Vermont Wood Fuel Supply Study

An Examination of the Availability and Reliability of Wood Fuel for Biomass Energy in Vermont
THE VERMONT WOOD FUEL SUPPLY STUDY
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Prepared by:
Adam R. Sherman, Principal Investigator
Biomass Energy Resource Center
50 State St., Montpelier, Vermont 05602
(802) 223-7770

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Vermont Department of Buildings & General Services

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THE VERMONT WOOD FUEL SUPPLY STUDY
EXECUTIVE SUMMARY

INTRODUCTION
With mounting interest and movement in Vermont toward further use of woody biomass for heating, power production, and (potentially) the production of liquid fuels, many questions have been raised about the availability and long-term reliability of woody biomass for these energy uses. How much wood is out there? Where specifically is it? How much of the forestland is actually available for some level of harvesting? How much will wood fuel cost in the years to come? How stable is the infrastructure necessary to make it available? What can be done to help the situation?

In an effort to better understand the forest resource capacity and the future availability of wood to reliably fuel biomass energy systems in Vermont, the Biomass Energy Resource Center (BERC), in partnership with the study’s stakeholders, initiated the Vermont Wood Fuel Supply Study (VTWFSS). While Vermont has been a national leader in biomass energy for the past 20 years, this study is the first to address these questions directly and comprehensively.

STUDY SCOPE AND METHODS
The geographic area this study consists of the 14 counties of Vermont and the surrounding 10 adjacent counties of New York, Massachusetts, and New Hampshire. Additional large consumers of low-grade wood such as biomass power plants and pulpmills outside the study area were factored in due to their impact on the supply of wood fuel in the study area. The study examines sources of woody biomass, both existing and potential.

Much of the available information on forest inventory, growth, and harvesting is incomplete and/or designed for examining the supply of higher-value timber products. Many of the studies conducted to date on wood supply similarly focus solely on timber products such as sawlogs and pulp. For these reasons, and given the specific questions the study sought to answer, this study and its approach are unique. The study developed three dynamic analysis tools (which are built upon the available information and use a series of reasonable assumptions) to:

- calculate current potential supply of low-grade wood from the net annual growth on timberland accessible and available for harvesting
- model the impacts of future market demand on the amount of in-forest supply
- examine the economics of wood fuel supply

This study addresses the sustainability of wood supply for energy broadly at the state and county levels. It quantifies the amount of low-grade, new-growth wood, beyond what is harvested today, that is available under different assumptions. Sustainability criteria can be built into assumptions which can be tested using the models developed for the study. In the fullest sense of the word, however, sustainability must be addressed in the forest management and harvest practices used on specific forest types and forestland parcels over time.

CURRENT WOOD FUEL SUPPLY
The 24-county study area has:

- one active pulpmill consuming over 750,000 green tons of low-grade wood annually (there are another three just outside the study area boundary that impact the study area’s wood supply);
six biomass power plants consuming over 1.4 million green tons annually (with another five just outside the study area that have impact on the study area supply); numerous institutional and commercial seasonal heating systems consuming approximately 40,000 green tons annually; and widespread use of firewood for residential heating totaling an estimated 1.4 million green tons of low-grade hardwood each year.

The combined consumption of residue and low-grade wood for the pulpmills, biomass power plants, seasonal chip heating systems, and residential wood heating within the study area is estimated at 3.5 million green tons annually. A significant portion of this consumption is met with wood originating outside the 24-county study area.

CALCULATION OF WOOD FUEL SUPPLY POTENTIAL FROM FORESTS
Based on USDA Forest Service information, Vermont and the surrounding counties in New York, Massachusetts, and New Hampshire have:

- 9.3 million acres of forested land area designated as “timberland”
- 1.1 billion tons of above-ground biomass inventory on timberland
- 24.8 million tons of net growth of new wood annually on timberland
- 4.8 million tons of average annual harvesting to supply all current wood product market demand (includes sawlogs, pulp, firewood, and biomass)
- 20 million tons of under-utilized wood grown annually

Of the 20 million tons of wood growth that is currently not utilized, what portion of this is low-grade wood appropriate for woodchip fuel production? Further, is it accessible and available for harvesting?

While the current consumption of low-grade wood for fuel and fiber represents a significant demand on the region’s forests, the forests are growing wood much faster than the current rate of harvesting. An in-depth analysis was conducted to determine the forests’ capacity to supply low-grade wood for biomass energy by examining the growth on standing forest inventory. For this study, a Microsoft Excel-based tool was created for calculating the amount of Net Available Low-Grade Growth (NALG).

From this point, the numerous variables were accounted for as part of the calculation of the forest’s under-utilized annual growth of low-grade wood suitable for biomass energy, including the rate of forest growth; the amount of forest biomass designated as low-grade wood deemed suitable for harvesting; physical and legal limitations on accessibility to the timberland on which the inventories stand; and the additional political, social, and economic limitations to the availability of the timberland. Based on these variables, a range of NALG wood was identified.
### Vermont Wood Fuel Supply Study

#### County inventory of Net Available, Low-grade Growth (NALG)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Key Assumptions</th>
<th>Vermont Counties NALG (green tons/yr)</th>
<th>TOTAL (all Counties) NALG (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>• No harvesting on public lands and on privately owned lands fewer than 50 acres</td>
<td>387,491</td>
<td>1,137,267</td>
</tr>
<tr>
<td></td>
<td>• 40% bole volume classified as low-grade and 0% tops and limbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate (based on current patterns)</td>
<td>• Moderate harvesting on public lands and very little on privately owned lands fewer than 50 acres</td>
<td>1,466,982</td>
<td>3,423,082</td>
</tr>
<tr>
<td></td>
<td>• 60% bole volume classified as low-grade and 50% tops and limbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggressive</td>
<td>• Increased harvesting on public lands and on privately owned lands fewer than 50 acres</td>
<td>2,342,053</td>
<td>5,343,465</td>
</tr>
<tr>
<td></td>
<td>• 70% bole volume classified as low-grade and 100% tops and limbs</td>
<td></td>
<td></td>
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</tbody>
</table>

The counties with the greatest concentrations of NALG were Windham County, Vermont, Essex County, New York, and Berkshire County, Massachusetts. Windham County has a long history of strong sawlog markets, but is far from the large pulp markets of northern New Hampshire and eastern New York, and therefore has a large inventory of low-grade material. Similar factors explain Berkshire County’s high concentration of NALG. The indicated high concentrations of NALG in Essex County, New York are likely due to underestimations of the county’s harvest.

**SUPPLY/DEMAND COMPUTER MODEL**

Similar patterns were observed when these supply and demand patterns were examined looking 10 years forward using a supply and demand computer model. It is important to note that the purpose of the model is not to predict the supply and demand into the future, but to better understand the various factors that impact it.
Four different modeling scenarios (runs) were tested, with results shown below:

1. Constant Demand Run – both biomass and timber (including pulp) demand remain at current levels
2. Increased Biomass/ Constant Timber Demand Run
3. Increased Biomass/ Decreased Timber Demand Run
4. Increased Biomass/ Increased Timber Demand Run

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Key Assumptions</th>
<th>NALG Results (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant Demand Run</strong></td>
<td>• Consistent levels of harvesting on public and private timberland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 60% bole volume classified as low-grade and 50% tops and limbs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Flat consumption for sawlogs, pulp, firewood, and chips</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Assumes Berlin and Groveton remain closed</td>
<td></td>
</tr>
<tr>
<td><strong>Increased Biomass &amp; Constant Timber Demand Run</strong></td>
<td>• Consistent levels of harvesting on public and private timberland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 60% bole volume classified as low-grade and 50% tops and limbs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 5% annual increased demand for biomass power and seasonal heating with chips and firewood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Flat consumption for sawlogs and pulp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Assumes Berlin and Groveton remain closed</td>
<td></td>
</tr>
</tbody>
</table>

*Diagram images of NALG 10-Year Projections for Constant Demand Run and Increased Biomass - Constant Timber Demand Run.*
Under the conditions of a Constant Demand Run—where the annual harvesting levels, timberland ownership, and amounts of wood designated as low-grade remained constant but forests continued to grow—the county inventories of NALG wood grow significantly over the 10-year period of the model. Despite the overall trend of surplus wood, the model indicates signs of stress in Chittenden County, Vermont and Washington County, New York—likely due to the combination of relatively high demand for wood and limited availability due to small parcel sizes.

For the Increased Biomass and Constant Timber Demand Run, the biomass demand was increased by 50 percent over the 10-year period (5 percent increase each year). This run begins to show further stress of the NALG inventories. One major reason for this was the assumption of 50 percent increase in residential firewood demand. This run shows a significant drop in the total volumes of NALG inventories in year 2015 when the increased demand for biomass reaches 50 percent.

Under the Increased Biomass and Decreased Timber Run, relatively few new patterns emerge. The reduction of demand for pulpwood frees up additional volumes for biomass, but the spatial allocation of demand shows the inventory stress on the same counties – Chittenden and Orleans in Vermont and Washington County in New York.
Similar patterns were observed under the Increased Biomass and Increased Timber Demand Run. The NALG inventory is not impacted by the increased harvest demand for sawlogs. The additional stress from the modeled increase in pulpwood demand is mostly allocated to the outside regions of the study area.

In addition to the generalized model runs above, several specific runs were performed to test the spatial allocation functions of the model by placing a 20MW wood-fired power plant in various counties to see its impact on the surrounding wood baskets. Four Vermont counties were tested – Addison, Bennington, Windsor, and Orleans. Of the four, only Orleans County showed significant impact on the NALG inventory. One last model run was conducted to test sensitivity to the forest net annual growth rate. All previous model runs kept forest growth constant at 2.24 percent annually, but when the forest growth was modeled to decline significantly over the 10-year period, NALG inventories are greatly reduced even under the constant demand scenario.

ECONOMIC ANALYSIS
How much will chips cost if demand increases? To answer this question, it is important to understand that there are two main categories of chips: residue chips derived as a by-product of some other primary activity, and chips produced as a primary fuel.

While prices for residue chips may rise in the future, the volumes produced will not change in response to an increase in demand (since it is unlikely that sawmills will make less lumber and more waste from each log processed.) By contrast, the supply of chips produced as a primary fuel, such as whole-tree chips and bole chips, will respond to increased demand if it is of sufficient volume and the price is right.

There are many variables that dictate the economics of wood-fuel supply. Perhaps the most significant variable is the extent to which the economics of harvesting low-grade wood depends on the integrated harvesting of more valuable products that subsidize the low-grade material. Therefore, for the purpose of this study, the economics under several scenarios were explored:

1. Current product mix ratios under integrated harvesting
2. Increased demand of low-grade wood under integrated harvesting
3. Complete independence from integrated harvesting (exclusively low-grade harvesting)

A price range of $40 to $64 per green ton for bole chips and $30 to $40 per green ton for whole-tree chips was identified using an economic model developed for this study. Chips tend to be on the inexpensive end of the spectrum when there is a strong sawlog market allowing integrated harvesting of low-grade trees at lower costs. If low-grade wood for chips was harvested as a stand-alone practice, prices would reach the high end of the price spectrum.

SURVEY
Surveys were used to gather further general information; test and fine tune key assumptions used in the supply calculation, the 10-year supply/demand model, and the economic analysis; and explore potential strategies to increase low-grade wood supply. Six main groups of stakeholders were identified within the forestry profession, the forest products industry, and the biomass energy industry. Mail-back surveys were developed and distributed to these six key groups.

CONCLUSIONS
Much was learned from the current wood fuel supply analysis, from in-forest NALG calculation, from 10-year supply and demand modeling, from the economic analysis, and from the surveys:
A majority of Vermont’s current supply of biomass fuel is produced as a by-product of commercial harvesting or primary processing of forest products. Vermont’s forests have the capacity to supply additional amounts of wood fuel for biomass energy. Some counties have greater capacity to expand the use of biomass energy than others. The ability of Vermont’s forests to sustain increased harvesting for biomass energy will depend to a certain extent on the future of the pulp and paper industry in the region. Higher market prices paid for wood fuel will stimulate mobilization of the in-forest NALG inventory and result in greater availability and reliability of the wood fuel supply. Bole chips and whole-tree chips have potential for becoming commodity wood fuel products. Loggers and mills are surviving—but just barely

How stable is the supply infrastructure that supplies wood energy? The bad news is that the harvesting, processing, and transport infrastructure that supplies wood energy in Vermont is almost entirely supported by the primary activities of the forest products industry. The average age of loggers in the region is 45 years. There are no new sawmills in Vermont. Two of the major pulpmills in the region ceased operations in 2006. The good news is that greater supply independence from the forest products industry can be achieved at higher prices and increased volumes. If the tipping points for volume of demand and price can be met, the growth of biomass energy can stimulate the necessary investment to strengthen the supply infrastructure.

Currently most of the chips produced and sold in the region for energy are sourced as a by-product stream of some other activities. The historic and current pricing of these chips have been directly tied to their status as by-products. If new volumes of wood are to be accessed for expanding the supply of fuel for biomass energy, market prices and strategies will need to be adopted that treat wood fuel as a commodity rather than as a by-product.

RECOMMENDED STRATEGIES
This study and the modeling tools developed for it, present the opportunity to take a fresh look at possible strategies and actions that can advance the goal of sustainably utilizing low-grade forest resources for biomass energy production in Vermont. The study itself has not developed new strategies – instead it has explored the details of wood fuel supply to improve our understanding of wood fuel availability and reliability so that, as policy decisions are made, we can ensure that growing demand for wood fuel is maintained within the capacity of the forest resource and is consistent with ecological and environmental values and management objectives, for years to come.

- Expand existing initiatives, such as the Current Use (or Use Value Appraisal) taxation program, and develop new incentives that help reduce property tax burdens on private landowners.
- Develop programs and initiatives that facilitate the coordination among the increasing number of small private timberland owners to achieve their forest management objectives and reach the scale necessary to keep small woodlots as “working forests”.
- Increase public outreach and education on the benefits of managed forests and highlight examples of well-managed forests.
- Expand public relations efforts to promote the forestry and logging professions as the stewards of Vermont’s working forests.
• Work with public and private partners to develop strategies to reduce the parcelization and fragmentation of large forest parcels.
• Work to maintain and enhance the forest harvesting infrastructure – equipment and personnel. Keep existing forest products markets in Vermont strong as their demand is the backbone of the existing harvesting infrastructure.
• Create a business development assistance program for parties interested in starting wood fuel supply businesses.
• Develop a portfolio of commercial lending programs and small grant programs that will make capital available to the forest products industry.
• Develop loan guarantee programs to help wood supply businesses without sufficient collateral to secure commercial financing.
• Support strong markets for high-grade and mid-grade forest products as a vehicle for enabling low-grade wood harvesting.
• Promote and make investments in distributed storage and processing sites.
• Encourage investment in fuel supply and transport infrastructure.
• Encourage the private development of year-round chipping yards.
• Explore with Vermont Agency of Transportation increasing Vermont’s interstate truck weight limit from 80,000 lbs to 99,000 lbs to conform to limits of neighboring states.
• Educate and develop consumer acceptance toward more equitable pricing for wood fuel as a necessary element toward achieving greater fuel supply availability and reliability.
• Purchase chips made from low-value species such as white birch, beech, and poplar.
• Encourage the procurement of bole chips and whole-tree chips from entire trees as a mechanism to transition toward a commodity fuel supply market.
• Build roundwood inventory in accessible chipping yards to reduce exposure to risk from poor weather and “just-in-time” inventory management.
• Develop the wood energy market in Vermont with consideration to the need to aggregate sufficient regional demand to achieve a critical volume sufficient to prompt new investment in fuel supply infrastructure.
• Use the NALG inventory information from this study to help plan county build out of biomass facilities for the future.
• Encourage the use of unique wood fuel purchasing contract mechanisms, such as pre-buys, 12-month spreads of payments, and diesel fuel price adjustments to attract new chip vendors into the market.
• Encourage longer-term contract commitments for greater market stability.
• Increase funding for state and federal programs to provide up-to-date and on-going data on: forest inventory, growth and harvest volumes, and harvested land area. Also improve data regarding the residential use of firewood.
• Continue, expand and fine-tune use of the methods and tools created as part of this study to re-examine the question answered over time and to enhance the model’s capabilities to address remaining unanswered questions.
1.0 INTRODUCTION

Vermont’s forest resource is abundant. More than 78 percent of the state’s land area is forested, and the current rate of annual forest growth exceeds the annual rate of harvest by two to one. Vermont’s forests have a long history of providing a wide range of forest products, including fuel for energy. Heating with wood is one of the oldest forms of biomass energy. Over the past 25 years, woody biomass energy has expanded in Vermont to include, in addition to traditional residential heating with wood stoves: large-scale power generation; heating and powering institutions such as schools, hospitals, and state offices; providing space heat for businesses and process heat for manufacturers; and the use of wood pellets for home heating.

