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Research Report

Timber Supply Study for the North Country of New Hampshire

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Disclaimer

Unless otherwise specifically stated, the information contained herein is made available to the public by the LandVest, Inc., North Country Council, Inc., and NH Division of Forests and Lands for use as a likely reference on the current and future wood supply situation for a hypothetical facility in Coos County. The estimates herein, and model simulations are based on the data sources we believe to be reliable and the analysis is based on our best professional judgment. Any changes in the assumptions or specifics may change the findings of this report. Neither LandVest, Inc., North Country Council, Inc. nor any other agency or entities thereof assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, product or process disclosed in this report.

Executive Summary

LandVest, Inc. has been retained by the North Country Council, Inc. to conduct a study of low-grade timber availability for a hypothetical facility in Coos County, NH. This research has been accomplished with the help of the NH Division of Forests and Lands.

Coos is the largest county in NH., and forestry industry has a long tradition as a key player in the county's economy. Before 2006, the Groveton and Berlin pulp mills consumed approximately 1 million green tons per year of low-grade wood. These facilities were sequentially closed in 2005 and 2006, and since that time there has been great interest in filling the void they left. Consequently we have been asked to provide an estimate on whether there is enough wood in this region to support a low-grade forest products facility, and whether we could predict that supply changing over time.

As a starting point for the research we had to pick a likely location for this hypothetical facility, and for a variety of reasons we chose Berlin. Once we had selected the central location we used existing data, with assumptions to try and define the likely wood basket. We next located all nearby facilities that utilize low-grade timber and estimated circular draw zones based on their total consumption. With that work in hand we eliminated entire counties based on level of competition, and arrived at a group of counties in New Hampshire, Vermont and Maine that our hypothetical facility could reasonably compete in for the fiber produced.

After we determined the counties to be included in the wood basket, we began the process of estimating the likely supply of low-grade timber. As a first step we identified several classes of ownership and made estimates in a range of what percentage of annual growth they might cut. The FIA data we used was available by county and by forest type down to three basic ownership levels – federal, state and private. For federal and state ownerships, we were able to convert that forest type data directly to Fiber habitat classes as a base for modeling. For "private" ownership, we used available data to estimate categories and assigned acres to those categories of ownership by pro-ration, then did the conversion to Fiber habitat class.

After above data preparation, we began the modeling process. We used the ATLAS-SRTS model and verified using the FIA inventory data with constant harvest and

no harvest assumptions. Next, we constructed a base model which was run under assumptions based on the FIA inventory and other factors. At the same time, the sensitivity analysis was conducted. Our base model simulations indicate that the potentially available round wood is 4.62 million green tons. Because there are numerous uncertainties in the future, we did another two additional model runs (i.e., low and high supply) with the assumptions of increase or decrease of the harvest, growth and inventory. Under the low supply and high supply cases, the available round wood is 4.15 and 5.08 million green tons respectively. In order to get the available low-grade wood, the wood consumption of existing wood product facilities was used to estimate how much wood they can procure from the study area. With this geographical analysis, the available low-grade wood ranges from 280,000 to 1,000,000 green tons. Under the normal conditions, there are about 640,000 green tons of low-grade wood available in the study area.

Table of Contents

Table of Figures

Table of Tables

Introduction

The State of New Hampshire (NH) is one of the most highly forested states in the United States (84%, Bryce 2007). The total forested land is 4.85 million acres, of which 4.67 million are classified as productive timberland. Most of the timberland is privately owned (77%), and the rest is owned by the state and federal governments.

Timber plays an important role in the NH economy and the forest provides income from recreation and tourism. The annual contribution of forest-based manufacturing, forest related recreation and tourism to New Hampshire's economy was more than $2.3 billion in 2005 (Bryce 2007). Landowners received about $45.9 million in stumpage revenue in 2005 and timber taxes paid to municipalities totaled $4.6 million. About 1.3 million cords of timber were harvested across the state in 2006, with 57% coming from the North Country (Coos, Grafton and Carroll counties). Coos County alone accounts for 35% of the state harvest. Coos County is the largest by land area of New Hampshire's 10 counties and these three northern counties account for 49.6% of the total land area in New Hampshire.

The role of the forest industry has undergone major changes in the North Country of New Hampshire, in large part due to global competition. In recent years, paper companies have sold their land and moved out of this region and facilities have been closed. This transition has shadowed the local economy due to too much dependence upon a few relatively large pulp and paper manufacturers (Bartlett et al. 2006). With the economy declining, much of the younger population moved downstate in search of better economic opportunities. The age of Coos County's population is older than the average for New Hampshire and the US (Table 1).

