 with one experimental operation. In 1982, ten systems were in operation, most of them established during the period of rapidly increasing financing costs. Discussions with equipment manufacturers indicate that, currently, financing for equipment can be secured by individuals who meet normal criteria.

4.3.1 Fuelwood

In addition to the production data available primarily from the individual state inventories, the most recent data on residential fuelwood use was evaluated. With one exception, New York, all of the comprehensive inventory resource reports for the other states pre-date the rather recent explosive growth of wood energy use in the residential sector. The reported quantities in some states were so significant; i.e., New York's 3 million cords, that it was deemed necessary to examine the most recent data to determine what effect such demands were having on the resource. In general, despite the large volume of wood being used for domestic heat, it appears that on a statewide basis, the various state resources are not being severely affected quantity wise.

4.4 Chipping Technology

The degree to which chipping technology is being applied was considered although the presence or absence of operations in an area does not necessarily constitute a significant factor. Certainly the presence of operations is evidence of a supply system and probably an established set of values for the fuel as it enters the supply system. These values or costs would reflect the value to the landowner in terms of stumpage, plus processing and transportation costs. Conversely, the absence of a system means that in the planning process the potential user must either proceed with the project in the faith that a system will be established or consider, as part of the project, taking some action to either establish or assist in the establishment of a system.

In the absence of any systems, there can be significant problems in the establishment of an adequate supply system. First, as pointed out in a previous section, the capital investment need for a single system can exceed $700,000. Dependent upon production capacity and working days, a single system may produce 30,000 tons per year. Thus the total investment need to create chip fuel for a large facility can entail several million dollars. In those situations where it is necessary to plan for the creation of a supply system, difficulties will arise due to the lack of comprehensive information on the economics of whole tree chipping systems.

In view of the fact that the technology of whole tree chipping is not yet being widely applied, it is not surprising that studies of the economics of application are relatively few. Most of the investigations so far have tended to either isolate the chipping operation from other operations, ignore or otherwise exclude some costs; i.e., road construction, or undertake studies under controlled conditions. Given that there are still only limited markets for wood chip fuel, the opportunities for investigations under the varying conditions that will be encountered in what may be termed "real world" conditions are limited.

The relatively high cost of chipping equipment, the capability of high production rates, and the low value of the end product all combine to create a situation wherein production is of critical importance. The high cost of equipment dictates that the system operate at high capacity levels. The capacity potential practically requires a steady flow of material for processing and to bring this about, there is a need for careful coordination of equipment and high standards of maintenance.

Despite the many variations found in several reports examining the economies of whole tree chipping operations in and around the northeast (variations in equipment, variations in certain costs included (and excluded), variations in terrain, and variation in timber conditions), when all is taken into account, the reported costs fall within a rather narrow range.

Table 4 is a distillation of cost data from various reports and indicates, where possible, the landing costs per green ton and the delivered costs per ton. Since the various reports were not consistent with respect to what items of cost were included, stumpage costs, road construction, and profit/taxes were excluded where such items were presented as a cost factor.

From Table 4, it can be seen that despite a wide range of conditions, the production costs at a landing are closely grouped. The early study (1974) should obviously be excluded since the time frame is of a period when capital costs, fuel costs, and labor were significantly lower than more recent years.

As an indication of the varying conditions found among the studies, a brief narrative of each study should be of assistance in establishing a relation (or lack thereof) among the investigations.

Study (1)

This study was conducted on a 50-acre site of predominantly pole-size hardwoods of mixed species. The site was essentially flat with a sandy loom. Of particular interest is the fact that the site was subject to various types of thinning treatments. The cost data reported in Table 4 is an average for all treatments. Landing costs varied with treatment and ranged from $5.17/ton to $8.26/ton. There was very little site improvement needed. Since this was public land, there was no stumpage cost.

Table 4

Estimated Unit Cost to Harvest and Deliver Whole Tree Chips

	Study	Year	Location	Estimated* Landing Cost	Estimated Delivery* Cost
(1)	USDA/FS	1974	Michigan	6.17	8.78
(2)	DOE	1977	Michigan	-	9.36
		1978	Newfoundland	-	15.16
(3)	USDA/FS	1979	Vermont	11.52	15.32
(4)	S.P.R. Assoc.	1979	Vermont	9.46	13.62
		1979	Vermont	10.92	13.84
(5)	Georgia Inst. of Technology	1979	West Virginia	11.47	17.15

* Cost/green ton

Source: (1) Mechanized Thinning of Northern Hardwood Polestands, Methods and Economics. F. Biltomen, W. Hillstrom, H. Steinhill, and R. Godman. USDA Forest Service Research Paper NC-137, June 4, 1976. North Central Forest Experiment Station, St. Paul, Minnesota.

(2) Assessment of Wood Chipping Machinery for Harvesting Non-Commercial Timber in New England. F. R. Erskine Crossley. DOE/ET/20077-T1. February 1981.

(3) A Preliminary Report on the Cost of a Whole-Tree Chip Harvesting System. N. K. Huyler. Northeastern Forest Experiment Station. 4820-FS-NE-4207-55, February 8, 1980.

(4) The Cost of Whole Tree Chipping in Vermont: Is it Cheap Enough to Burn? J.P.R. Associates, Inc., Stowe, Vermont. February 12, 1980.

(5) Wood Energy Potential in West Virginia. C. Aton, L. Fisher, J. C. Wynill, J. Birchfield. Project A-2297, November 1979. Georgia Institute of Technology.

Study (2)

The report includes two references to whole tree chipping operations. The first, in Michigan, involved 15 acres of hardwood on a fairly level site. The stand was to be thinned. The data precluded an estimation of landing costs, however, the information did include costs of \$0.43/ton for stumpage and \$1.31/ton profit.

The second reference was to be a trial or test operation in Newfoundland and involved clear-cutting of approximately 100 acres of white birch. Trees were quite small, 76%, being 1"-4" (seedling/sapling). Equipment was not matched and the chipper operated well below capacity. There was no stumpage cost and the labor was inexperienced.

Study (3)

This study was conducted as a trial or test of a mechanized whole tree chipping system in central Vermont, and consisted of a time and motion study of a selection cut in mixed hardwood/softwood pole and small saw timber stand. Terrain ranged from 5 to 15 percent slope with an average being 8 to 10 percent. The access road to the landing site had an adverse grade in excess of 20 percent which contributed to a significant loss of productivity. Of particular interest is the fact that this operation well illustrates the effect that factors such as inadequate equipment and adverse terrain can have on production. In this specific case, there was insufficient transport equipment (vans) to handle chipper production; and as a result, the chipper operated at below capacity. The steep access required diversion of one skidder to haul vans and tractors to the landing site. Thus, the capacity of the skidders was underutilized and this, in turn, resulted in underutilization of the chipper. Cost elements did not include stumpage or profit.

Study (4)

The report explores various estimates of whole tree chipping costs and draws upon analysis of three operations in Vermont (one of which is Study 3 above).

The first operation involved an operator new to whole tree chipping technology. The methodology did not involve time studies but estimated costs based upon reported production. The harvested site was a 20 year red pine plantation. Production ranged from a low of 23 tons/day to a high of 172 tons/day. Although the reason for such a discrepancy is not described, it is inferred that equipment down time and inexperience were contributing factors. There were no details on site conditions.

The second operation also concerns an operator new to the technology. The operation reported involved the clearing of some 150 acres for agricultural use. The site was primarily softwoods with 50-60 year sawtimber white pine in the overstory. Sawtimber was separated out for sawmill markets. Average production was 119 tons/day. Although there were no details on site conditions, it is assumed that since the land was being cleared for agricultural purposes, the terrain was fairly level.

Study (5)

This analysis of estimated costs did not involve a study or investigation of any particular operation, rather it is a calculation of costs based upon an assumed operation using conventional equipment. Of interest is the methodology used that incorporates in the theoretical operation the probable effect of steep terrain on production costs. Table 5 reflects the calculated composite cost of the operation for material produced on "flatland" and "hillside." The analysis concludes that the landing cost per ton of chips produced on the flatland would be $6.66/ton versus a cost of $15.20/ton on the hillside.

Supplemental Cost Studies

In 1977, Arola and Hilkstom[4] reviewed the early Study (1) and recalculated costs of production to reflect 1977 conditions. On a per ton basis, landed costs in 1977 were estimated to be $7.42/ton, an increase of $1.25/ton.

In 1978, the USDA Forest Service, North Central Forest Experiment Station, under a contract with the former Energy Research and Development Administration (ERDA), utilized a highly detailed harvest system simulator to estimate production rates and costs of producing chips in northern Wisconsin and upper Michigan.[5] A portion of the estimated harvesting costs and production data is reproduced below (Table 6). The 9-inch average diameter and 120 basal area information is of interest because it allows, to a degree, and it should be emphasized only to a degree, some comparison with the cost and production data contained in Study (3). In that study, the mean diameter was 9.2 inches and the mean basal area was 123.2 square feet.

Table 5

Estimated Harvesting Cost for Thinnings (Dollars/Green Ton)*

Average DBH		Basal Area 90	120	150	180
	Feller Buncher	.91	.84	.78	.75
9	Skidder-Chipper	3.56	3.49	3.44	3.42
	TOTAL:	4.47	4.31	4.22	4.17
	Feller-Buncher	.56	.53	.56	.53
12	Skidder-Chipper	2.47	2.43	2.88	2.74
	TOTAL:	3.03	2.96	3.44	3.27

Table 6

Simulated Actual Production (Green Tons/Hour) Thinning*

Average DBH		Basal Area 90	120	150	180
	Feller-Buncher	30.59	33.12	36.05	37.12
9	Chipper	37.60	38.70	38.90	39.86
	Feller-Buncher	49.69	52.23	72.54	77.83
12	Chipper	54.29	54.89	46.44	48.77

*Sources: Tables 2.14, 2.17, Forest Residues Energy Program

In comparing the above data to the information in Study (3), it should be emphasized that one set of data is computer generated while the other is a "real world" observation. In addition, there are equipment differences and in Study (3), there was a mis-match of equipment, adverse terrain, and adverse weather. In the Vermont study, the Feller-buncher production time varied from an estimated 27 tons/hour with no delays to an actual production time of 19.1 tons/hour. The computer simulation for the Wisconsin, Michigan study region indicates a production time of 33.1 tons/hour. Thus, the Vermont production rate with no delays can be considered relatively close. The chipper production time (both sets of data are based on a 22" chipper) is simulated to be 38.7 tons/hour. The Vermont operation with no delays is calculated to be 43.4 tons/hour with actual being 15.3 tons/hour. Again, the Vermont production data under ideal conditions are relatively close to the computer simulation.

Any conclusions to be drawn from the above are limited. Existing studies of production under field conditions generally represent short-term observations, in essence a "snap-shot" of what was observed over a relatively short period of time. The few studies to date and the varying conditions found in the studies seem to indicate that whole tree chipping in the northeast can range from $10-$15/ton at a landing. Again, it should be noted that these costs exclude stumpage, site improvement costs, and operator profit. These factors are treated too inconsistently to permit any meaningful assessment as to effect upon total costs; however, in a commercial operation, they will, to some degree, have to be considered.

Stumpage

Stumpage costs, where reported, range from zero to $1.50/ton. The situation is reflective of limited markets, low commodity value, and in situations where land clearing is involved, a negative value. As markets become established, a commodity value will be established and on a site-to-site basis, the commodity value will be effected, as are traditional products, by such factors as demand, site accessibility, volume, and in general, those factors that effect production and delivery costs. Unlike traditional stumpage prices, wood chips, at least those for energy purposes, should not be effected by quality factors or species available.

Site Improvement

Site improvement costs will be highly variable and site specific. They may include road construction/improvement, skid road construction, landing area construction, and site rehabilitation. Such costs, when necessary, will be more of a factor with respect to chip production costs, when the primary operation will be chip production. Where chip production is incorporated into a traditional operation, such improvement costs probably will be borne for the most part by the higher value products.

Other Costs

There are, in an economic sense, a variety of costs that will effect the cost of producing whole tree chips. For example, in a supply area where numerous small landowners are the characteristic, it may be necessary to operate on several sites during the year. This entails site inspection, landowner negotiations, and movement of men and equipment from site-to-site. In one way or another, such items incur a cost that must be eventually factored into a comprehensive analysis of production economics.

In Study (5), which is a calculation of estimated costs in West Virginia, such items as stumpage and site improvement were included. With a factor of \$1.20 for stumpage and \$2.10 for site improvement, the calculated landing cost of \$11.47 increases to \$14.36/ton.

The economics of whole tree chipping is, of course, of critical concern to both the potential user and the supplier. In those situations involving energy use, the potential user is primarily concerned with the cost of the fuel in comparison with other fuels. The potential supplier is concerned that the market price is adequate to support all costs of production. At best, current information is only able to quantify, to a limited degree, certain elements of cost. However, despite inadequacies, the data does permit approximation of costs when evaluated in terms of prevailing local conditions.

Competition

In addressing competition as a factor of supply, it is appropriate to discuss, in general terms, the demands for raw material by forest industries. In general, when marketing the raw material; i.e., logs, poles, piling, pulp, etc., the material must conform to some set of specifications. Specifications would include species, length, minimum diameter, and allowable defects. In essence, all trees do not have equal value in the marketplace and competition is not for the resource as a whole but for those elements of the resource that the market finds acceptable. In contrast, it can be said that to the potential industrial user of wood as a fuel, all trees are equal. Thus, if there is an adequate supply of unutilized biomass to meet fuel needs, there is no competition. There have been concerns raised that in the application of whole tree chipping technology, higher value elements would be misallocated. Such a situation is certainly possible but highly improbable considering marketplace economics. For example, a recent survey of hardwood veneer prices in Vermont indicates a delivered value of $250-$400 per thousand board feet (MBF). At an approximate conversion factor of 6 tons per MBF and a fuel chip value of $18/green ton, the delivered chip value is slightly over $100. Thus, the value of the higher grade material in traditional markets is 2-1/2 - 4 times the fuel value. It is highly unlikely that a well managed woods operation will ignore economics.

4.5 Transportation

An evaluation of a particular supply area for a site-specific facility must include analysis of the transportation network and its capability to support the movement of whole tree chips from the woods to the using facility.

While it is generally assumed that truck transport will be the predominant mode of transportation, the mandated requirement that the new Burlington facility utilize rail transport for 75% of its supply should provide some insight as to the feasibility of utilizing rail transport for wood chips.

With respect to road transport, there are three factors to consider:

- the general availability of roads throughout the supply area to permit access to the resource,
- the major roads linking harvest areas to the facility, and
- the capability of local roads in the vicinity of the site to support chip transport vehicles.

With respect to the effect of local road limitations on harvesting site access, Monteith[6] estimated that harvest areas in excess of 2 miles from an all-weather road are less likely to have temporary usable roads and construction or improvement would probably be quite expensive. However, on a statewide basis, the estimated net effect in New York State is a reduction of only 7 to 8 percent of total resource availability. It should be pointed out that Monteith combines the factor of distance from road with the factor of land with a slope in excess of 30 percent.

On the other hand, Hewett in the study for Northern Vermont,[7] states that stands harvested for wood chips will either have to lie about one-half mile of an existing road or have to be cut in association with some other, more profitable land use activity. This study concludes that access limitation will restrain harvesting operations on 45 percent of the commercial forestland in the region (1.2 million acres).

It would appear that at this stage of development, much has yet to be learned before it is possible to quantify, with any assurance, the limitations that may be imposed on a supply area by the presence (or absence) of local roads. Only one study, the Huyler report,[8] makes mention of access limitation with respect to van truck operation.

The second factor, major routes to the facility, is more straightforward. Since transportation costs are normally based on ton/ miles, the more direct the route, the less the cost. A circuitous route, even with a prescribed 50-mile supply zone, may well make the transport costs of a low value product prohibitive.

The third factor, the ability of local roads to handle traffic in the vicinity of the plant site, proved to be a critical factor in the Burlington situation. As originally contemplated, truck deliveries would have averaged 5-6 per hour. There was considerable public concern over the ability of local roads to handle the contemplated truck traffic. The result of the concern was an imposition of a limit on the amount of supply to be delivered by truck. The Burlington situation indicates that large-scale users need to evaluate local traffic capabilities to ensure the present system is adequate.

In addition to the above discussion, it is appropriate to call attention to recent widespread national concern over the condition of bridges in the highway system. If one assumes that the documented deterioration of bridges in the major highway system is paralleled by deterioration of structures in secondary and rural systems, then one must consider the possibility that in some local situations, accessibility to the resource may be further limited.

4.6 Terrain Limitations

Terrain conditions, especially degree of slope has a twofold effect upon harvesting operations. As a given, as slope increases, production decreases, thus adverse terrain conditions have an increasing negative effect on the economics of whole tree chipping. At some point, the use of mechanized equipment is no longer feasible in terms of present day equipment. The net result of terrain limitation is to reduce to some degree, availability of the resource. For the northeast region as a whole, limitations due to steep topography do not appear to be a significant impediment to the establishment of whole tree chipping operations. No one state within the region can be characterized as having significant adverse terrain restraints. But keeping in mind that for economic reasons the transport of low value wood material is confined to relatively small areas, severe terrain conditions may be of significance when evaluating a potential supply area for a specific site.

At the present time, very little research has been done on terrain limitations. A review of the few studies that have addressed this subject indicates varying opinions among the investigators.

A West Virginia study[9] indicates that approximately two-thirds of the state has a slope of 25% or better which severely limits the use of a totally mechanized felling, retrieval and chipping operation. For specific equipment, this study indicates a slope limit of 30-35% for feller-bunchers and feller-forwarders. For rubber tired skidders, the slope limitation is 40%.

In contrast, a study of the northern Vermont area catagorically states that "Slopes greater than 15 percent effectively eliminate the use of mechanize whole tree harvesting."[7]

A limited study in Massachusetts [13] indicates that a 25% slope is the upper limit.

A study[6] in New York State indicates the following maximum operating slopes for various equipment:

Machine	Maximum Operating Slope (%)
Crawler	60
Rubber-tired skidder w/shear	40
Feller-buncher	60
Horse/oxen	30

To some extent, the harvesting of sites that contain some adverse slopes can be carried out by combining mechanized systems with conventional logging equipment (chainsaw felling). However, a limited study undertaken in Michigan[11] indicates that conventional operations are limited with respect to whole tree chip production. The operation is labor intensive and low in productivity. The fact that each tree is felled individually means that stems must be assembled in bunches for efficient skidding to the chipping site. Such a system is workable in a multi-product operation where higher value timber products can absorb costs but whether conventional techniques can be utilized to economically harvest sites with adverse terrain where the product is primarily wood chips is questionable.

Some research is being done on the use of such systems as cable logging on steep terrain and while such systems are technically feasible, the economics, especially in regard to the harvest of low-value timber, needs to be demonstrated.

From the above, it is apparent that insufficient data exists with respect to actual working conditions of mechanized systems and to the extent that terrain limitations will reduce available supply. This is not surprising given the relatively few operations at present and the wide range of operating conditions that have yet to be experienced before adequate knowledge is available. In this early stage of what may be termed increased fiber recovery, terrain limitations, except in very local situations, should not be a major constraint.

5.0 Individual State Assessment

The following is a state-by-state assessment of the potential for industrial wood energy. Visits were made to each state and discussions held with appropriate state officials. For the most part, meetings were held with state forestry officials and generally involved those personnel concerned with utilization. The level and quality of information available varied among the states. Resource information was the most consistent data element available. Somewhat surprising was inconsistency with respect to current removal information. Only two states, Maine and Vermont, assess the annual harvest of forest products. Other states rely upon data generated during the periodic timber resource inventory conducted by the USDA Forest Service.

Some states were quite knowledgeable with respect to the number of whole tree chipping systems operating within the state. Others had little or no information which is probably reflective of a lack of systems.

In assessing the potential, various factors were examined. The initial factor reviewed, as might be expected, was the wood resource estimates for each state. As has been mentioned, such data is the most consistent and readily available information for each state and is based upon periodic inventories conducted by the USDA Forest Service in cooperation with the state. These inventories contain a wealth of data including evaluations of the resource down to the county level. However, the inventory data are not a total biomass assessment but are a measure and analysis of what is considered the commercial elements of the resource. Thus, only species regarded as commercial are analyzed and the quantitative data are in terms commonly utilized in the forestry area; i.e., cubic feet, board feet. Until recently, it has been necessary to manipulate the data with various factors in order to arrive at some estimation of tonnage. Recent publications by the USDA Forest Service of data that converts the basic resource inventory information to green tonnage units, although somewhat empirical at this stage, is a significant improvement and has been utilized in the state assessment.

The removals data, where available, have been utilized to evaluate the utilization of the resource for traditional markets. To a degree, it measures competition.

Most of the states were able to furnish a directory of primary wood using industries and this information was utilized to evaluate, in a general sense, the significance of forest products industries within a state, the distribution and the type of industry. Indirectly, the presence and location of such industries provides an insight to the potential supply system since with few exceptions, most primary forest industries draw their supplies locally and harvesting operators tend to be local.

Landowner data are available from two sources. Delineation of public versus private is contained in the state resource survey. Studies on landowner attitudes and characteristics are now available for most of the northeastern states.

Transportation networks were evaluated only from a general perspective by utilizing USGS Base Maps which indicate all principal roads, rail systems, and topography.

In addition, where appropriate, additional studies pertinent to one or more factors were utilized.

In some areas, additional factors that could effect supply were evaluated. For example, in New York State, the role of the Adirondack Park Authority was discussed with state officials to determine what potential effect regulations might have on the resources within that special region.

In each state, assumptions were made.

- The practice of clearcutting, exclusive of land clearing operations, will not be widely employed.
- The value of energy wood chips to the user will be determined by the costs of alternative fuels.
- There will be no developments in the regulatory area that apply specifically to wood chip technology.

The first assumption evolves from the concerns that have been expressed about whole tree chipping technology and a review of the various reports done in several states on landowners. The studies indicate that among those who have harvested their forestland in the past, clearcutting has not been widely applied. Clearcutting, as a practice separate from land clearing, has only been applied on from 5 to 13 percent of the land harvested. The assumption is thus made that this condition will not change materially.

The second assumption is an indication that potential industrial users will place a value on wood energy in terms of the value of alternative fuels. In essence, the market will be a "buyer's" market.

The third assumption is critical with respect to the economics of whole tree chipping technology and wood energy supply. In the granting of the approval for the construction of the new 50 MW generation facility in Burlington, Vermont, the Public Service Board imposed somewhat arbitrary conditions in regard to transportation modes. The net effect will be to increase the cost of fuel. An adverse regulatory environment that affects one or more elements of supply could result in further limitations of supply.

Connecticut

Two resource inventories have been taken in Connecticut, one in 1952 the other in 1971. As might be expected in an urbanized state, the period between surveys indicated a loss of commercial forestland from an estimated 1.9 million acres reported in 1953 to 1.8 million acres in 1972. As of the 1972 report,[12] 58 percent of the state is considered commercial forestland. Despite the loss of some 167 thousand acres, from a resource standpoint, the loss of acreage was offset by an increase in growing stock volume from 1,504 million cubic feet to 2,351 million cubic feet.

Commercial forestland is for the most part fairly evenly distributed throughout the state with the counties ranging from 44 percent commercial forestland to 66 percent.

In terms of net volume of growing stock, there is a relatively high degree of uniformity with respect to the distribution by volume by stand-size classes among the counties. Data indicates that in all regions the bulk of the growing stock volume is in sawtimber and poletimber stands which is significant since the economics of whole tree chipping seems to indicate that with the exception of land clearing operations, chipping operations will only operate efficiently in sawtimber-poletimber stands.

Land Ownership

A 1976 report[13] indicates there were approximately 66 thousand private owners of Connecticut's commercial forestland. By far, the largest form of private ownership is individual comprising 61,200 owners or 93 percent of the total private ownership.

As is characteristic of the northeastern states, ownership of the forest resources is overwhelmingly private. Public ownership is less than 10 percent with Federal land being almost non-existent at about 2 thousand acres. The bulk of public land, 146 thousand acres, is in state ownership. State lands are located in each county in fairly small parcels ranging from about 2 thousand acres to 34 thousand acres. There appears to be no forest industry owned land in the state.