With recent price increases for fossil fuels and the desire for more in-state power generation due to the future uncertainty of the Hydro-Quebec and Vermont Yankee power contracts, there is growing demand for biomass heat and power systems in Vermont. Currently, there are numerous biomass energy projects under consideration in the state.

Most of the woodchips that have fueled both heating systems and power plants over the past two decades in Vermont have been produced as a by-product of harvesting and primary processing of such higher value forest products as paper and lumber. Up to this point, biomass energy has been the consumer of waste material from the forest products industry, relying heavily on the health and activity of the pulp and sawmill sectors as its source of fuel.

Clearly biomass has the potential to play an expanded role in Vermont’s energy future, but there are important questions that need to be answered so that strategies can be developed to use biomass resources appropriately.

Key questions for Vermont are:
- How much wood fuel is currently harvested and consumed?
- What is the amount of wood fuel imported and exported?
- Do our forests have the capacity for additional harvesting for increased use of biomass energy? If so, how much wood is out there and where specifically is it?
- How much of the total forestland is likely available for future harvesting?
- How dependent is biomass energy fuel supply on the rest of the forest products industry?
- What are the price and volume thresholds where wood fuel harvesting can become more independent of by-product derived wood fuel?
- What are potential strategies for improving the availability and reliability of wood fuel?

The Vermont Wood Fuel Supply Study (VTWFSS) has three main focus areas:
1. Calculate the available volumes of clean wood by-product and under-utilized net annual growth of low-grade wood in the forests of Vermont and the surrounding counties of adjacent states.
2. Untangle and examine the numerous factors governing low-grade wood availability and pricing, and model the projected supply and demand over the next 10 years.
3. Identify the barriers to increasing the availability and reliability of wood fuel for energy and present possible strategies that will help overcome these barriers.

The purpose of this study is to establish a baseline of information from which strategies can be developed to help stabilize and gradually improve the availability and reliability of the woodchip fuel supply in the region. It is not intended to be a rigorous study that delves in great detail into every factor that impacts wood fuel supply.
The amount of wood fuel identified in this report is not intended to be the definitive answer—instead the study presents the results of scenarios built upon the best available data and the use of reasonable assumptions. The information presented in this study will be important for developing the strategies to improve the availability and reliability of wood fuel for current biomass energy systems as well as to ensure that if the use of biomass energy is expanded in Vermont, it is done appropriately—well within the capacity of the forest resource.

1.1 Background

In many parts of the country, biomass energy is a new concept based on a fledgling fuel market. Fueling power plants and large boilers with waste and/or low-grade wood has many advantages over the use of fossil fuels like oil, natural gas, and coal. In Vermont, biomass energy for power generation and institutional and commercial heating has a 25-year history. During that time, the demand for wood for fuel has grown slowly but steadily. Numerous factors have helped fuel the growth of biomass energy use, including such public policies as the provision of state aid to Vermont school districts installing woodchip heating systems and the development of Renewable Portfolio Standards (RPS) in other states. In the meantime, the forest products industry, the source of most of the fuel for biomass energy, has been struggling in a very competitive global market.

The fuel supply chain for biomass energy is complex and highly dependant on numerous factors that are often beyond the market’s control. Over the past 20 years in Vermont, many factors have dictated the availability and reliability of woodchips as a fuel for biomass energy systems: the price of diesel fuel, weather, strength of regional pulp and sawlog markets, and even the strength of the US dollar as it impacts the export of wood products from the region.

Demand for biomass fuel has gradually increased over time in Vermont, but with many ups and downs along the way. At the same time, the rest of the forest products industry’s wood consumption has leveled off. In the case of pulp and paper, their wood consumption has been declining. In the northeastern US from 1997 to 2001, pulp production has declined by 18 percent, resulting in the same decrease in demand for biomass feedstock.

For many decades, the region’s pulpmills have been the major consumers of low-grade wood from the forests. While they have historically had a firm command of their supply, pulpmills in the Northeast have been negatively impacted by international competition. In the past 10 years,

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1 For example, Burlington Electric’s wood-fired McNeil Station is dispatched based on electric grid demand, resulting in variable fuel chip requirements over its 20 year history.
Sawlog and pulpwood harvest in Vermont from 1993-2004

With fewer loggers sending logs to sawmills and pulpmills, with warm, wet autumns and early springs, and with the recent softening of the lumber market due to slowed growth in the new home market in the United States, supplies of wood residue fuel in Vermont are tight. At the same time, with rising fossil fuel costs each year, there is interest in using more biomass energy in the state for building heating systems, combined heat and power systems, and power generation plants. There is plenty of low-grade wood in the forests, but, there may not be enough capacity to harvest, process, and deliver it to new users.

Healthy, local markets for low-grade wood are extremely important to the long-term management of Vermont’s woodlands. Without markets and revenue from the sale of low-grade wood, landowners are under significant economic pressure to harvest only the best trees (called “highgrading”) and then sell the land for the highest price (often as smaller parcels). This pattern of land fragmentation and parcelization is a threat to the long-term stewardship of woodlands throughout the Northeast.4

As the biomass energy industry in Vermont grows and matures, woodchip fuel supply will likely slowly transition from a by-product-driven market to a commodity fuel market. If Vermont is to achieve greater energy independence by developing a successful biomass industry, wood fuel supply issues must be addressed.

1.2 Stakeholders
In the fall of 2005, a group of stakeholders convened to discuss the need for greater biomass fuel availability and reliability. The stakeholder group was comprised of representatives from state

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3 Based on conversations with several industry experts.
government, public- and private-sector power producers, and not-for-profit organizations. This group decided to commission a study to examine the issues and work towards solutions.

**Vermont Department of Forests, Parks and Recreation (FPR)**
FPR is responsible for the conservation and management of Vermont’s forest resources, the operation and maintenance of the state park system, and the promotion and support of outdoor recreation for Vermonters and its visitors. The Forestry Division of FPR coordinates the planning and implementation of all stewardship activities on more than 300,000 acres of state-owned forest land. The division provides technical assistance to private landowners, at their request, to help manage their properties. It administers the Use Value Appraisal Program on private land, involving more that 9,000 landowners and 1.4 million acres. Marketing and Utilization section personnel inventory and promote the manufacture of forest products in the state and assist businesses, communities, and others on issues related to wood products and wood energy generation.

**Vermont Department of Buildings and General Services (BGS)**
BGS works to deliver quality operational services and facilities management, enabling government agencies to fulfill their missions. The Engineering and Construction Division of BGS manages the planning and development of accessible complexes, buildings, and spaces for conducting the business of the State of Vermont. Numerous state facilities under BGS care use woodchips for heating.

**Joseph C. McNeil Generating Station**
The McNeil Generating Station, located in Burlington, Vermont is a 50 megawatt power-generating station. It is jointly owned by the Burlington Electric Department (50 percent), Central Vermont Public Service (20 percent), Vermont Public Power Supply Authority (19 percent), and Green Mountain Power (11 percent). The McNeil Station burns approximately 350,000 tons of woodchips annually.

**Ryegate Power Station**
The Ryegate Power Station is a 20-megawatt power generating facility located in East Ryegate, Vermont. It became operational in 1992 and is owned by Suez Energy and Catamount Energy. The Ryegate plant burns approximately 250,000 tons of chips annually.

**1.3 Biomass Energy Resource Center (BERC)**
BERC served as principal investigator for the Vermont Wood Fuel Supply Study and authored this report. BERC is an independent nonprofit that assists in the development of biomass energy projects. While BERC promotes biomass energy, its initiatives aim to better inform the process of studying, assessing, and implementing successful projects. BERC has no stake in any specific technologies or processes, therefore can supply independent, objective information, advice, and guidance to organizations and individuals at all stages of the development and management of biomass energy, including fuel-supply assessments. As an advocate for the responsible development and use of biomass energy, BERC has maintained its objectivity and neutrality throughout this project to present unbiased, objective information.

**1.4 Scope of Study**
The VTWFSS focus is on sources of clean woody biomass, including low-grade wood in the forest, by-products from primary manufacturing of forest products, and tree trimmings and clean wood waste from communities. This study did not examine the potential for supplying construction and demolition derived sources of wood. The scope on the demand side was pulp,
firewood, and chipped fuel from various sources. While other materials such as sawdust and bark are discussed because they are in fact common forms of wood fuel, woodchips are the focus of the study.

County-level data was used for this study. Much greater detail resolution could be achieved using growth and yield models and GIS software for the parcel-specific level, but the study’s intent was to examine the region’s capacity at the county level. For this reason, it was determined that the best methodology was a more general approach, using USDA Forest Service - Forest and Inventory Analysis (FIA) county inventory data.

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The geographic focus of the study is the State of Vermont. However, all the surrounding and adjoining counties of New York, Massachusetts, and New Hampshire were included in the study area because woodchips and low-grade wood tend to flow in either direction across the state’s borders. Because significant volumes of wood move beyond the boundaries of the 24-county study area, several large consumers of woodchips and low-grade wood were included, despite their being outside the area of study.

Calculation of the current supply of in-forest net growth is not intended to be used for planning purposes. The 10-year supply/demand modeling is similarly not intended as a prediction of the future supply. Further, the economic analysis contained in this study is not intended to be used as a prediction of future woodchip pricing. The intent and real value of the information supplied in this study is achieving a better understanding of what the potential of the resource is and how the market behaves by examining how both are affected by various factors. While this study does not and cannot account for what the sustainable harvest levels are on the ground level for each unique forest, it does focus on the overall sustained-yield capacity of the forests by examining only the net annual growth of new wood and not the standing forest inventory.

1.5 Methodology Overview
From the outset, the principal investigator and the study’s stakeholders agreed to approach this project by assembling the best existing data and research available, and developing a methodology that would supplement the existing information to the extent necessary to weave all the information together and paint a coherent picture of the wood fuel supply situation in Vermont. The relative strength and reliability of the data generated by this study are based on the data available. Where hard data were not available, best guesses and key assumptions were used, although every effort was made to fine tune these using the review and feedback from forestry experts.

An extensive literature review was conducted. All available and relevant data and literature were compiled. Throughout the study the most up-to-date information was used. However, in many cases the most up-to-date information was several years old. Where there was an absence of
published data, the gaps were filled in through personal communications, telephone conversations, and mail-back surveys.

This methodology was intended to yield new information:

- An assessment of the current regional supply and demand for low-grade wood (for Vermont and the adjoining counties of adjacent states)
- A calculation of the in-forest volume of wood that could potentially be provided to expand the use of biomass energy (Net Available Low-Grade Growth or NALG)
- A better understanding of the supply and demand impacts over the next 10 years under various scenarios
- An assessment of the current state of the wood supply infrastructure in Vermont
- An estimation of the necessary market price and volume thresholds necessary for wood fuel to be reliably available in the future

In summary, the methodology followed the process below:

1. Identify the key questions the study aims to answer
2. Review and compile all existing supply and demand information and related literature
3. Develop methodology to answer questions using the available information
4. Identify where key information is missing or where data are suspect
5. Compile data on current consumption of wood fuel
6. Develop a tool to calculate potential wood fuel supply from existing data and key assumptions
7. Examine the complex factors governing the availability and pricing of woody biomass
8. Develop a computer model to project the future supply of woody biomass under different demand-based scenarios
9. Conduct a survey to gather further information (fill in blanks and test some key assumptions used in the calculations)
10. Perform an economic analysis
11. Synthesize information
2.0 CURRENT WOOD FUEL SUPPLY

Within the geographic study area there are currently six power plants, thirty-four schools and eight other public facilities, and numerous businesses consuming chipped wood as their primary fuel. In addition, several of the region’s pulp and paper mills fire their industrial-sized boilers using wood. There are two active pulp and paper mills that consume significant volumes of wood fuel from Vermont. A large majority of the wood fuel for seasonal heating systems currently comes from sawmills, whereas a majority of the wood fuel for the industrial boilers and power plants is harvested directly from the forests.

The first step of calculating the study area’s current amount of wood fuel was to determine the volumes of existing by-products and harvested wood fuel that is already supplying the existing market.

The methodology used for this part of the study was a combination of examining the supplies wood wastes and by-products generated as well as the demand from the larger consumers like pulpmills and biomass energy plants. Data were compiled from a variety of sources, including published data and telephone and e-mail surveys of industry experts.

2.1 Sawmill By-products

In the process of sawing logs into lumber, sawmills produce by-products—bark stripped from the log before the log is cut, sawdust from the sawing action, and wasted wood (slabs) that are usually chipped. The bark by-product from sawmills is either used as low-grade fuel to fire drying kilns or sold as mulch to the horticulture markets. Sawdust is also a valuable by-products used for livestock bedding and converting into wood pellet fuel. Woodchips from sawmills are typically screened to meet paper-making specifications, and then blown into the back of a trailer for delivery to pulpmills, biomass power plants, or seasonal heating systems.

The data used in this graph come from several sources. The data for Vermont counties come from the Annual Harvest Report produced by the Vermont Department of Forests, Parks and Recreation. These data are based on surveys.
of primary wood consumers like pulpmills and sawmills. Sawmill residues are tabulated as a part of the Vermont harvest report. For Massachusetts, New York, and New Hampshire counties, data were compiled by estimating the chip production from sawmills’ listed production of lumber. Data was compiled from state directories of sawmills, excluding sawmills with capacity under one million board feet\(^5\).

Data on the amounts of by-products generated by the forest products industry were gathered and assembled into a spreadsheet. A majority of this data were obtained from the Vermont Department of Forests, Parks and Recreation Annual Harvest Reports. Further telephone survey work was conducted to fill in any gaps.

It is important to note that the amounts of chips from sawmills are unlikely to increase in the future to meet the growing market demand for wood fuel.

### 2.2 Other Wood By-products

There are two other main categories of clean wood by-products that could be used for chip fuel:

- Community (urban) wood waste, and
- Wood waste from secondary wood products manufacturing.

Both categories generate relatively small volumes of material. This study focuses on the concentrated volumes of community wood wastes that are separated from the solid waste stream and are processed into a usable fuel for biomass energy. We have not included a specific analysis of the small volume of wood waste from secondary wood products sources such as furniture manufacturers.