Table 1. The population composition comparison among Coos County, New Hampshire and US

	Age Class									
Area	**<5**	**5-14**	**15-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**85+**
Coos County	5.1%	13.3%	10.8%	10.9%	15.8%	15.1%	10.6%	9.4%	6.6%	2.4%
NH	6.1%	14.7%	12.6%	13.0%	17.9%	14.9%	8.9%	6.3%	4.2%	1.5%
US	6.8%	14.6%	13.9	14.2%	16.0%	13.4%	8.6%	6.5%	4.4%	1.5%

Source: U.S. Census Bureau, 2000

Although some pulp and paper manufacturers are moving out of this region, a viable timber resource still exists. This report will try to understand how that resource base can support alternative (or traditional) wood using facilities and the local economy. The emphasis will be placed on the low grade wood traditionally utilized by the pulp and paper mills. In order to address these issues, this report will provide baseline estimates for supplying a forest products facility in Coos County.

Recent Studies in or around Coos County

Several wood supply studies have been completed covering Coos County and/or areas adjacent to Coos County (Turner and Caldwell 2001, INRS 2007, 2008, VT biomass). The most recent study was conducted by Innovative Natural Resource Solutions LLC (INRS) to evaluate the availability of biomass for Clean Power Development's proposed biomass facility in Berlin, NH. This study used the USDA Forest Service forest inventory and analysis (FIA) data, the annual harvests of Coos County as reported on the NH Department of Revenue Administration Report of Cut (1998-2005) and delivery prices to estimate the potentially available biomass fuel. The wood basket in this study was defined by a 30 mile radius and it found that there is approximately 300,000 green tons of biomass available.

Another wood supply study covering the whole state of New Hampshire was authored by Caldwell LLC in 2006 (Caldwell 2007). Those model simulations show the annual available timber to be approximately 3 million greens tons of roundwood per year. Other trends indicated by this report show that the softwood inventory is expected to increase faster than hardwood and that overall inventory tends to increase over the 50-year model simulation. The result is consistent with the wood supply study for the states of New York, Vermont, New Hampshire and Maine (Turner and Caldwell 2001).

A wood fuel supply study was carried out in State of Vermont in 2007 by Sherman. The goal was to understand the forest resource capacity and future availability of wood to reliably fuel biomass energy plants in Vermont. The study area includes all 14 counties of Vermont and the surrounding 10 adjacent counties of New York, Massachusetts and New Hampshire. The net available low grade growth ranges from 0.4 million green tons to 2.3 million greens tons[1] of biomass per year under different assumptions (from conservative to aggressive).

[1] The estimate is from all VT counties only.

All these studies used the FIA data in their analysis, because it is considered reliable and is readily available. Two of above studies (Sherman 2007; INRS 2008) built their own modeling program to do the wood supply projections while the other two (Turner and Cardwell 2001; Cardwell 2007) used ATLAS-SRTS program. ATLAS was developed to be compatible with the FIA data and Turner and Cardwell (2001) also incorporated the SRTS model (Abt 1989) in conjunction with the ATLAS program. This combination of models appears to be a good tool for wood supply studies and has been used in preparing this report.

Objectives

Facing the current economic challenges in Coos County and the north country of NH, the major goal of this study is to evaluate forest resource availability for potential and existing markets that incorporates an evaluation of the short and long-term timber supply in and around Coos County, New Hampshire. Although many wood supply studies have been done, few have taken into account all information that has potential to significantly impact actual forest resource availability, such as inoperable/inaccessible areas and political/legal restrictions. This study covers the low grade wood product with emphasis on wood availability, including these constraints, for a hypothetical facility in Coos County. The study also focuses on long-term fiber availability without specific pricing permutations other than using the likely demand in the sub-regional timber supply (SRTS) model. Neither logging infrastructure nor its specific impacts on non-timber related forest benefits are evaluated or identified.

Process

This study is based on current standing timber inventories, estimated growth rates, estimates of acreage in production, regional demand and takeaway, inaccessible and inoperable areas, and other contributing factors. The projection period is for 50 years, spanning 2005 to 2055. In order to accomplish the stated objectives, the study was carried out as follows:

- Step number one is to choose the possible location of a wood product facility and delineate the study area, which is the wood basket. This was derived through geographical analysis of the current pulp mills and power plants' capacity and location (i.e., the area from which they likely procure their supply).