Of significance is the numbers of owners and the acreage they control in terms of the size class acreage. Table CT-1 indicates the ownership profile.

Table CT-1

Estimated Number of Private Owners and Acreage Owned, Connecticut

Size Class (Acres)	Owners Number	Owners Percent	Acres Owned Number	Acres Owned Percent
1-9	36,100	55	152,400	9
10-19	9,900	15	132,000	8
20-49	10,900	16	328,400	20
50-99	5,800	9	397,500	24
100-199	2,500	4	314,900	19
200-499	700	1	207,100	12
500+	100	-0.5	126,700	8
Total:	66,000	100	1,659,000	100

The significance of the above data lies in the combination of a large number of small owners controlling a significant amount of the resource. If, for example, as indicated in work done in Vermont, whole tree chipping systems find parcels less than 100 acres the least desirable for operations, then in Connecticut approximately 61 percent of the commercial forestland is in parcels less than 100 acres. Over one-third of the commercial forestland is in parcels smaller than 50 acres. Thus, in Connecticut, regardless of what constitutes a minimum acreage requirement, in order to secure large quantities of whole tree chips, a large number of landowners will be involved.

Timber Utilization

As a 1974 report indicates, the production of timber products is not a major industry in any of the southern New England States.[14]

In 1952, it was reported that there were some 120 operating sawmills in Connecticut. By the time the 1971 survey was taken, 63 were listed. A 1982 directory prepared by the Connecticut Department of Environmental Protection, Bureau of Forestry, indicates an increase to some 115 sawmills. Analysis as to location does not indicate any significant concentration in any one particular region.

Since Connecticut does not monitor annual utilization, there is no data base to compare current or recent activities with information produced in 1971. However, the availability of some periodic reports provides some insight with respect to timber production activity since the last resource inventory.

In 1971, it was reported that for Connecticut, the industrial roundwood harvest amounted to the following (Table CT-2).

Table CT-2

Industrial Roundwood Harvest - 1971

Product	Thousand Cubic Feet
Sawlogs	4,639
Pulpwood	922
Other(1)	242
Total:	5,803

(1) Veneer and cooperage logs and bolts, piling, posts, shingle and dimension bolts, and charcoal wood.

The data indicates that the major portion of the harvested roundwood was in sawlogs which comprise about 80 percent of the volume. In conventional units, sawlog production amounted to 27.6 million board feet plus an estimated 10,849 cords of pulp. In addition, 674,000 cubic feet or 8,400 cords of fuelwood were produced.

Total removals from growing stock including logging residues and "other removals" amounted to 18.2 million cubic feet.

A USDA Forest Service report for 1976[15] indicates that removals in Connecticut were 16.7 million cubic feet from growing stock. Total removals amounted to some 17.5 million cubic feet, slightly less than that indicated for 1971. In essence, the 1976 report indicates that for that year the removal categories were similar to the 1971 reported data. In terms of the reported net annual growth of growing stock in 1976, some 81.8 million cubic feet, growth far exceeded removals.

In 1978, total production of pulpwood from roundwood in Connecticut is reported to be about 5,000 cords or 425,000 cubic feet.[16] This would represent a decline of almost 50 percent of that reported in 1971. Since production was up in many of the other northeastern states, this decline was not due to general economic conditions.

Fuelwood

With respect to fuelwood production, reported as some 8 thousand cords in 1971, a 1980 report on New England fuelwood use[17] indicates that in 1978 some 800,000 cords of fuelwood were probably acquired by residential users. This would represent a substantial increase over the total of 12,339 cords reported in 1971. Details of the 1978 fuelwood survey only permit a limited analysis. Of the total, approximately 596,000 cords were "self-cut", the remainder was purchased. If the "self-cut" is assumed to have all come from within the state, then this would represent some 50.6 million cubic feet. Not all of this volume represents a drain from growing stock however.

A source study conducted in Vermont in 1979[18] indicates that of "self-cut" fuelwood, 33 percent was from trees/branches blown down, dead, or rotten; 23 percent came from trees from land clearing operations, and 7 percent were logging wastes. Assuming a similar source situation exits in Connecticut, then the growing stock resource is not yet being severely effected by fuelwood harvests insofar as the category "self-cut" is concerned. However, some 183,000 cords were purchased. This represents approximately 15.5 million cubic feet. The 1971 survey indicates that

3,912 cords of the total 12,339 cords come from plant by-products. The volume of unused, coarse sawmill residues in 1971 was only 270 thousand cubic feet or approximately 3,000 cords. Thus, it is highly unlikely that as fuelwood demand has increased, significant quantities were supplied by mill residues. In fact, the 1978 Pulpwood Report indicates 6,000 cords of pulpwood coming from manufacturing residues as against only 12 cords in 1971. At this point, one can only speculate where the volume originates. Given the somewhat limited resource base, less than 2 million acres, the combined cubic foot volume, self-cut, and purchased fuelwood, represent some 66 million cubic feet, and it becomes somewhat critical to know what components of the resource are contributing to the supply.

In summary, insofar as the resource base is concerned, in the absence of current data, it would appear that net growth is still far in excess of industrial removals. However, the large volume of wood being consumed for residential heating and more importantly the source of the wood needs investigation. The demands for fuelwood could very well be a competitive factor insofar as industrial wood energy is concerned.

Chipping Technology

In view of the fact that the pulp industry is not a strong element in Connecticut, it is not surprising that chipping technology is not widely employed. Of the total roundwood production of pulpwood reported in 1978 (5,000 cords), 4.4 thousand were retained in the state for domestic industries and 600 cords were exported to other northeastern states. Thus, unless there is a significant change in Connecticut's pulpwood industry, pulpwood production will not provide an incentive for investments by loggers in whole tree chipping equipment.

An industrial wood energy user would thus have to look to the development of a supply system in which the harvester:

a) would conduct only whole tree chipping operations with the material being utilized for fuel, in which case the price of the fuel would have to be high enough to meet the costs of the operation, or

b) provide chips from material harvested in an integrated logging operation.

As has been indicated, Connecticut does not produce significant quantities of industrial roundwood. By way of comparison, in 1971, Connecticut produced approximately 27 million board feet; in 1972, Vermont production was over 100 million board feet.

The 27 million board feet production does not require an extensive supply system. The 1982 directory of industry produced by Connecticut also listed some 125 loggers. This is rather a large number of loggers in terms of what is produced, however, many are part-time operators, others specialize in certain species and products, many are small mill owners who probably restrict operations to those required to fill the mill's needs.

In the northeast, subject to many variables, it is generally considered that a small logging operation should be able to produce from 7-10,000 board feet per day. Thus, it appears that many loggers are small and raises the question as to how many mills are capable of financing a mechanized chipping operation. One cannot conclude, however, that the lack of a large forest industry and supply system precludes the establishment of an industrial fuel supply system. However, one can deduce that it will probably be more difficult in economic terms since there are fewer opportunities to market forest products.

Transportation

In view of the fact that the state is quite urbanized, there is a well developed highway system. There are probably very few forested areas in the state lacking ready access to a state or local road.

Terrain

The state is not noted for its mountainous terrain; hence, any restrictive terrain limitations on mechanized equipment will be very local and the net result should be minimized from a supply standpoint.

Summary

The State of Connecticut does not have a large resource base in terms of commercial forestland. Although growth to removals relationships appear to be still quite favorable, the large number of small wood lots, the limited forest industry and possible competition for residential fuelwood will limit opportunities for large-scale industrial use of wood fuel.

Maine

Two forest surveys have been conducted in Maine. The first in 1954-1958, and the latest in 1968-1970. In the 12-year interim between surveys, the commercial forestland increased by almost one-half million acres, from an estimated 16.4 million acres reported in 1959 to 16.8 million acres in 1971. Maine has the largest amount of commercial forestland of all the northeastern states and with 90 percent of its land area in forestland has the largest proportion of its land area in forests by any state.[19]

As of the last survey, growing stock volume amounted to some 21.2 billion cubic feet, an increase of approximately 4 billion feet over that reported in 1959.

The resource is well distributed throughout the state with the percentage of commercial forestland for individual counties ranging from 70 percent to 91 percent.

Land Ownership

Maine is the only northeastern state lacking detailed ownership data. Federal ownership is relatively insignificant, comprising only some 73 thousand acres, less than 1 percent. Other public ownership is modest, some 238 thousand acres or about 1 percent. The rest, and obviously the bulk of the commercial forestland is privately owned. One unique feature of private ownership is the large amount of forest industry owned land, some 8 million acres or 48 percent. The bulk of the forest industry land is located in the northern counties. Table M-1 indicates the area of commercial forestland by ownership in each county.

Table M-1

ACRES OF COMMERCIAL FORESTLAND IN MAINE COUNTIES
BY OWNERSHIP CLASS, 1971 (THOUSAND ACRES)

County	Total Land Area	COMMERCIAL FORESTLAND						
		Federal	State	Other Public	Forest Industries	Farm	Other	Total
Aroostook County	4,365.2	6.1	25.5	48.3	2,175.5	275.1	1,215.8	3,746.3
Capitol Region								
Kennebec County	(557.8)	N/A	N/A	N/A	N/A	(63.5)	N/A	390.0
Knox County	(236.1)	N/A	N/A	N/A	N/A	(21.1)	N/A	165.6
Lincoln County	(290.7)	N/A	N/A	N/A	N/A	(17.5)	N/A	217.4
Waldo County	(471.8)	N/A	N/A	N/A	N/A	(58.6)	N/A	359.2
Total	1,556.4	0.4	11.6	5.7	12.3	164.7	937.5	1,132.2
Casco Bay Region								
Androscoggin County	(303.6)	N/A	N/A	N/A	N/A	(47.7)	N/A	228.3
Cumberland County	(562.4)	N/A	N/A	N/A	N/A	(50.2)	N/A	430.6
Sagadahoc County	(164.5)	N/A	N/A	N/A	N/A	(14.8)	N/A	130.3
York County	(640.8)	N/A	N/A	N/A	N/A	(62.5)	N/A	497.9
Total	1,671.3	4.9	7.5	5.5	25.5	175.2	1,069.5	1,288.1
Hancock County	983.7	0.6	9.6	--	290.6	49.4	512.5	862.7
Penobscot County	2,169.9	3.5	11.4	4.6	1,023.2	125.9	684.6	1,852.6
Piscataquis County	2,497.6	0.3	39.5	2.6	1,241.0	73.7	821.1	2,178.2
Somerset County	2,492.3	0.1	11.4	2.6	1,331.0	121.9	765.7	2,232.7
Washington County	1,634.5	19.9	25.3	1.4	828.3	10.4	553.7	1,439.0
Western Maine Region								
Franklin County	(1,093.9)	N/A	N/A	N/A	N/A	(48.6)	N/A	994.1
Oxford County	(1,332.3)	(37.5)	N/A	N/A	N/A	(77.2)	N/A	1,168.4
Total	2,426.2	37.5	21.1	5.1	1,327.6	125.8	645.3	2,162.5
State Total	19,797.1	73.3	163.0	75.2	8,255.0	1,122.1	7,205.7	16,894.3

Land ownership attitude surveys similar to those undertaken for the rest of the northeastern states are not yet available for Maine. However, it is known that in the northern part of the state there is a somewhat unique form of forestland ownership and management. In this area, owners have a "common and undivided interest" in the land. Owners may each own a portion of a parcel of land, yet the parcels are not defined by normal boundry descriptions. Gains or losses from the ownership are shared according to each ownership interest. Under such a system, if a portion of the timber on a parcel were harvested, all owners would receive a pro rata share of the proceeds regardless of where on the parcel the harvest took place. As an outgrowth of this system a specialized management system has evolved. Groups of owners have organized to form a unified land management system. Individuals or firms have been retained to undertake management responsibilities and land managers have been delegated to assume ownership responsibilities. Proceeds from sales, less operating costs, are then divided among all owners. It is estimated that approximately 3 million acres of commercial forestland are being managed by such management organizations.

At this point, there is no reason to expect that owners of the remaining forestland hold attitudes towards forestland that differ significantly from surveys conducted in the other states. This is, in part, documented in a landowners survey, conducted in 1978 by the Maine Audubon Society,[20] of forestland owners in Cumberland County. That survey indicated that the major reason given for owning forestland was that it was part of the residence. Approximately 72 percent of those responding to the survey indicated that they has harvested the woodland. Of those classified as non-harvesters, only 3 percent indicated opposition to harvesting.

Given the large amount of forest industry ownership of commercial forestland in Maine and the significant presence of the pulp and paper industry, it is appropriate to call attention to the opinion expressed by many investigations that material from such ownerships will be confined or otherwise restricted to the use of forest industries. While it is certain that insofar as commercial products are concerned, the needs of the industry will have first priority. It is illogical to assume that surplus material, cull, and other unutilized biomass will be withheld from a market for arbitrary reasons. Owning and managing forestland is not without cost and given a market it can be expected that industrial forestland managers will respond to market opportunities more readily than other private owners.

Utilization and Growth

Maine has a long history as a timber producing state, over 250 years in fact, and the resource continues to support numerous primary forest product manufacturers who produce a wide variety of products. Included are pulp and paper, sawmills, plywood and veneer mills, fencing and a variety of other products. The 1970 survey indicated there were approximately 429 primary wood-using plants in operation, the 1981 directory indicates only a slight decrease to 394.

Although no geographic region lacks wood-using industries, the distribution shows considerable variation with the highest concentration (50) in Oxford County which borders on New Hampshire. In generalized terms, the bulk of the forest industries are located in the southern half of the state and is reflective of the general development of the state which is primarily in the southern region.

The pulp industry is a dominant factor, owning approximately 93 percent of the estimated 8 million acres of industry owned commercial forestland. According to the 1970 survey, of the 408 million cubic feet of wood harvested, 274 million cubic feet (67 percent) amounting to 3.1 million cords, was pulp.

As of the 1970 report, the production of industrial roundwood products amounted to some 390 million cubic feet. As might be expected, pulpwood production is very significant and the relation between pulpwood production and other products is shown in Table M-2 which indicates the output from roundwood of major categories.

Table M-2

Industrial Production from Roundwood, 1970

Product	Thousand Cubic Feet	%
Sawlogs	105.7	27
Pulpwood	273.7	70
Other*	10.5	3
Total:	390.1	100

*Includes: Veneer and cooperage logs and bolts, piling, poles, posts, railroad ties and shingle bolts.

Total industrial product output, including products from plant by-products amounted to 411.1 million cubic feet. Ninety-five (95) percent of the industrial production came from roundwood.

Since Maine is one of the few states that monitors the annual cut of timber, data for the years 1974-1980 were examined to both update the 1970 information and gain insight as to levels of harvest since the last survey.

Table M-3 is reported information for each year by the State of Maine in terms of pulpwood cords, hardwood and softwood timber in board feet. A conversion factor has been used to convert units to cubic feet and allow some comparison to 1970 data.

In comparison with the reported 1970 information, the general trend in production has been upward with a high of 458.6 million cubic feet reported in 1979. Insofar as 1979 production data is concerned, pulpwood production in relation to total production declined to 59 percent.

A preliminary report for 1981 production indicates a slight increase (1 percent) over 1980 production.

The estimated annual net growth in 1970 was 711 million cubic feet. The annual removals were approximately 409 million cubic feet indicating a ratio of 1.7 to 1.0.

The 1970 report points out that removals were increasing faster than growth and despite the size of the resource, removals could exceed growth. One reason for this rather unfavorable condition is that the forests are producing timber far below their potential. Many stands have a large proportion of their volume in rough and rotten trees. Thirty-six (36) percent of all hardwood trees on commercial forestland are either rough or rotten. Of the estimated net volume of timber on Maine's commercial forestland, 24.0 billion cubic feet, approximately 2.8 billion cubic feet, or 11 percent is in the rough/rotten class. Thus despite current conditions which indicate an increasing unfavorable ratio between growth and removals, there is a considerable quantity of low quality material uitable for wood energy utilization. The 1970 survey indicated that insignificant amounts of rough and rotten volumes were being utilized as roundwood products. Of the total roundwood output, including fuelwood, only an estimated 7.5 million cubic feet, less than 1 percent was being utilized.

Table M-3

Maine Timber Cut in Cords and Board Feet for Years 1974-1980

	1974	1975	1976	1977	1978	1979	1980
Pulpwood (1000 Cords)	3,384.3	2,491.8	2,802.4	2,810.1	3,184.8	3,177.8	3,368.3
Hardwood Timber (M Bd. Ft.)	219,491	150,955	164,028	161,118	174,354	187,461	140,902
Softwood Timber (M Bd. Ft.)	638,016	615,025	816,302	851,239	925,821	921,722	782,071
Total Cords (1000)[1]	5,099.3	4,023.8	4,763.1	4,834.9	5,385.1	5,396.2	3,368.3
Total Cubic Feet (1000)[2]	433,420	342,020	404,860	410,970	457,730	458,680	286,310

[1] 2 Cords = 1,000 Bd. Ft.

[2] 85 Cubic feet per cord.

Source: Maine Timber Cut Reports - 1975, 1976, 1977, 1978, 1979, 1980. Maine Department of Conservation, Bureau of Forestry.

Fuelwood

It should be pointed out that the data in Table M-3 represents only the removal of industrial roundwood products from the resource and, as such, does not indicate total biomass drain. Excluded are logging wastes and fuelwood removals. The 1970 survey indicated that some 219,000 cords of fuelwood were harvested representing approximately 17 million cubic feet. Obviously 1970 preceded the oil problems of 1973/74 and Maine, like other New England states experienced a dramatic increase in the use of wood for energy. Fuelwood use is not monitored on an annual basis; therefore, in the absence of annual data, existing sources were used to indicate, with some reservations, the potential effect that fuelwood use is having on the resource base.

As indicated, the 1970 survey identifies the use or output of some 219 thousand cords from roundwood, plus an additional 105,000 cords from plant by-products.

A 1979 survey[21] conducted throughout New England indicated that for the heating seasons 1976-1977, 1977-1978, 1978-1978, 430 thousand, 539 thousand and 575 thousand cords, respectively, were used. Although the use is reported on the basis of heating seasons, it can be assumed that New Englanders do not have a propensity to cut and burn frozen, green fuelwood and, therefore, a significant portion of the reported use was, in fact, acquired during the preceding calendar year.

It should be noted that the above data from the USDA survey represents estimates on the amount of fuel consumed (burned). For the 1978-79 season, the USDA survey indicates that some 640 thousand cords were acquired. In essence, more wood was acquired than burned. Whether this is a standard factor to be applied in previous years is not reported.

Two other sources of data were examined with respect to residential fuelwood use in order to estimate the potential effect of such use on a supply system.

In 1982, the Maine Office of Energy Resources published a historical summary of energy use in Maine from 1960-1980.[22] For the residential sector, the reported wood consumption for 1980 shows almost a doubling in consumption over that reported in 1970, from 324 thousand cords to 654 thousand cords.

A recent Energy Information Administration report[23] indicates that for 1980, residential wood consumption was approximately 600,000 cords.

Since estimating residential wood energy consumption is still more of an art than a science, discrepancies between surveys exist. For the purpose of this report, it is believed sufficient to estimate that approximately 600,000 cords of wood are being consumed in the residential sector for heating.

Not all of this is obtained from standing trees. The 1970 survey estimates that of the total 324,000 cords utilized for fuelwood, approximately 105,000 cords (32 percent) came from mill residues. Although the level of harvests have increased substantially since 1970, it is highly unlikely that mill residues are still contributing about one-third of the residential fuelwood considering that the 1970 survey indicates that only approximately 36,000 cords equivalent in coarse residues were unused at primary manufacturing plants. The reported utilization of sawmill residues for pulp has increased from 248,000 cords in 1970 to 760,000 cords in 1980.

In perspective, if the total estimated residential cordwood usage is assumed to come from standing timber and on commercial forestland, then in terms of the 1970 survey, this would represent some 48 million cubic feet, which in comparative terms, represents about 7 percent of annual net growth.

However, if information gathered in Vermont on the sources of fuelwood is applicable to Maine, then over 50 percent of the self-cut fuelwood came from such sources as dead or rotten trees, material from land clearing, and logging wastes. Thus, in terms of the effect on the resource, fuelwood harvests would not be severely affecting the resource base.

Chipping Technology

Chipping technology, while not yet being extensively applied in the northeast, is being utilized in Maine. Officials estimate that at least 18 chipping systems are in operation. In addition to mobile systems, the pulp industry has established several chip mills which are operated as intermediate stationary facilities that chip roundwood production transported to the facility where it is chipped and then transported to a pulp processing plant.

As of the 1981 Preliminary Report, Maine has started to report a category of "Biomass Chips for Energy." In 1981, a total of approximately 10,000 cords of "biomass" chips were used for fuel.

Thus in Maine, whole tree chipping technology is established and is being employed primarily to produce feedstock for the pulp industry but is also producing a limited amount of chips for use as industrial fuel.

Transportation

An adequate transportation network is critical both in terms of providing access to the resource and in the efficient transportation of harvested products to the market. In Maine, the northern portion of the state is a remote area with a low population density. Major state highways are limited to the eastern section, and the road system is primarily secondary. Access to the resource in many areas depends on the existence of restricted private roads.

In the southern portion of the state, the transportation system is much more highly developed and contains an interstate network as well as numerous major state highways.

Despite the remote character of the northern area, the resource is available as evident from harvesting data published by the state. The two northern counties, Aroostock and Piscataquis, have consistently ranked first and second over the years in the volume of timber cut and have accounted for approximately 40 percent of the total timber harvest. The net effect of what appears to be a limited transportation network in this region, insofar as wood enrgy is concerned, will probably be to limit the transportation distance of a low value product such as chipped biomass for fuel.

Terrain

As a whole, the state is not generally characterized as consisting of steep rugged terrain. The western area contains the steepest area containing portions of the White Mountains and it is in this region that the most severe limitations on the use of mechanized systems will be found. Other than this region, with respect to steep terrain limitations, there appears to be no significant areas that would severely constrain the use of whole tree chipping systems.

Summary

The State of Maine contains a large resource base that supports an active forest industry. With respect to the volume of timber products harvested, the pulp and paper sector is the most significant. Although current growth exceeds removals, removals are increasing at a rate faster than growth and this factor could create problems for the sawmill sector in the future. However, from a industrial wood energy standpoint, there are large quantities of currently unutilized, low quality material suitable for energy purposes. The availability of such material is dependent upon the economics of harvesting.

Although detailed land ownership data are not available yet for the state, it is assumed that the pattern is similar to that found in New Hampshire and Vermont wherein the amount of the resource held in small uneconomical parcels was not significant.

1982 Resurvey of Maine

In 1984, the Northeastern Station, USDA Forest Service, released a statistical report based on the 1982 forest survey of Maine. This report[24] was reviewed to determine if significant changes had occurred to the forest resource during the 11-year period since the last survey.

Although the recent resurvey indicates that there are disturbing changes taking place with respect to certain valuable commercial species, the 1982 data does not indicate trends that would have an adverse effect on wood biomass. It should be pointed out that for the purposes of this report only those factors that may affect the supply of wood biomass for industrial energy use were analyzed. In this limited context, three basic factors were examined: the size of the resource base in terms of the area of commercial forestland and the change since the last survey; the net volume in terms of cubic feet and the change between surveys; and the growth and removals data. An additional item, not present in the previous survey, has been included since it describes the resource in terms of biomass tonnage.

Commercial Forestland

During the period between the previous surveys (1958-1971), the amount of commercial forestland increased by almost 3 percent. In the interim (1971-1982), the increase has been approximately 1 percent and the current area of commercial forestland is estimated to be approximately 17.1 million acres. The latest data appears to indicate a leveling off in the amount of forestland which is not surprising since about nine-tenths of the state is considered forestland. In terms of significant changes among the nine geographic regions of the state, only two (Hancock County and Casco Bay Unit) registered declines that amounted to 9 percent and 1 percent, respectively.