Examples of clean wood waste from communities are holiday trees, branches, brush, tree trimmings, untreated and unpainted wood, and wooden pallets. Often, these materials are not separated from the rest of the waste stream, especially in rural areas. If they are, they are typically mixed with leaves and grass clippings and either composted or disposed of in a “stump dump.” More urban areas with strong recycling programs tend to separate this material from the municipal solid waste (MSW) stream.

Per capita estimates of clean wood waste generated are 0.048 tons/year.\(^6\) Based on 2005 US Census Bureau data, the 24-county study area has a population of 1.4 million people. Based on this estimate, there are 67,200 tons generated of clean wood waste.

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\(^5\) Assumes sawmills with capacities less than 1 million board feet do not typically chip slabs, trimmings, etc.

\(^6\) Based on Chittenden Solid Waste District (CSWD) data for 2006.
In Vermont, counties that separate clean wood waste from the other MSW are Chittenden, Addison, and Rutland. The Chittenden Solid Waste District reports 7,300 green tons of clean wood waste is diverted from landfills and used for biomass energy or colored for use as an ornamental mulch product. Addison County reports diverting 600 green tons annually used primarily for bulking agent for composting. Rutland County reports diverting 560 tons annually for a variety of uses.

These volumes of clean community wood waste are often under-utilized and could be a larger part of the fuel stream for biomass energy. However, this is a waste product that will not increase significantly to meet the growing demand for wood fuel.

Another source of clean community wood waste is tree trimmings from professional arborists—many of whom use chippers to dispose of brush and bulky wood for more efficient transport. No comprehensive data exists quantifying these amounts of chips. Many tree service companies chip their trimmings into the back of small dump trucks (typically 5-20 cubic yard holding capacities) and transport the chips to the nearest location for disposal. Many arborists contacted for this study reported that they deliver chips to nurseries, farms, compost operations, or other nearby locations where they are allowed to dump the chips without having to pay a disposal fee. However, several arborists in the Chittenden county area deliver their chips to the nearby McNeil Generating Station, where they are paid on a per ton basis. Generally, the delivery of small volumes of relatively low-quality chips from these sources is not viewed as a feasible wood fuel supply option.

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7 Personal communication, Nancy Plunkett, Chittenden Solid Waste District
8 Personal communication, Katie Johnson, Addison County Solid Waste District
9 Personal communication, Dean Wilson, Rutland Solid Waste District
2.3 Harvested Low-grade Wood for Fuel and Fiber

For decades, wood fuel has been harvested directly from forests to supplement the amounts of by-product-derived fuels from sawmills and other non-forest sources. Types of harvested wood fuel include “whole-tree” chips produced in the woods, low-quality logs (“roundwood”) chipped either in the woods or at a remote location, and firewood either cut and split at the landing or elsewhere.

The most common fuel chips harvested from the forest are whole-tree chips. Despite the name, whole-tree chips have most commonly been made from the leftover tops and limbs of commercial timber harvests. However, there are exceptions when the whole tree is, in fact, chipped. Land-clearing operations frequently harvest the whole tree and chip it without removing tops and limbs. When the pulp market is weak and prices are low, some loggers will whole-tree harvest and feed low-quality trees directly to the chipper because the market price for pulpwood will not cover the additional step and cost of de-liming.

![2004 Pulp, Firewood & Whole-tree Chip Harvest](image)

**2004 low-grade wood harvest data and estimates**

**PULP MARKET**

Most pulpmills in the region purchase a majority of their wood as logs that are otherwise unsuitable as sawtimber. Additionally, most pulpmills also supplement this volume by purchasing clean chips from sawmills within a reasonable trucking distance. While many pulpmills use other fuel sources for process steam and onsite generation of power (natural gas, hydro-power, etc.), several mills burn bark waste that is stripped from the pulpwod prior to chipping to meet a percentage of their energy requirements. Several pulpmills purchase additional amounts of whole-tree chips to fuel their steam boilers. In 2004, the USDA Forest Service published a study by Baker, Hansen, Akers entitled *Pulpwood Production and Consumption in the Northeast* -2001.

The study reported average pulpmill feedstock in the northeastern states at 78 percent roundwood and 22 percent mill residues.
<table>
<thead>
<tr>
<th>Mill Name</th>
<th>Location</th>
<th>Estimated Roundwood Consumption (green tons/yr)</th>
<th>Estimated Wood Fuel Consumption for Steam Boilers (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Paper</td>
<td>Ticonderoga, NY</td>
<td>750,000</td>
<td>87,500</td>
</tr>
<tr>
<td>Fraser Paper Co.</td>
<td>Berlin, NH</td>
<td>Closed May 2006</td>
<td></td>
</tr>
<tr>
<td>Groveton Paper Board Co.</td>
<td>Groveton, NH</td>
<td>Closed Feb. 2006</td>
<td></td>
</tr>
<tr>
<td>Dirigo Paper</td>
<td>Gilman, VT</td>
<td>Uses pre-processed pulp</td>
<td>100,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>187,500</strong></td>
</tr>
</tbody>
</table>

Pulpwood demands within the 24-county study area (roundwood and mill chips)

The charts above and below do not account for the volumes of paper-grade chips from sawmills used by the pulpmills for making paper, the other mill residues used for boiler fuel, or the bark stripped prior to chipping the roundwood.

<table>
<thead>
<tr>
<th>Mill Name</th>
<th>Location</th>
<th>Estimated Roundwood Consumption (green tons/yr)</th>
<th>Estimated Wood Fuel Consumption in addition to burning bark waste (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finch Pruyn Paper Co.</td>
<td>Glens Falls, NY</td>
<td>638,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Domtar</td>
<td>Windsor, PQ</td>
<td>800,000</td>
<td>0</td>
</tr>
<tr>
<td>New Page/Meade</td>
<td>Rumford, ME</td>
<td>900,000</td>
<td>0</td>
</tr>
<tr>
<td>International Paper Androscoggin Mill</td>
<td>Jay, ME</td>
<td>371,500</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>25,000</strong></td>
</tr>
</tbody>
</table>

Pulp and paper mills outside the study area with considerable draw from with the 24-county study area.

**FIREWOOD MARKET**

Residential firewood has been the mainstay of low-grade wood markets in Vermont for a long time. The harvesting and processing of firewood frequently occurs “under the radar screen” and it is therefore difficult to estimate the current levels of its harvesting and use.

In December of 2000, the Vermont Department of Public Service (VT DPS) released a study entitled *Vermont Residential Fuel Wood Assessment 1997-1998*. In that year, VT DPS estimated that approximately 250,000 cords or 625,000 green tons of low-grade wood was burned to heat homes in Vermont. The department also estimated that 31 percent of Vermont homes use wood for some portion of their heat requirements.
Using 1997 US Census Bureau population data for Vermont and the reported volumes of firewood use in the state, a per capita firewood use was calculated as 1.02 green tons. Applying this figure to 2005 US Census Bureau data for all the 24 counties, it is estimated that the total firewood consumption for the 24-county study area is 1,433,040 green tons annually. Admittedly, this approach has its weaknesses (assuming the per capita rate stayed the same over the period of time from 1997 to 2005 while the total population grew), but in the absence of better data, it is a reasonable approach.

While no data exists on either firewood consumption or harvesting for the time period of 1997 to 2005, anecdotally, the demand for residential firewood has grown over the past two years in direct response to the higher heating oil costs after Hurricane Katrina.

**BIOMASS POWER PLANTS**

The following are biomass power plants within the 24-county study area. There are several more plants in counties surrounding the study area that were examined as part of the supply/demand model.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Location</th>
<th>Generation Capacity</th>
<th>Approximate Wood Fuel Consumption (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joseph C. McNeil Station</td>
<td>Burlington, VT</td>
<td>50MW</td>
<td>380,000</td>
</tr>
<tr>
<td>Ryegate Power Station</td>
<td>Ryegate, VT</td>
<td>20MW</td>
<td>250,000</td>
</tr>
<tr>
<td>Bridgewater Power</td>
<td>Bridgewater, NH</td>
<td>15MW</td>
<td>229,000</td>
</tr>
<tr>
<td>Whitefield Power and Light</td>
<td>Whitefield, NH</td>
<td>13.8MW</td>
<td>187,000</td>
</tr>
<tr>
<td>Pine Tree Power</td>
<td>Bethlehem, NH</td>
<td>15 MW</td>
<td>227,000</td>
</tr>
<tr>
<td>Hemphill Power</td>
<td>Springfield, NH</td>
<td>13.8MW</td>
<td>208,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>1,481,000</strong></td>
</tr>
</tbody>
</table>
The following are biomass power plants outside the 24-county study area that have significant impact on study area supply.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Location</th>
<th>Generation Capacity</th>
<th>Approximate Wood Fuel Consumption (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pine Tree Power</td>
<td>Westminster, MA</td>
<td>20MW</td>
<td>215,000</td>
</tr>
<tr>
<td>PSNH Schiller Station</td>
<td>Portsmouth, NH</td>
<td>50MW</td>
<td>400,000</td>
</tr>
<tr>
<td>Kenetech Energy Systems</td>
<td>Chateaugay, NY</td>
<td>19MW</td>
<td>240,000</td>
</tr>
<tr>
<td>Bio-Energy</td>
<td>Hopkinton, NH</td>
<td>11MW</td>
<td>Closed</td>
</tr>
<tr>
<td>Boralex Stratton Energy Inc.</td>
<td>Stratton, ME</td>
<td>45MW</td>
<td>325,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>1,180,000</strong></td>
</tr>
</tbody>
</table>

SEASONAL WOODCHIP HEATING MARKET
Seasonal heating systems work best using uniform, high-quality chips and only need fuel in the winter months. To date, these heating systems have been largely dependant on the by-product chips from sawmills as their fuel source. Typically sawmills sell their chips to year-round markets like the pulpmills or power plants, but many sell their chips in the winter months to schools and institutions with woodchip heating systems. Sawmills are in the business of making lumber, not by-products. Unless they receive more logs and produce more lumber, sawmills will not increase their production of chips. In the past few years, there has been a gradual increase in the seasonal demand for chips from hardwood sawmills while at the same time there has been a gradual decrease in sawmill activity.

Within the 24-county study area, there are an estimated 39,650 tons of chip consumption for seasonal heating per year. A large fraction of this consumption comes from the 14 counties of Vermont. The majority use by-product chips from sawmills, but there are some larger facilities that use whole-tree chips. There are also an increasing number of schools burning “bole” chips, or chips made from chipped low-grade logs.

- Approximately 6,100 tons come from whole-tree chips\(^ {10} \)
- Approximately 5,300 tons come from bole chips\(^ {11} \)
- Approximately 28,250 tons come from “paper” chips from sawmills\(^ {12} \)

Within the study area, Washington County, Vermont has the greatest concentration of seasonal heating systems.

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\(^{10}\) Montpelier and Waterbury State Office Complexes use a majority of the whole-tree chips for heating in the study area.

\(^{11}\) Accounts for schools now using bole chips as well as a portion of the Waterbury and Montpelier Complexes’ use of bole chips to supplement whole-tree chips.

\(^{12}\) Accounts for schools and other facilities using sawmill chips in the study area.
WOOD PELLET PRODUCTION

Over the past 15 years in the Northeast, wood pellet fuel production has had a relatively minor impact on the low-grade wood market. For many years, the feedstock used for pellet production was exclusively sawdust from local sawmills. In the past several years, however, wood pellet manufacturers have experienced a tremendous surge in demand from the residential pellet stove heating market, primarily in response to recent price increases in fossil fuels like heating oil, natural gas, and propane.

This spike in pellet fuel demand has almost completely exhausted sawdust supplies. Several pellet fuel manufacturers like New England Wood Pellet, based in Jaffrey, New Hampshire (located with the 24-county study area), have resorted to purchasing chips and even pulp roundwood to meet their growing need for wood feedstock. New England Wood Pellet currently operates its flagship plant in Jaffrey, New Hampshire, producing approximately 80,000 tons of pellets annually, its new Schuylerville, New York plant, which will produce 100,000 tons annually, and its Palmer, Massachusetts distribution facility, which imports 80,000 tons of imported wood pellet fuels via rail from the western US and Canada.  

13 Personal communication, Charlie Niebling, New England Wood Pellet.
3.0 CALCULATION OF WOOD FUEL SUPPLY POTENTIAL FROM FORESTS

The second and more difficult task (after quantifying the current wood fuel consumption) was to calculate the volumes of wood grown each year by the study area’s forests. This represents wood available to fuel expanded use of biomass energy in the region.

In order to accurately calculate this potential supply in a way that provided meaningful information, a tool was developed in which county-specific data on forested land base, forest inventory, forest growth, and harvesting could be entered and the net supply calculated for each county within the study geographic area.

The Microsoft Excel-based spreadsheet tool created for this study uses the following formula:

\[ NALG = (((((V \times P) \times N) / K) \times J) - F) + (((((R \times P) \times O) / K) \times J) - G) \]

(Note: the above formula is a simplified version of the actual formula used in the tool.)

Where:
- \( V \) = Bole of Growing Stock Trees, Non-commercial Trees, and Cull Trees on Timberland
- \( P \) = Net Annual Growth Rate
- \( N \) = Bole Growth % Low-grade
- \( K \) = Total Timberland Area (acres)
- \( J \) = Calculated Net Timberland Accessible and Available for Harvesting Annual Growth
- \( F \) = Amount of Bole Wood Harvested in Green Tons
- \( R \) = Tops & Limbs of Growing Stock Trees, Non-commercial Trees, and Cull Trees on Timberland
- \( O \) = Top & Limb Growth % Suitable
- \( G \) = Amount of Tops & Limbs Harvested

While designing and constructing the tool, it was clear that there were many areas where county-specific data was not available and estimated values were needed to complete the calculations. The tool, therefore, was designed to be used dynamically, using a series of key assumptions that can be adjusted as desired.

Specific assumptions for each of the following key input categories were used:

- Forest growth rate
- Low-grade portion of net annual growth of growing stock, cull, and non-commercial species bole inventory
- Low-grade portion of net annual growth of growing stock, cull, and non-commercial species tops and limbs inventory
- Physical limitations on timberland access for harvesting
- Availability of timberland for harvesting based on social, economic, and political factors as well as ownership type and parcel size.
The tool created for this study has advantages as well as several drawbacks. The tool was created in Microsoft Excel and is very adaptable and flexible in its capacity to be fine-tuned and modified. The design of the tool weaves the best existing data together and allows the user to insert various assumptions where key data is not available. The design also allows the user to test the various key assumptions’ impacts on the calculated inventories to learn more about the outputs’ sensitivities to these inputs.

The tool allows the user to sift through many layers of information to examine the under-utilized portion of the net annual growth of low-grade wood. It is important to note that there is a distinct difference between the study’s method for quantifying only the net annual growth of low-grade wood and how harvesting happens in practice. In reality, the harvesting of wood is not conducted at low intensity (only the net annual growth) over a large area each year. On the contrary, commercial harvests are typically conducted on a smaller land area, with greater harvest intensity (wood volume removed per acre), and with much longer intervals between harvests.

The following sections of this third chapter detail all the data that is used in calculating NALG.