- Available data such as current forest inventories, land ownership patterns, and recent harvest were all analyzed for the study.
- The ATLAS-SRTS model was used to simulate the future available timber in terms of the current inventory and supply/demand assumptions. The model verification was conducted and then the base model run was performed. At the same time, the sensitivity analysis was done on inventory, growth and harvest.
- The simulations experiments were carried out to estimate the upper and lower parameters on timber supply with varying assumptions. We then discussed the total low grade wood that can be derived from the simulations.
- Based on the model simulations, the potentially available timber is investigated by examining the spatial distribution of current forest product facilities and their annual wood consumption.
- Based on the above, we were able to summarize and draw conclusions based on the simulations described above.

Wood Basket/Study Area

Timber supply is influenced by many factors, some quantifiable, others less so, and clearly it can vary for economic and biotic reasons beyond the scope of this report. Given the purpose of this study, our first step was to identify the feasible reach of a Coos County facility, which would use low grade wood (biomass or pulpwood) – defining the the "wood basket". For this study, the "wood basket" is synonymous with 'study area'.

In order to get the feasible reach of a new Coos County facility, it was necessary to establish a probable location for the site. We picked Berlin because it was the home of the former Nexfor Fraser mill (in Berlin) which annually consumed about 1 million green tons of wood[2]. It also has an extensive road infrastructure which still exists with numerous primary and secondary roads going through or close to this area, and is a sizable town with an experienced (in wood) workforce. More importantly, Berlin has industrial sites which are the likely home of a new, potential industrial facility.

[2] Personal communication with the former procurement manager for Nexfor Fraser

After we picked the central point (Berlin) we next mapped the location and the wood consumption capacity of nearby pulp mills and power plants (Table 2). These facilities were chosen because they are the major processing plants that use low grade wood (INRS 2007, 2008; Sherman 2007), hence it can be assumed they will compete with our hypothetical facility and help shape the procurement range. A 75-mile radius was used for mills/power plants with the highest annual wood consumption, and for all other pulp mills, the radius is weighted by their annual wood consumption (Figure 1). A circle is drawn with the weighted radius for the power plants if their annual consumption is higher than 300,000 green tons.

Table 2. Wood consumption and location of pulp mills and power plants

Plant Name	Location	Type	Status	Consumption (Green Ton)
Androscoggin Mill	Operating	Jay, ME	Pulp	1,645,000
Madison Paper Industries	Operating	Madison, ME	Pulp	250,000
Masonite Corp.	Operating	Libson Falls, ME	Pulp	100,000
Newpage Corp.	Operating	Rumford, ME	Pulp	1,300,000
Sappi Fine Paper	Operating	Skowhegan, ME	Pulp	2,300,000
Bridgewater Power	Operating	Bridgewater, NH	Power plant	229,000
Whitefield Power and Light	Operating	Whitefield, NH	Power plant	187,000
Pine Tree Power	Operating	Bethlehem, NH	Power plant	230,000
Hemphill Power	Operating	Springfield, NH	Power plant	208,000
PSNH Schiller Station	Operating	Portsmouth, NH	Power plant	450,000
Finch, Pruyn, & Co., Inc.	Operating	Glens Falls, NY	Pulp	638,000[3]
International Paper Co.	Operating	Ticonderoga, NY	Pulp	750,000
Joseph C. McNeil Station	Operating	Burlington, VT	Power plant	380,000
Ryegate Power Station	Operating	Ryegate, VT	Power plant	260,000
Pine Tree -Tamworth	Operating	Tamworth, NH	Power plant	300,000
Alexandria - Power	Operating	Alexandria, NH	Power plant	200,000
Borelex - Livermore Falls	Operative	Livermore Falls, ME	Power plant	350,000
Clean Power Plant	Proposed	Berlin, NH	Power plant	368,500
Fraser Papers-Vision Power	Proposed	Gorham, NH	Wood boiler	220,000
Vermont Fuel Co.	Proposed	Island Pond, VT	Wood pellet	100,000
Presby Environment, Inc.	Proposed	Wihtefield, NH	Wood pellet	660,000
Laidlaw EcoPower	Proposed	Berlin, NH	Power plant	750,000