Volume

The net cubic foot volume in the components, growing stock trees and rough/rotten trees, is now estimated to be 25,466 million cubic feet, an increase of approximately 5 percent over that reported in 1971. Again, we point out that from a biomass point of view, ignoring such concerns as to whether that increase has occurred on more desired species or on lower value components, the data indicates an increase in the biomass inventory over the survey period.

Growth vs. Removals

Net growth exceeded removals by an estimated 30 percent. However, there is a large discrepancy between softwoods and hardwoods in that softwood growth is only exceeding removals by about 5 percent. In contrast, hardwood growth exceeded removals by 94 percent. Total removals in 1981 amounted to some 601 million cubic feet (including salvable dead trees and material from other sources) as compared to approximately 476 million cubic feet in 1970. The average annual removals from growing stock volume for the period 1971-1981 was 349.5 million cubic feet. The average annual removals reported in the 1972 survey was 408.7 million cubic feet.

Green Weight

Estimates on green weight of forest biomass have only recently been added to state survey data. The Maine 1982 report contains the first estimate insofar as that state is concerned, thus, there is no historical data for comparison purposes. According to the recent survey, there is an estimated 1,504,381.8 thousand green tons of wood biomass on the commercial forestland of the state.

The tonnage for all species is distributed among the following classes of material.

Class of Material	Thousand Tons
Sawtimber trees:	
Sawlog portion	343,595.4
Upper stem	60,533.8
Sub-Total	404,129.2
Poletimber trees	346,378.6
Total all growing stock	760,507.8
Rough cull trees	78,536.1
Rotten cull trees	45,594.0
Salvable dead trees	33,341.1
Saplings	224,145.3
Stumps	20,581.9
Tops - growing stock	293,678.4
Tops - rough and rotten	47,997.2
Total all non-growing stock	743,874.0
TOTAL ALL CLASSES:	1,504,381.8

Average 88 tons per acre.

From a potential energy view, if it were possible to consider the current inventory of material in the rough rotten and salvable classes as readily available and further assume that it would be economically feasible to harvest only such material for industrial energy, then the present quantities would supply the equivalent of 11 50 MW utility plants over a 30-year lifespan (at a consumption requirement of 500,000 green tons/year).

Conclusion

The recent 1982 resurvey of Maine's forest resources does not indicate any significant change in the resource insofar as the potential for industrial energy use. The amount of commercial forestland has increased slightly in the interim between surveys, the net inventory of biomass has increased and growth still exceeds removals.

Massachusetts

The largest of the southern New England states, Massachusetts, has slightly less commercial land proportionately than Connecticut. Where Connecticut has 58 percent of its land in commercial forestland, Massachusetts has 56 percent. However, total commercial forestland in Massachusetts is 2.7 million acres versus 1.8 million acres in Connecticut.

Two resource surveys have taken place, in 1952 and 1971. In the interim, Massachusetts lost approximately 14 percent of its commercial forestland. Despite the decrease in land, the net volume of growing stock had increased significantly with the average cubic feet per acre reported at 1,213 cubic feet. The forest resource is not evenly distributed. The percentage of forestland on a county basis varies from a low of 28 percent to a high of 73 percent.[25] Generally, the most heavily forested areas are in the western portion of the state.

Land Ownership

As is the common pattern in the northeast, ownership of the forest resource is predominantly private. Federal lands are insignificant at nine thousand acres, less than one percent. While total public commercial forestland ownership is some 13 percent, the bulk of this ownership, 240 thousand acres is state forestland with the balance being county and municipal.

Forest industry ownership is negligible, being reported at 30 thousand acres, about 1 percent. Thus, 86 percent of the commercial forestland, 2.4 million acres, is private, non-forest industry ownership.

As is characteristic of an urbanized state, the forest resource is owned by owners holding small units. A study[26] undertaken in 1973 indicates that the 2.4 million acres of private commercial forestland of Massachusetts is owned by an estimated 103.9 thousand owners.

As is the case in Connecticut, a large number of small owners hold a significant portion of the resource. Table MA-1 indicates the private landownership pattern with respect to size classes of ownership.

Table MA-1

Estimated Number of Private Owners
and Acreage Owned - Massachusetts

Size Class	Owners		Acres Owned	
(Acres)	Number	Percent	Number	Percent
1-9	62,800	60	192,600	8
10-19	14,200	14	180,600	7
20-49	14,100	14	433,500	18
50-99	7,100	7	487,700	20
100-199	4,100	4	523,800	22
200-499	1,300	1	373,300	15
500+	300	-0.5	240,800	10
Total:	103,900	100	2,432,300	100

Thus in 1973, 33 percent of the privately owned land was in units smaller than 50 acres and 53 percent was in units smaller than 100 acres. As was pointed out in the Connecticut analysis, the current economics of whole tree chipping technology may preclude the harvesting of industrial wood energy from a significant portion of the state's privately owned commercial forestland.

Utilization and Growth

There has been a considerable fluctuation in the number of primary wood-using industries in the state since 1952. In that year, there were some 365 operating sawmills. At the time the 1971 survey[27] was conducted, there has been a drastic decrease to 123 mills. The 1980 directory of sawmill operators[28] lists 161 commercial mills and indicates a decrease from 177 in 1977. Thus, mill activity increased after the 1971 survey and appears, as of 1980, to be in a decline.

As might be expected from the distribution of the resource, the bulk of the mills are located in the western part of the state.

According to the 1980 Directory, there were some 144 loggers engaged in the harvesting of forest products.

In 1971, the survey indicated the following removals (Table MA-2).

Table MA-2

Industrial Roundwood Harvest - 1971

Product	Thousand Cubic Feet	Percent
Sawlogs	12,333	90
Pulpwood	1,042	8
Other(1)	288	2
Total:	13,633	100

(1) Veneer, logs and bolts, piling, poles, dimension bolts, roller handles and fencing.

As can be seen, sawlog production comprises the major (90%) volume. In conventional units, sawlog production amounted to 73.5 million board feet and pulpwood, 12 thousand cords. In addition, 533 thousand cubic feet or 6,660 cords of fuelwood were produced.

Total removals from growing stock, including logging residues and "other removals," amounted to 31.4 million cubic feet in 1971.

In 1976, a USDA Forest Service Report[29] indicates that total removals from growing stock amounted to 35.2 million cubic feet, an increase of 3.8 million cubic feet. In view of the reported growth in 1976 of some 141.8 million cubic feet, the data indicates a continuing growth that far exceeds reported removals. If the 1976 data are reflective of conditions since the last survey (1971), then inventories have continued to increase as harvesting activities remained fairly stable.

Since the pulp industry is often cited as a potential competitor for supplies, the 1978 survey of pulpwood production in the northeast was examined.[30]

The 1971 survey indicated a production of some 24.5 thousand cords of pulpwood almost evenly divided between roundwood (12.2 thousand cords or 1.0 million cubic feet) and plant by-products (12.3 thousand cords or 1.0 million cubic feet).

The 1978 survey, while indicating a insignificant increase in production (from 24.5 thousand cords to 28.1 thousand cords), does indicate a significant change in source. Roundwood production had decreased to 4.6 thousand cords while the equivalent in plant by-products had increased to 23.5 thousand cords. It would appear that pulpwood production remained a minor component of timber product utilization.

Fuelwood

In contrast to what appears to be a rather stable situation with respect to the utilization of industrial roundwood products, residential fuelwood use presents a different picture. A 1980 study[31] indicates significant increases in the use of residential fuelwood.

The 1971 survey reported a total fuelwood output of some 15 thousand cords or 1.2 million cubic feet. Of this amount, 6.6 thousand cords or 533 thousand cubic feet came from roundwood while a greater amount, 8.4 thousand cords or 672 thousand cubic feet, came from plant by-products. Fuelwood usage in 1976, 1977, and 1978 are reported to be approximately 611, 701, and 816 thousand cords, respectively. The actual amount of fuelwood acquired (not burned) in 1978 was approximately 919 thousand cords or 75.5 million cubic feet.

This 75.5 million cubic feet of residential firewood represents twice as much volume as the total removals reported in 1976. While the source of the fuelwood supplies is not known, in view of the reported volume of unused residues at sawmills in 1971 and the reported pulp production from mill residues in 1978, it is highly unlikely that significant quantities of fuelwood came from forest industry residues.

Although several studies have been done in the northeast on residential fuelwood use, it is impossible to utilize the data in terms of evaluating the effect of residential fuelwood use on the resource. Most all investigators indicate how much wood is cut versus the volume purchased. For the "self-cut" category, most researchers categorize, to some extent, sources. Thus, a Vermont study indicates that approximately 33 percent of cut wood came from trees/branches blown down, dead, or rotten. But the same study indicates that 32 percent came from unknown sources. Other researchers have utilized different categories with such broad definitions as "live trees." Practically all researchers, because the surveys have been consumer oriented, have not attempted to explore where the purchased wood originates. Massachusetts' purchases amount to about 38 percent of the total acquired or the equivalent of some 28 million cubic feet. If, as the various reports infer, fuelwood is not competing for sound merchantable material suitable for industrial products, then it is competing for much of the material suitable for low value wood chip energy; namely, logging residues, land clearing material, rough and rotten, and surplus growth.

Chipping Technology

There appears to be no widespread application of whole tree chipping technology. Current operations appear to be associated with land clearing operations. The 1978 assessment of pulpwood production in the northeast does not indicate any Massachusetts production insofar as pulp is concerned.

Transportation

Transportation limitations should not be a major limiting factor within the state. Massachusetts contains an excellent network of roads and highways north to south and east to west that not only provide for internal movement but also provide linkage with surrounding states and their resources.

Terrain

Terrain limitations with respect to current technology will reduce availability of the resource in local situations. It does not appear to be a major factor. One limited analysis was undertaken[32] for Franklin County, Massachusetts, which is located in the northern part of the state bordering on Vermont and New Hampshire. The analysis was limited to the category of "dense, older forests" defined as those forests 40-plus feet in height and with at least 80 percent crown closure. The study indicated that this category of forestland amounted to approximately 61 percent (285 thousand acres) of the total land area. With respect to slope, it was determined that 22 percent (62 thousand acres) of the category was on slopes 15-25 percent and 25 percent (71 thousand acres) were on slopes greater than 25 percent. If one selects a 25 percent slope as the limit for effective use of a mechanized system, then approximately 25 percent of the category would be unavailable with current technology. However, the 71 thousand acres of "dense, older forests" on slopes over 25 percent only represent approximately 20 percent of the total forest resource. By limiting the investigation to one category, one can only obtain a short-term view of a portion of the resource, since over the life cycle of a wood-using facility other categories of forestland will reach a harvest stage. Had the total forest resource been analyzed with respect to slope, a more definitive picture could be obtained in terms of availability or unavailability because of terrain conditions.

Special Conditions

Massachusetts does have a Cutting Practices Law (M.G.L., Ch., 32, Sections 40-46) which, in essence, requires timber landowners to notify the Bureau of Forest Development of intentions to cut timber from forestlands. Before cutting proceeds, an approved cutting plan must be obtained.

In addition, those engaged in the business of harvesting timber or other forest products for hire or profit must obtain a license from the state.

The net effect of this law on a potential industrial wood user would be indirect and, in some instances, direct. Indirectly, the effect might be a certain constraint upon supply in terms of volume removed. Clear-cutting is not prohibited under the law but dependent upon the degree of enforcement, indiscriminate clearcutting would be limited. In view of the larger number of small owners, the details involved in notification procedures, cutting plans and other reporting requirements may deter some landowners from harvesting. It should be noted that the law, so far, does not appear to have inhibited the harvesting of forest products since available data indicates that supply has been able to adjust rather rapidly to periodic fluctuations in demand.

If the large industrial user should elect to engage in harvesting operations in order to ensure an adequate supply system, then as a harvester an annual license would be required. This requirement does not appear to have had a detrimental effect on the number of harvesters available since the directory indicates a fairly large number of individuals engaged in harvesting as well as several out-of-state listings.

Summary

At the present time, available information seems to indicate that the resource base in Massachusetts is capable of supporting a limited number of intermediate, large-scale industrial facilities. Although current forest industrial use is a minor portion of the net annual growth, the resource base is not large and the pattern of many small wood lots may, in local situations, result in much of the resource being unavailable from an economic standpoint. The limited number of primary forest industries in some regions will create difficulties in the establishing of whole tree chipping systems for the production of low value wood energy chips. The most favorable situations would appear to be in the western and northern areas where the resource base is more concentrated as are the primary forest industries and the harvesting infrastructure and, equally important, the opportunity to tap the resource base of such states as Vermont and New York.

New Hampshire

Three forest surveys have been undertaken in New Hampshire, 1948, 1960, and 1973. These surveys indicate there has been little change in the amount of commercial forestland over the years and in 1973 the state had about the same acreage as reported in the first survey, almost 4.7 million acres. Forests cover 86 percent of the land area ranking the state as the second most heavily forested state in the nation, second to Maine.[33]

Although the area of commercial forestland did not change significantly over the 25-year span of the surveys, the volume of growing stock increased some 60 percent due to a declining timber demand. As of the latest survey, the growing stock volume amounted to some 6.6 billion cubic feet. In addition to growing stock volume, there was an additional 8.6 million cubic feet in rough and rotten trees.

The commercial forestland is fairly evenly distributed throughout the state with all of the 10 counties being at least 71 percent forested.

On a per acre basis, the average volume of growing stock was 1,402 cubic feet. Ninety-four (94) percent of the commercial forestland is fully stocked or overstocked with trees of all kinds; however, only 54 percent of the forestland is stocked with growing stock trees. Thus, on an average acre, one in three trees is classed as rough or rotten.

Land Ownership

As of 1973, 87 percent, 4.1 million acres, of the commercial forestland was in private ownership.[34] Most of the 13 percent in public ownership is in the White Mountain National Forest (10%); thus, New Hampshire has the highest percentage of all the northeastern states in Federal ownership, conversely, the state has the lowest percentage of the states in state and local ownership.

Although there are fewer than 50 forest industry owners in New Hampshire, they account for almost 947 thousand acres of commercial forestland, 23 percent of total private ownership.

There are a large number of private owners, some 87 thousand in fact, and the bulk are individuals owning some 2.4 million acres which represents approximately 60 percent of the private commercial forestland. Thus, the availability of the resource, for whatever purpose, is dependent upon the decisions of numerous owners.

Of major significance, at least in terms of harvesting economics, is the pattern or distribution of size class ownerships. Table NH-1 indicates the amount of commercial land and number of owners involved in various size classes.

Table NH-1

Estimated Number of Private Owners of Commercial Forestland
and Acreage by Size Class, New Hampshire, 1973

Size Class (Acres)	Number of Owners	%	Acres Owned	%
1-9	55,900	64	159,100	4
10-19	8,200	9	103,400	2
20-49	9,300	11	270,600	7
50-99	6,800	8	469,600	11
100-199	4,700	5	604,700	15
200-499	2,000	2	596,800	15
500+	600	1	1,877,900	46
Total:	87,500	100	4,082,100	100

In contrast to the land ownership patterns found in the three southern New England states and such other urbanized states as New Jersey, the amount of land in New Hampshire in parcels less than 100 acres is approximately 24 percent, while in the more populated states such acreage is much more significant ranging from 53% to 66%.

Utilization and Growth

The 1972 survey indicated some 185 primary wood-user industries in the state including 142 sawmills, 2 woodpulp mills, 16 wood chipping plants and 25 specialty industries. A 1980 report[35] lists 252 sawmills, 10 turnings and square mills, 2 pulp mills, 1 veneer plant, and 4 miscellaneous. Thus, the number of sawmills increased, veneer and pulp mills remained unchanged while other categories declined.

While the primary industries are generally distributed throughout the state, with the exception of the north central area which contains the White Mountain National Forest, the majority of the industries are found in the southern half of the state.

In 1972, sawlog production, including veneer, accounted for 60 percent of the total cubic foot production of industrial roundwood products, with pulpwood accounting for approximately 34 percent.

Between the two surveys of 1959 and 1972, sawlog production declined from approximately 233 million board feet to 182 million board feet, a decrease of 22 percent. Pulpwood production also registered declines, from 216.4 thousand cords to 200.7 thousand cords.

Although New Hampshire does not annually survey roundwood production, the 1980 report does present data on annual cuts of lumber and other products based upon reports of the Yield Tax Receipts. The data carries the caution that the estimates are generally regarded as low due to under-reporting. However, this data does serve as a guide to the trend in production since the last survey (Table NH-2).

Table NH-2

Annual Cuts of Lumber and Other Products According to Yield Tax Receipts, New Hampshire, 1972-1979

Year	Sawlogs (1000 Bd.Ft.)	Pulpwood (Cords)	Boltwood (Cords)
1972	136,979	178,846	4,820
1973	145,674	163,193	13,054
1974	179,984	205,825	4,451
1975	175,354	171,016	20,551
1976	164,367	187,488	4,778
1977	192,705	182,154	12,595
1978	186,823	120,312	3,807
1979	241,477	276,957	26,429

Despite the inaccuracy of the information, the general trend conforms to data available from the adjoining states of Maine and Vermont, and indicates increasing production of both sawlogs and pulpwood exceeding 1972 production and in 1979, exceeding production reported in 1959.

The total industrial roundwood harvest as reported in 1972 is shown in Table NH-3 along with estimated production for 1979. The latter year is taken from New Hampshire data and, insofar as accuracy is concerned, should be used with caution.

Table NH-3

Industrial Roundwood Harvest - 1972, 1979
(Thousand Cubic Feet)

Product	1972	1979
Sawlogs	30,466	40,246 (2)
Pulpwood	17,060	23,541
Other	2,679 (1)	2,246 (3)
Total:	50,205	66,033

(1) Includes veneer logs and bolts, cooperage logs and bolts, piling, posts, dimension, excelsior, and turney bolts.

(2) Probably includes veneer logs.

(3) Material other than logs.

Source: Reference NH-3

Roundwood removals, when compared to net annual growth, indicates net annual growth in excess of removals. In 1972, the net annual growth of growing stock was some 236.3 million cubic feet compared to total roundwood removals from all sources amounting to 51.6 million cubic feet of which 44.1 million cubic feet came from growing stock. Although new survey data are not yet available, a 1976 estimate[36] by the USDA Forest Service indicates that in 1976 net annual growth for New Hampshire was 251.6 million cubic feet versus a roundwood production of 55.4 million cubic feet from all sources with the portion coming from growing stock estimated to be 47.3 million cubic feet.

There is a considerable quantity of low value (rough and rotten) material present in the resource. Of the total trees, 1-in-3 is in the rough and rotten category; in trees over 5.0 inches in diameter, 1-in-5. The 1972 report indicates that of the estimated 867 million cubic feet of this material, only a negligible amount, 2.0 million cubic feet, were utilized in the production of roundwood products. Although the use of fuelwood has increased significantly in recent years and undoubtedly is making use of such material to some extent, it is highly unlikely that volumes are being reduced significantly.

Fuelwood

In addition to industrial roundwood products, in 1972, approximately 1.4 million cubic feet of fuelwood from roundwood was harvested (estimated to be 18,668 cords.)

Although the 1980 New Hampshire report indicates that in 1979, some 35 thousand cords of fuelwood were cut, this is about 10 percent of what was reported burned during the 1978-79 heating season in a 1980 New England Fuelwood Survey.[37] The higher figure of 376 thousand cords is a more accurate figure to use. This would represent an additional 30 million cubic feet, most, but not all coming from roundwood production.

Chipping Technology

Chipping technology is being utilized in the state. While data are lacking on the number of operations, a marketing report published by the state is the only known effort in the northeast that includes references to the price of total tree chips both for pulp and fuel.[38] According to the 1982 report, pulp quality chips (both hardwood and softwood) average $13.00 per green ton, including stumpage, at the point of production. The delivered price would vary dependent upon transportation distance. The average price for fuel quality chips (biomass) ranges from $10.00 - $13.00 per green ton at the point of production, with delivered prices to New England markets ranging from $13.00 - $22.00 per green ton.

For comparative purposes, it should be noted that the same report lists the prices of pulp chips produced from mill residues (Table NH-4).

Table NH-4

Mill Residue Pulp Chips
(Produced from Slabs and Edgings)

Species	F.O.B. Sawmill Per Green Ton	Delivered to Pulp Mill Per Green Ton
Pine and Hemlock	$12.00	$19.00-$27.00
Spruce and Fir	$12.00-$14.50	$23.00-$30.00
Hardwoods (mixed)	$10.00-$13.00	$18.00-$23.00

It should also be noted that the USDA Forest Service is currently funding the New Hampshire Division of Forests and Lands, Department of Resources and Economic Development, to undertake studies of whole tree chipping systems under a range of field conditions.

Transportation

From a statewide perspective, the transportation network ranges from well-developed in the southern half of the state, where settlement and development has concentrated, to limited in the more sparsely populated northern region. In addition, the presence of the White Mountain National Forest and the nature of the terrain restricts road systems both north and south as well as east to west. Thus, as one travels northward, the ability to transport products in a direct and economical manner becomes increasingly difficult and becomes a critical factor with respect to a low value product such as wood energy.

It can be expected that on a site-specific basis, the limitations with respect to major transportation networks will be reflected at the local level.

Terrain

In terms of what is currently known about the limitations that steep terrain imposes on whole tree chipping operations, it would appear that considerable areas of commercial forestland in the northern part of the state, the White Mountain area, may be limited with respect to the use of whole tree chipping technology. In this region, there are numerous elevations that range from 3,000 feet to Mt. Washington, the highest point, in excess of 6,000 feet. The steepness of the terrain will, in some areas, preclude the use of mechanized equipment and in other areas severely reduce production.

Special Conditions

The most noteworthy of the regulations pertaining to the harvesting of forest products in New Hampshire is the Yield Tax (Revised Statutes Annotated 1979). In essence, the Yield or Severance Tax is a ten percent tax based upon the stumpage value at the time of cutting. Although the tax should and probably is reflected in the ultimate cost of the product, the harvest data available does not indicate that the tax has had an adverse effect on the removal of wood products from forestland.

Summary

There is a significant resource base that supports an active and apparently expanding forest products industry. In turn, the industry is supported by an extremely adequate supply structure as evidenced by the significant and rapid increases in production since the last survey. Although there are numerous private landowners of the resource, the amount of forestland in small, uneconomical units does not at this time appear to be a significant factor when viewed at a state level. Because recreation is a large factor in the economy and due to the ready proximity to the large population concentrations in other parts of the northeast, small land ownerships may be a factor in some local areas where recreational development is predominant. In the northern region, the large concentration of Federal land and its recreational orientation, plus a limited transportation network and steep terrain, will be factors that will reduce the effective use of the resource for industrial energy.

1982 New Hampshire Resurvey

In 1982, the U.S. Forest Service, Northeastern Station, conducted the fourth survey of New Hampshire's forest resources. While the results of the survey are still in preparation, some preliminary data were made available to PYROS, Inc. to permit updating some of the more pertinent information initially discussed in this report.

1. Timberland Area (formerly known as commercial forestland in previous reports)

The latest survey indicates that the timberland area is now approximately 4,803,475 acres, an increase of about 2 percent since the 1973 survey.

2. Growing Stock

The net volume of growing stock is now estimated to be some 8.3 billion cubic feet. This represents a 25 percent increase over the 6.6 billion reported in the 1973 survey.

3. Rough and Rotten

The volume in rough and rotten trees is estimated to be some 953.8 million cubic feet, a 10 percent increase since the last survey.

4. Green Weight

The green weight data, included for the first time, are estimated to be some 502 million tons including material classified as salvageable dead trees.

Insofar as this report is concerned, the latest survey data does not allow the conclusions based upon analysis of earlier information. Although the above is based upon preliminary data, it is evident that growth is still exceeding removals and the amount of forestland continues to remain at a fairly stable level.

New Jersey

Two surveys have been completed of the state's timber resources, the first in 1955 and the second in 1971. Over the 16-year period, the amount of commercial forestland decreased 12 percent from an estimated 2,120 thousand acres to 1,856 thousand acres. Commercial forestland now comprises 38 percent of the land area.