USFS – FIA

The Northeastern Forest Inventory and Analysis (NE-FIA) Unit of the USDA Forest Service, headquartered in Newtown Square, Pennsylvania, has the responsibility of providing detailed forest resource information on the nature, condition, and use of the forests in 13 northeastern states. Its purpose is to:

- Collect and disseminate information about the forests of the northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.
- Maintain a current and comprehensive database of the renewable forest resources of the northeastern United States.
- Develop and apply scientific knowledge and technology in support of the inventory and analysis project.
- Provide information and technical assistance for the development of periodic national and regional assessments.
The NE-FIA is required to periodically inventory the forest resources in each state. The NE-FIA unit has conducted inventories in Vermont in 1948, 1965, 1973, 1983, and most recently in 1997.

Their methods for calculating forest inventory -

“Because it is impossible to count every tree in Vermont, FIA personnel used a scientifically designed sampling method. First, photo interpreters studied aerial photographs of the entire State. Next, a grid of nearly 22,000 points was overlaid on the photos. If forested, each point was classified according to land use and tree size. From this information, a sample of 926 plots was selected for measurement by FIA field crews. The sample included plots that were established during previous forest inventories; plots established in 1948 were measured for the fifth time. The re-measurements yielded valuable information on how individual trees grow. Field crews also collected data on the number, size, and species of trees, and the related forest attributes. All this information was used to generate reliable estimates of the condition and health of Vermont’s forest resource, and how it is changing over time.”

The NE-FIA program’s timeline for updating forest inventory is different from state to state. For example, this study used the most up-to-date forest inventory data available: Vermont from 1997, Massachusetts from 1998, and New York and New Hampshire, both from 2005. Vermont’s and Massachusetts’ county forest inventory data were adjusted to 2005 in an effort to make valid comparisons as part of the methodology.

3.1 Landbase and Ownership

For the purpose of this study, the forested land area referred to as “timberland” was examined. Timberland is defined by the USDA Forest Service as “forest land capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.”

Vermont has 4.6 million acres of forested land, which is nearly 80 percent of the state’s total land area. Timberland, or productive and unencumbered forestland, accounts for approximately 98 percent or 4.5 million acres. More than 86 percent of Vermont’s timberland is privately owned. The remaining 14 percent is owned publicly between federal, state, and municipal entities. The surrounding counties in New York, Massachusetts, and New Hampshire have similar distribution of timberland ownership.

The total 24-county study area has 9.3 million acres of timberland. Windsor County is Vermont’s largest county in total land area as well as in acres of timberland. Coos and Grafton counties in New Hampshire are the first and second largest in the study area.  

All timberland area and all timberland ownership classes were included in this study. Further discussion of the importance of the landownership and its impact on the availability and reliability of the wood fuel supply is included in section 3.6.

### 3.2 Above-ground Biomass Inventory

NE-FIA forest inventory data exist for numerous subcategories of forest inventory. FIA data focus primarily on “growing-stock trees”, or live trees of commercial species classified as sawtimber, poletimber, saplings, or seedlings; that is, all live trees of commercial species except rough and rotten trees. Other subcategories include cull trees (rough and/or rotten trees), and salvable dead trees. While growing stock trees (including cull and salvable dead trees) account for a large portion of the total forest inventory, for biomass energy we also need to examine the inventory of non-commercial species.

Traditional methods of measuring forest volume are inadequate for the purpose of biomass studies because they focus on the volume of timber products in the tree stem or bole. Wharton and Douglas (1995) developed a new method of estimating the amount of total forest biomass using regression equations to determine the weight of the total tree based on stem volume measurements. The method is very comprehensive and covers all forest biomass (including seedlings, saplings, and shrubs) not just the traditional focus on growing stock trees.

For this study, customized county data were required because the published FIA tables were either too focused on growing stock volume or too inclusive of all forest biomass. NE-FIA program personnel provided the customized county data for above-ground biomass (above a one foot stump) of live trees five inches DBH (diameter at breast height) or greater for the following forest inventory categories:

- Growing stock trees
- Cull trees
- Non-commercial tree species

---

15 Timberland area and ownership data for Vermont is from 1997 FIA tables.
Customized above-ground biomass data exclude:

- Seedlings and saplings
- Shrubs
- Biomass of roots, stumps, and foliage

The Wharton and Douglas study determined the total forest biomass in Maine using the 1995 FIA forest inventory data. The proportions of various components of the tree in relation to the stem volume that Wharton and Douglas determined were based on the average composition of Maine’s forest. These proportions were then used to generate the FIA biomass data for all the northeast states. These NE- FIA biomass data do not take into account the differing ratios of hardwood to softwood volumes from state to state. Maine’s forests are comprised of 62 percent softwoods, whereas Vermont’s forests are roughly 22 percent softwoods. In the absence of solid data, it is generally assumed that softwoods tend to have less top and limb wood than hardwood species.

![Diagram used by Wharton, et al to describe the various categories of forest biomass](image)

Therefore, the data used in this study likely underestimate the amount of the top and limb component of the above-ground biomass.

Because the most complete set of data for Vermont is from 1997 and Massachusetts’ data are from 1998, the biomass inventory data from these states needed to be calculated forward to match the newer 2005 data available for both New York and New Hampshire. This involved a linear calculation where averaged net annual growth rates were applied to the starting inventory, the annual removals from the state harvest reports were subtracted, and this process was repeated forward to 2005.
As of 2005, the 14 counties of Vermont were calculated to have approximately 513.3 million green tons of above-ground biomass and the total 24-county study area had 1.058 billion green tons of above-ground biomass on timberland. According to the NE-FIA data and NE-FIA’s use of the Wharton/Douglas methodology for determining the proportions of tree mass, approximately 88 percent is in boles and the remaining 12 percent is tops and limbs.

When these numbers are examined by comparing them back to the acres of timberland, the county patterns change. In raw inventory, large counties like Coos and Grafton in New Hampshire have the highest total inventory. But when the biomass inventory is examined per acre of timberland, counties like Bennington and Windham in southern Vermont show higher stocking levels per acre. Conversely, rural counties that host or are in close proximity to large-scale consumers of forest products (such as Clinton, New York; Orleans, Vermont; Caledonia, Vermont; and Coos, New Hampshire), have low inventory per acre of timberland.
3.3 Net Annual Growth

As trees grow each year, they add weight and volume. The actual growth rates vary according to a wide range of factors, including soils, species, stand age, stocking levels, etc. Young trees grow faster than older trees. Very young trees put most of their growth into height, adding little volume. Older trees will put less growth into height and more into diameter, which contributes far more volume to the stand. Very old trees will grow very slowly, with most of their growth in diameter rather than height.

The NE-FIA unit defines forest net annual growth as “the change, resulting from natural causes, in growing-stock volume during the period between surveys (divided by the number of growing seasons to produce average annual net growth). The simplified NE-FIA formula for net growth is:

\[
\text{Net Growth} = \text{In-growth} + \text{Accretion} - \text{Mortality}
\]

To clarify, the definitions are listed below:

- In-growth = addition of new wood from new trees.
- Accretion = addition of new wood on existing trees.
- Mortality = loss of wood from tree deaths.

This measurement of net growth does not account for changes in inventory due to harvesting.

The problem with the FIA definition is that it focuses on growing-stock volumes and does not account for the rate of growth for whole trees. In this study it was assumed that net annual growth rates of top and limb wood are proportionally consistent with the net annual growth rates for bole or stem wood.

For this study a net annual growth rate was used that reflects the combined growth in total tree mass, less the natural mortality rate averaged over all forest types. Based on the most recent 1997 FIA data, Vermont forests are growing at a rate of 2.24 percent annually.16

Based on the FIA data for Vermont and surrounding counties, and assuming a net annual growth rate of 2.24 percent, the state’s forests are growing at a rate of approximately 2.41 green tons per acre per year of above stump biomass, excluding foliage. Approximately 2.24 green ton per acre are in bole net annual growth, whereas the remaining 0.17 tons per acre are in tops and limbs.

This study did not use growth/yield models such as NE-TWIG and FIBER (developed by the USDA Forest Service) that project future forest growth based on very specific stand composition and condition information. For the purpose of calculating the forest’s averaged capacity to grow low-grade wood for biomass energy, the level of detail from growth/yield models would be excessive.

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3.4 Low-grade Wood

It was very important to make sure that the fuel wood amounts calculated for this study not include high-quality timber inventory that should be used for furniture, lumber, etc. For this reason, the study focuses on the portion of the total inventory and net annual growth that is, in fact, low-grade and suitable for use for chipped fuel. The determination of the volumes of forest biomass that are low-grade versus high-grade material is a subjective task. FIA plot measurements include assigning growing stock into various quality categories. Qualitative data recorded by FIA field crews as part of the plotMeasurement process were not used for this study.
The methods used by FIA to designate stem quality are conservative (overestimating the low-grade portion) and did not address non-growing stock volumes\textsuperscript{17}.

In reality, each parcel may differ significantly from the next in terms of the proportions of low-grade to high-grade material. For the purpose of this study, low-grade wood is defined as any wood unsuitable as a sawlog. This includes bole volumes that would be suitable for pulp, firewood, and production chips. Of the total mass of the bole portion of trees, this study identified a range of 50-75 percent based on the survey responses from the county and consulting foresters as well as follow-up personal communication with forestry experts.

While the inventory of top and limb wood is not nearly as large as the low-grade bole inventory for the study area, it is still a significant amount of otherwise un-merchantable material that has potential to be used for biomass energy. Tops and limbs, however, also have ecological value for the carbon and nutrients that can be recycled back into forest soil to maintain the health and productivity of the working forests. There is considerable debate on what the soil impacts are of whole-tree harvesting. While many foresters agree that selective harvesting of cull and diseased trees and leaving the healthy trees improves the quality of the stand, the debate on long-term effects of whole-tree harvesting continues.

What portion of the tops and limbs inventory should be included for this study’s calculation of the forest growth useable for energy? This is a difficult question because, even amongst foresters and other experts in the field of forestry in the region, there is a lack of agreement on what level of removal of tree tops and limbs from the forest is sustainable. Many foresters point to research that has been conducted emphasizing the need to return the carbon and nutrients contained in the tops and limbs to the forest soil to maintain long-term forest productivity. An equal number of professional foresters in the region believe proper use of whole-tree harvesting is a sustainable practice. For the purpose of this study a full range of tops and limbs removal from 0 to 100 percent was tested. It should be noted that model runs using 100 percent extraction of tops and limbs assumed 100 percent bole extraction, because it would be impractical to harvest proportionally more tops and limbs than stem wood.

An important question is: What portion of the inventory of low-grade wood will become classified as high grade over time as smaller diameter trees grow larger? To answer this question, a general assumption was made that for the amount of low-grade wood that becomes high-grade wood, a similar amount of high-grade wood becomes low-grade due to stand damage—both natural and human caused.

\textsuperscript{17} Personal communication, Randall Morin, Northeastern FIA, USDA Forest Service
Assuming 65 percent of bole volume and 50 percent of the tops and limbs as low-grade, the annual growth of low-grade wood is 7.3 million green tons for Vermont and 14.9 million green tons for the total 24-county study area. The full analysis of the sensitivity of low-grade portions is presented in Section 3.7.

3.5 Harvest Data

In the Northeast, forestry departments and agencies of several states collect harvest activity data while other states do not. Fortunately, Vermont gathers harvesting data annually via a survey distributed to mills throughout the region that received wood harvested in Vermont. Unfortunately, New York and Massachusetts do not gather annual harvesting data. New Hampshire gathers harvesting data through the stumpage tax the state levies on the revenue landowners receive from timber harvests. Both Vermont and New Hampshire data were used to the fullest extent in the supply calculation. Vermont and New Hampshire’s data include detailed breakouts of the volumes of veneer, sawlogs, pulp, and whole-tree chips harvested in each county.

None of the four states has accurate harvest data for firewood on the county level. Firewood harvesting is often by individuals on their own land and therefore “below the radar screen.” It is
The Vermont Wood Fuel Supply Study

extremely difficult to track. The best estimates available for Vermont consumption of firewood are from a 2000 study by the Vermont Department of Public Service, entitled Vermont Residential Fuel Wood Assessment 1997-1998. The county consumption data for residential firewood used in this study was based on the methods presented in Section 2.3 above.

![2004 Vermont Total Harvest - 2.67 Million Green Tons](image)

Source: Data from Vermont Forests, Parks & Recreation - 2004 Harvest Report

### 3.6 Access and Availability

Of the 4.5 million acres of timberland in the 14 counties of Vermont and the 9.3 million acres in the total 24-county study area, how many acres are reasonable to consider both “accessible” and “available” for harvesting low-grade wood? Obviously, every acre of timberland is not accessible or available for harvesting.

General physical limitations such as slope, elevation, wetlands, distance to roads, deer yards, stream buffers and riparian areas, areas designated as wilderness, and forested areas with easements limiting or prohibiting timber harvesting were taken into account to reduce the starting area of timberland in each county to a smaller area that is accessible to harvest. While the study-area counties may have fairly wide variations in the total timberland area that is restricted due to any number of these factors, region-wide averages were assigned for each category. The tool is capable of using county-specific data for each category if that data become available at a later date.

General assumptions of the average percentage of timberland that is considered “inaccessible” were made and used throughout the supply calculation for exclusion in the inventory of potential fuel wood:

- Areas with excessive slopes
- Areas at high elevations
- Areas with hydric soils
- Areas with excessive distances to roads
- Areas with mapped deer yards
- Areas within buffers of steams and other surface water
- Areas designated as wilderness
- Areas with easements restricting or prohibiting harvesting

While forest areas designation by the USDA Forest Service as timberland (capable of producing 20 cubic feet/year) may already account for some of the exclusions listed above, it is unlikely that the USDA methodology fully accounts for these factors. In Vermont, approximately 98 percent of the forested area is designated as timberland. When the exclusions listed above were entered into the calculations, the result was a 22 percent reduction in the timberland area deemed “accessible.”
In addition to accounting for the physical limitations to accessibility for harvesting, the various social, economic, and political factors that tend to further limit the amount of timberland that is available for harvesting are factored into this study. The method used requires assigning a blanket probability factor to each category of landownership in each county, as detailed below. The landownership categories are:

- Federal
- Miscellaneous Federal
- State
- Municipal
- Corporate
- Forest Products Industry
- Farmer
- Individual

The individual category of landowners is extremely important because they are the largest timberland owner group in Vermont and their attitudes and behaviors in regard to commercial harvesting are the most difficult to predict of all the landowner groups. For public, corporate, forest products industry, and even farmer-owned timberland, fairly accurate predictions can be made for the likelihood of harvesting. Non-industrial Private Forest (NIPF) owners are more likely to harvest when the timberland parcels owned are greater than 50 acres.\(^{18}\) For the Individual timberland ownership category, the county acreage was further broken out into two subcategories by parcel size—individually owned parcels fewer than 50 acres and individually owned parcels more than 50 acres.\(^{19}\)

Based on a combination of data sources including the National Woodland Owners survey (Butler and Leatherberry, 2006) and reasonable assumptions, coefficients of timberland availability were assigned to each of the ownership classifications. The federal and individual smaller than 50 acres classification were ranked as the least available for harvesting while, forest industry and individual greater than 50 acres were ranked as the most likely available classifications of timberland ownership.