The resource is not evenly distributed. Of the 21 counties, four, located in the northeastern sector, are considered to have no commercial forestland. In the other counties, the amount of commercial forestland varies from a low of 22 percent to a high of 60 percent.

Despite the significant loss of productive land, the growing stock volume increased by 10 percent in the interim between surveys and as of 1972 contained approximately 1.4 billion cubic feet.[39]

Land Ownership

Commercial forestland ownership is predominantly private. Public ownership amounts to approximately 319 thousand acres, or 17 percent. The bulk of this, 13 percent, is in state forests.

Of private land, that owned by forest industry is negligible, only 1 percent or approximately 16 thousand acres. The resource base is held by numerous owners estimated at over 63 thousand.[40]

In view of the fact that the resource base is limited and there are a large number of owners, it is not surprising that a significant portion of the resource is in small parcels. Table NJ-1 indicates the pattern of private commercial forestland ownership in the state.

Table NJ-1

Estimated Acreage and Number of Private Owners of
Commercial Forestland by Size Class, New Jersey, 1972

Size Class	Number of Owners	Acreage	Percent (Acreage)
1-9	34,600	190,800	12
10-19	11,300	196,600	13
20-49	12,700	370,000	24
50-99	3,100	254,400	17
100-199	1,400	208,100	13
200-499	400	150,300	10
500+	100	167,700	11
Total:	63,600	1,537,900	100

Source: Reference 40.

From the above data, it can be seen that 25 percent of the privately owned commercial forestland is in parcels smaller than 20 acres and almost 50 percent is in parcels under 50 acres.

One interesting feature of the New Jersey landowner survey is the statistic that indicates that 59 percent of the private landowners indicated they never plan to harvest their land. While this percentage is not unusual compared to some other states in the region (for example, the response was 67 percent in New Hampshire and 55 percent in Vermont), the amount of forestland potentially affected by such plans varies significantly. In both New Hampshire and Vermont, the amount of commercial forestland involved was only 13 percent, whereas in New Jersey the amount is 49 percent. Thus, in New Jersey if the landowners maintain their position, then approximately one-half of the privately owned acreage will not be available for harvest.

It should be noted that there are many reasons why, at any particular time, a given number of landowners may state their intentions not to harvest and the data should not be interpreted to mean there is widespread opposition to harvesting. The data does indicate that there are large numbers of owners holding considerable acreage of forestland who have no plans to harvest and this introduces a large degree of uncertainty with respect to availability of supply.

Utilization and Growth

New Jersey is a highly urbanized state with one of the highest population densities in the nation. Timber products are not as significant in the state's economy as is the case in many of the other states in the region.

In 1955, the survey indicated there were 150 active sawmills in the state. The 1972 survey indicates 45 commercial mills were in operation. A 1982 sawmill directory[41] lists 59 sawmills of which 21 are categorized as part-time.

Three wood-using pulpmills were operating in 1970; however, these mills were not dependent upon roundwood production from timber stands relying instead on feedstock from waste paper, cardboard, and other fiber products.

Of the 59 sawmills, the majority (38) are located in the southern counties.

In view of the fact that timber products are a minor component of the state's economy, it can be expected that the production of timber from forestland is small. Timber removals from growing stock, as reported in 1971, was 16.0 million cubic feet. With respect to the output of roundwood products, the major category was pulpwood, followed by fuelwood, then sawlogs and miscellaneous products (Table NJ-2). This is a slightly different ranking of products than that found in most of the other states, especially with regard to fuelwood.

Table NJ-2

Output of Roundwood Products - New Jersey, 1970

Product	Thousands of Cubic Feet
Pulpwood	3,720
Fuelwood	3,216
Sawlogs(1)	2,201
Other(2)	1,264
Total:	10,501

(1) Includes 215 thousand cubic feet of veneer logs.

(2) Includes piling, posts, poles, fencing bolts, handle stock, dimension bolts, and mine timbers.

For the major products, in conventional units, the data in Table NJ-2 indicates the following production:

Pulpwood	46,505 cords
Fuelwood	40,200 cords
Sawlogs	15,214,000 board feet

Although New Jersey does not monitor annual removal of timber products, some indication as to production trends can be gained from data furnished by the state with respect to the estimated harvest in 1979.[42] This data indicates that the production of pulpwood had declined to 20,000 cords, fuelwood had increased to 900,000 cords, and sawlogs had increased to 23,492,000 board feet.

The information indicates a drastic decrease in pulp production. Although a change in production might be reflective of economic conditions in a particular industry, if this was the case in New Jersey, it was very local since examination of pulpwood harvests in Vermont and Maine (the two states who do monitor annual harvests) do not indicate declines in production.

Although the 1970 survey indicated a favorable growth to removals ratio (25 million cubic feet versus 16 million cubic feet), this ratio may have been significantly altered by fuelwood usage in the intervening years.

Fuelwood

With respect to fuelwood, the reported data indicates a significant increase over the figures shown in the 1971[39] survey. In the intervening years, the oil situation obviously has resulted in a dramatic change in the use of wood for residential heating.

In view of the significant increase in fuelwood, and the rather limited resource base, the fuelwood data was examined to determine the effect that increased utilization might be having on the resource. As indicated in other areas of this report, existing data on fuelwood sources are somewhat fragmentory and incomplete.

With respect to New Jersey, a special fuelwood use survey was conducted in 1981 updating the above 1979 information.[43] The survey indicates consumption of approximately 1 million cords. According to the survey, cordwood acquisition is divided into two broad categories: purchased versus self-cut. Of the total, the self-cut category amounted to approximately 686 thousand cords (68 percent), or approximately 54.8 million cubic feet.

The survey contains source information with respect to the volume of "self-cut," but not the purchased category. For the "cut" category, consumer responses indicated the following sources of fuelwood (Table NJ-3).

Table NJ-3

Sources of Self-Cut Residential Fuelwood

Source	Cords	Cubic Feet	Percent
Live trees	129,000	10,320,000	19
Dead trees	418,000	33,440,000	61
Tops	11,000	880,000	2
Rural tree removal	29,000	2,320,000	4
Urban tree removal	99,000	7,920,000	14
Total:	686,000	54,880,000	100

Analysis of the above has to be done with some degree of caution. The information does not relate data to the commercial forestland base, hence some of the sources undoubtedly consist of material from non-commercial forestland. One important category is the indicated production from "live trees." Insofar as commercial forestland is concerned, sources could include growing stock and material from the rough and rotten inventory. If substantial quantities or volumes are coming from the growing stock category, then in terms of the reported 1970 growth data which indicated that the average annual net growth was 25 million cubic feet, then fuelwood removal, plus industrial product removal, could be bringing growth and removals into balance.

If the category classified as "tops" is strictly interpreted to mean material from logging operations on commercial land, then according to the 1970 data, a high portion of logging residues are being utilized.

A significant "unknown" is the source of the "purchased" wood category. This represents an additional 25 million cubic feet.

The uncertainty about the source of the reported large volumes of fuelwood adds a complication to any analysis of the potential for industrial wood energy use in the state.

Chipping Technology

It is not known to what degree chipping technology is being utilized in the state. Certainly the status of the pulpwood industry and the small quantities of roundwood produced do not provide a significant stimulus for investment in equipment. In addition, the relatively small size of the primary forest industry and its supply demands on the timber resources of the state indicate a rather modest supply system. Unlike the situation in other states where chipping systems are operated in association with the production of conventional timber products, chipping systems in New Jersey will be dependent on chip markets exclusively.

That chipping technology is being utilized, to some degree, is evidenced by references in a special area report[44] that indicates wood chips are produced in the Pinelands region from right-of-way clearings, housing development, and agricultural reclamation. Material is utilized in sewage sludge management and roofing shingle manufacture.

Transportation

New Jersey's highly urbanized status and its proximity to other highly developed areas has resulted in a comprehensive transportation network that provides direct access not only to all regions of the state but also to surrounding areas. It does not appear that transportation would be a factor adversely affecting a supply system.

Terrain

The state cannot be characterized as possessing rugged terrain. The fact that the state is one of the most densely settled is testimony to the fact that terrain features have been conducive to development, and whatever supply is available will not be limited due to adverse land features.

Special Conditions

A significant portion of the commercial forestland is located in the southern portion of the state and is designated as the "New Jersey Pinelands." Approximately 69 percent of the area containing an estimated 680 thousand acres of commercial forestland is privately owned. This area has received considerable attention and has been the object of special legislation known as the Pinelands Protection Act which is administered by the New Jersey Pinelands Commission.

Authorities are considering how best to bring about approved management practices to protect and conserve this area. It is quite evident that the production of timber products is considered important; thus, whatever controls are imposed will take into consideration timber production. At this time, no conclusions can be made as to what affect future administrative decisions may have on any potential supplies.

Summary

Several factors will limit opportunities to utilize wood biomass for industrial energy purposes in intermediate-size facilities insofar as the state's resources are concerned.

The resource base is not large or well distributed throughout the state. It is reasonable to assume that urbanization of the area will continue with the result being a further decrease in the amount of commercial forestland and continued sub-division of that remaining into numerous small units. It is estimated that currently almost 50 percent of the resource is in ownership parcels less than 50 acres.

While it is feasible to import supplies from neighboring states, many adjacent areas in both New York and Pennsylvania are heavily urbanized. The fact that New Jersey is a coastal state will also limit the size of an economic supply zone for many sites.

New York

Three forest resource inventories have been completed for New York state by the USDA Forest Service. Previous studies were made in 1956 and 1970, the most recent study was conducted in 1980.[45] The most current data indicates that commercial forestland increased approximately one million acres from that reported in 1970 and now amounts to 15.4 million acres, 51 percent of the total land area.

Growing stock volume has increased to 15.8 billion cubic feet, a 38 percent increase between surveys. The average cubic foot volume per acre is 1,024 cubic feet.

In general, the resource is fairly well distributed throughout the state. As might be expected, local areas with large urban communities; i.e., Syracuse, Buffalo, New York City, will have limited quantities of commercial forestland.

At this point it should be indicated that New York State is a complex area to analyze. It is a large state with a large degree of diversity among its regions in terms of terrain, climate, population and development. In addition, there are several counties marked by a non-uniformity in size, ranging from slightly over 100 thousand acres to over one million acres. Population densities vary from extremely dense concentrations in the New York City area to the remote and sparsely populated regions in the upper Adirondacks.

In order to permit more manageable use of the data, the state has been divided into eight units. These units are not uniform with respect to land area and range in size from 2.6 million acres to 6.0 million acres. Table NY-1 indicates the units, their size, and the relation between commercial forestland and total land area.

Table NY-1

Geographic Units, Total Land Area and
Commercial Forestland, 1980

Geographical Unit	Total Land Area (1000 Acres)	% of Total State Area	Total Commercial Forestland (1000 Acres)	% of Total Commercial
Lake Plain	6,044.6	20	2,164.4	14
Southwest Highlands	3,107.8	10	1,732.5	11
South-Central Highlands	4,048.7	13	2,416.9	16
Adirondack	4,348.9	14	2,598.4	17
Western Adirondack	2,846.0	9	1,554.8	10
Eastern Adirondack	2,844.8	9	1,268.0	8
Capitol District	2,627.1	9	1,394.8	9
Catskill - Lower Hudson	4,366.7	15	2,276.0	14
Total:	30,234.6		15,405.8	

Source: Reference 45.

From the above, it can be seen that only two units, Lake Plain and Eastern Adirondack, have less than 50 percent of the land area in commercial forestland. However, with respect to the Eastern Adirondack unit, approximately 94 percent of the total area is forestland. This unit has a high proportion of forestland (1.4 million acres) in a Reserve.

Land Ownership

The ownership of commercial forestland is primarily private and amounts to approximately 94 percent. Federal land is negligible being less than 1 percent. State and local government holdings comprise 6 percent.

Of the private ownership, it is estimated there are 300 forest industry owners with approximately 1.0 million acres.[46] This would represent a slight decrease from 1.1 million acres reported in the 1968 survey.[47] That survey indicated that of the 1.1 million acres, the pulp and paper industry owned 0.7 million acres (60 percent), the lumber industry 0.2 million acres (20 percent), and "other" was 0.1 million acres (10 percent).

In 1980, total private owners were estimated to be 506,500, including 300 forest industry. Of the remaining, the largest category was individual, with some 333,000 individuals, followed by farmers estimated to be 133,500. Corporate and other owners amounted to 39,200.

In terms of commercial acreage held by these owners, individual-held acreage is estimated at 7.2 million acres or 50 percent; farmer-held acreage is 3.9 million acres or 27 percent; corporate and others, 2.1 million acres or 15 percent; and forest industry at 1.0 million acres or 7 percent.

In a situation where there are many private owners of the resource, there are at least two factors that can have an effect on potential supply. The first involves the potential problem of adequate supplies being dependent upon the decision of many individuals. As has been documented in many studies, owners express many reasons for owning forestland and these reasons create an attitude with respect to harvesting. Fortunately, all the studies indicate no significant hostility to harvesting activities. Attitudes can change, of course, especially in local situations. However, as several researchers have pointed out, over a period of time, ownerships change and, therefore, attitude surveys as such can only reflect responses at a point in time.

However, the second factor which involves the pattern of private landownership with respect to size can be significant now and in the future when viewed from what currently appears to be the economics of whole tree chipping. Despite the gross size of the resource, a continuing trend towards fracturing the resource into smaller uneconomical units can have adverse consequences both for supplies of traditional industrial products as well as chipping.

Two studies,[46,48] although not entirely comparable, provide some indication as to the trend in private forestland ownership during the interval between the 1968-1979 surveys. (Table NY-2).

Table NY-2

Private Commercial Forestland in New York State
Size Class - 1980-1968

Size Class (Acres)	1980 Acres Owned	Percent	1968 Acres Owned	Percent
0-9	902,400	6	214,800	2
10-19	1,011,600	7	---	
(10-49)	---		2,530,600	19
20-49	2,658,500	18		
50-99	2,516,000	18	1,788,500	15
100-199	2,342,500	16	---	
(100-249)	---		2,775,300	21
200-499	1,837,200	13	---	
(250-499)			1,564,900	12
500-999	542,600	4	756,400	6
1000+	2,616,000	18	3,776,300	27
Total:	14,426,800		13,389,100	

From the above, it can be seen that the commercial resource has and probably will continue to be fractured into smaller and smaller units owned by increasing numbers of individuals. The very small units, 0-9 acres, quadrupled in size and now represents 6 percent of the private commercial forestland. The under 50-acre category now comprises 31 percent, a situation similar to conditions found in Connecticut and Massachusetts. Only the category 100-500 acres remains basically stable.

Utilization and Growth

The two major sectors of New York States' forest industry are the sawmill industry and the pulp and paper industry. In 1979, sawlogs accounted for over 60 percent of the total harvest with pulpwood comprising more than 36 percent.[49] In 1967, sawlog production was 55 percent of the total harvest and pulpwood about one-third.

Sawmills in a quantitative sense have, over the years, experienced a drastic decline in numbers falling from almost 1,800 in 1947 to 302 in 1967. However, during the 1970s, this decline has apparently reversed and some 467 were listed in 1976 increasing to 494 in 1979.

Although the sawmill industry is widely distributed throughout the state, on a regional basis there are significant differences both in numbers of mills and production (Table NY-3).

Table NY-3

Regional Location of Sawmills and Production - 1979

Region(1)	Number of Sawmills	%	Production (Million Board Ft.)	%
Northern	178	36	176.6	30
Southeastern	83	17	134.8	23
Southwestern	233	47	284.5	47
Total:	494	100	595.9	100

Source: Reference 49.

(1) The source report further consolidates the state into three regions. For identification, the three regions comprise the following units identified in Table NY-1 (page 2).

Northern Region: Adirondack, Western Adirondack, Eastern Adirondack units

Southeastern Region: Capital District, Catskill-Lower Hudson units

Southwestern: Lake Plain, Southwest Highlands, South Central Highlands units

In contrast to the sawmill industry, the pulpwood industry while increasing production has accomplished this with fewer mills. In 1967 there were a reported 16 mills; in 1974, 13 mills; and in 1979, 11 mills. The pulpwood industry is concentrated in the northern region, as is pulpwood production.

Table NY-4 indicates, by region, pulpwood production for the two survey years, 1967 and 1979.

Table NY-4

Pulpwood Harvest, by Region, for 1967, 1979

Region	Pulpwood Harvest (Cords) 1967	%	1979	%
Northern	274,800	70	516,200	79
Southeastern	60,800	15	85,000	13
Southwestern	58,700	15	49,600	8
Total:	394,300	100	650,800	100

Source: Reference 49.

Although quantitative data on the logging industry are not available, it is obvious from the size of the forest industry and the significant increases in production that a substantial supply system exists.

Production of roundwood products has increased substantially when the two survey periods are examined (Table NY-5).

Table NY-5

Industrial Roundwood Harvest - 1967, 1979

Product	1967 (Thousand Cubic Feet)	1979
Sawlogs	56,025	91,997
Pulpwood	31,554	55,318
Other(1)	10,305	4,939
Total:	97,884	152,254

Includes: Veneer logs and bolts, bat stock, piling, poles, posts, cabin logs, bowl stock, handles, ladders, shingles, dimension stock, and chemical wood.

In addition, in 1967, there was 35.5 thousand cubic feet of fuelwood from roundwood, representing 444 thousand cords which increased to 265.6 thousand cubic feet or 3.3 million cords in 1979.

Total removals from growing stock including logging residues and "other removals" increased from 136.7 thousand cubic feet in 1967 to 251.6 thousand cubic feet in 1979.

Although the total quantities of removals have increased significantly between surveys, it should be again pointed out the resource base has also increased. If one examines the reported net volume of all live timber on the commercial forestland as reported in 1980, it comprises some 17.4 billion cubic feet. When compared to the total cubic foot removals, removals were 2-3 percent of net volume. In terms of net growth for the period between surveys, average net growth of growing stock was approximately 2-1/2 times timber removals.

It should be noted that the most recent report describing the forest resources of New York State includes, for the first time, statistics on the net weight of all live timber on commercial forestland. Thus, it is now possible to convert traditional forestry statistics to terms and units more comprehensible to those potential users with an interest in fiber. Table NY-6 is an excerpt from the survey, further modified to indicate estimated tonnage of the various components on a per acre basis.

Table NY-6

Net Volume and Weight of All Live Timber on Commercial Forestland by Class of Material, New York, 1980

Class of Material	Volume (a) All Species (Million Cubic Ft.)	Volume (b) All Species (Thousand Tons)	Tons/Acre
Sawtimber trees:			
Sawlog portion	7,644.8	332,278.9	
Upper stem	1,593.2	68,112.3	
Total:	9,238.0	400,391.3	26
Poletimber trees	6,531.9	256,596.3	17
Total Growing Stock	15,769.9	656,987.5	43
Rough trees (c)	1,162.1	50,241.7	3
Rotten trees (c)	498.3	17,563.5	1
Saplings (d)	---	169,611.2	11
Stumps (e)	---	16,265.1	1
Tops, Growing stock	---	213,411.9	14
Tops, Rough & Rotten	---	40,289.9	3
Total:	17,430.3	1,164,370.8	76

(a) Excludes bark
(b) Includes bark and sound cull
(c) Bole portion of trees 5.0 inches dbh and larger
(d) Includes entire tree above ground
(e) Of all live trees 5.0 inches and larger.

Source: Reference 45.

- There is a significant quantity of low-value material in the rough and rotten category, in excess of 1 billion cubic feet and representing over 100 million tons. This material is finding little utilization in terms of the reported 1979 removals data, only 27.6 million cubic feet or some 1.1 million tons, about 1 percent.

- There is considerable material in logging wastes representing 47 million cubic feet from the growing stock category. This represents a quantity probably in excess of one million tons.

Fuelwood

The significant volume of fuelwood, the largest reported for any of the northeast states was analyzed in terms of the possible effect it was having on the resource base. Output from roundwood amounted to some 3.3 million cords, 5 times the volume of pulpwood, plus an additional equivalent of 241 thousand cords from manufacturing residue. This was slightly larger than the estimated 207 thousand cords of manufacturing residue going to the pulp industry.

Table NY-7 illustrates the reported source of fuelwood in 1967 and 1979.

Table NY-7

Estimated Source of Fuelwood for 1967, 1979
(Thousand Cubic Feet)

Source	1967	%	1979	%
Growing Stock	9,928	23	33,284	11
Rough and Rotten	12,541	29	21,106	7
Salvable Dead Trees	8,425	20	119,418	42
Other Sources	4,626	11	91,932	32
Mill Residues	7,116	17	19,349	7
Total:	42,636	100	284,989	100

Source: Timber Resources of New York, R. H. Ferguson, C. E. Mayer. USDA Forest Service Resource Bulletin NE-20, 1970. Northeastern Forest Experiment Station.

Forest Statistics for New York, 1980. T. S. Considine, Jr., T. S. Frieswyk. USDA Forest Service Resource Bulletin, NE-71, 1982. Northeastern Forest Experiment Station.

As can be seen from the above, there has been a significant change in the sources of fuelwood with supplies from growing stock, rough and rotten, and mill residue categories declining significantly in a proportional sense, while dead material and other sources show significant increases.

Chipping Technology

Chipping technology is being used to a limited degree within the state. Current operations involve land clearing, some production of wood chips for fuel for pulp plants, and a limited fiber market for roofing material. The pulp industry has increasingly utilized manufacturing residues as a source of fiber. In the 1967 survey, it was reported that the equivalent of 68,000 cords of pulpwood (5.5 million cubic feet) was equivalent of 68,000 cords of pulpwood (5.5 million cubic feet) was utilized by the fiber industry from plant by-product material. The 1979 survey indicates that the equivalent of 207,400 cords (17.6 million cubic feet) were utilized.

In addition to fiber, there is a strong demand from other markets (Table NY-8) and the net effect, with respect to plant residues, is a high degree of residue utilization. Of the estimated 60 million cubic feet of residues generated in 1979 by primary wood manufacturers, 87 percent was utilized by various markets.

Table NY-8

Production and Utilization of Manufacturing Residues by Type of Residue and Use - 1979 (Thousand Cubic Feet)

	Type of Residue			
Use	Bark	Coarse (a)	Fine (b)	All Types
Fiber	86	17,246	297	17,629
Industrial Fuel	2,045	1,352	2,124	5,521
Domestic Fuel	3,179	5,940	1,860	10,979
Other	3,659	1,290	13,803	18,752
Total Used:	8,969 (65%)	25,828 (94%)	18,084 (94%)	52,881 (87%)
Total Unused:	4,853 (35%)	1,582 (6%)	1,245 (6%)	7,680 (13%)
Total Production:	13,822	27,410	19,329	60,561

If product markets continue to expand and exceed residue production by manufacturing activities, then some products may well stimulate whole tree chipping operations. Further refinement of processing equipment can also lead to higher recovery of primary products and reduce residue production. In any event, unless users of wood energy wish to compete for mill residue supplies, it is apparent that as a supply source, mill residues are limited.

Transportation

From a statewide perspective, with one exception, the state can be described as having an extensive road network with several limited access, high-speed highways, and numerous major state highways. The one exception, a major forest area, is the Adirondack region in the north central portion of the state.

Monteith[48] has indicated that in New York State, in the short run, a criteria for measuring biomass availability in terms of road sparsity only reduces the resource availability by some 6 percent using a standard of sites more than 2 miles from an all-weather road on land with a slope greater than 30 percent. On a regional unit basis, the Monteith report has estimated the amount of forestland further than 2 miles from an all-weather road (Table NY-9).

Table NY-9

Forestland Greater Than 2 Miles From An All-Weather Road

Unit	% of Total Forest Area	Acres (Thousand)
Lake Plain	1	17
Southwest Highlands	0	0
South Central Highland	3	114
Adirondack	3	119
Western Adirondack	8	207
Eastern Adirondack	18	504
Capitol District	1	15
Catskill-Lower Hudson	2	74
Total:	3	1,050

Source: Reference 48.

Thus, according to the above reference, transportation limitations will affect only 3 percent of the forest area and about 6 percent of the resource.

Terrain

New York State has a wide range of terrain conditions. The Monteith report indicates that the distribution of steeply sloped lands are located in a regional sense in the Adirondack regions and along the southern border adjacent to Pennsylvania.

While the Monteith study indicates operating limits in terms of slope for various logging equipment, the maximum operating slopes tend to be higher than those described by other researchers. However, the report does indicate that for practical purposes, the optimal range for current equipment is from 0 to 30 percent. With 30 percent as the limit, it is estimated that only about 2 percent of the total biomass is on slopes greater than 30 percent and thus, in terms of current technology, not accessible for harvest. In terms of total forest area, the study indicates that all regional units have at least 95 percent of the forest area in slopes 0-30 percent.

Special Conditions

It should be noted that there has been created an Adirondack Park Authority which currently is preparing regulations governing the use of land within the Adirondack region. Since the basic concern is directed to preserving the forested character of the region, regulatory efforts apparently will be directed more to developments that would alter the basic rural characteristics. Some efforts or regulations may be directed towards limiting or otherwise controlling the practice of clear-cutting and, thus, have some effect, at a localized level, on supply.

Summary

The State of New York has a large resource base that is well distributed throughout the state. There is a significant forest industry and a requisite supply system utilizing the resource and this too is well distributed. Average annual net growth is far in excess of current removals. Mill residues from primary forest industries are highly utilized, and there is little surplus from these sources for use as industrial wood energy. There is a large, not highly utilized volume of material suitable for wood energy in the rough and rotten category. In overview, the resources of the state appear capable of supporting a substantial usage of wood energy for industrial purposes. However, on a local basis, some difficulties with respect to supply of industrial wood energy can be expected. Terrain limitations in some regions may limit the use of current mechanized whole tree chipping technology. In the more rural areas, lack of an adequate road system will both limit supply in terms of transportation and access to the resource. In some areas, the pattern of land ownership may reduce the availability of the resource because of numerous small, uneconomic units.

Pennsylvania

Three resource inventories have been undertaken in Pennsylvania; 1958, 1968, and the most recent survey conducted in 1977-1978. The latest survey indicates during the interim since the previous survey (1968) the amount of commercial forestland decreased some 300 thousand acres, about 2 percent. In 1968, there was an estimated 16.2 million acres of commercial forestland; in 1978, 15.9 million acres, second to Maine. Approximately 55 percent of the state is commercial forestland.[50]

For the most part, the resource is fairly well distributed throughout the state. The one exception is the Southeastern unit containing counties with numerous urban communities including Philadelphia, Bethlehem, Reading, Lancaster, York, and Harrisburg. In this region, only 22 percent of the land is commercial forestland whereas in all other regions, the proportion of commercial forestland ranges from 45 to 82 percent.

Because there are numerous counties in the state, Pennsylvania, like New York, has been subdivided into units which vary in size with respect to total land area. Table P-1 indicates the units, their size, and the relation between commercial forestland and total land area.

Table P-1

Geographic Units, Total Land Area and Commercial Forestland - 1978

Geographic Units	Total Land Area (1000 Acres)	% of Total State Area	Total Commercial Forestland (1000 Acres)	% of Total Commercial
Western Unit	5,606.4	19	2,534.3	16
Southwestern Unit	2,636.8	9	1,597.1	10
Allegheny Unit	3,993.6	14	3,282.2	21
North Central Unit	4,028.8	14	2,859.8	18
South Central Unit	2,953.6	10	1,642.0	10
Northeastern Unit	2,287.4	8	1,357.3	9
Pocono Unit	2,748.1	10	1,656.7	10
Southeastern Unit	4,523.5	16	994.3	6
Total:	28,778.2	100	15,923.7	100

Despite the loss of almost 2 percent of the commercial forestland between the two most recent surveys, growing stock volume increased from an estimated 17.8 billion cubic feet in 1965 to 21.7 billion cubic feet in 1978.

Land Ownership

Although private ownership of the forest resource predominates, a pattern in keeping with the rest of the northeastern states, and comprises 78 percent of the ownership, public ownership (estimated to be 22 percent) is the highest of the region. Of this ownership, only 3 percent is Federal; the rest, 19 percent, is state and local. Forest industry ownership is 964 thousand acres, 16 percent, and is primarily located in the Alleghany and North Central units.[51]

There are an estimated 490 thousand owners of the 12.4 million acres of private commercial forestland, a rather formidable number. However, a majority of these owners, 63 percent, hold units less than 10 acre units but only contain about 8 percent or approximately 1 million acres.

Farmer-owned commercial forestland still comprises a significant part of the total, amounting to 3.5 million acres, over 25 percent of the total private forestland.

Land ownership patterns show considerable variation among units in two respects. First, in terms of the amount of private ownership, the range is from 58 percent in the Allegheny unit to 96 percent in the Western unit. Table P-2 indicates, for each unit, the amount of commercial forestland in various ownership classes. The second variation among regions is in terms of the size class of ownerships, where for example, the amount of forestland in small units varies from a high of 68 percent in the Southeastern unit for parcels less than 50 acres to a low of 18 percent in the Allegheny unit. The latter is reflective of the peculiarities of the Allegheny unit which has not only the largest amount of commercial forestland but also has the largest amount of public land and forest industry ownership.

Table P-3 indicates the estimated number of private owners and acreage owned by size class for each geographic unit.

From Table P-2, it can be seen that the profile of small ownerships varies significantly among the units. Two regions have a significant portion of the commercial forestland in small holdings. If for example, one selects parcels of less than 50 acres as being questionable with respect to the economical operation of whole tree chipping equipment, then in the Western unit almost 50 percent of the private commercial forestland is in such ownerships. In the Southeastern unit, 68 percent is in parcels less than 50 acres. A further look at these two units indicates that in the Southeastern unit, the potential supply difficulties, because of many small

Table P-2

AREA OF COMMERCIAL FORESTLAND BY OWNERSHIP CLASS AND GEOGRAPHIC UNIT - 1978
(Thousands of Acres)

Ownership Class	Western	South-Western	Allegheny	North Central	South Central	North-Eastern	Poconos	South-Eastern	Total
Federal	3.1	1.0	485.1	0.9	11.6	0.0	0.8	0.0	502.5
State	94.4	220.3	863.8	749.4	412.7	110.4	230.8	113.9	2,795.7
County/Municipal	11.3	46.5	15.2	21.6	20.5	8.9	27.5	21.2	172.7
Total Public	108.8 4%	267.8 17%	1,364.1 42%	771.9 27%	444.8 27%	119.3 9%	259.1 19%	135.1 14%	3,470.9 22%
Forest Industry	25.6	85.6	568.5	161.8	44.6	36.4	20.7	20.9	964.1
Farmer	892.2	352.0	233.3	403.3	378.1	630.6	301.6	320.6	3,512.7
Other Private	1,506.7	891.7	1,116.3	1,522.8	774.5	571.0	1,075.3	517.7	7,976.0
Total Private	2,425.5 96%	1,329.3 83%	1,918.1 58%	2,087.9 73%	1,197.2 73%	1,238.0 91%	1,397.6 81%	859.2 86%	12,452.8 78%
TOTAL	2,534.3	1,597.1	3,282.2	2,859.8	1,642.0	1,357.3	1,656.7	994.3	15,923.7

Table P-3

ESTIMATED NUMBER OF PRIVATE OWNERS AND ACRES OF COMMERCIAL FORESTLAND
OWNED BY SIZE CLASS AND GEOGRAPHIC UNIT

Size Class (Acres)	Western	South-Western	Allegheny	North Central	South Central	North-Eastern	Poconos	South-Eastern	Total
				OWNERS					
1-9	73,000	33,900	15,900	33,600	37,700	34,400	20,700	60,700	309,900
10-19	12,600	2,600	7,800	2,800	8,400	5,300	5,200	9,000	54,200
20-49	24,800	6,500	5,600	9,300	5,400	5,000	6,500	8,100	71,200
50-99	7,600	4,100	3,400	5,100	3,600	4,000	3,000	2,000	32,800
100-199	3,400	2,200	1,300	2,500	1,600	2,200	1,700	500	15,400
200-499	700	700	900	900	700	600	600	100	5,200
500-999	100	100	100	200	*	100	200	*	800
1,000+	*	100	100	200	100	*	100	*	600
Total	122,200	50,200	35,100	54,600	58,000	51,600	38,000	80,400	490,100
*Less Than 50									
				ACRES OWNED (1,000 Acres)					
1-9	241.4 10%	76.0 6%	81.6 4%	133.8 6%	111.2 9%	100.1 8%	53.9 4%	230.0 27%	1,028.0 8%
10-19	161.4 7%	28.6 2%	93.8 5%	32.4 2%	115.5 10%	69.7 6%	63.2 5%	120.9 14%	685.5 5%
20-49	749.3 31%	199.8 15%	175.9 9%	289.0 14%	157.6 13%	160.6 13%	207.3 15%	233.9 27%	2,173.4 17%
50-99	497.0 20%	275.8 21%	229.1 12%	334.3 16%	236.9 20%	269.8 22%	207.2 15%	112.9 13%	2,163.0 17%
100-199	399.5 17%	294.9 22%	175.4 9%	323.5 15%	210.1 18%	263.8 21%	228.2 16%	72.7 9%	1,968.1 16%
200-499	178.9 7%	190.6 14%	215.0 11%	274.6 13%	184.8 15%	200.8 16%	187.4 13%	16.5 2%	1,448.6 12%
500-999	51.8 2%	57.1 4%	87.7 5%	119.2 6%	31.5 3%	55.1 4%	124.9 9%	2.0 --	529.3 4%
1,000+	146.2 6%	206.5 16%	859.6 45%	581.1 28%	149.6 12%	118.1 10%	325.5 23%	70.3 8%	2,456.9 20%
Total	2,425.5	1,329.3	1,918.1	2,087.9	1,197.2	1,238.0	1,397.6	859.2	12,452.8

uneconomical parcels, is exacerbated by the fact that this unit has the smallest resource base, only some 994 thousand acres; thus, if small ownerships were the only limiting factor, almost 60 percent of the resource would be questionable leaving some 400 thousand acres in larger units. Given that this unit contains several large urban areas, one would have to consider that over the long term it is reasonable to expect further fracturing of the larger parcels into smaller units, thus eroding the resource base.

In the Western unit, although small units are significant, so is the size of the resource base. In this unit, there are some 2.5 million acres of commercial forestland; thus, despite the large number of small units which account for almost half of the resource, some 1.3 million acres remain in larger, more economical units.

With the exception of these two regions, all the other units have much less of the resource in small units. For these units, the proportion ranges from a low of 11 percent in the Allegheny unit to 24 percent in the Northeastern unit. From Table P-1, it can be seen that all of these units have a significant resource base, each having in excess of one million acres. In these areas, any problems arising from small holdings would be local and probably be confined to the vicinity of large urban areas.

One other unit, the Allegheny, has a land ownership profile significantly different. In this area, there are large concentrations of public land amounting to approximately 42 percent of the commercial forestland. The Allegheny National Forest contains some 485 thousand acres; state land, 863 thousand acres; and county and municipal ownership approximately 15 thousand acres. Concerns have been raised about the uncertainty associated in securing long-term supplies from public lands. Whether or not such concerns have validity is beyond the scope of this report. However, if the issue is valid, then in this region an uncertainty about public land policy would become a factor in the supply planning process for facilities considering large-scale uses of wood energy. If supply from public land is an issue, then, as a factor, it is local and will vary in importance with site and the relative importance of public land within the supply area.

Utilization and Growth

Three surveys have been made of the forest products industries in Pennsylvania. These surveys generally reflect the situation found in other northeastern states; namely, that over the past two decades there has been a general decline in the number of industries. Although in recent years the number of sawmills has increased, numbers do not approach those recorded in the late fifties to early sixties. In Pennsylvania, sawmills dominate the primary forest industry. In 1964, survey data indicates some 999 operating sawmills; in 1969, this sector had declined to 684 sawmills but the 1976 survey indicated an increase to 740.[52]

Pulp production is also a significant primary industry in the state with 9 operating mills.

The dominance of these two primary industries in terms of roundwood production from the resource is clearly shown in Table P-4 which indicates the total cubic feet production from roundwood of various products.

Table P-4

Timber Product Output from Roundwood - 1976
(Million Cubic Feet)

Product	Cubic Feet	Percent
Sawlogs	103.7	59
Pulpwood	53.1	30
Fuelwood	10.4	6
Other*	9.2	5
Total:	176.4	100

*Includes: mine timbers, ties, wood fiber, charwood and chemical wood, handle and bat stock, shingle and turnery bolts.

Source: An Analysis of Pennsylvania's Forest Resources. D. S. Powell, T. J. Considine, Jr. USDA Forest Service Resource Bulletin, NE-69, 1982. Northeastern Forest Experiment Station.

The distribution of sawmills is fairly uniform throughout the state as indicated in Table P-5. As might be expected, the smallest number is found in the Southeastern unit, which is heavily urbanized and has the least amount of commercial forestland.

Table P-5

Number of Operating Sawmills by Geographic Region
for Years 1964, 1976

	Number of Operating Sawmills		
Region	1964	1976	% Change
Western	139	115	-17
North Central*	289	214	-26
Southwestern	150	104	-31
Northeastern*	160	104	-16
Southeastern	117	77	-34
South Central	144	126	-13
Total:	999	740	-26

*Data source combined the Poconos unit into the Northeastern unit and the Allegheny unit into the North Central unit.

Source: Reference 52.

Although the above data indicates, in a quantitative sense, a decline in the number of operating facilities, the significance is minor since the loss occurred in the smaller mills, primarily those in the production category of less than one-half million board feet a year which registered a decline of approximately 42 percent. However, while this loss was occurring, mills in the production category of over one million board feet per year increased by 23 percent. Thus, the numerical loss of sawmills had little effect on the resource, markets were fewer but larger.

Pulp industries are located in various sections of the state and in terms of facilities have remained stable; production increases have been met through the expansion of existing facilities.

As can be seen from Table P-4, the remaining primary forest industries consume a minor portion (5%) of timber production. These industries tend to be specialized and small.

State forestry officials estimate there are some 600 loggers active in the supply system of timber products in the state.[53]

Timber products production in 1979 registered a somewhat modest increase of 12 percent over that reported in the 1969 survey.[52] In 1969, total timber product production amounted to 148.9 million cubic feet; in 1976, 166.1 million cubic feet. Of the various product categories, only sawlogs and pulpwood volumes increased (Table P-6).

Table P-6

Change in Timber Products Production - 1969, 1976

Product	1969	1976	% Change
	Million Cubic Feet		
Sawlogs	87.5	103.7	+19
Pulpwood	49.7	53.2	+ 7
Veneer Logs	2.1	2.1	*
Cooperage Logs	1.2	0.5	-58
Mine Timbers	5.8	4.6	-21
Miscellaneous(1)	2.6	2.0	-23
Total:	148.9	166.1	+12

*Less than 0.5 percent.

(1) Includes handle and bat stock, posts, charcoal wood, and wood fiber products.

Source: Reference 52.

In view of the fact that there are significant variations among the geographic regions of the state with respect to the amount of forestland, it is to be expected that each region's contribution to the total timber harvest would show variations. Since harvest or production data are only obtained periodically, it is only possible to make comparisons between specific years. Table P-7 is a comparison between 1969 and 1976 in terms of the two major categories of timber products, sawlogs and pulpwood, by geographic region.

Table P-7

Sawlog and Pulpwood Production, by Region - 1969, 1976

Region	Sawlogs (Million Board Feet) 1969	% of Total	1976	% of Total	Pulpwood (Thousands of Cords) 1969	% of Total	1976	% of Total
Western	85.9	16	95.6	15	14.8	2	6.2	1
Southwestern	97.7	18	105.6	16	82.0	13	72.4	11
North Central	192.4	35	246.2	38	313.9	51	354.5	57
South Central	68.1	12	85.5	13	110.0	18	53.1	8
Northeastern	58.3	11	63.0	10	74.1	12	117.2	19
Southeastern	41.0	8	48.3	7	27.1	4	21.8	4
Total:	543.4	100	644.2	100	621.9	100	625.2	100

Source: Reference 52.

With respect to comparisons between the two years, the above data indicates that while the sawlog production in each region remained relatively unchanged in terms of a region's contribution to the total, all regions show an increase in production with significant increases in the North Central region. Pulpwood production, on the other hand, not only shows significant changes with respect to each region's contribution to total production, but also shows significant changes in terms of the regions production. Thus, the Western region shows a decline of over 50 percent as does the South Central region. The North Central and Northeastern regions show significant increases.

If pulpwood production is a significant factor in the establishment of whole tree chipping operations, then those areas with significant pulpwood harvests probably will stimulate the establishment of chipping operations.

Growth

The average annual net growth for the period between surveys was 555 million cubic feet. Compared to the average annual removal of 255 million cubic feet, the ratio for the state as a whole indicates a very favorable 2 to 1 relation. The USDA Forest Service projections, at least as far as the next 30 years are concerned, are favorable. From now until the year 2008, growth is expected to increase from an estimated 609 million cubic feet per year to 675 million cubic feet per year by 2008. Removals are projected to increase at a rate that reduces the present ratio of 2.2/1.0, to 1.1/1.0 by the end of the projected period, thus bringing growth and removals into balance.

Fuelwood

Two sources of data estimate fuelwood usage in two specific periods. The USDA Forest Resource report for 1978[50] indicates production of some 247 thousand cords of fuelwood from both roundwood and manufacturing residues. A 1982 state report[54] indicates residential fuelwood useage of approximately 3 million cords in 1980. Taken at face value, this would indicate at least an eleven-fold increase over a four year period. Since the data are somewhat questionable, it is used with caution.

Three million cords is approximately 240 million cubic feet and could be a significant drain upon the resource base depending on the source of the material. According to the 1982 survey, respondents reported that of the 2.5 million cords of fuelwood self-cut by primary users, most of the fuel came from dead trees. The various sources of self-cut fuelwood, as reported by users, would seem to indicate that only minor quantities are coming from potential growing stock. The sources, as reported, are:

Live trees	-	11%
Dead trees	-	75%
Logging Waste	-	8%
Land Clearing	-	6%

If the above data are somewhat reflective of actual conditions, then it would appear that despite the large volume, in a quantitative sense, going into domestic fuel, the net impact on the resource base is small. From a potential industrial wood energy users view, the impact with respect to potential competition would be small.

Chipping Technology

State officials were able to identify at least 6 whole tree chipping operations active in the state. Current delivered prices for pulp quality chips are in the \$18 - \$22 per green ton price range, which is a price range comparable to that reported in New Hampshire. Thus, whole tree chipping technology is being utilized but not extensively. The wood procurement division of one fiber industry, active in whole tree chipping technology, indicated that chipping operations have to be part of an integrated logging operation to maximize returns.

Transportation

Transportation would not appear to be a significant factor in Pennsylvania. There is an extensive interstate road system linking the various regions of the state as well as a state and secondary network.

Terrain

The topography of the state, while not classified as "rugged," does have terrain features that result in steep slopes insofar as the use of mechanized equipment is concerned. The Southwestern unit is described as containing some of the most rugged mountainous terrain in the state and contains Mt. Davis, the highest point in the state with an elevation of some 3,000 feet. The South Central unit is characterized by a series of ridges and valleys nearly parallel and often extending unbroken for many miles. One industry employing whole tree chipping technology indicated that feller-buncher equipment is limited to 18-degree slopes with conventional logging technology being utilized on steeper slopes.

Thus, in some local areas, the application of fully mechanized chipping systems will be limited.

Summary

Pennsylvania has a large resource base, one of the largest in the northeast. Despite the fact that there are numerous private landowners for the state as a whole, less than one-third of the commercial acreage is in units of less than 50 acres. Only two regions, the Western and Southeastern, have significant areas of commercial forestland in small parcels.

The resource is well distributed throughout the state and supports widespread forest industry activity concentrated in sawmilling and pulp. Growth trends indicate a favorable growth to removals ratios now and in the future.

There is an extensive transportation network making most of the resource available. Varying terrain conditions will undoubtedly restrict the application of whole tree chipping technology in some local supply areas, thus limiting the economical harvest of potential supplies.

There appears to be an excellent potential for the use of wood as an industrial fuel with respect to the resource and its availability.

Rhode Island

Rhode Island, the smallest of the New England States and of the states in this study, has a limited amount of commercial forestland. As of the last inventory, completed in 1971, total commercial forestland amounted to some 395 thousand acres. This represents a loss of approximately 35 thousand acres since the previous inventory of 1953. Despite the decrease in area, the net volume of growing stock has almost doubled to 347 million cubic feet.

Although commercial forestland occupies 59 percent of the state, the resource is not evenly distributed. The proportion of forestland varies among counties from 28 percent to 66 percent,[55] with the most heavily forested areas being in the western portion.

Land Ownership

The bulk of the commercial forestland in Rhode Island is in private ownership. Only 52 thousand acres (8 percent) are public owned. All of the state land, 12 thousand acres, is located in one county. The remaining public land is county and municipal ownership in relatively small parcels in each county.

As one of the most densely populated states, it is not surprising that the resource is owned by a large number of owners. A 1973 study[56] indicates that there were some 14 thousand private owners of the commercial forestland. Apparently, there is no forest industry ownership and the bulk of the private ownership is by individuals. Of the 14 thousand owners, almost 13,000 are individual, representing 293 thousand acres, 81 percent of all private ownership.

As might be expected with a small resource base and a large number of owners, the resource is fractured into many small units (Table RI-1).

Table RI-1

Estimated Number of Private Owners
and Acreage Owned - Rhode Island

Size Class (Acres)	Owners		Acreage Owned	
	Number	Percent	Number	Percent
1-9	6,700	47	21,800	6
10-19	2,400	17	29,100	8
20-49	2,800	20	83,500	23
50-99	1,500	11	94,400	26
100-199	600	4	72,600	20
200-499	200	1	43,600	12
500+	(-50)	(-0.5)	18,200	5
Total:	14,200	100	363,200	100

From the above, over one-third of the total commercial forestland is in parcels smaller than 50 acres. Over 60 percent is in parcels smaller than 100 acres. This pattern of ownership is fairly consistent in the southern New England States; whereas, a similar study for New Hampshire and Vermont indicates that only 12 percent of the commercial forestland is in parcels less than 50 acres, and 23 percent in units smaller than 100 acres. As has been pointed out, the economics of whole tree chipping systems limit the feasibility of harvesting small parcels, thus the pattern of land ownership can be a significant factor.

Utilization and Growth

Given the limited size of the resource base, it is not unexpected that there is a limited forest industry. A 1971 survey[57] indicates 19 operating sawmills in the state compared with 30 in a 1952 study. The 1978 pulpwood study of the northeast[58] lists no pulpmills. Timber removals data indicate no veneer logs harvested. Thus, the industry is primary sawmills with some piling and post activity.

The 1971 survey indicates the following data with respect to industrial roundwood harvest (Table RI-2).

Table RI-2

Industrial Roundwood Harvest - 1971, Rhode Island

Product	Thousand Cubic Feet
Sawlogs	607
Pulpwood	573
Other(1)	19
Total:	1,199

(1) Includes piling, posts, dimension bolts, and charcoal wood.

In conventional units, sawlog production amounted to 3.6 million board feet, pulpwood to 6,738 cords. In addition, 898 thousand cubic feet or 11,221 cords of fuelwood were produced from roundwood.

The 1978 pulpwood survey indicated production in that year of 1,000 cords, a significant reduction from the 1971 survey.

Total removals from growing stock in 1971 amounted to some 3.5 million cubic feet, including logging residues and other removals.

A 1976 USDA Forest Service report[59] indicates that total removal from growing stock amounted to some 3.0 million cubic feet from that in 1971. In essence, the resource in the state, insofar as growth is concerned, is far exceeding removals.

The 1976 report also indicates a net annual growth of 17.3 million cubic feet of growing stock, an increase of 2.4 million cubic feet from that in 1971. In essence, the resource in the state, insofar as growth is concerned, is far exceeding removals.