### Area and Number of Family Owned Forests for 24 County Study Area by Parcel Size

<table>
<thead>
<tr>
<th>Size of Forest Land Holdings</th>
<th>Area</th>
<th>Number of Ownerships</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9 acres</td>
<td>4.9%</td>
<td>53.7%</td>
</tr>
<tr>
<td>10-49 acres</td>
<td>23.5%</td>
<td>32.9%</td>
</tr>
<tr>
<td>50-99 acres</td>
<td>15.3%</td>
<td>6.7%</td>
</tr>
<tr>
<td>100-499 acres</td>
<td>33.9%</td>
<td>6.2%</td>
</tr>
<tr>
<td>500-999 acres</td>
<td>5.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>1,000 -4,999 acres</td>
<td>7.7%</td>
<td>0.1%</td>
</tr>
<tr>
<td>5,000 + acres</td>
<td>9.3%</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Source: Customized data provided by Brett Butler, NE-FIA*

If the assumptions on timberland accessibility and availability for harvesting are applied to the starting area of timberland in the Vermont and the total study area, there are 1.5 million acres in Vermont and 3.3 million acres in the 24-county area of accessible and available acres of timberland for harvesting.


\(^{19}\) The “Individual”, “Family”, and “NIPF” landownership categories have significant overlap.
3.7 Results and Sensitivity Analysis

Four key variables were identified as having significant impact on the NALG calculation:
1. Net annual forest growth rates (1-3 percent)
2. Proportions of low-grade bole wood (60-75 percent)
3. Percentage of tops & limbs extracted (0-100 percent)
4. Percent land area of timberland accessible and available for harvesting (25-50 percent)

Using these four key variables, three scenarios were developed to test the sensitivity of their impact on bottom line. The “Conservative” scenario presented below is intended to model the situation in which harvesting opportunities are more limited than they are today. The “Moderate” scenario models conditions most representative of the current situation. The “Aggressive” scenario is intended to model the supply of NALG under conditions where there are greater harvesting opportunities. The figures presented below are not intended to be definitive answers to the question of how much wood is out there, but instead to establish a reasonable range and demonstrate how the key four variables influence the results.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Key Assumptions</th>
<th>14 Vermont Counties NALG (green tons/yr)</th>
<th>TOTAL (all 24 Counties) NALG (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>• No harvesting on public lands and on privately owned lands fewer than 50 acres</td>
<td>387,491</td>
<td>1,137,267</td>
</tr>
<tr>
<td></td>
<td>• 40% bole volume classified as low-grade and 0% tops and limbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>• Moderate harvesting on public lands and on privately owned lands fewer than 50 acres</td>
<td>1,466,982</td>
<td>3,423,082</td>
</tr>
<tr>
<td></td>
<td>• 60% bole volume classified as low-grade and 50% tops and limbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggressive</td>
<td>• Increased harvesting on public lands and on privately owned lands fewer than 50 acres</td>
<td>2,342,053</td>
<td>5,343,465</td>
</tr>
<tr>
<td></td>
<td>• 70% bole volume classified as low-grade and 100% tops and limbs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The graph above depicts the county data for NALG under the assumptions of the “Moderate” run. While the total amount of NALG for the 24-county study area is 3.4 million tons, there are specific counties, which under the various assumptions used, yielded negative values. This suggests that in the years 2004 and 2005, the harvesting levels of low-grade wood from accessible and available timberland in those counties exceeded the forest’s growth rate of new low-grade wood. Orleans and Caledonia Counties in Vermont are located near the hub of the low-grade wood markets in northern New Hampshire. The NALG results for two counties, Orange and Windsor in Vermont illustrate the imperfections in the tool, given the data and assumptions used. These two counties show surplus bole NALG while having a deficit of tops and limbs NALG.
3.8 Discussion

Overall, the patterns emerging from the calculations of NALG were predictable. Many of the counties within a close transportation distance of a large-scale biomass power plant or pulpmill have slightly lower NALG inventories. Counties that are located centrally between several large-scale consumers have the lowest inventories. Counties located the furthest away from the big mills have the largest inventories. One major exception to this pattern is the inventory calculated for Essex County, New York. With the presence of International Paper’s Ticonderoga Mill and the nearby Finch Pryun pulp and paper mill in Warren County, New York, the inventory calculated is surprisingly high. This is likely due to the fact that no county harvest data was available for New York and estimates used in the calculation were low.

With the recent closures of Fraser Paper’s pulpmill in Berlin, New Hampshire and the Groveton paperboard plant in Groveton, New Hampshire in 2006, it would be interesting to see how the county NALG inventories will change in the years to come. The current loss and the potential further loss of pulpmills is a major factor that will be explored in further detail in the next chapter of this study.
4.0 SUPPLY/ DEMAND COMPUTER MODEL

There are a number of computer modeling programs that are routinely used to project forest inventory, growth, and composition under various demand and environmental assumptions. Perhaps the most notable work done in recent years in the region was conducted by Sendak, Abt, and Turner (2003). Sendak et al. integrated several existing forest inventory models: SRTS (Sub-Regional Timber Supply), ATLAS (Aggregated Timberland Assessment), and Flex FIBER (Forest Increment Based on Ecological Rationale). Sendak et al. used the integrated models in a NEFA (Northeast State Foresters Association) commissioned study that examined the 50-year projection of timber supply for northern New England (Maine, New Hampshire, and Vermont) and New York.

To better suit the needs of this study, Resource Systems Group was contracted to design and construct a computer model based on the framework of the MS Excel spreadsheet-based wood supply calculation tool described in Section 3.0 above. This computer model was developed to project the impacts of various market factors on the volumes of low-grade wood over a 10-year period. This computer model was based on the same framework of the spreadsheet that calculates the volumes of low-grade wood in each county. This model is not a Growth/Yield model. It does not take into account such forest conditions as species, age structure, slope and aspect to project the growth and potential yields.

4.1 Model Description

The supply-and-demand-model is spatially constructed on a county basis. Also included are major consumption centers such as wood-fired power plants or pulpmills located beyond the study area counties. The model consists of four major parts as detailed below:

![Simplified flow chart depicting the function of the model](image-url)
1.) The available supply model has four components:
   - Forest inventory, growth, and mortality
   - Availability and accessibility constraints
   - Forest-residue supply from high-value harvesting
   - Mill-residue generation from manufacturing

2.) The demand model has five components:
   - Consumption of saw timber and high-value products:
   - Consumption of pulp
   - Consumption of low-grade chips
   - Consumption of residential firewood
   - Consumption of mill residues

3.) The geographical allocation model determines how consumption is distributed by counties. This is embodied in a spatial-allocation procedure that includes the cost constraints on wood transportation. Built into the demand allocation is the rule that 75 percent of wood will generally come from within a 50-mile radius of a wood-use facility while the remaining 25 percent will come from the area beyond the 50-mile ring, but within a 75 mile area. While pulpmills routinely draw from a larger area (over 100 miles), the allocation rule above represents the average fuel procurement of biomass energy facilities.

4.) A set of input scenarios for changes in demand, supply, and possibly transportation, over a 10-year period are entered into the model. This allows the user to test a range of policy options or postulated system changes.

The model is specifically designed to examine sustained-yield harvest levels at the county level under different scenarios, but it does not directly model the price of wood. The model can be extended for periods beyond 10 years.
4.2 Scenarios Tested

There are a huge number of possible combinations of input assumptions that could be examined with the computer model that was constructed. For the purpose of this study, four were chosen that were designed to test the model and explore a few possible scenarios of what the demand impacts will be on the inventory of net annual growth in the study-area forests.

The four model runs examined were:
1. Constant Demand Run – both biomass and timber (including pulp) demand remained at current levels.
2. Increased Biomass - Constant Timber Demand Run
3. Increased Biomass - Decreased Timber Demand Run
4. Increased Biomass and Timber Demand Run

In addition to the four general model runs several additional runs were designed and tested to examine specific functions of the model.

4.3 Results and Sensitivity Analysis

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Key Assumptions</th>
<th>NALG Results (green tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Demand Run</td>
<td>• Consistant levels of harvesting on public and private timberland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 60% bole volume classified as low-grade and 50% tops and limbs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Flat consumption for sawlogs, pulp, firewood, and chips</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Assumes Berlin and Groveton remain closed</td>
<td></td>
</tr>
<tr>
<td>Increased Biomass &amp; Constant Timber Demand Run</td>
<td>• Consistant levels of harvesting on public and private timberland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 60% bole volume classified as low-grade and 50% tops and limbs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 5% annual increased demand for biomass power and seasonal heating with chips and firewood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Flat consumption for sawlogs and pulp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Assumes Berlin and Groveton remain closed</td>
<td></td>
</tr>
</tbody>
</table>
### Increased Biomass & Decreased Timber Demand Run
- Consistent levels of harvesting on public and private timberland
- 60% bole volume classified as low-grade and 50% tops and limbs
- 5% annual increased demand for biomass power and seasonal heating with chips and firewood
- 5% annual reduction of sawlog and pulpwood consumption.

### Increased Biomass & Increased Timber Demand Run
- Consistent levels of harvesting on public and private timberland
- 60% bole volume classified as low-grade and 50% tops and limbs
- 5% annual increased demand for biomass power and seasonal heating with chips and firewood
- 5% annual increase in sawlog and pulpwood consumption.

#### 4.4 Discussion

**CONSTANT DEMAND RUN**

The results for the constant demand run overall were not surprising. The general county-by-county pattern of forest annual growth exceeding annual removals was advanced 10 years with the NALG amounts increasing across the board. Counties like Orleans and Caledonia in Vermont, which were slightly in the negative
in 2004, rebounded to positive inventories of NALG in the first and second year of the model (presumably due to the closure of Groveton and Berlin). However, the combined draw from International Paper’s Ticonderoga Mill and to a lesser extent, Finch Pryun’s pulpmill in Glens Falls had significant impact on Washington County, New York in this model run. Washington County NALG inventories were negative throughout the 10-year period. Also Chittenden County inventories were projected throughout as negative. This is likely due to the lower probability of timberland availability (due to smaller parcel sizes) and the per capita use of residential firewood. It is important to note that negative numbers depicted in different model runs under various scenarios do not imply that there is over harvesting in a particular county.

INCREASED BIOMASS DEMAND & CONSTANT TIMBER (SAWLOG AND PULPWOOD) DEMAND RUN

This demand run was similar to the previous run where Orleans and Chittenden County show negative values and Washington County, New York is negative for the duration. In the last year of the 10-year model, Coos County, New Hampshire also dipped into negative inventory. The incremental increase of biomass demand starting at five percent in year one and rising to 50 percent in year 10, tested the resilience of the NALG inventory. It was in the last two years of the 10-year model at 45 and 50 percent increased demand where the threshold was crossed and significant reductions of NALG inventory occurred.

INCREASED BIOMASS & DECREASED TIMBER (SAWLOG & PULPWOOD) DEMAND RUN

In general, there were similar patterns observed in this run as the previous run where demand for biomass was increased from five percent in year one to 50 percent in year 10. The expected result of increased NALG inventory due to decreased pulp consumption did not have as much impact.
as was anticipated. Many of the major pulp consumers are in the periphery of the study area and
t heir demand is allocated evenly in a radius around their locations. The amount of low-grade
wood that was freed up by declining pulp consumption was relatively minor compared to the
increase of consumption from within the core of the study area.

INCREASED BIOMASS & INCREASED TIMBER (SAWLOG AND PULP) DEMAND RUN

Once again, similar patterns to the
previous runs with the increased
biomass demand
were observed. As
far as impact on the
NALG inventory,
the model’s greatest
sensitivity is to
increased biomass
within the study
area. The impact of
increased pulp
collection
pulling from the study area periphery was not significant and the increased demand for sawlogs
does not impact the NALG projections

20MW WOOD-FIRED POWER PLANT RUNS

In addition to the generalized model runs above, several specific model runs were performed to
test the spatial allocation functions of the model by placing a 20MW wood-fired power plant
consuming approximately 250,000 green tons annually in various counties to see its impact on the
surrounding wood baskets. These model runs were conducted using the same general assumptions
that were used for the constant demand run.

- Addison County, Vermont - no major impact in host or surrounding counties.
- Bennington County, Vermont – no major impact in host or surrounding counties.
- Orleans County, Vermont – AULGNAG volumes dipped well into the negative before
slowly recovering after seven years.
- Windsor County, Vermont– no major impact in host or surrounding counties.

These four counties were selected at random as a sampling of what the forest inventory impacts
would be if a 20MW wood-fired power plant was brought online. The impacts on other counties
of hosting a 20MW power plant could be examined in the future using this model.

One of the interesting results from the 20MW power plant model runs was the lack of county-
specific impact the demand had on the host county. Due to the fairly dispersed consumption rule
the model uses, the demand allocation was spread evenly over the 50- and 75-mile radii.
NET FOREST GROWTH RATE RUN

All of the above runs of the model assumed a constant rate (2.24 percent) of forest net annual growth for the 10-year period, but as forests grow older, growth tends to slow. To test what impact the rate of forest growth has on the county inventory of NALG wood, a Constant Demand Run was tested with the following modifications:

- 2006 - 2.15% net annual growth
- 2007 – 2.05% net annual growth
- 2008 – 1.95% net annual growth
- 2009 – 1.85% net annual growth
- 2010 – 1.75% net annual growth
- 2011 – 1.65% net annual growth
- 2012 – 1.55% net annual growth
- 2013 – 1.45% net annual growth
- 2014 – 1.35% net annual growth
- 2015 – 1.25% net annual growth

The results of this run were interesting. The most revealing outcome was that the total NALG inventory began to decline in the first year of applying the lower rate of forest growth. This indicates how extremely sensitive the whole model is to the forest rate of growth and how important it is to fully understand how fast forests are growing. This is a realistic scenario because as forest stands mature they senese the rate of growth slows.

![NALG 10-Year Projection](image)

**NALG 10-Year Projection**

Declining Net Annual Growth Rate - Constant Demand Run

The graph shows the projected green tons of NALG from 2005 to 2015 for NY, MA, & NH Counties and Vermont Counties.
5.0 ECONOMIC ANALYSIS
All of the analysis presented thus far has been focused on answering the questions: How much wood fuel is currently consumed in the region? How much additional low-grade wood could be used for biomass energy? What are the various impacts of demand on the forest inventory? While this is very important information, it is incomplete without putting it into context of economics. This section of the study attempts to answer the following questions – At what market price points can the inventories of NALG be mobilized? What are the economic dependencies of woodchip prices to different degrees of integrated harvesting? What are the sensitivities of the harvesting costs to the degree of integrated harvest? If only low-grade wood for energy was selectively harvested and no higher value timber was cut at the same time, what would the wood fuel cost?

5.1 Complex Factors
Generally, there are numerous factors that affect the price of chips—everything from the competing markets’ relative strength or weakness at a given point in time, to the cost of diesel used to run harvesting and processing equipment and trucks, to extended periods of wet weather.

MACRO-ECONOMICS
In traditional macro-economic theory, supply and demand within a free market system will reach a price and quantity equilibrium point. Any shift in the demand can be measured in what price increase (p1 to p2) is necessary to secure the additional quantity (q1 to q2) of a given good.

![Graph showing supply and demand](image)

Unfortunately, wood fuel markets do not behave this simply. In economic theory, the price elasticity of supply of a product is measured by the responsiveness of the quantity supplied to a change in price of product. Price elasticity is measured as the percentage change in supply that occurs in response to a percentage change in price. By-products of harvesting and manufacturing other wood products will be comparatively inelastic because the quantity supplied to the market will not respond to an increase in price in the same way a primary product will respond to a similar price increase.