Fuelwood

The northeastern states, heavily dependent upon oil as a residential heating fuel, have increasingly used wood as an alternative fuel and Rhode Island is no exception. The 1971 survey indicated a production of almost 12,000 cords of fuelwood, the bulk of the production (11,221 cords) coming from roundwood.

A 1980 study of New England fuelwood usage[60] indicates a consumption in 1976, 1977, and 1978 of approximately 84 thousand, 98 thousand, and 109 thousand cords, respectively, in Rhode Island. This represents some 8.7 million cubic feet insofar as 1978 usage is concerned. This would be approximately one-half the net annual growth of growing stock reported in

1976. As has been pointed out, if the available data from work done in other northeastern states is fairly typical of conditions in Rhode Island, with respect to sources of fuelwood, then a significant portion of residential fuelwood is not coming from growing stock. However, in the absence of specific information, this is an assumption. Regardless of the unknowns, unless there has been a drastic increase in total removals, it would appear that even if all the fuelwood volume as reported in 1978 (some 8.7 million cubic feet) came from growing stock, this quantity when added to the reported removals of 3.0 million cubic feet in 1976 would total some 12 million cubic feet. Since the net annual growth in 1976 was reported to be 17.3 million cubic feet, growth would still be exceeding removals.

Summary

The small resource base within the state clearly limits opportunities for large-scale industrial use of wood for energy. In addition, the geographic location of the state limits the potential supply area. The adjacent counties in Massachusetts and Connecticut, which border on the west, north, and east, also tend to be urbanized and have a limited amount of commercial forestland which undoubtedly is held in many small ownerships. Over the long term, one can probably expect to see a diminishing supply of available biomass both through continued conversion of forestland to other uses and fracturing of larger units into smaller uneconomic parcels.

Vermont

Three forest surveys have been completed for Vermont. The first survey was in 1948, the second in 1966, and the latest available in 1973.[61] A fourth survey is currently underway.

In the seven year interim between 1966 and 1973, the area of commercial forestland increased by some 135 thousand acres and as of 1973, Vermont contained approximately 4.4 million acres of commercial forestland, 75 percent of the total land area. The growing stock volume increased 331.7 million feet to a total of 4.7 billion cubic feet.

Distribution of the resource is fairly uniform throughout the state. Only one county, Grand Isle, a small geographic region in Lake Champlain, is not considered in survey data. All other counties have at least 50 percent of the area in commercial forestland (Table V-1).

Land Ownership

The commercial forestland is predominantly in private ownerships. Only 10 percent, approximately 441 thousand acres, is in public ownership, with Federal ownership accounting for some 232 thousand acres primarily in the Green Mountain National Forest, state forestland accounting for 168 thousand acres, and some 41 thousand acres in municipal parcels.

Of the 3.9 million acres in private ownership, forest industry lands amount to 666 thousand acres, approximately 17 percent of the total private.

Table V-1

Area by Land Classes, Geographic Units and Counties - 1973

County	Total Land Area (Acres)	Commercial Forest Land (Acres)	Percent
Caledonia	391,900	291,300	74
Essex	424,500	396,100	93
Franklin	422,700	236,900	56
Grand Isle	53,300	---	--
Lamoille	303,600	251,200	83
Orange	441,700	335,900	76
Washington	452,800	361,300	80
Total Northern Unit	2,947,900	2,211,700	75
Addison	501,500	285,800	57
Bennington	430,200	370,700	86
Chittenden	341,100	195,700	57
Rutland	593,300	444,900	75
Windham	503,600	428,500	85
Windsor	617,800	492,600	80
Total Southern Unit	2,987,500	2,218,200	74
Total	5,935,400	4,429,900	75

Source: Reference 61.

There are numerous owners of the resource (approximately 74,000), thus, to a degree, the resource is composed of many parcels varying in size. Due to the fact that, at some point, even though land may still be classified as commercial forestland, the size of a parcel may become too small to harvest economically, and it is important to know the pattern of landownership. Table V-2 is data from a landowner study undertaken by the USDA Forest Service in 1973.[62]

From Table V-2, it is possible to determine how much of the resource is in small ownerships. Since there is no definition of what constitutes "small," two data points were selected: under 50 acres and under 100 acres. In Vermont, approximately 14 percent of the commercial forestland is in parcels smaller than 50 acres. This is significantly less than patterns in such urbanized states as Connecticut, Massachusetts, and Rhode Island where surveys indicate over one-third of the commercial forestland is in parcels less than 50 acres.

In the less than 100 acre category, in Vermont, 25 percent of the resource is in such parcels versus over 50 percent in the three southern New England States.

Thus, insofar as either of these two size classifications are concerned, the amount of resource in such parcels, while not insignificant, does not appear large enough at the present time to be considered a significant restrictive factor with respect to potential supply.

Table V-2

Estimated Number of Private Owners of Commercial Forestland and Acreage Owned
By Size Class and Form of Ownership - Vermont, 1973

Size Class	Individual[a]	Corporation	Other[b]	Total	
Acres	Number	Number	Number	Number	Percent
			OWNERS		
1-9	33,500	-	-	33,500	43
10-19	8,600	-	1,100	9,700	12
20-49	13,800	300	700	14,800	20
50-99	7,700	-	100	7,800	10
100-199	6,200	200	400	6,800	9
200-499	3,500	100	300	3,900	5
500+	600	100	100	800	1
Total:	73,900	700	2,700	77,300	100
			ACRES OWNED		
1-9	57,900	-	-	57,900	1
10-19	96,500	-	9,700	106,200	3
20-49	357,200	9,700	19,300	386,200	10
50-99	444,200	-	9,700	453,900	11
100-199	695,300	19,300	57,900	772,500	19
200-499	859,400	38,600	48,300	946,300	24
500+	425,100	791,900	48,300	1,226,300	32
Total:	2,935,600	859,500	193,200	3,988,300	100

a) Includes joint ownership.

b) Includes partnerships, undivided estates, clubs, associations, etc.

Source: Reference 62.

Utilization and Growth

A 1974 USDA Forest Service report[63] indicates that in 1952 there were some 488 operating primary wood manufacturing plants in Vermont. By 1972, the total has declined to approximately 202. In 1981, a state survey[64] indicated a slight increase to 249 primary facilities. Table V-3 indicates the composition of the primary industries for each of the three years.

Table V-3

Number of Operating Primary Wood Manufacturing Plants, 1952, 1972, 1981

Type of Plant	1952	1972	1981
Sawmills	425	170	220
Veneer	10	4	3
Pulp	2	1	1
Other(1)	51	27	25
Total:	488	202	249

(1) Includes: Turning and square mills, clapboard, woodenware, shingle, excelsior and cooperage, novelty fence mills and specialty mills.

As Table V-3 indicates, the trend, consistent with that in several of the other northeastern states, shows a decline in all categories with a recent increase almost exclusively confined to the sawmill sector.

Primary plants are well distributed throughout the state and are found in every county except Grand Isle. With respect to the Northern unit and Southern unit, approximately the same number of industries are found in each region.

Since Vermont is one of the few states that monitors the harvest of forest products on an annual basis, it is possible to analyze production in detail. Annual production data for sawlogs are available from 1945 to 1980.[65] Pulpwood production is available from 1953 to 1980. Analysis of production indicates considerable variation over the years.

With respect to sawlogs (including veneer logs), the high point of production was in 1951 when, according to the records, approximately 273.4 million board feet were cut. As a point of reference, the 1972 survey indicated that production in the survey year of sawlogs and veneer logs amounted to 132.1 million board feet. In 1980, production is shown as 198.1 million board feet. The low point of production occurred in 1971 when the harvest was 127.5 million board feet.

The production of pulpwood exhibits similar fluctuations ranging from a high of 273 thousand cords in 1980 to a low of 111.9 thousand cords in 1969. The 1972 survey indicates a pulpwood harvest of 135.5 thousand cords.

The production data indicates that despite the ,trend from the 1972 survey to increasing sawlog production, the harvest of sawlog products has not reached the quantities recorded in 1951, when, according to data, the resource base, at least in terms of acres of commercial forestland, was smaller.

In contrast, pulpwood production has recorded the highest production in the last few years.

Of interest, with respect to whole tree chipping technology, is the fact that since 1974 Vermont has been reporting volumes produced from whole tree chips. Table V-4 shows production through 1981.

Table V-4

Whole Tree Chip Harvest, 1974-1981

Year	(Green Tons) Pulp	Fuel	Total
1974	32,804*	--	32,804
1975	61,994*	--	61,994
1976	85,624*	--	85,624
1977	68,388*	--	68,388
1978	48,928*	--	48,928
1979	112,331	39,530	151,861
1980	123,732	108,256	471,844
1981	87,435	75,894	370,771

Source: Reference 64, 65.

It is interesting to note that during the 8 years of recorded data, there is considerable fluctuation in the quantities of whole tree chips produced for the pulp industry. While some variation can be explained by short-term economic conditions in the pulp industry, the volume of roundwood pulp production does not match the variations indicated in chipping operation.

If the variations in production of pulp chips reflect demand fluctuations on the part of the pulp industry than this might indicate, given the economic need to maintain production, whole tree chip operators would find a market for industrial fuel attractive, even at a lower price for fuel chips, given that such markets would be more stable with respect to demand.

In 1972, the net annual growth was 106.6 million cubic feet versus a removal of 47.8 million cubic feet, resulting in a ratio of 2.2 to 1.

The estimated net annual growth for 1983 is 122 million cubic feet. Using the removal estimates in Table V-5 results in a ratio of 1.5 to 1. This still represents a favorable balance but a narrowing of the gap between what is grown annually and what is removed.

The 1972 survey does point out that annual net growth in Vermont is well below potential and is the lowest of the New England States. The primary reason for the low growth is the high proportion of inferior trees stocking the forestland. It is estimated that almost 30 percent of all live trees over 5 inches in diameter are considered in the rough and rotten category. This converts to over 1 billion cubic feet of timber. A recent report by the USDA Forest Service which presents estimates on aboveground tree biomass[66] indicates that the per acre green weight of biomass in rough and rotten trees could be 22 tons. This is the highest for any of the northeastern states; and if this material could be removed to provide growing space for growing stock, the growth situation in Vermont would vastly improve.

Fuelwood

The use of wood fuel for residential heating has increased significantly since the mid-seventies. The 1972 survey indicated fuelwood production amounting to 54,187 cords of which 36,070 cords (67%) came from roundwood and the remainder from plant by-products.

In 1980, use of residential fuelwood has grown to approximately 452,000 cords.[67] Unfortunately, current data on the sources of the fuel are both incomplete and the source information that is available is defined in categories other than that in the USDA Forest survey. Recent surveys on residential use generally separate sources into two general categories: self-cut and purchased, and proceed to analyze only sources for the self-cut category. Since no investigations have been made of the "purchased" fuel sources, the source of significant quantities of residential fuelwood is currently unknown. A very rough analysis of current information involves a study of Vermont residential use conducted by the USDA Economic Research Service.[68]

According to the study, approximately 36 percent of residential wood is purchased. With respect to the reported 1980 consumption, this would mean that of the 452,000 cords, approximately 289,000 cords were self-cut versus 163,000 purchased.

Of the self-cut, the USDA report indicates that potentially 32 percent (93,000 cords) could have come from growing stock. If consumer response does accurately reflect source, some of the remaining 68% (289,000 cords) come from such categories as dead or rotten, land clearing, small trees, and logging residues. With respect to the potential effect on growing stock, assuming the 32 percent all comes from growing stock material, this would mean a removal of some 7.4 million cubic feet.

The purchased material sources probably come from logging wastes, plant by-products, growing stock, rough and rotten, etc. If one assumes that half of the 163 thousand cords purchased comes from growing stock, using as a rationale that commercial suppliers of fuelwood will be concerned economically with volume production, then this would represent an additional removal of 6.5 million cubic feet.

Thus, if the fuelwood removals, as estimated, are added to the reported 1980 industrial production, the removal from growing stock of industrial and non-industrial products could be as follows (Table V-5):

Table V-5

Removals From Growing Stock-1980

Product	Thousand Cubic Feet
Sawlogs (1)	29.7
Cordwood(1)	22.8
Fuel	13.9
	66.4
Logging Residues(2)	8.1
Other Removal(2)	6.8
Total:	81.3

(1) The same ratios as those calculated from the 1972 survey were used with respect to roundwood production from growing stock versus rough and rotten, dead trees, and other.

(2) The same removal as reported in the 1972 survey was used.

Thus, on the basis of the above, there has been a considerable increase in removals. The 1972 survey projected an increase in removals over time for various years. For 1983, projected removals from growing stock were estimated to be some 68 million cubic feet. Although the above figure of 81.3 million cubic feet is considerably higher than the Forest Service projection in 1972, it is highly unlikely that at the time the estimate was made, the oil crisis of 1973 and the resultant dramatic increase in wood energy use was foreseen.

Chipping Technology

Chipping technology is being utilized in the state as evidenced by data reporting production of whole tree chips for fiber and fuel. As indicated in Task I, two operations are furnishing fuel to the existing Burlington Municipal generation facility and one secondary pulp and paper plant is utilizing wood chipped fuel. State officials estimate at least 10 systems in operation during 1982.

As the new Burlington wood chip-fired 50 MW generation facility comes on line, a significant number of new systems will be required to meet the estimated annual need of 400,000 green tons.[69] Thus, the technology is established and operational knowledge is growing.

Although several studies have been undertaken in Vermont on whole tree chipping, most have been limited to short-term observations on a limited number of sites. From these studies, it appears that in Vermont at least weather and terrain can impose serious limitations on the efficient and economic use of mechanized systems.

Transportation

Although Vermont is considered as being predominantly a rural state, it supports a comprehensive road system throughout the state. There are two interstate systems and an extensive state system, plus numerous roads maintained at the town level.

Insofar as the adequacy of the transportation system to transport material is concerned, there would appear to be few limitations. However, as the public hearings on the Burlington facility revealed, the ability of local roads in the vicinity of a facility requiring large quantities of trucked chips may be a problem with respect to site.

With respect to the adequacy of roads to provide access to the forestland, one study[70] addressing the feasibility of a 50 MW generation plant in the northern part of the state concluded that road access could limit availability on 45 percent of the area. However, this study placed somewhat restrictive terrain limitations on the use of whole tree chipping systems and also assumed single product harvesting, which, given the low value of wood fuel, would limit the amount of costs incurred for site improvement; i.e., road improvement. It certainly is true that the presence of a road does not guarantee access to the resource especially with respect to the current equipment used to transport chips. Van trucks are much more limited in use on low quality roads and are especially limited on-site. A New York State study[71] using different standards estimated only 7 to 8 percent of the resource in that state would be limited.

Terrain

Vermont, with the Green Mountains forming more or less the "spine" of the state, will have terrain that will limit the use of totally mechanized chipping systems. To some extent, chipping technology can be combined with conventional logging technology but very little study has been done in this area despite the fact that many whole tree operations apparently combine the two systems.

In view of the fact that there is no common agreement among researchers as to what constitutes a terrain limitation, it is difficult to assess at a state level how much the resource will be affected by terrain. If mechanized equipment is limited, as suggested by some researchers, to slopes no steeper than 15 degrees, than a significant portion of the resource may be unavailable to fully mechanized systems. Resource availability then is a matter of to what extent conventional systems can harvest material economically.

Summary

There is a substantial wood resource in the state. The resource supports a significant forest industry and production of timber products has been increasing since the last survey taken in 1972. Chipping technology is being utilized increasingly to produce pulp quality chips and chips for industrial energy use. A 50 MW wood chip-fired generation plant is currently under construction in Burlington that will consume approximately 500,000 green tons annually, and when operational will require a significant number of whole tree chipping systems.

While there are numerous private landowners of the resource, the acreage of commercial forestland in small parcels is not that significant to materially effect potential availability.

Resource surveys indicate that Vermont's forestland contains considerable quantities of low quality material suitable for fuel purposes and currently being unutilized. If such material can be economically harvested, not only would supplies furnish quantities of low value fuel but, in addition, the removal of such timber would materially improve the growing conditions of the resource.

On a local basis, terrain limitations, insofar as current technology is concerned, will limit availability of the resource.

1982 Vermont Recovery

During 1982, the U.S. Forest Service, Northeastern Station, conducted the fourth survey of Vermont's forest resources. Appropriate preliminary data have been made available to PYROS, Inc. to allow some updating of information initially presented in this report.

1. Timberland Area (formerly known as commercial forest land in previous reports)

The 1982 survey indicates approximately 4,422,134 acres of timberland. This represents a slight and insignificant (less than 1 percent) decline in the amount of timberland since the last survey in 1973.

2. Growing Stock

The current net volume of growing stock is estimated to be about 6.3 billion cubic feet, an increase of some 1.5 billion cubic feet since the last survey. This represents an increase of almost 34 percent.

3. Rough and Rotten

The volume of rough and rotten material is estimated to be about 1.1 billion cubic feet. This represents a slight (3 percent) decrease from data reported in the previous survey.

4. Green weight

For the first time, the green weight of material is reported and it is estimated that there is approximately 413.4 million green tons.

The latest preliminary data contains nothing that would alter the initial conclusions previously stated. The slight decrease in the amount of timberland is insignificant insofar as having a major impact on the forest resource. Growth continues to exceed removals as is evidenced by the continued increase in net growing stock volume.

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"ASSESSMENT OF POTENTIAL WOOD SUPPLY FOR INTERMEDIATE SCALE THERMOCONVERSION FACILITIES"

TASK III

"ASSESSMENT OF POTENTIAL WOOD SUPPLY FOR INTERMEDIATE SCALE THERMOCONVERSION FACILITIES IN THE SOUTHEAST"

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1.0 Summary

The four states involved in Task III have a significant resource base estimated to be approximately 74.6 million acres of commercial forestland. In comparison to the northeastern states, the resource area of the four states contains almost 10 million more acres.

In each of the states, the resource supports numerous forest industries with pulpwood being the largest category of industrial timber product produced. Except for Florida, the resource in the other states is fairly well distributed throughout the area. In Florida, over 70 percent of the commercial forestland is located in the northern part of the state. Similarly, in Florida the primary forest industries are concentrated near the resource while in the other states the industries are generally found throughout a state.

As was the case in the northeast states, there are large quantities of low quality, low value biomass present on the forestland. In terms of tonnage, the four states have a total estimated aboveground green weight of 569 million tons in rough and rotten timber. Despite the fact that the southern states contain almost 10 million more acres of commercial forestland, the amount of low quality material is less than that in the northeast by almost 250 million tons. This is due in part to the rather significant acreage in the southern states that is in plantation growth and, thus, under intensive management.

There is little evidence that the resource base in any of the four states has been subdivided to any significance into small uneconomical units.

As was the case in the northeast, ownership is predominantly private. There is very little public land in the area, however, unlike the situation in the north, the amount of land owned and managed by forest industries is significant.

Terrain limitations appear to be a minor factor throughout the region. Year-round water problems on some sites appear to be a significant factor that limits operation in some local areas.

Whole-tree chipping technology is not being extensively utilized in the region. Current operating units are used for land clearing, fiber production, and chips for fuel.

In general, throughout the area, there is a significant resource base that is currently being underutilized by the forest industry. For the most part, there are few limitations with respect to potential supplies of biomass for industrial energy purposes insofar as resources are concerned. Only in Florida, where the bulk of the resource is concentrated in the northern regions, is there a limitation to the widespread feasibility of utilizing the resource.

2.0 Purpose of Study

The purpose of this study is to assess the potential for siting intermediate size facilities (500-2000 green tons per day) in certain states in the southeast based upon potential resource availability. The study utilizes data evaluated in Task I which examined various factors affecting the supply of biomass for the existing Burlington Electric Department's municipal generation plant which utilizes approximately 100,000 green tons of wood chips annually. In addition to current needs, the municipality has under construction a new 50MW wood chip fueled generation facility which is expected to require some 500,000 green tons annually. Additional data were developed in Task II which assessed the feasibility of utilizing wood biomass for industrial energy in each of the northeastern states. In essence, this study replicated the previous northeastern study and, to some extent, provides a comparison between the two regions.

Although this assessment does not attempt to quantify the amount of biomass potentially available for wood energy purposes, the study includes quantification assessments that have been made by other sources for each of the states. As was done in the northeast study, the size of the resource base is evaluated as is the latest information on demand for industrial products. The production of nonindustrial timber products (usually fuelwood) was not, as was done for the northeast states, evaluated since the size of the resource base and climatic difference indicated that fuelwood consumption should have no material effect on the resource.

2.1 Scope and Methodology

This study involved the four states of Alabama, Florida, Georgia, and South Carolina. These states, as a group, do not constitute a single region but are part of an area generally referred to as the southeast region.

As was done in the northeast, the basic timber resources of each state were analyzed utilizing the most recent USDA Forest Service inventory data available and incorporating, where available, supplemental information provided by state forestry officials and other appropriate sources.

In several respects, analysis of the supply potential in the four states of Alabama, Florida, Georgia, and South Carolina was less complex than the work undertaken in Task II which involved the northeast states. For one thing, the forest resource base available in the four states is larger than that in the total nine states of the northeast (Table 1).

Table 1

Commercial Forestland
Southeast States and Northeast Region

Southeast	Commercial Forestland (Acres)	Northeast	Commercial Forestland (Acres)
Alabama	21,658,900	Connecticut	1,805,600
Florida	15,664,100	Maine	16,894,000
Georgia	24,839,000	Massachusetts	2,797,700
South Carolina	12,502,900	New Hampshire	4,692,000
		New Jersey	1,856,800
		New York	15,405,800
		Pennsylvania	17,478,000
		Rhode Island	395,300
		Vermont	4,429,900
Total	74,664,900	Total	65,755,100

Not only is the total resource base greater, but in each of the four states the resource base is significant. Thus, from a biomass standpoint, not only does there exist a significant supply potential in each state (a condition not found in several of the northeast states), but despite development interest in the "sunbelt" region, the resource base is of sufficient size to absorb diversions of forestland to other uses for several years before being critically affected.

It should also be noted that there is considerable interest in tree biomass in the southeast and this is reflected in research directed to the subject including efforts to quantify potential supplies for energy and other uses. Thus, in the southeast there is at the present time a more comprehensive body of information on tree biomass than is found in other regions.

3.0 Background

Many areas of the southeast, like the northeast, rely heavily on oil and natural gas which must be imported either from domestic sources or foreign areas. Shortages and escalating costs have caused concern and stimulated interest in alternative fuels. The residential use of wood energy has been somewhat less dramatic than the northeast but space heating needs are less severe.

With an abundant resource base, the forest industries, as might be expected, took advantage of opportunities to utilize wood residues as a dependable, less expensive, fuel source. However, considerable interest in wood energy has been found in industries not associated with forestry and conversions to wood have been made in such industries as textiles and brick manufacturing. The State of Georgia has implemented programs to stimulate the use of wood fuel in institutions. For the most part, wood fuel has primarily been manufacturing residues and a supply system based upon forest biomass is slowly evolving. Analysis of current state surveys of manufacturing residues indicates a high degree of utilization for both fiber products and industrial energy supplies. Thus, if increasing demands for energy fuel supplies are to be met without competing for existing industrial residues, then supplies must come from forest biomass.

4.0 Factors Affecting Supply

As was discussed in Task II, there are many factors that will have an effect on the potential available supply of wood for industrial energy use. In general, the discussion of factors that may significantly affect supply that are detailed in the Task II analysis are applicable to the southeast states. The basic difference between the two regions is the degree of importance of the factors.

4.1 Resource Base

The forest resource of the four states is quite significant. As indicated in Table 1, the quantity of commercial forestland in the area is larger than that of the entire northeast. At the present time, the size of the resource base appears to have reached a degree of stability and no significant additions are expected in the future. Under the pressure of further development activities, it is expected that diversions of commercial forestland will take place. However, given the size of the resource, such diversions should not materially affect the total supply of biomass in the foreseeable future.

4.2 Land Ownership

As was the case in the northeast, ownership of the resource is predominantly private. Although total Federal ownership is larger, (approximately 4.6 million acres versus approximately 1.3 million acres in the northeast), the percentage is about 6 percent which is slightly higher than the 2 percent for the entire northeast region and varies from 10 percent in Florida to 4 percent in Alabama.