Again, there are many variables to consider. The most important of these is the extent to which the economics of harvesting low-grade wood depends on integrating the harvesting of more valuable products to subsidize extraction of the low-grade wood.
INTERDEPENDENCY

Energy from woodchips has a 25-year history in Vermont and the surrounding area. In that time, woodchip prices have remained relatively flat. When the market prices paid for chips are compared to the rate of inflation, chips actually have experienced a negative price growth over the past two decades in the region.

Because the wood-energy industry has relied on the low-value wood by-products from other wood-using industries, it has not controlled wood prices in the market the way the pulp and paper and lumber industries have. The pulp and paper industry has had a strong command of its supply and has the greatest impact on the biomass energy sector’s wood supply and price. There are two main scenarios that demonstrate the supply/demand influences and wood price impacts related to pulpmills and the biomass power plants. In the first scenario, when pulp and paper regional markets are strong and ramping up production, biomass power plants have to pay more for wood. A strong paper industry tends to use more marginal wood because their demand for wood feedstock is high. When the dollar weakens, it is good for US manufacturers. Suddenly those competing products from Europe and Canada are more expensive. It becomes easier to export and harder to import. The wood or paper product is more competitive than it was yesterday with no change in its production. The domestic paper or wood products industry then ramps up production and uses more wood. Wood that was previously sent to the chipper now is not sent and is therefore less available for biomass. The graph above shows the price data for New Hampshire over the past 10 years. The graph shows distinct peaks and valleys in the chip prices that can be tied directly to major events in the pulp market during that same time. For example, the original closure of the Berlin, New Hampshire pulpmill in 2001 initially sent the chip prices down. When harvesting capacity was lost and the mill then reopened two years later, the prices went back up.

But there is another, somewhat opposite, factor/scenario that influences the supply and demand balance between pulpmills and biomass plants. When pulpmills are strong and their demand goes
up, more roundwood is cut —leaving more tops and limbs on the landing to be fed to the chipper. Conversely, if the pulp market is weak and biomass is not paying enough to cover the harvesting costs, less roundwood is cut and less top and limb wood is left for chipping on the landing. Which factor plays out over the other depends on the markets and the harvest specifics from woodlot to woodlot.

HARVEST COSTS

Harvesting costs depend largely on harvesting efficiency and harvesting efficiency is highly variable. In some situations (large harvest areas with relatively high harvest levels in cords per acre), independent harvesting of low-grade material can be profitable using efficient, mechanized harvesting techniques. Conversely, the harvesting costs for horse logging are very high and low-grade wood is difficult to harvest profitably. These are the exceptions to the rule, however, not the norm. Most typical harvests in Vermont require some sawlog removal to subsidize the removal of the low-grade wood. Costs per unit of wood harvest can vary widely. The following factors are significant players in the variable costs of harvesting:

- Accessibility (distances to nearest roads, terrain, skid distances, existing layout of skid roads, etc.)
- Harvest area
- Harvest volume per acre
- Ratio of sawlog to pulpwood (and/or other low-grade products)
- Species mix

Additional costs of chipping and transport to the end markets can also be highly variable. Chipping costs fluctuate as widely as transport costs but can range from $2 per ton and upward to $10 per ton based on the size of the chipper and how efficiently the operator uses the chipping equipment. Transport costs of moving 20-24 ton loads out of the woods and to the markets depend on multiple factors, but the most important is the haul distance.

In a study entitled *The Cost of Extracting Logging Residues for Biomass Fuels – Great Lakes Region* (2005), the author, Donald Peterson, explored the costs of extracting tops and limbs (to a four-inch top) using various harvesting techniques—from mechanized cut-to-length (CTL) harvesting and forwarding to mechanized whole-tree harvesting and skidding. This study examined these costs on a range of forest types including Northern Hardwoods. The costs identified for the various methods of harvesting only included stumpage paid to the landowner, chipping cost at the landing, and the cost of transport to mills. In the case of the CTL harvest methods, skidding costs were factored because it required going back into the woods to get the residue wood after the logs were removed. For the whole-tree harvesting of Northern Hardwoods, the study identified a cost of $14.41 per ton based on no cost to harvest or skid, $4.27 per ton for chipping, $8.00 per ton for transport to the mill, and $2.14 per ton stumpage.

While the Peterson study provided excellent information for understanding the costs to extract the top and limb residues of a commercial sawlog and pulpwood harvest, it does not address the full cost of harvesting and extracting chips from either pulpwood or whole trees, which would require adding in the harvesting and skidding costs. For this reason, the VTWFSS has attempted to calculate the full costs of harvesting wood fuel.

5.2 Economic Model Description

Several studies that forecast timber supply have included economic analysis of the timber markets in the Northeast. Sendak, et al. (2003) used an econometric model called SRTS (Sub-regional...
Timber Supply) as a part of a study that integrated this econometric modeling with timber supply and demand projections.

While there are a number of economic models, none worked for the purpose of this study due to the major difference of the market behavior of timber as a primary product and biomass fuels as by-products. For that reason, a model was created for this study into which many variables can be entered.

A basic model was developed that allows the user to input wood product mix harvested, average harvesting costs, average stumpage paid to the landowner, average hauling distances and costs, and average market price paid for each of the wood products. From these inputs, the model reports the overall profitability of the harvest. The main output from the model is the market price necessary to allow a harvest to break even or generate a small profit. The model is built on the key assumption that in the majority of cases, if a harvest cannot break even or better, the harvest will not happen.

ECONOMIC MODEL INPUTS

- Harvest product mix
  - % Hardwood sawlogs
  - % Softwood sawlogs
  - % Hardwood pulp
  - % Softwood pulp
  - % Hardwood firewood
  - % Hardwood bole for chipping
  - % Whole-tree chips from entire trees
  - % Whole-tree chips from tops & limbs

- Stumpage
- Average cost to harvest and extract to landing (including de-limbing as necessary)\(^{20}\)
- Average distance to market and hauling cost per mile
- Average price paid at mill\(^{21}\)
- Average cost to chip\(^{22}\)

For the purpose of this study, the economics of woodchip harvesting, production and transport were explored using the model under several scenarios:

1. Current product mix ratios under integrated harvesting
2. Increased demand of low-grade wood under integrated harvesting
3. Complete independence from integrated harvesting (exclusively low-grade wood harvested)

\(^{20}\) Based on responses from Logger Survey of this study (see Section 6)
\(^{22}\) Based on responses from Chipping Contractor Survey of this study
5.3 Results & Sensitivity Analysis

Four chip sources were examined –
1. Sawmill chips
2. Whole-tree chips from only tops and limbs of sawlog and pulpwood harvesting
3. Whole-tree chips from entire low-grade trees
4. Bole chips from low-grade logs

The focus of the study was then turned to the potential of whole-tree chips from entire trees and bole chips as primary or commodity wood fuel. The underlying questions that needs to be answered is: If demand for woodchip fuel grows beyond the supply of residue-derived chips, what will the commodity fuel chips cost with and without the influence of integrated harvesting and what prices would be necessary to mobilize a portion of the calculated NALG wood?

The chart below shows the results of the economic modeling work.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Key Assumptions</th>
<th>Bole Chips</th>
<th>Whole-tree Chips</th>
</tr>
</thead>
</table>
| Current Average Harvest Mix             | • Average product mix for Vermont (39% sawlogs, 25% pulp, 25% firewood, and 10% chips)  
                                         |             | $43/green ton   | $30/green ton   |
|                                         | • $80-$85/cord average harvest and extraction cost                              |             |                 |
|                                         | • 50-75 mile haul distance to mills                                              |             |                 |
|                                         | • Average sawlog price $400/MBF                                                 |             |                 |
|                                         | • Average pulpwood price $80/cord                                               |             |                 |
|                                         | • Average cost to chip = $6.00/ton                                               |             |                 |

| Increased Proportion of Low-grade Wood  | • Increased low-grade for energy (30% sawlog, 10% pulp, 20% firewood, 20% bole chips, and 20% whole-tree chips)  
                                         |             | $51/green ton   | $36/green ton   |
|                                         | • $80-$85/cord average harvest and extraction cost                              |             |                 |
|                                         | • 50-75 mile haul distance to mills                                              |             |                 |
|                                         | • Average sawlog price $400/MBF                                                 |             |                 |
|                                         | • Average pulpwood price $80/cord                                               |             |                 |
|                                         | • Average cost to chip = $6.00/ton                                               |             |                 |

| Complete Independence from Integrated Harvesting | • Average product mix for Vermont (39% sawlogs, 25% pulp, 25% firewood, and 10% chips)  
                                                      | • $80-$85/cord average harvest and extraction cost                              | $64/green ton   | $40/green ton   |
|                                                | • 50-75 mile haul distance to mills                                              |             |                 |
|                                                | • Average cost to chip = $6.00/ton                                               |             |                 |

Note: the chart above is a depiction of the market prices for chips under various levels of integrated harvesting. It is not a prediction of future prices.

The price difference between bole chips and whole-tree chips from entire trees in the chart above is due to the lower costs per unit to skid whole trees and the avoided costs of de-limbing.

It is important to note that the model constructed is a dynamic model where any of the inputs can be altered to explore different scenarios. Any number of possible scenarios can be tested using this tool to test the price points various wood fuel markets would need to pay for the wood fuel to be mobilized.
The chart below illustrates the results of combining the price analysis with the calculations of NALG inventory.

The graph above depicts the supply curve of bole chips and whole-tree chips from entire trees, which are relatively elastic in comparison to the inelasticity of sawmill chips and whole-tree chips from tops and limbs. It is assumed in the case presented above that the harvesting and processing of higher-value forest products remains constant. (The x and y axis are reversed in this graph where the x axis is quantity and the y axis is price. The previous graphs showed quantity on the y axis and price on the x axis.)
5.4 Discussion
The purpose of this study is to provide a general assessment of the availability and reliability of wood fuel for biomass energy. The economics are a very important piece of the puzzle. More thorough economic analysis should be conducted to explore this area in greater detail. Many factors in this analysis were intentionally over-simplified. For example, not sufficiently accounted for were the way in which the harvesting methods and economies of scale impact woodchip production costs. Instead, generalized costs for harvesting, chipping, and transport were used.

An important point that should be reiterated is that the analysis conducted was to explore the market price conditions necessary to mobilize the volumes of calculated NALG inventory for biomass energy. The graph above illustrates the point that greater mobilization of the resource can be achieved at higher market prices. At current market prices, there is a lower probability of increasing the supply.

In the chart above, the reason the bole chip line continues higher and steeper than the line for whole-tree chips is based on the assertion that some limits, such as the amount of timberland on which whole-tree harvesting can be effective employed, will restrict the amount of wood fuel sourced from whole-tree chips. Because there is a significant portion of timberland where whole-tree harvesting may not be feasible, the potential for use of bole chips derived from smaller harvests allows for a steeper supply curve. If the timberland ownership and parcel sizes in Vermont were not accounted for, bole chips and whole-tree chips would likely have similar supply curves.
6.0 SURVEY
Throughout this study, there have been many gaps in the data needed to accurately estimate the current market demands, calculate the in-forest capacity to support increased use of biomass energy, project the supply and demand trends 10 years into the future, and understand the related economics. For these reasons, surveys were employed to:

- Gather further general information
- Test and fine tune key assumptions used in the supply calculation, the 10-year supply/demand model, and the economic analysis
- Explore potential strategies to increase low-grade wood supply

To accomplish the points above, six main groups of stakeholders within the forestry profession, the forest products industry, and the biomass energy industry were identified. Mail-back surveys were developed and distributed to these six key groups:

- Consulting and county foresters
- Logging contractors
- Sawmills
- Firewood processors
- Chipping contractors
- Chip fuel consumers

6.1 Chip Consumers
Surveys were mailed to 42 chip consumers in the study-area counties to learn more about their chip fuel demand and purchasing methods. Twenty three completed surveys were returned for a 54.8 percent response rate. The chip consumer survey was designed for and distributed to primarily seasonal heating users, not to the larger power plants. Separately, the chip procurement details for larger-scale consumers were explored via a series of telephone, email, and personal conversations with representatives of the biomass power plants.

RESULTS
- A majority of survey respondents consumed 500-1,000 green tons annually
- More than 87 percent of respondents purchase chips directly from a supplier versus using a broker
- 48 percent of respondents burn paper-grade sawmill chips as primary fuel
- A majority (56 percent) indicated that their demand for chips has not increased over time
- More than 72 percent stated they are currently having no trouble securing their supply of chips
- A majority (52 percent) do not use a chip specification to ensure quality when purchasing fuel
- A small minority (fewer than 9 percent) reported purchasing fuel chips cooperatively with others
- Only a small percentage (9 percent) indicated that they offer their supplier a spread of contract payments over all 12 months of the year
- Somewhat more respondents (18 percent) indicated that they offer their supplier a pre-buy option for their annual requirement of chips
- Only 34 percent expected their demand for chips to grow in the future
- More than 79 percent listed paper-grade chips as their preferred source/type of chip fuel
- Only 40 percent stated they would be willing to pay extra for chips from a supplier who would guarantee their annual supply
Of the 40 percent who were willing to pay extra for guaranteed supply, 70 percent claimed to be willing to pay $2.50-$5.00 per green ton more than they currently pay.

A majority (52 percent) indicated that they were not willing to pay more for “green” certified sources of wood.

Of those who responded that they were willing to pay extra from “green” certified sources (nearly 37 percent of total respondents), 100 percent responded that they would pay between $1.00 and $5.00 extra per green ton.

Only 39 percent responded that they were willing to purchase bole chips directly from a logging/chipping contractor rather than paper chips from a sawmill.

Only 27 percent answered that they were willing to purchase chips cooperatively with other buyers.

**DISCUSSION**

There were no unexpected responses from the chip consumers. A large majority of the market prefers the low price and quality of a clean sawmill chip. While some respondents seemed willing to pay extra for greater security, few seem to want to lose their supply of sawmill chips.

### 6.2 Sawmills

Surveys were sent to 66 sawmills with an annual production capacity of one million board feet and larger in the counties of the study area. Twenty-three completed surveys were returned for a 34.9 percent response rate.

**RESULTS**

- More than 98 percent of survey respondents have been in business for more than 20 years.
- More than 98 percent of respondents stated they chip their slabs, trim, and off-cut.
- More than 68 percent of sawmills that do not currently sell chips to seasonal heating markets would consider it.
- 43 percent of respondents who already supply the seasonal heating market send more than 80 percent of their production of chips during the winter months.
- 43 percent listed $23-$26 per ton as the price they are paid for their chips at the nearest pulpmill.
- 42 percent listed $23-$26 per ton as the price they are paid for their chips at the nearest biomass power plant.
- Slightly more than 37 percent listed $31-$35 per ton as the price they are paid by the seasonal heating market while another 37 percent listed $36-$42 as the price they are paid.
- More than 60 percent of sawmills that send chips to the pulpmill have either no contract or a contract for fewer than 12 months.
- Very few (8 percent) listed a preference for having a contact for any term longer than 24 months.
- Roughly 50 percent use the services of a broker.
- 33 percent burn a portion of their chip volumes (in addition to bark and shavings) to fuel their drying kilns.
- Only 24 percent responded that they would not consider storing pulpwod in their yard for supplemental chipping if the market for chips grew over the next few years; 23 percent said they would consider it, and the remainder said maybe.
- A majority (16 percent yes and 58 percent maybe) said they would consider receiving, storing chipping, and selling bole chips from pulpwod.
When asked what price per ton they would need for bole chips (from pulpwood) chipped at the sawmill, the responses were more diverse–12.5 percent said $32-$38, 25 percent said $39-$44, 12.5 percent said $45-$50, 12.5 percent said $51-$56, and 37.5 percent said more than $57 per ton.

In addition, a series of three open-ended questions were asked:

- “What are the biggest market changes you have observed in the past 12 months?”
  - The most common responses were:
    - “fewer sawmills producing chips”
    - “increased demand for chips”
    - “less production of chips at existing mills due to weather and softening of lumber markets”
    - “high cost of logs”
    - “bad weather”

- “How does this affect your business?”
  - “increased demand for our chips”

- “What further market changes do you envision in the next 12 months?”
  - “more of the same” “increased energy costs”

**DISCUSSION**

An interesting result of the survey was that 98 percent of the responding sawmills have been in business for more than 20 years. This is an indicator that there is not much new investment or new entries into the primary sawmill market in the region.

Despite the nature of the sawmill business, where making more lumber and less waste through greater efficiency is the goal, there seems to be a healthy amount of interest from sawmills in what role the emerging biomass energy market could play for their businesses in the future.

One sawmill, which sells all of its annual chip (and sawdust) production to a wood pellet manufacturer, stated-

> “I believe if we were to store roundwood pulp for chipping, it would make economic sense to flail debark [before] chipping to produce both bark, which is a viable product for us and then clean chips for value-added end product (pellets). With these two high end markets available, it seems as if whole-tree chips will be the main supply chain for biomass fuel in the future.”

While the respondent was speaking of producing a clean chip for the wood pellet market, it could also be used as a premium fuel chip for the seasonal heating market, which prefers the quality of a bark-free chip.

**6.3 Foresters**

In an effort to understand more about the management of the predominantly privately owned forestland in Vermont and surrounding counties, private consulting foresters and county foresters were sent surveys. In total, 48 surveys were mailed and 22 completed surveys were returned for a 44.9 percent response rate.
RESULTS

- A majority (64 percent) of survey respondents have been professional foresters for more than 20 years
- A large majority of the forestland they manage is enrolled in the state Use Value Appraisal (UVA) program
- Future timber value was the most common objective given for their client’s management/ownership
- Stumpage sale was listed as the most (64 percent) common type of timber sale administered over “cut and haul contact” and “lump sum bid”
- A majority of foresters (54 percent) believe the amount of low-grade wood has increased over the past 10 years
- A majority of responding foresters felt “low-grade” wood accounts for 60-70 percent of growing stock trees on timberland in Vermont
- 17 percent was the average percentage of harvests that utilize whole-tree harvest methods the responding foresters administer
- Conversely, 83 percent was the average percentage of timber sales on which felled trees were de-limbed at the stump
- 86 percent felt that better markets for low-grade wood are necessary for good forest management
- 66 percent felt that too much low-grade wood is left in the forest
- 90.5 percent felt that the pulp market would not grow in the future
- 62 percent felt that the firewood market would grow in the future
- 70.5 percent felt there should be less whole-tree harvesting
- The average response to the question “What is the minimum harvest size to warrant whole-tree harvesting?” was 27.42 acres at 11.83 cords per acre
- The average response to what price per cord (at the landing) needs to be paid to stimulate more removal of low-grade wood?” was $65.36 (or $26.14/green ton) for roundwood
- When asked which type of wood fuel they would prefer to see increase in the future – five percent said they did not want any increased fuel consumption, five percent responded whole-tree chips as the preferred fuel, 47.8 percent preferred roundwood cut for bole chips, while 39 percent preferred a mixture of increased whole-tree chips and bole chips
- When asked what action was needed to increase harvesting of low-grade wood for biomass energy, the most common response was “price paid for fuel needs to come up”

In addition, a series of three open-ended questions were asked:
- “What are the biggest market changes you have observed in the past 12 months?”
- “How does this affect your business?”
- “What further market changes do you envision in the next 12 months?”

“Loss of hardwood pulp market” was the number one response to the first question followed closely by “drop in high-end sawlog prices.” The third most common response was “price drop for pulp paid by remaining mills.”

“Puts jobs on hold until prices rebound” was the most common response to the second question followed by “lower stumpage paid to landowner.”

Several respondents predicted “this winter will put many loggers and some mills out of business” while others foresaw continued low-prices for sawlogs.
DISCUSSION
With many of the surveys, the notes scribbled in the margins of the returned surveys contained as much valuable information as the body of the survey itself. The responses to many of the questions asked depended widely on the specific circumstances. When asked what price needs to be paid to stimulate more removal of low-grade wood, there were the answers that were written in the blank box, and on several occasions, notes similar to the following were received –

“$60/cord at the landing, but this is when there is enough sawtimber to cut also. $100/cord would be necessary if no sawtimber was cut to subsidize the harvesting of low quality wood.”

Several private consulting and county foresters expressed concern about the need to leave tops and limbs in the woods for soil health and long-term productivity:

“Chipping for biomass energy can be effective, but we need to do it sustainably. If we focus on wood only as a fuel source, and forget that wood is necessary component of forest soils, we could deplete our forests of organic matter and reduce their long-term productivity. Organic matter in soil holds nutrients and water and is even more important as the climate changes due to global warming.”

Another interesting comment from a consulting forester –

“Whole-tree chips are not going away. Harvesting efficiency is greatly enhanced by cutter, grapples, and chippers. Chipping has become the only realistic way to remove gross volume small diameter pulp. The trick will be to ensure that jobs with larger wood be cut conventionally and that we don’t chip over and over on the same site.”

A few of the other interesting outcomes of the forester survey were that whole-tree harvesting accounted for an average of 17 percent of total harvests. While this is a low percentage, it is only the number of harvests not the percent of the total harvested volume. It would have been interesting to ask a follow-up question that would try to estimate the percentage of total volumes harvested in Vermont that come from whole-tree harvests. Also, the average threshold of when whole-tree harvesting became effective was interesting: 27 acres at 12 cords per acre. According to the results, if a fairly well-stocked hardwood forest is approximately 22 cords per acre, it would require removing more than half the wood inventory on a harvest area close to 30 acres for whole-tree harvesting to be effective.

6.4 Firewood Processors
Because there was such little data available on residential consumption of firewood and the resulting harvesting impacts, firewood processors were added as a group to survey in an effort to build upon the 10-year information from the Vermont Department of Public Service study. Mail-back surveys were sent to 137 firewood processors ranging in size from those producing enough to supply their own needs to those serving several hundred customers. Thirty-two completed surveys were received for a response rate of 23.7 percent.

RESULTS
- 61 percent have been in the business of processing firewood for more than 20 years
- The average number of customers they serve is 60
- 64 percent felt there are good markets for low-grade wood
• 59 percent of their firewood sold traveled fewer than 20 miles and 90.6 percent traveled fewer than 50 miles
• 51 percent of their firewood was harvested within 20 miles of their base of operations and 81 percent came from within 50 miles
• The average price paid for delivered firewood in log lengths was $75.24 per cord
• 86.5 percent of their markets are residential heating
• Only 21.9 percent would consider receiving and storing additional roundwood for chipping as an add-on to their firewood business

DISCUSSION
Although the intent of the firewood processor survey was to fill in the gaps of the last decade since the last firewood survey in the Vermont, surveying the firewood processors was no substitute for the full surveying of the residential heating market. While this survey yielded some very useful information, there is still little known on how much state wide consumption of firewood has changed over the past ten years.

6.5 Logging Contractors
Mail-back surveys were distributed to 738 logging contractors and 79 completed surveys were received for 10.7 percent response rate. Obviously 10.7 percent is an extremely low response rate and raises concern about the reliability of any conclusions drawn from this information.

RESULTS
• 64 percent of respondents have been in logging business for over 20 years
• Skidders are the most common piece of equipment owned by loggers (average 1.24 skidders per survey respondent), followed closely by log loaders (0.53 units per respondent)
• Average annual harvest for respondents were:
  o 523,000 board feet of sawlogs
  o 751 cords of pulp
  o 291 cords of firewood
  o 2,102 tons of WTC for power plants
  o 92 tons of bole chips
• 67 percent exclusively de-limb logs at the stump while only 13 percent exclusively use whole-tree harvesting
• 65 percent feel currently there is not a good market for low-grade wood and 33 percent do feel there is a good market for low-grade wood
• 68 percent say they are currently able to harvest and sell all the low-grade wood marked on jobs
• 78 percent do not currently chip wood directly or indirectly
• 51 percent have at one time supplied biomass power plants
• 83 percent truck pulpwood a maximum of 100 miles to the nearest pulpmill while only 42 percent truck pulpwood a maximum of 50 miles to the mill
• 72 percent of respondents currently have no form of written contract with the pulpmill they supply
• Average-price reported for roundwood at the pulpmill is $35 per ton or $53.62 per cord
• 23 acres at 14 cords per acre was the average response to the question: What is the minimum sized harvest that can use whole-tree harvesting?

23The $53.62 price is significantly below market prices and is likely a result of respondents reporting the price paid at the landing instead of at the mill. The $35 per ton figure is consistent with market prices.
• 41 percent would prefer to see an increase in pulpwood used to make bole chips for future demand of biomass energy while 43 percent would prefer a market mix of both whole-tree chips and bole chips from chipping roundwood for the future demand
• 79 percent are actively searching for new markets for low-grade wood
• 19.5 percent were willing to consider buying a chipper to supply biomass power plants
• 16.8 percent were willing to consider buying a chipper to supply the seasonal heating market
• When asked how long a contract they would prefer to supply biomass energy systems in general, 24 percent prefer having a 12-24 month contract, 36 percent prefer a 24-36 month contract, and 30 percent would prefer a contract term longer than 36 months

In addition, a series of three open-ended questions were asked:

• “What are the biggest market changes you have observed in the past 12 months?”
  The most common responses were-
  o “Loss of low-grade markets”
  o “Pulpmills closing”
  o “Lower prices paid for sawlogs”
  o “Higher diesel costs”
  o “Warm wet weather”
  o “More loggers selling out or retiring”

• “How does this affect your business?”
  To which the most common responses were-
  o “Less profit”
  o “Higher costs”
  o “Can’t get in the woods”
  o “Many jobs on hold until prices come up”
  o “Hauling further for the same money’
  o “Can’t do jobs with too much low-grade and not enough high-grade wood”

• “What further market changes do you envision in the next 12 months?”
  To which the most common responses were-
  o “Continued loss of markets”
  o “Lower prices”
  o “Going out of business”
  o “Growth of biomass energy market”
  o “Continued low sawlog prices from increased competition from wood imports”

DISCUSSION
The fact that 64 percent of the respondents have been logging for more than 20 years was not unexpected, but supports the evidence reported in several other studies that loggers are aging and the younger generation is not being attracted to the logging profession. The average response to the question of when whole-tree logging becomes effective was surprisingly close to the average to the same question asked in the forester survey—23 acres at 14 cords per acre. It is also interesting that while a majority of loggers feel there are not good markets for low-grade wood and majority of the respondents stated they were able to harvest and sell all low-grade wood marked on sales.
6.6 Chipping Contractors

Mail-back surveys were distributed to 39 logging contractors and 11 completed surveys were received for 28.2 percentage response rate.

RESULTS

- Only 9 percent of respondents exclusively chipped wood as a subcontracted part of the total harvest. The large majority chip wood as a part of integrated harvesting of sawlogs, pulp, and firewood
- 73 percent have been in the logging business for more than 20 years
- 67 percent chip between 20,000 and 50,000 green tons annually.
- Among the 11 respondents, they own:
  - 6 harvesters
  - 9 shears
  - 27 skidders
  - 16 chippers
  - 26 log loaders
  - 27 tractors (trucks)
  - 50 chip vans (box trailers)
  - 2 bulldozers
  - 1 de-limber
  - 3 excavators
  - 6 live-bottom trailers
  - 2 straight frame log trucks
- Average annual chip production was 24,125 green tons of whole-tree chips
- 45 percent log and chip within 75 miles of home and the remaining 55 percent work within 100 miles of home
- 45 percent haul chips within 75 miles of where the chips are harvested and 55 percent haul chips within 100 miles of where they are harvested
- When asked how many weeks in a given year they run their chipper, 10 percent responded 20-30 weeks, 50 percent responded 31-40 weeks, and 40 percent responded 41-52 weeks
- When asked how much of their annual volumes come from just tops and limbs, just whole trees, and just de-limbed pulpwood, the average response was 50 percent tops and limbs, 50 percent whole tree, and 8 percent pulpwood
- 89 percent replied they are able to cut and sell all low-grade wood marked on a timber sale, but only 78 percent stated they were able to sell all the low-grade wood they ended up cutting
- 62 percent responded that they routinely haul pulpwood more than 100 miles to a pulpmill
- 37 percent who sell pulp to a pulpmill have no contract and none had a contract longer than 24 months
- $32.53 was the average price reported by respondents for pulpwood delivered to the pulpmill
- 60 percent felt there are good markets for low-grade wood while the other 40 percent felt there are not good markets
- 56 percent said they are actively looking for new markets for low-grade wood
- 100 percent of respondents not currently supplying seasonal heating markets said they would consider it
- Only 30 percent said they work with a chip broker to market their chips
• 82 percent reported being paid by biomass power plants between $27 and $30 per green ton
• 15 acres at 21 cords per acre was the average response to the question: What is the minimum size harvest where whole-tree harvesting becomes effective?
• “Fuel costs” and “instability of market” were the first and second most common responses to the question: What is the greatest barrier to your business?
• 50 percent indicated they would consider storing pulpwood in a yard over the summer months for chipping into bole chips for seasonal heating market in winter
• 67 percent stated they would like a 12-24 month contract to make bole chips for the heating market
• When asked what price per ton they would need to be paid for bole chips responses ranged widely from $32- $52 per ton
• Only 33 percent said they would find it useful if seasonal heating consumers offered a 12-month spread of contract payments
• 60 percent said it would be useful if seasonal heating consumers purchased their chips together
• 100 percent responded that they have enough work to keep their chipper busy.
• 60 percent stated that they are interested in expanding their business
• 100 percent indicated their interest in being listed as a potential supplier in a directory

In addition, a series of three open-ended questions were asked:

• “What are the biggest market changes you have observed in the past 12 months?”
  The most common responses were:
  - “Higher diesel costs”
  - “Pulpmills closing (Fraser and Groveton)”
  - “Put on quota (volume limits to what they can send) at remaining pulpmills”
  - “Smaller woodlots”

• “How does this affect your business?”
  To which the most common responses were:
  - “Other mills have dropped prices”
  - “Less profit”
  - “Producing less chips for less money”

• “What further market changes do you envision in the next 12 months?”
  To which the most common responses were:
  - “Loss of loggers”
  - “Warmer and shorter winters –bad for heating chip demand and bad for working in woods”
  - “Lower prices”
  - “Less pulpwood and more chips”
  - “Growth of biomass energy market”
  - “Continued high fuel costs”

DISCUSSION
Similar pattern were seen in the response to the chip contractor survey as seen in several of the other surveys. 73 percent of the chip contractor respondants have been in the logging business for over 20 years. Obviously the loss of pulp markets and higher production costs like diesel fuel make things tougher for these contractors. “Instability of the market” was frequently listed as an
issue that chip contractors deal with—pointing a need for developing the market in ways which greater stability can be achieved. With the average price paid for pulpwood paid at the nearest mill at $32.53/ton, the fact that 62 percent of respondents stated they routinely haul pulpwood over 100 miles, and over the road diesel prices at roughly $3.00/gallon, Vermont needs local markets for low-grade wood.