With respect to patterns of private ownership, very little information is available. The general opinion expressed by various forestry officials throughout the region was that the resource had not yet been fragmented to any significant degree into small uneconomical units. This opinion, in part, is substantiated by a limited landowner study undertaken in Alabama in 1973. At that time, approximately 45 percent of the private commercial forestland was in units smaller than 500 acres.

In comparison, the various studies in the northeast indicate that the private commercial forestland in units less than 500 acres range from 54 percent to 95 percent with three states containing 90 percent or greater.

Forest industry ownership in the region is consistently more significant than in the northeast. Where the northeast states varied from no forest industry ownership (Connecticut) to 48 percent (Maine), the four southern states range from 17 percent to 30 percent (Table 2).

Table 2

Forest Industry Ownership

State	Acres	% of Total
Alabama	4,202,620	19.7
Florida	4,696,802	29.9
Georgia	4,318,200	17.3
South Carolina	2,242,580	17.9

In addition to ownership, in each state the forest industries lease and manage considerable other private acreage.

It is conceivable that in some localized supply zones, a predominance of industry-controlled lands could result in limited supplies of industrial wood energy especially if management is short rotation crops.

4.3 Utilization and Growth

Analysis of production data in each of the states indicates that the forest resource is underutilized. Removals from growing stock timber as a percentage of net growth varied from a low of 51 percent (South Carolina) to a high of 68 percent (Florida). Thus, inventories of biomass are increasing.

There is a significant, and for the most part, widely distributed forest industry throughout the region. Only in Florida is the industry "regionalized" to any great extent and this is due to the fact that the resource is "regionalized." To the potential large scale industrial wood energy user, the presence of a significant forest industry connotes a supply system; a potential source of fuel from manufacturing residues although it must be noted that existing information indicates that with respect to manufacturing residues, a high degree of utilization now exists exceeding 90 percent in some states. In addition, as has already been noted, the forest industries could also be a source of competition for the resource in some situations.

It should also be noted that like the forests of the northeast, considerable quantities of low grade, low-value wood biomass are found as part of the resource. There is no indication that this material is being utilized to any significant degree at the present time.

4.4 Chipping Technology

In general, whole tree chipping technology is not extensively being utilized. All states report some chipping operations and, like the situation in the northeast, operations involve land clearing, some pulp chip production, and some fuel chip production. In this area, like the northeast, current supplies of wood energy chips are primarily coming from plant residues but the reported high degree of utilization of these residues indicates that growth in the use of wood for industrial energy purposes will either entail competition for those plant residues now being utilized for other purposes or increased reliance upon forest biomass, and hence, increased application of whole-tree chipping technology.

4.5 Transportation

In general, with the exception of southern Florida, transportation networks appear to be adequate to provide both access to the resource and transportation. Although there are large rural areas in the region, terrain conditions have not limited the development of road systems as is found in some areas of the northeast.

4.6 Terrain Limitations

Although steep terrain appears to be the most critical limiting factor to harvesting activities in the northeast, some steep terrain and wet site conditions are the reported adverse factors in the south. Available information indicates, however, that these limitations do not affect significant areas of the resource and estimates indicate that the effect ranges from a low of 3 percent in South Carolina to 7 percent in Alabama and Florida. These estimates, contained in the various state survey reports, may be somewhat conservative since they refer to general harvesting activities and not specifically to whole-tree chipping technology. However, given the general nature of the terrain throughout the region, it is doubtful that whole-tree chipping technology would find severe limitations over significant areas.

5.0 Individual State Assessment

The following state-by-state assessment of the potential for industrial wood energy was conducted utilizing the format developed for the Task II assessment of the northeast. Basic information was obtained from the most recent inventory data obtained from the regional USDA Forest Service experiment stations. As has been pointed out, the resource inventory reports in the southeast states have been supplemented with additional reports that address the recent interest in biomass quantities including estimated potential quantities of tree biomass available for such uses as industrial fuel. In addition, the survey reports also contained information with respect to the amount of the resource affected by adverse terrain conditions. This data was extremely useful in evaluating the factor of terrain on potential supplies.

Unlike the northeast, there is very little information on patterns and attitudes of nonindustrial landowners. This is reflective of the fact that in these states the urbanization process is still confined to the scattered major metropolitan areas.

In all the states, appropriate forestry officials were contacted for supplemental information.

In one significant area, forestry practices in the south differ from that of the northeast. The production of softwood timber on short rotations is a significant aspect of southern forest management. Thus, harvesting is followed by regeneration. In essence, clear-cutting is a more widely accepted management practice. This has implications for whole tree chipping technology both in terms of effectiveness and the need to clear sites of residues as a prelude to regeneration. As the various survey reports document, there are potentially large supplies of tree biomass available both from residues from harvesting operations and conversions of sites to more suitable species. The net result is that in these states it is possible to more readily quantify potential supplies of biomass based upon economic opportunities to produce traditional timber products.

ALABAMA

The most recent inventory, conducted in 1982, indicates that there are approximately 21.6 million acres of commercial forestland in the state[1] This represents a slight increase over that reported in the 1971 inventory[2] and is a reversal of the trend established between the 1963-1971 surveys which saw a 2 percent decline. The current estimate of commercial forestland is approximately 66 percent of the total land area.

The resource is fairly well distributed throughout the state. Only 2 of the 67 counties are less than 1/3 forested and only 10 are less than 50 percent.

The volume of growing stock increased over the survey periods about 7.3 percent and is now estimated to be 21.7 million cubic feet. The north and western regions of the state appear to contain a heavier volume per acre than the south and eastern regions. The latter areas contain volumes ranging from 907-924 cubic feet per acre while the other regions contain from 1006-1171 cubic feet per acre. Overall, there has been a slight increase in per acre volume from 947 cubic feet in 1971 to 1002 in the most recent survey.

Land Ownership

Forest ownership in Alabama is predominantly private. Over the years, there has been relatively little change among the categories of ownership. During the interim since the 1971 inventory, the private non-industry category declined slightly but forest industry ownership increased some 200,000 acres so that currently this class of owner represents an area of approximately 4.4 million acres, slightly more than 20 percent of the total commercial forestland. Public ownership remains at about 5 percent (about 1.1 million acres). Thus, over the years, the total amount of commercial forestland has remained fairly stable as has the ownership.

The .6 million acres of national forests are distributed among four forests located in various regions of the state. The .4 million acres of "other" public land is widely distributed with almost two thirds of the counties having some public ownership. At the county level, this type of public ownership is in relatively small units.

Forest industry ownership is widespread and only 5 of the 67 counties are reported as having no forest industry-owned land. This widespread representation of forest industry ownership can be taken as one indication that forest harvesting activity is not concentrated in any particular region.

Detailed information about the characteristics of private land ownership, especially in the large nonindustry ownership sector is not available. However, some insight with respect to the pattern of private land holdings can be gained from landowner information compiled in 1973[a] This information, as shown in Table AL-1, indicates that over 50 percent of the commercial forestland in the private sector is in parcels

(a) Information from M. Hinson, Manager, Forest Products Development. Alabama Forestry Commission, April 1983.

of 500 acres and larger. Approximately 45 percent is in units smaller than 500 acres and amounts to some 9.3 million acres. Due to the fact that the survey did not detail the pattern of holdings less than 500 acres, it is not possible to estimate how much of this land may be in small uneconomical parcels. However, a brief comparison with some northeast states indicates that while the amount of commercial forestland in Alabama in units less than 500 acres amounts to some 45 percent, the percentage of such land would be 68 percent in Vermont and 95 percent in Rhode Island. The data, while not conclusive, seems to indicate that in Alabama the resource has not, as yet, been significantly subdivided into the small acreages characteristic of the northeast.

Table AL-1

Alabama 1973

Number of Landowners and Size of Forest Ownership

Size (Acres)	Number of Landowners	Acres in Ownership	%
1-499	202,439	9,301,544	45.5
500-4,999	4,529	5,104,310	25.0
5000+	345	6,028,293	29.5
Totals	207,313	20,434,147	100.0

Utilization and Growth

Alabama has a significant and important forest industry. The various industries are distributed throughout the state, reflective of the fact that the resource is widely distributed.

In terms of numbers, the forest industry with the exception of sawmills has remained fairly stable over the past decade. Comparing recent 1981 information with 1971 survey data[3] indicates that with respect to the major primary industries, the number of pulp and paper mills in 1981 was 14 (one less than that in the previous study). Veneer and plywood has increased from 32 to 37, reflecting the continued growth of the southern pine industry.

With respect to the sawmill industry, there has been a 13 percent decrease in numbers and in 1981 there were 280 mills compared to 323 in 1971. The trend has been consistent with other states in that the smaller mills are disappearing and the existing mills have much greater production capacity.

In essence, the situation in Alabama conforms to the pattern found in the other southeastern states, wherein one finds a significant and relatively stable forest industry indicative of the important position the south occupies in the production of forest products.

Production and growth data from the latest 1982 inventory is not yet available, therefore, it has been necessary to look at somewhat isolated recent data sources in relation to the previous (1971) inventory.

In 1971, total removals amounted to 739.6 million cubic feet of which approximately 1680 million cubic feet was roundwood, 37 million cubic feet was attributed to logging residues, and some 22 million cubic feet was comprised of land clearing and cultural material.[2]

Pulpwood production is the major roundwood product and in 1971 amounted to 4.8 million cords. A recent survey of pulpwood production[4] indicates that 1980 production of pulpwood from roundwood was 6.2 million cords or 527 million cubic feet, a 29 percent increase over 1971 production.

Analysis of 1981 forest products production based upon reported severance tax receipts[5] indicate that sawlog production amounted to approximately 1.1 billion board feet. This would represent a slight decline from the 1.5 billion board feet reported in 1971. However, state officials indicated that data based on tax receipts are somewhat conservative and, therefore, it appears that insofar as sawlog production is concerned only minor differences are involved.

The data, although limited, seems to indicate that currently the resource is still being underutilized since in 1971 the survey indicated that net growth was 1.2 billion cubic feet, some 448 million cubic feet in excess of timber removals.

In addition to growing stock volumes, there is considerable quantity of low-grade, low-value biomass estimated to be in excess of 2 billion cubic feet.[6] Inm terms of tonnage, it is estimated that the total aboveground green weight of this material is 207.9 million green tons.[7]

As was found in other investigations, current information indicates that very little of this material is currently being utilized. In Alabama, only about 1 percent annually appears to be contributing to roundwood production.

With respect to mill residues, in 1971, it was reported that approximately 85 percent of primary industry residues were being utilized for fiber, fuel, and other uses. State officials estimate that current utilization rates are in the neighborhood of 90 percent.

Chipping Technology

Chipping technology is being utilized to a modest extent in the state. Forestry officials estimate that from 8-10 operators are utilizing whole-tree chipping equipment for land clearing, pulp chip production, and wood energy production. Considering the size and importance of the pulp industry in the state, the number of whole-tree chip operations is small. However, this may in part be due to the fact that the fiber industry is utilizing considerable quantities of manufacturing residues estimated to be over 2 million cords.[2]

Quantitative Estimates

Somewhat theoretical estimates have been made of the potential supply of wood for industrial energy purposes in Alabama.[8]

One method assumes that a portion of wood biomass will be recovered annually from such sources as rough and rotten, excess growth, mortality, logging residue, small trees, and unused manufacturing residue. The calculated total of such biomass is 382 million green tons. At a 5 percent annual recovery, 19 million tons would be available. At a 10 percent recovery rate, 38 million tons would be available.

A second method is based upon assumed annual recoveries from fewer sources such as commercial harvesting operations, manufacturing residues and material recovered from land clearing, and small timber. This method indicates a somewhat lower potential availability of from 9-12 million tons annually dependent upon whether tonnage from small timber is included or excluded.

Based upon assumptions that indicate a 100,000 pound/hour boiler will require approximately 139,000 green tons annually, the range of estimates with respect to potential quantities of biomass indicate that for Alabama, the estimates would support from 64-174 large industrial boilers.

Transportation

The State of Alabama has an extensive highway system that contains five interstate systems and numerous state primary and secondary systems serving all parts of the state. Since all counties are reported to produce timber products and since forest industries are distributed throughout the area, it appears that an adequate system for providing both transport of products and access to the resource exists.

Terrain

Adverse terrain conditions, serious to the extent that a significant portion of the resource would be affected, is not considered a major factor in Alabama. Classification of the harvestable commercial forestland in 1982[a] indicates that of the total 21.3 million acres of commercial forestland only 1.5 million acres (7 percent) is considered to be affected by such factors as wetland and steep slopes.

Summary

The State of Alabama has a considerable resource base estimated to be approximately 21.3 million acres. This resource is fairly well distributed throughout the state and supports a large quantity of biomass that is underutilized despite the presence of a significant and widespread forest industry.

The resource has been increasing both in size and quantity since 1952. However, it is believed that the size of the resource in terms of commercial forestland acreage has stabilized and will decline to some extent in the future. This decline is not expected to be significant and is projected to amount to some 1.5 million acres over the next 40 years. This would mean a diversion to other uses of approximately 37,500 acres annually.

The importance of southern softwood timber provides economic incentives to intensively manage forestland for the continued production of desirable species. The disposal of undesirable biomass provides opportunities with respect to supplies of wood energy. Thus, management objectives in terms of the continued production of traditional forest products can and should result in supplies of energy biomass.

(a) Information from Alabama Forestry Commission Staff.

The fact that the resource does not appear to have been subject to significant subdivision that results in small uneconomical units provides opportunities for management of much of the resource.

Adverse terrain is not considered to be a significant deterrent to harvesting operations.

The feasibility of utilizing wood biomass for industrial energy purposes should be considered as being quite significant.

FLORIDA

Five forest inventories have been taken of the state's resources during the past 47 years. The latest survey was completed in 1980. Over the years, changes in land use have brought about a decline in the amount of commercial forestland. A USDA Forest Service Report[9] indicates that in 1952 there were 18.1 million acres of commercial forestland. The 1980 survey[10] reports 15.7 million acres (a 13 percent loss). Between 1970 (the time of the fourth inventory) and the most recent 1980 survey, there had been a decline of 597,000 acres. As of 1980, commercial forestland comprised 45 percent of the total land area.

Despite losses to the forest base, the volume of growing stock has increased in the interim between the most recent surveys by 18 percent (from 11.6 billion cubic feet in 1970 to 13.6 billion cubic feet in 1980).

The resource is not uniformly distributed throughout the state as indicated in Table FL-1. Almost 80 percent of the commercial forestland is located in the two northern regions which contain approximately 50 percent of the land area.

Land Ownership

Ownership of commercial forestland is predominantly private. Of the total 15.7 million acres reported in 1980,[10] approximately 10 percent or 1.5 million acres were in Federal ownership, 5 percent or 0.5 million was owned by state and local governments, and the remaining 86 percent (13.4 million acres) in private ownership. Of the private holdings (4.6 million acres) approximately 30 percent are forest industry lands.

Table FL-2 indicates the ownership pattern for the four regions of the state.

Table FL-1

Total Land Area and Commercial Forestland by Regions - 1980
(Thousand Acres)

Region	Total Land Area	% of Total Land	Commercial Forestland	% of Total Commercial
Northeast	9,717.7	28	6,844.4	44
Northwest	7,308.9	21	5,512.0	35
Central	10,056.1	29	2,473.7	16
South	7,919.3	22	834.0	5
Totals:	34,002.0	100	15,664.1	100

Source: Forest Statistics for Florida, 1980, W. A Bechtold, R. M. Sheffield. USDA Forest Service Resource Bulletin SE-58. Southeastern Forest Experiment Station, July 1981.

Table FL-2

Ownership of Commercial Forestland by Regions
(Acres)

Region	National Forest	Other Public	Forest Industry	Other Private
Northeast	426,047 (42%)	160,871 (14%)	2,704,971 (58%)	3,552,581 (40%)
Northwest	515,606 (51%)	714,805 (61%)	1,949,784 (41%)	2,331,866 (27%)
Central	64,104 (7%)	286,532 (24%)	42,047 (1%)	2,080,992 (24%)
South	0 (0%)	10,215 (1%)	0 (0%)	823,756 (9%)
Totals:	1,005,757	1,172,423	4,696,802	8,789,195

From the table, it can be seen that the bulk of the public land is in the northwestern region and the major portion of the forest industry holdings are in the northeastern area.

As yet, there does not seem to be the detailed knowledge about timberland ownership that was available for the northeastern states. Florida forestry officials were able to supply a limited ownership study that involved private, nonindustrial forest landowners in the subject area of pine reforestation.[11] From that study, one can infer that in comparison with the northeastern states, forestland ownership involves somewhat larger parcels in Florida. Analysis of the Florida survey indicates that of some 947 respondents, 43 percent indicated ownership of parcels smaller than 50 acres. While this may seem high, a recent survey in New York State indicated that 87 percent of the landowners had parcels less than 50 acres and 75 percent of the landowners in Vermont were in that category. If the Florida survey is representative of private timberland ownership then the limited data indicates that in Florida the bulk of the ownership is in larger parcels.

Utilization and Growth

As of the 1980 survey, there were approximately 148 primary wood-using plants in operation. A study conducted in 1975[12] indicates 125 primary industries in that year, a decline from 139 in 1965. Thus in 1979, the earlier trend of fewer industries had been reversed and as of the reporting period, the total exceeded that reported in 1965. As might be expected from the regional concentration of the resource, the majority of the forest industries are in the two northern regions. In 1975, 42 percent of the primary wood-using plants were located in the northeast region and 28 percent in the northwest. Thus, 70 percent of the industries are concentrated in the northern regions. The profile of primary industries indicates 74 percent are sawmills, 7 percent veneer mills, 8 percent pulp mills, and 11 percent miscellaneous. The trend, at least for the period 1969-1975, indicates a relatively stable situation with respect to sawmills, a decline in the number of veneer mills from 17 in 1969 to 9 in 1975, a slight increase in pulp mills (1), and a decrease in miscellaneous facilities.

Reported production of industrial products in 1979 was an estimated 460.7 million cubic feet.[10] This represents a 53 percent increase over production reported for 1975.[10] However, the trend for the decade 1969-1979 is somewhat erratic, increasing from 324.9 million cubic feet in 1969 to an average of 355.6 million for the 1971-1973 period, decreasing to 300.5 million cubic feet in 1975, and then increasing to the 1979 production level.

Despite the predominance in numbers of the sawmill industry, the major industrial timber product is pulpwood. As Table FL-3 indicates, over 60 percent of the 1979 production was pulpwood.

Table FL-3

Industrial Timber Products, 1979
(Thousand Cubic Feet)

Product	Production	Percent
Sawlogs	134.4	29
Veneer logs/bolts	15.8	4
Pulpwood	296.1	64
Other	14.3	3
Total:	460.7	100

Source: Reference 10.

Over the brief historical period 1969-1979, production trends indicate increasing production of sawlogs, erratic production of veneer logs that increased during the early 1970s with a sharp (over 50%) drop in 1975 and rising in 1979 to approximately 1969 production levels. Pulpwood production has declined as a portion of total production but 1979 production quantitatively was at a high for the decade. The output of miscellaneous products has also had erratic production levels but ended up the decade with production slightly more than double that reported in 1969.

In addition to industrial production, Florida does utilize fuelwood products to a modest degree. For the 1979 survey period, some 67 thousand cords of fuelwood were produced, the equivalent of 4.5 million cubic feet. Thus, the total output of timber products, industrial and nonindustrial, amounted to 465.2 million cubic feet. With respect to net annual growth, reported at 785 million cubic feet of growing stock, total timber product production from all sources was 59 percent of the net annual growth. However, all of the timber product production did not come from growing stock since approximately 16 percent or 73.6 million cubic feet came from such nongrowing stock material as plant by-products, cull trees, dead trees, and other sources. Thus, material from growing stock trees (391.6 million cubic feet) was approximately 50 percent of net annual growth.

In terms of total removal from growing stock including logging residues and other removals, cubic footage amounted to 541.7 million cubic feet or 69 percent of net annual growth.

Florida's commercial forestland also contains a considerable volume of rough and rotten material estimated to be 1.8 billion cubic feet. A recent estimate[13] of the state's forest biomass indicated 864 million green tons, of which an estimated 18 percent (155.5 million tons), was in rough and rotten trees.

The analysis of the sources of roundwood products in 1979 indicates that little of the rough and rotten category is currently being utilized. Of the total 417.1 million cubic feet of roundwood production in 1979, only 6.7 million cubic feet (less than 2 percent) came from cull trees. In terms of the total rough and rotten inventory, utilization was negligible.

Chipping Technology

There is no quantitative information relative to how extensively whole tree chipping technology is being utilized in the state. However, it is being employed and given the fact that pulpwood production is an important component of the forest industry plus the fact that there are few steep terrain limitations, one can assume that conditions are favorable for increased utilization of the technology.

In view of the fact that 96 percent[14] of the residues generated by primary industries is now being utilize, any significant increase in demand for the use of wood for industrial energy will have to be met either by competing for existing plant residues or from forest biomass.

Transportation

It does not appear that the transportation network would be a factor insofar as limiting either access to the resource or transportation of the product. The dependence of the area on recreation and the production of agricultural crops has stimulated the development of an extensive highways system serving all portions of the state.

Terrain

Unlike many areas of the northeast where steep terrain conditions will limit the application of whole-tree chipping technology, there are few, if any, areas in Florida where adverse slopes will limit use of mechanized equipment. However, wet site conditions will undoubtedly limit, if only on a seasonal basis, production in some areas. The severity of such limitations will be more prevalent in the southern portion of the state, an area with limited forest activity.

Adverse site conditions, severe to the extent that management opportunities are limited, are estimated to affect only about 7 percent of the commercial forestland. This would amount to slightly over 1 million acres and the primary limiting factor is year-round water problems. On a regional basis, these limiting site conditions are largely found in the Central Florida Unit which contains about 16 percent of the commercial forestland.

Quantitative Estimates

Two estimates of the potential tree biomass for wood energy have been made. One estimate based on methods developed at the Georgia Institute of Technology has been described in a previous section.[9]

In essence, the Georgia estimates involved a range based upon two methods: one involving conversion of cubic foot volumes of various categories of tree biomass including annual unused plant residue; and the method is oriented to material from commercial harvesting operations. The range in terms of green tons was 9-18 million green tons for the first or "Category" method and 5-6 million green tons for the second or "Multiplier" method.

For the sake of brevity, the results of the "Category" method are utilized where both in terms of the initial report estimates and the results from substituting more recent data in the original calculation.

Category Method

The basic calculation involves converting the cubic foot volume of various tree biomass components to pounds of biomass and then multiplying the weight by a Btu per pound factor. The basic equations are:

Softwood

X Ft^3 (57 lbs/ft^3) (4,300 Btu/lb) = Total Btu's for softwood.

Hardwood

X Ft^3 (55 lbs/ft^3) (4,300 Btu/lb) = Total Btu's for hardwood.

For the purposes of this report, the interest is in green tons. Thus, the above calculations were used only to obtain tonnage. Table FL-4 summarizes the Georgia estimate.

Table FL-4

Summary of Initial Category Method

Component	Green Tons (Hardwood and Softwood)
Trees less than 5 inches D.B.H.	117.3×10^6
Rough	39.5×10^6
Rotten	9.0×10^6
Annual Excess Growth	6.8×10^6
Annual Other Removals	3.9×10^6
Annual Mortality	2.0×10^6
Annual Logging Residue	0.6×10^6
Annual Unused Plant Residue	0.1×10^6
Total:	179.2×10^6 Green Tons

The resultant quantity of 179 million tons is termed the "Theoretical Total." The Georgia report reduces this gross quantity by two assumptions:

- a 5 percent annual recovery resulting in an estimate of 9 million tons; and
- a 10 percent annual recovery resulting in an estimate of 18 million tons.