6.7 Discussion
The six surveys provided useful information that helped substantiate some of the key assumptions used. In addition to learning more about how these groups do business and view the biomass energy market, we began the process of testing the waters of what possible strategies could be used to improve the availability and reliability of wood fuel supply. Concepts such as regional roundwood yards to store low-grade logs for chipping into bole wood were tested with each of the groups. Other possible strategies were explored involving longer-term contracts, 12 month spreads of contract payments, and per-buy options for chip purchasing. While the information gathered on these potential strategies is useful, further surveying of these groups may prove useful as the study’s stakeholders continue efforts to develop strategies to strengthen wood fuel supply in Vermont.
7.0 CONCLUSIONS
What was learned from the current wood fuel supply analysis, from in-forest NALG calculation, from 10-year supply and demand modeling, from the economic analysis, and from the surveys?

- A majority of Vermont’s current supply of biomass fuel is produced as a by-product of commercial harvesting or primary processing of forest products.
- Vermont’s forests have the capacity to supply additional amounts of wood fuel for biomass energy.
- Some counties have greater capacity to expand the use of biomass energy than others.
- The ability of Vermont’s forests to sustain increased harvesting for biomass energy will depend to a certain extent on the future of the pulp and paper industry in the region.
- Higher market prices paid for wood fuel will stimulate mobilization of the in-forest NALG inventory and result in greater availability and reliability of wood fuel supply.
- Bole chips and whole-tree chips have potential for becoming commodity wood fuel products.
- Loggers and mills are surviving—but just barely.

7.1 Wood Availability
There is a finite volume of by-product derived fuel and a very large portion of that by-product resource is currently being utilized by existing markets. Any significant growth of demand for wood fuel will need to be harvested from the forests.

Forests are abundant in Vermont and the surrounding counties of New York, Massachusetts, and New Hampshire. Biomass energy can be expanded to use more wood (above the current demand for existing biomass by the forest products industry as it exists today) within the volumes of what our forests grow annually.

Depending on the factors, variables and key assumptions used and tested in this study, there are approximately 1.0 - 1.5 millions tons of low-grade wood grown each year on timberland that is likely accessible and available for harvesting in Vermont alone. The southern part of Vermont has the highest concentration of this wood.

The 10-year supply/demand model indicates that one of the most important factors to which the supply of NALG is sensitive is the net annual growth rate of the forests. Slight variations in the rate of growth have extremely significant impact on available fuel wood supply.

Vermont’s forests are owned mostly by non-industrial private landowners. The availability of low-grade wood for fueling biomass energy is highly dependent on the forest management and harvesting choices they make. The rate of forestland ownership turnover and the rate of parcelization will have significant impacts on the availability of these forestlands in the years to come.

The scale of harvesting, the methods used, and the resulting efficiencies vary widely and forest parcel size is a key factor. Developing both bole and whole-tree chip fuel sources will help diversify the scale of harvests from which fuel chips can be derived.
7.2 Harvesting Infrastructure Capacity and Stability

The potential to lose harvesting infrastructure and capacity if a large volume consumer, like a pulpmill, goes out of business, is high. Biomass energy competes with pulpmills for low-grade wood but also depends on the pulpmill to support a significant portion of the supply capacity – everything from the loggers themselves, to their chain saws and skidders.

In order for biomass energy to take the pulp industry’s place at the table in the region and keep the harvesting infrastructure in place both higher prices for wood fuel will need to be paid as well as larger volumes consumed.

7.3 Biomass Energy Market

Historically, biomass (low-grade wood chipped for energy) is not a profit center for the logger—it merely helps the cashflow of a logging business. Harvesting sawlogs and other higher value forest products has, on-average, subsidized the market price of biomass fuels. Current prices for chips derived from other primary activities such as sawmills do not reflect the full cost of harvesting, processing, and transporting chips. The perceived value gap, however, is not as wide as many may believe. The following chart shows the average market prices for various grades of timber. When the units have been converted to green tons, the situation is put into perspective—the value gap between sawlogs and low-grade wood is not very wide. The estimated average market value of hardwood sawlogs of $475 per thousand board feet translates to $95 per green ton. It is extremely important to point out that no one is recommending high-quality logs be chipped for energy.

<table>
<thead>
<tr>
<th></th>
<th>S/MBF</th>
<th>$/Cord</th>
<th>$/Green Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwood Sawlog</td>
<td>$475.00</td>
<td>$237.50</td>
<td>$95.00</td>
</tr>
<tr>
<td>Softwood Sawlog</td>
<td>$300.00</td>
<td>$150.00</td>
<td>$60.00</td>
</tr>
<tr>
<td>Hardwood Pulp</td>
<td>$180.00</td>
<td>$90.00</td>
<td>$36.00</td>
</tr>
<tr>
<td>Softwood Pulp</td>
<td>$180.00</td>
<td>$90.00</td>
<td>$36.00</td>
</tr>
<tr>
<td>Firewood</td>
<td>$160.00</td>
<td>$80.00</td>
<td>$32.00</td>
</tr>
<tr>
<td>Hardwood Pulp for Bole Chips</td>
<td>$160.00</td>
<td>$80.00</td>
<td>$32.00</td>
</tr>
<tr>
<td>Whole-tree Chips</td>
<td></td>
<td>$32.00</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Prices indicated above are for roundwood with the exception of whole-tree chips*

The above chart does not reflect the additional cost of chipping the pulpwood into a useable fuel nor the additional chip transport costs from a processing yard to the end user. On average, $18-20 per green ton would cover the chipping and trucking costs. Assuming under current market conditions:

- Low-grade roundwood could be secured for roughly $28 per ton (avoiding cost to truck further to pulpmills),
- Logs dry slightly during storage and loss of water sold per ton is lost revenue
- An average $8/ton for chipping,
- An average trucking cost of $10/ton, and
- The supplier makes 15-20% profit margin

Assuming the points above, bole chips can be produced for of $52-$57 per green ton.

What if the ratio of the harvesting of high-grade material to low-grade material changed, so that the market demanded fewer sawlogs but wanted more low-grade material? Because the current pricing of low-grade wood is keep artificially low by the higher market prices paid for sawlogs,
the price point where low-grade wood becomes available under this scenario increases. If the ratio of high-grade to low-grade market volume demand changes significantly, the biomass energy market will need to bear a higher price for its wood fuel.

<table>
<thead>
<tr>
<th>Price of Woodchips</th>
<th>Equivalent Price of #2 Heating Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>$30 per green ton</td>
<td>$0.41 per gallon</td>
</tr>
<tr>
<td>$40 per green ton</td>
<td>$0.55 per gallon</td>
</tr>
<tr>
<td>$50 per green ton</td>
<td>$0.69 per gallon</td>
</tr>
<tr>
<td>$60 per green ton</td>
<td>$0.83 per gallon</td>
</tr>
<tr>
<td>$70 per green ton</td>
<td>$0.96 per gallon</td>
</tr>
<tr>
<td>$80 per green ton</td>
<td>$1.10 per gallon</td>
</tr>
<tr>
<td>$90 per green ton</td>
<td>$1.24 per gallon</td>
</tr>
<tr>
<td>$100 per green ton</td>
<td>$1.38 per gallon</td>
</tr>
</tbody>
</table>

Note: Does not account for differences in average seasonal combustion efficiencies.

The chart above shows that if the price of wood fuel increases above its current (2007) level, wood energy will still be economically viable in almost all cases when compared to the cost of heating oil.

The harvesting infrastructure existing today is primarily supported by the markets for higher quality wood. If sawmills experience slowdowns and pulpmills close in Vermont and the surrounding region, the infrastructure necessary to harvest biomass cannot presently be supported solely by biomass markets. To achieve greater reliability for wood fuel for biomass energy, biomass markets need to be able to grow in their own right to achieve greater independence from the vulnerable position of being considered merely a by-product of the forest products industry, or relegated to the role of “bottom-feeder” of the forest wood supply. Low-grade wood needs to be of sufficient value to sustain its share of the infrastructure, even in the face of market fluctuations in the rest of the forest products industry.

Woody biomass used for energy needs to transition from being seen and treated in the market as waste utilization to the production of a commodity fuel. If the expectation is that biomass fuels will always be a by-product, there is little potential for expanded biomass supply to fuel further biomass energy in Vermont. By-product derived biomass fuel will always be vulnerable and insecure, albeit inexpensive. By-product wood fuel’s availability and reliability is highly dependent on the health and stability of timber markets.

Commodity biomass fuel will cost more, but will also be more accessible, reliable, and secure over time. Under the proposed commodity model biomass fuel will be less dependent on the health of the rest of the forest products industry. **Two main pathways exist to achieve the transition from by-product to commodity:**
   - Expanded use of bole chips, and
   - Expanded use of whole-tree chips.

Much of the harvesting infrastructure in place in Vermont’s logging industry is set up for removing limbs at the tree stump and forwarding just the log to the landing. For this portion of the harvesting market, the expanded use of bole chips made from low-grade logs to replace the declining demand from the pulpmills is the ideal strategy. For the portion of the market that can support forwarding the whole-tree and processing logs at the landing, expanded use of whole-tree chips will be the best option. This second pathway eliminates the need to delimb and therefore costs less to produce chips. The downside for the second pathway is that the scale of harvesting where it is effective is limited, and many foresters are wary of nutrient and carbon depletion of forest soils from whole-tree harvesting.
8.0 RECOMMENDED STRATEGIES

This study and the modeling tools developed for it, present the opportunity to take a fresh look at possible strategies and actions that can advance the goal of sustainably utilizing low-grade forest resources for biomass energy production in Vermont. The study itself has not developed new strategies – instead it has explored the details of wood fuel supply to improve our understanding of wood fuel availability and reliability so that, as policy decisions are made, we can ensure that growing demand for wood fuel is maintained within the capacity of the forest resource and is consistent with ecological and environmental values and management objectives, for years to come.

The recommendations below are strategies BERC believes are worth pursuing in light of the results developed in this study. They are presented as possible next steps for advancing the conclusions of this report that there is underutilized, low-grade wood available for use in Vermont, but that use is not unlimited and is sensitive to increases in demand. These recommendations are presented in four categories below for consideration by the sponsors of this study. It is important to emphasize that these are professional recommendations of the principal investigator and BERC, and they have not been endorsed by other stakeholders or the study sponsors:

8.1 Wood Availability

- Expand existing initiatives, such as the Current Use (or Use Value Appraisal) taxation program, and develop new incentives that help reduce property tax burdens on private landowners.
- Develop programs and initiatives that facilitate the coordination among the increasing number of small private timberland owners to achieve their forest management objectives and reach the scale necessary to keep small woodlots as “working forests”.
- Increase public outreach and education on the benefits of managed forests and highlight examples of well-managed forests.
- Expand public relations efforts to promote the forestry and logging professions as the stewards of Vermont’s working forests.
- Work with public and private partners to develop strategies to reduce the parcelization and fragmentation of large forest parcels.

8.2 Harvesting Infrastructure Capacity and Stability

- Work to maintain and enhance the forest harvesting infrastructure – equipment and personnel. Keep existing forest products markets in Vermont strong as their demand is the backbone of the existing harvesting infrastructure.
- Create a business development assistance program for parties interested in starting wood fuel supply businesses.
- Develop a portfolio of commercial lending programs and small grant programs that will make capital available to the forest products industry.
- Develop loan guarantee programs to help wood supply businesses without sufficient collateral to secure commercial financing.
- Support strong markets for high-grade and mid-grade forest products as a vehicle for enabling low-grade wood harvesting.
- Promote and make investments in distributed storage and processing sites.
- Encourage investment in fuel supply and transport infrastructure.
- Encourage the private development of year-round chipping yards.
• Explore with Vermont Agency of Transportation increasing Vermont’s interstate truck weight limit from 80,000 lbs to 99,000 lbs to conform to limits of neighboring states.

8.3 Biomass Energy Market

• Educate and develop consumer acceptance toward more equitable pricing for wood fuel as a necessary element toward achieving greater fuel supply availability and reliability.
• Encourage purchasing chips made from low-value species such as white birch, beech, and poplar.
• Encourage the procurement of bole chips and whole-tree chips from entire trees as a mechanism to transition toward a commodity fuel supply market.
• Build roundwood inventory in accessible chipping yards to reduce exposure to risk from poor weather and “just-in-time” inventory management.
• Develop the wood energy market in Vermont with consideration to the need to aggregate sufficient regional demand to achieve a critical volume sufficient to prompt new investment in fuel supply infrastructure.
• Use the NALG inventory information from this study to help plan county build out of biomass facilities for the future.
• Encourage the use of unique wood fuel purchasing contract mechanisms, such as pre-buys, 12-month spreads of payments, and diesel fuel price adjustments to attract new chip vendors into the market.
• Encourage longer-term contract commitments for greater market stability.

8.4 General

• Increase funding for state and federal programs to provide up-to-date and on-going data on: forest inventory, growth and harvest volumes, and harvested land area. Also improve data regarding the residential use of firewood.
• Continue, expand and fine-tune use of the methods and tools created as part of this study to re-examine the question answered over time and to enhance the model’s capabilities to address remaining unanswered questions.
LITERATURE CITED AND REFERENCES


Vermont’s Forests – Growing, Changing, Vermont Agency of Natural Resources.  
http://www.anr.state.vt.us/Env99/vtforest.html


Thorne, S., and D. Sunquist. 2001. New Hampshire’s Vanishing Forests: Conversion,  
Fragmentation, and Parcelization of Forests in the Granite State. SPNHF Report of the  
New Hampshire Forest Land Base Study.
GLOSSARY OF TERMS

**Biomass** – plant or animal derived biological matter.

**Bole** – Trunk or main stem of a tree.

**Bole Chips** – Woodchips made exclusively from the trunk or main stem of a tree.

**Clean Chips** – Woodchips that are free of bark and dirt, often also referred to as “paper chips.”

**D.B.H.** - Diameter at Breast Height is a standardized measurement of the diameter of tree stem outside bark at 4.5 feet from the ground.

**Firewood** – chunks of roundwood typically cut into lengths and split. Most common use is for residential heating.

**Growing Stock Trees**- Commonly defined as “living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings with the exception of rough or rotten cull trees.”

**Net Annual Growth** – Net annual growth is the change, resulting from natural causes, in growing-stock volume during the period between surveys (divided by the number of growing seasons to produce average annual net growth). Components of net growth are in-growth plus accretion, minus mortality, minus cull increment, plus cull decrement.

**Pulpwood** – Low-grade logs used for making pulp and paper

**Paper Chips** – Woodchips that are used for making pulp and paper. These chips are typically bark and dirt free and have been screened to remove over and under sized chips.

**Roundwood** – Logs.

**Sawlogs** – Logs suitable to saw into lumber. Typically need to be straight and relatively unblemished.

**Sawtimber** - Live trees of commercial species at least 9.0 inches DBH. for softwoods or 11.0 inches for hardwoods, containing at least one 12-foot sawlog or two noncontiguous 8-foot sawlogs per tree, and meeting regional specifications for freedom from defect.

**Stemwood** – The trunk or bole portion a tree.

**Volume of All Live Trees** - The cubic-foot volume of sound wood in living trees that are at least 5.0 inches DBH from a 1-foot stump to a minimum 4.0-inch top DOB (diameter outside bark) of the central stem.

**Whole-tree Chips** – Wood chips most commonly produced from the left-over tops and limbs of commercial timber harvesting. Increasing amounts of whole-tree chips are produced by feeding entire trees into the chipper.