As previously pointed out, the cubic foot data utilized in the Georgia study were based upon USDA Forest Service statistics[9] published in 1978. The cubic foot volumes were not of total biomass but were the volumes measured and reported in the traditional fashion. In the interim, more recent data are available from the recent resurvey of the state and since several of the biomass components are reported in terms of total biomass, this new information was substituted to determine if there would be significant changes in the final estimated quantities.

Recalculated Category Method

Table FL-5

Components	Green Tons (Thousands)	
Trees less than 5 inches D.B.H.	126.1	(1)
Rough & Rotten	117.5	(1)
Excess Growth	6.9	(2)
Annual Other Removals	3.9	(3)
Annual Mortality	2.0	(2)
Annual Logging Residues	0.6	(2)
Annual Unused Plant Residues	0.1	(2)
Total (Theoretical)	257.1	

Quantity @ 5% Recovery	12.9 Million Green Tons
Quantity @ 10% Recovery	25.7 Million Green Tons

Source:

(1) Multiresource Inventories -- Forest Biomass in Florida, N. D. Cost, S. P. McClure. USDA Forest Service Research Paper SE-235. Southeastern Forest Experiment Station, July 1982.

(2) Florida's Forest, W. A. Bechtold, H. A. Knight. USDA Forest Service Research Bulletin SE-62. Southeastern Forest Experiement Station, February 1982.

(3) Reference 9.

Thus, utilizing the most recent information results in an increase in potential quantities of wood for energy use.

The USDA Forest Service Southeastern Forest Experiment Station, in a research paper (Reference 11), estimates that at least 13.9 million tons of energy wood could be harvested annually over the next 20 years.

The Forest Service estimates are based on quantities of biomass that could be harvested from two major sources. The major source would be the 5.2 million acres of commercial forestland that is classified as poorly stocked and offer significant opportunities for regeneration by removal of existing biomass estimated to be 28 tons per acre. If 5 percent of the acreage were cleared each year with an average yield of 20 tons per acre, approximately 5.2 million tons could be harvested annually over the next 20 years.

Similarly, it is estimated that on the 257,000 acres of timberland harvested annually, there is some 18 tons of forest biomass left per acre exclusive of logging residues. These residues would amount to 4.6 million tons annually. An additional 4.1 million tons annually could be recovered from the logging wastes.

Thus, various methods and assumptions estimate that wood biomass for energy use could range from 5 to 18 million green tons annually. On a calculated needs of a 100,000 lb/hr industrial boiler for approximately 139 thousand green tons of wood per year, the estimates indicate that the wood biomass would sustain from 35-129 units. In terms of the estimated needs of the Burlington, Vermont 50MW generation facility for 500,000 ton per year, the estimated supply would sustain 10-36 such units.

Summary

The State of Florida has a significant resource base that supports an active forest industry. The forest resources are not uniformly distributed throughout the state but are concentrated in the north. Significant development activity is expected to continue, resulting in additional diversion of commercial forestland to other uses. However, current projections indicate a loss over the next 30 years of approximately 1.3 million acres which would reduce the existing base of 15.7 million acres to about 14.4 million acres. Over that period of time, growth is expected to continue to exceed removals although the difference will decrease due to the fact that removals of softwood will continue to increase, and since softwood volume predominates, the net effect will be a narrowing of the gap.

Forest management opportunities in Florida suggest that significant quantities of energy biomass could be harvested without adversely affecting timber supplies.

Supply limitations due to transportation systems and adverse terrain appear to be minor. Although detailed information is lacking on land ownership patterns, it is believed that as yet the forest resource is not fractured into small uneconomical holdings to the significant degree found in the more populous northern states.

GEORGIA

Five forest surveys have been made of the state's resources. Data for the latest survey undertaken in 1980 is not yet fully available and only data for the southeast[15] and southwest[16], regions were available at the time of this assessment. For the state as a whole, the survey data of 1972[17] was utilized and the limited 1980 information used where appropriate.

Between the survey periods of 1960 and 1971, the state lost almost 1 million acres of commercial forestland. This left 24.8 million acres, the second largest of the lower 48 states. According to the 1972 survey, the greatest loss occurred in the southeast and southwest units which accounted for 72 percent of the almost 1 million acre decline. Examination of the recent 1980 data for these regions indicates a continued loss that amounted to approximately 511,000 acres. Although the recent loss appears to be less than the 684,000 acre loss reported during the previous survey period, analysis of the data indicates an acceleration since a considerable contribution to the earlier loss was a 325,000 acre withdrawal in the Okefenokee National Wildlife Refuge. If this item is set aside, then the actual loss in the 1960-1971 survey period to agriculture and urban development was 359 thousand acres whereas the loss to such other uses in the 1971-1980 period was approximately 511,000 acres. If the rest of the state continued the trend indicated in the earlier study, then it would appear that the area has lost at least another million acres. However, in perspective, the state appears to be losing 80,000-90,000 acres of commercial forestland a year but given the size of the resource, the loss would not be critical over a long-term period.

The resource is fairly well distributed with all units being at least 50 percent commercial forestland. In terms of the proportion of commercial forestland within a survey unit, the highest concentration is in north Georgia with 75 percent of the total land area in commercial forestland and the lowest concentration is in southwest Georgia with 51 percent in commercial land. Table GA-1 indicates the land classification for each of the survey units.

Table GA-1

Land Area by Class and Survey Unit
(Thousand Acres)

Unit	All Land	Commercial Forest	%	% of Total Commercial
North	4,226.4	3,192.5	75	13
North Central	6,235.2	3,992.2	64	16
Central	10,550.6	7,321.9	69	29
Southeast	10,713.9	7,440.6	69	30
Southwest	5,653.6	2.884.8	51	12
Total:	37,379.7	24,832.0	66	100

During the period between the 1961-1972 surveys, the inventory of growing stock timber increased from 19.6 to 25.3 billion cubic feet, an increase of 29 percent. However, inventory increases were not uniform throughout the state. The southeast unit registered the lowest increase, 9 percent in terms of volume in all live timber. The highest increase 56 percent, took place in the north central unit.

Analysis of the most recent survey data for the southeast unit indicates that the total volume had increased by 13 percent during the 1971-1981 survey period. A similar analysis for the southwest unit indicates that during the latest survey period, total volume increase was 17 percent less than the percentage increase of 25 percent recorded during the previous survey period.

Land Ownership

Ownership of the forest resource in Georgia is predominantly private. Of the estimated 24.8 million acres of commercial forestland, approximately 6 percent is in government ownership, of which 5 percent is Federal and 1 percent state and local. The remaining 94 percent is private and of this amount, 4.3 million acres is owned by forest industries. In addition, some 0.9 million acres of other private forestland is leased to forest industry.

Although details on the pattern of land ownership are not available, discussions with state forestry officials indicate that as yet the fracturing of the resource base into small units has not reached the degree of importance found in several of the northeastern states. Given the size of the resource it is highly unlikely that a critical situation will develop in the foreseeable future except in the immediate vicinity of established metropolitan centers.

Utilization and Growth

Two sources of data on primary industries in Georgia indicate decline in total numbers. Between 1971 and 1974, the number of primary industries remained relatively unchanged with 368 indicated in 1971 and 366 in 1974.[18] A recent[19] survey indicates that in 1981 the total number of primary industries was approximately 322. The most significant change occurred in the sawmill catagory which in 1981 had declined to 248 facilities. However, as has been pointed out before, total numbers are somewhat immaterial since the trend has been to fewer but larger units.

The forest industries in the state are fairly well distributed thoughout the region, reflective of the widespread distribution of the resource.

Analysis of three data intervals on production of industrial timber products indicates a rather stable level of production for the last decade. *Production in 1971[18] was reported to be approximately 919 million cubic feet. Production in 1974 was approximately 985 million cubic feet. Data for 1980[20] indicates timber production of about 994 million cubic feet

Thus, while 1980 production was 8 percent greater than 1971, it was only 1 percent greater than 1974. Since annual data is not available, it can only be assumed that the three data points over the 10-year period are reflective of average conditions.

With respect to the relative position of sawlog production versus pulpwood, the three data points are not sufficient to define any trend. However, comparing the 1980 data with 1971 data indicates that in 1980, sawlog (including veneer logs and bolts) production had increased in terms of percentage of total production from 37 percent in 1971 to 47 percent in 1980. Pulpwood on the other hand had decreased from 59 percent in 1971 to 51 percent in 1980. The miscellaneous category which amounted to about 4 percent in 1971 was only 2 percent in 1980. Thus, the latest data indicate a slight shifting with respect to the total production of the two major categories. Only the miscellaneous category exhibits a net reduction in production, a trend that has shown up in other states.

Future production levels will, of course, be dependent upon many factors and all projections of future demand indicate an increasing need for forest products. The USDA Forest Service has projected the ability of Georgia's resources to supply increased quantities of forest products. Assuming a continuation of recent trends, it is estimated that the resource could sustain an increase in production by year 2001 that is 70 percent greater than the volume removed in 1971. If accelerated timber management activities were implemented, than by year 2001 production could be double the 1971 volume. Thus, it is clear that currently the resource is being underutilized, in fact, net growth exceeds annual removals by 55 percent.

From the standpoint of potential wood energy use, there is a considerable quantity of low value material represented in the total biomass volume. Of the estimated 28 billion cubic feet in all live trees 5.0 inches and larger, almost 2.7 billion cubic feet (10 percent) is in trees that do not qualify as growing stock material. A recent publication[21] estimates that such material is equivalent to approximately 135 million green tons of aboveground tree biomass.

Examination of the sources of roundwood production in 1971 indicates that of the reported 813 million cubic feet produced, only 2 percent or 16.9 million cubic feet came from cull material. Thus, of the reported volume of 2.7 billion feet of cull material, less than 1 percent was utilized.

Quantitative Estimates

Estimates have been made of the potential biomass for wood energy. Two methods were developed at the Georgia Institute of Technology and reported in a 1979 publication.[22]

The estimates for Georgia result in a range of values based upon two methodologies and various assumptions. One method involves the conversion of cubic foot volumes of various categories of tree biomass including annual unused manufacturing residues. The other method is based on recovery of material from annual commercial harvesting operations. The range for each methodology was 21-43 million green tons for the "Category Method", the methodology involving portions of various categories of biomass, and 15-20 million green tons for the "Multiplier Method" which is based primarily on the recovery of material from commercial harvesting operations.

It should be noted that in the development of the methodologies the researchers have stated that the estimates do not include economic and other factors that might affect availability of supply.

In addition to the estimates developed at Georgia Tech, the USDA Forest Service developed estimates for the State of Florida[23] which could be applied to Georgia. The Forest Service estimates are based upon quantities of biomass that could be harvested from two major sources. The major source would be the large acreage of commercial forestland that is classified as poorly stocked and offer significant opportunities for regeneration by removal of existing biomass. In the State of Florida, it was estimated that such land could yield an average of 20 tons per acre. If this yield is applicable to the State of Georgia and if the estimated 6.1 million acres of this category were treated at the rate of 5 percent per year (305,000 acres), about 6.1 million green tons per year could be harvested annually for the next 20 years.

In addition, an estimated 400,000 acres are harvested annually. In the Florida estimate, approximately 18 tons of living residual biomass remains. Recovery of this material would add some 7.2 million green tons. It was also calculated that some 16 tons per acre in logging residues remained. This material amounts to some 6.4 million tons. Thus, in theory, material removed to permit regeneration plus material recovered from harvesting operations amount to approximately 19.7 million tons per year.

On a theoretical basis, the various estimates result in a range of from 15-43 million tons annually. If an industrial boiler of 100,00 lbs/hr requires approximately 139 thousand green tons per year then the estimates indicate a potential supply capable of supporting 108-300 units.

Transportation

An adequate transportation network for the movement of forest products is evident in the state considering that of the 159 counties in Georgia only one was reported as having no product drain in 1980. The fact that practically all regions experienced some logging activity indicates that the resource is widely distributed and fairly accessible.

Terrain

According to the 1972[17] survey, about 4.5 million acres of commercial forestland (18 percent) is situated in deep swamps, bays, along stream margins, and in steep mountainous terrain where accessibility is difficult. Thus, it appears that although as much as 1/5 of the commercial forestland may have terrain conditions that will adversely affect supply, these conditions and sites will be localized and the effect must be evaluated for a potential supply area identified with a site-specific facility.

Summary

The State of Georgia has a significant resource base, the largest of the four states evaluated in the southeast. The resource is well distributed throughout the state as is the forest industry.

The commercial forestland is predominantly in private ownership and although detailed information on ownership is not available, it is believed that as yet the resource has not been subdivided into small uneconomical units to any significant degree. Despite increased development activities in Georgia and other "sun-belt" states, diversions of commercial forestland to other uses is not expected to be significant for many years.

Limitations on harvesting operations due to adverse terrain conditions exist on about 20 percent of the resource but such situations will only be significant at local levels.

The feasibility of using wood for industrial energy purposes appears to be excellent.

SOUTH CAROLINA

There have been five surveys of the state's forest resources with the first being completed in 1936 and the latest in 1978.[24] Thus, there exists a 42-year record of changes and trends.

Since the last survey, completed in 1968, the amount of commercial forestland has increased slightly from 12.4 million acres in 1968 to 12.5 million acres in 1978. Sixty-five percent of the state is in commercial forestland.

The forest resource is fairly well distributed throughout the state with only four of the forty-six counties being less than 50 percent forested.[25]

In the interim since the last survey. the inventory of growing stock has increased some 29 percent, from 13.3 billion cubic feet to 17.2 billion cubic feet.

Land Ownership

Ownership of the forest resource in South Carolina is predominantly private. Of the 12.5 million acres of commercial forestland, approximately 9 percent or 1.0 million acres is public and the bulk of this land, 5 percent, is in national forests.

Forest industry ownership is 18 percent and, in addition, some 83 thousand acres of other private land is leased to forest industry.

Seventy-three percent is farmer, individual, and corporate ownership. There is little information with respect to the pattern of land ownerships but in view of the fact that the state is not considered an "urbanized" region, it is assumed that significant sub-division of the resource base has not occurred. During the 10-year period between surveys, only an estimated 11.8 thousand acres of commercial forestland were diverted annually to urban uses; this represents a very small portion of the total resource base.

Utilization and Growth

Beginning in 1967, several studies were made of the state's primary wood-using industries.[26] During the period 1967-1976, the number of primary industries declined by 38 percent, a decrease in total numbers from 283 in 1967 to 173 in 1976. By far, the greatest decline was in sawmills which registered a 44 percent decrease. Despite this decrease, production capacity was not adversely affected since, as was found in other states, the remaining mills as well as new construction expanded capacity.

The next largest decline was in the miscellaneous industry category which experienced a 38 percent decline. However, this category was small in number with 13 in 1967 and 8 in 1976. The trend in South Carolina follows a similar trend in other states.

Pulpmills increased in number during the period from 5 in 1967 to 7 in 1976.

In general, the primary forest industries are distributed throughout the state.

Since 1967, production of industrial timber products in South Carolina has increased approximately 2 percent annually. In 1977, the production of industrial timber products totaled some 533.1 million cubic feet, of which approximately 449.5 million cubic feet or 84 percent came from roundwood products and the remainder from plant residues.[SC1] In 1976, approximately 90 percent of plant residues were utilized.

With respect to industrial timber production, the production of pulpwood is by far the most significant factor (see Table SC-1).

Table SC-1

Output of Industrial Timber Products - 1977

Product	Cubic Feet Production	%
Pulpwood	296,355,000	56
Sawlogs	165,689,000	31
Veneer	48,631,000	9
Other	22,524,000	4
Total:	533,199,000	100

In addition, some 31,103,000 cubic feet of fuelwood was produced primarily for domestic fuel.

However, not all of this material came from growing stock, therefore, to evaluate production in terms of growth, it is necessary to adjust data to reflect growing stock removals. Approximately 407.1 million cubic feet was identified as coming from growing stock on commercial forestland. In addition, 48.4 million cubic feet was removed from growing stock as logging residues and 40.3 million cubic feet as "other" removals, thus, the total was 495.9 million cubic feet. Net annual growth was 963.3 million cubic feet thus the ratio of growth to removals was 1.9-to-1.

There is a significant volume of low quality material on the commercial forestland estimated to be some 2.2 billion cubic feet in rough, rotten and salvable dead trees. The 1977 roundwood production removed only some 32 million cubic feet, approximately 1 percent of the estimated inventory. Excluding salvable dead trees, it is estimated that material in the rough and rotten category amounts to some 162 million green tons.[27] This estimate includes tonnage in stumps and saplings. A more conservative quantity, based upon material in the bole, tops and branches, would be 107 tons with an average green tonnage per acre being 8.6 tons.[28]

Chipping Technology

Chipping technology is being utilized to some extent in the state. The South Carolina Forestry Commission indicated a possible 6-8 operations producing both pulp quality chips and energy material. Operations involve pulp company harvesting and land clearing activities.

In addition to mobile in-woods chipping operations, stationary facilities have been established which process tree length material offsite, and then transport the processed biomass to the using facility.

Transportation

All regions of the state appear to support a well developed wood system capable of both providing access to the resource and transportation of harvested material to user sites.

Terrain

Terrain limitations in South Carolina should be insignificant with respect to being a factor in supply. Estimates[24] as to the degree that adverse terrain in the state limits harvesting operations indicate that only about 3 percent or 400,000 acres of the total commercial forestland contain severe site conditions such as steep slopes (over 40 percent) or areas with year-round water conditions. Thus, it appears that the vast majority of the resource is accessible for harvesting as far as terrain is concerned.

The location of adverse terrain is reported to be regional in that the steep slopes are found in the mountainous areas of the Piedmont Unit and the wet sites primarily located in the Northern Coastal Plain.

Quantitative Estimates

Various estimates have been made of the potential supplies of wood energy biomass in South Carolina. These estimates range from 6-26 million green tons annually.

One method developed for several states in the southeast[29] is based upon recovery of certain categories of the state timber resources such as sources from annual mortality, logging residues, excess growth, manufacturing residues, rough and rotten material, small trees, and material from land clearing. The estimated amount of such material utilizing this methodology ranges from 13-26 million green tons annually depending upon whether one assumes 5 percent or 10 percent of the total is recovered.

An alternative method[29] utilizes material recovered in conjunction with normal harvesting operations, manufacturing residues, and land clearing. This method produces a range of 6-9 million green tons annually dependent upon whether timber less than 5 inches in diameter is included.

A third estimate has been made by the Southeastern Forest Experiment Station of forest biomass that could be harvested in the state without adversely affecting timber supplies.[27]

This estimate concludes that over the next 10 years at least 16.7 million green tons of forest biomass could be harvested annually based upon the following:

- 2.1 million acres of poorly stocked land in need of regeneration. Estimated yield is 40 tons per acre for a total of 8.3 million tons annually if carried out over a 10-year period.
- 200,000 acres of timberland harvested annually. There is an estimated yield of 24 tons per acre of forest biomass left standing for a total of 4.8 million tons annually.
- In addition to the standing biomass on harvested land, there is an estimated 18 tons per acre in logging residues with the total amounting to 3.6 million tons.

Thus, the various estimates under several assumptions yield a wide range of values. As a reference point, if one uses the estimated needs of a 100,000 pounds/hour industrial boiler as described in Reference SC7, then such a facility would require approximately 139,000 green tons of biomass annually. On the basis of the low/high values of the various estimates, the quantities would support from 43 to 187 facilities.

Summary

The State of South Carolina has a significant forest resource base amounting to approximately 12 million acres of commercial forestland. For the most part, the resource appears accessible for harvesting with only 3 percent of the commercial forestland considered as having adverse terrain conditions. Unlike many states in the northeast, the resource base has not yet been subject to significant sub-division that creates small uneconomical units.

Although there is a significant well distributed forest industry in the state, the resource is being underutilized with annual removals representing approximately 51 percent of net annual growth. There is a considerable volume of low quality tree biomass that is ideal for energy use but at the present time is scarcely being utilized.

The feasibility for utilizing wood for industrial purposes in South Carolina, insofar as the resource is concerned appears to be very good.

Addenda

Having examined the potential of using wood biomass for industrial purposes in thirteen states located in two different regions of the country, it seems appropriate to record some general observations. Again, it should be emphasized that these investigations focused on only one aspect of industrial wood energy use; the resource and its potential to supply demand.

With respect to wood energy use, there are two major interest groups. The first group, broadly categorized, consists of interests basically concerned with energy. Their particular areas of interest would include such subjects as energy supply and demand, conservation, and alternative energy sources.

The second group, again broadly categorized, consists of those concerned with the forest resource and would comprise forest industries, public and private institutions, and individuals more or less directly involved with the resource.

The degree of coordination between the two groups appears to range from fair to indifferent. In all fairness to the first group, this group is becoming increasingly difficult to identify, since many, either created by government or funded by government programs, have ceased to exist or have had program support severely curtailed in accord with current government policies.

The second group is much more institutionalized and has a long history of involvement with the resource. With respect to the use of wood biomass for industrial energy, the interest of this group is not basically with energy per se. The fundamental interest lies in the fact that the use of wood energy provides another market for timber products. The fact that wood energy requirements are non-specific either in regard to species or quality, increases interest because of the opportunities to remove unmarketable biomass and improve the productive capacity of forestland.

The interest is not uniform, however, and in general terms the intensity of interest seems to be greatest in those regions where the forest resources are an important economic factor.

In the early flush of enthusiasm about the potential of wood biomass energy, a lot of information was generated and, as is often the case, some information was, at the least, misleading especially with respect to biomass supply and the factors that have an effect upon supply.

At this stage of development in the industrial use of wood energy, it is certainly difficult to identify, in any one area, a formalized supply system especially in terms of the highly specialized structure that exists for other fuels. The basic reason why a well established system is lacking is due to the fact that few demands (or markets) exist yet for forest biomass. The bulk of current industrial demand for wood biomass fuels is being met by manufacturing residues. Where there exists a demand for industrial fuel from forest biomass, supply is coming from operations engaged in the harvesting and supply of traditional forest products and land clearing operations.

We think it appropriate to describe the current state of development of biomass energy supply for industrial use as being somewhat embryonic. The technology to harvest and process tree biomass is available. It is apparent, from isolated case studies, that the technology has limitations that restrict its application on some terrain. Unless the technology is improved, the net result will be a reduction in the size of the resource base that can effectively be harvested to produce biomass. This situation could produce problems in the future if the pulp industry utilizes whole-tree chipping technology to a greater extent than was found in this study.

The rather limited use of the technology at present to produce material acceptable to the pulp industry apparently is due to a current lack of confidence in the ability of whole-tree chipping operations to produce quality feedstock and the economics of pulpwood production that still favor roundwood production.

In all probability, the eventual emergence of an established biomass energy supply system will be centered in the current structure that supplies industrial timber products to forest industries. This is where the harvesting expertise resides and, in addition, this is where, historically, the primary interface with the non-industrial forest landowner has existed.

If the utilization of wood biomass for industrial energy increases, it is logical to expect that refinements will occur in the supply system to more adequately tap the resource given the wide range of conditions that characterize the resource throughout a region. Such refinements could include the emergence of brokers, especially in the area of manufacturing residues, but could encompass specialized harvesting operations. The establishment of stationary centralized offsite chipping facilities has already occurred in some areas primarily in connection with fiber production and appears feasible as an element in a fuel supply system.

The large unknown, with respect to potential supply, is the role of the non-industrial private forest landowner. Although the potential that markets for industrial wood energy hold for improving the quality of existing private forestland by providing outlets for the vast quantities of low value or surplus growth has been widely touted, the fact remains that there must be a radical change on the part of large numbers of owners in their attitudes on forest management. Numerous studies, at least in the northeast, have indicated that while no significant hostility exists towards harvesting operations, significant owners also do not think in terms of long-term planning. If demand for wood energy exceeds supplies available from normal harvesting activities, then some actions must be forthcoming that reach greater numbers of owners more effectively than does existing programs.

In general, the current development of industrial wood energy use is progressing in a trial-error fashion insofar as supply systems are concerned. There is no widespread experience under a large variety of conditions. Ultimately, the feasibility of using the forest resource as a source of energy will be determined by factors existing in the rather small region that comprises the supply zone for a site-specific application.

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