3 The consumption for Finch-Pruyn and International Paper was obtained from VT wood fuel supply study (Sherman 2007)

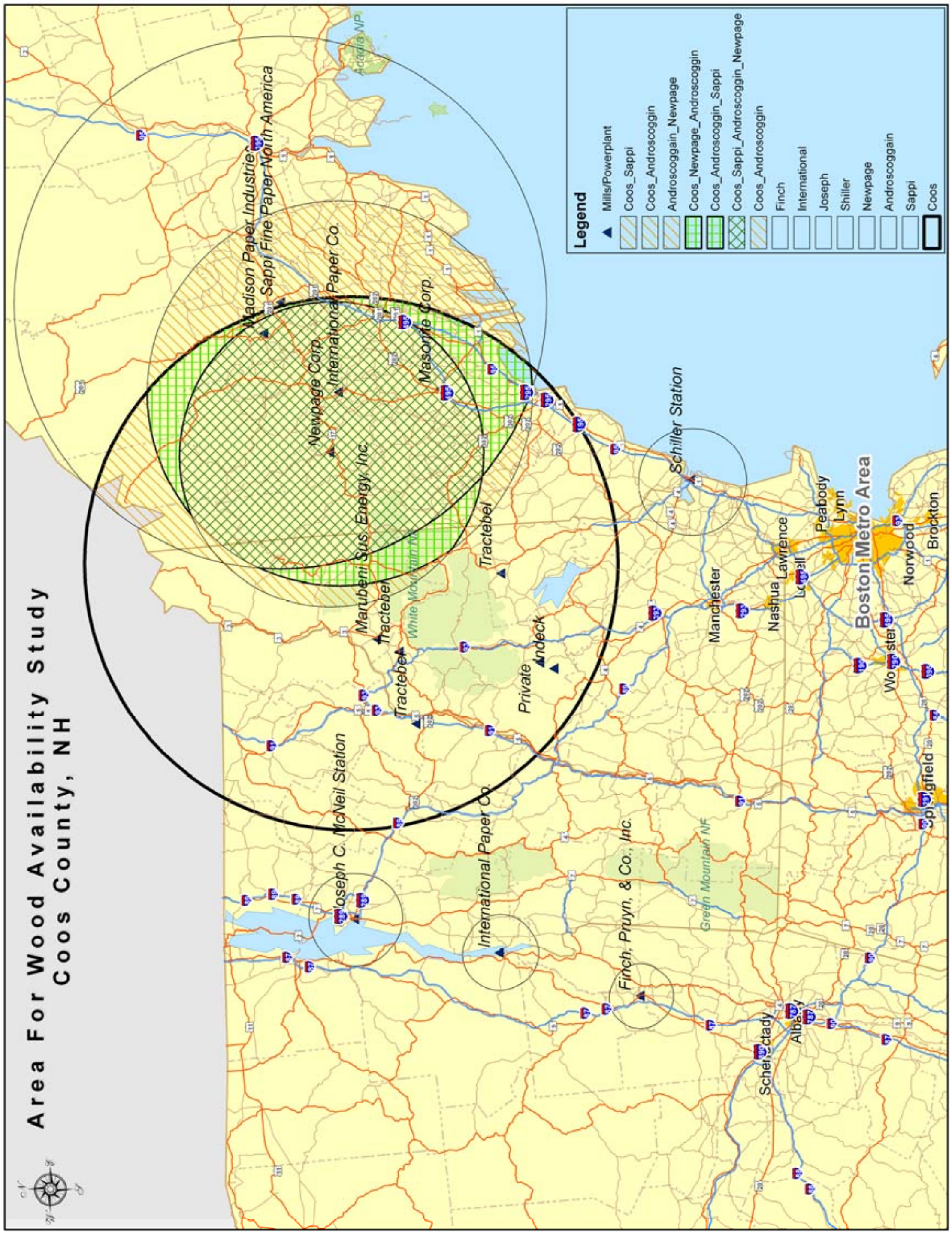

Figure 1. Study area with 75-mile radius

We next took out the areas which have the most overlap among those circles (i.e., the cross-hatched area). In other words, if there were more than three circles which overlapped, that county was not included in our study area. These overlapping areas translate to intense competition, so our assumption was that a wood using facility in Coos County would be at a distinct competitive disadvantage. The residual areas not covered within the overlapping wood basket of three or more facilities is then defined as a part of the study area. We did not include parts of counties, so there are some counties where a small proportion of land could have been included, and others where a small proportion should have been excluded. Thus, study area has been determined to be the following counties covering a three state area: (a). Coos, Grafton, Carroll, and Belknap counties, New Hampshire; (b). Essex, Caledonia, Washington, Orange, Orleans, Washington, Chittenden, and Franklin counties, Vermont; and (c). Oxford county, Maine (Figure 2). Overall, the study area covers approximately 6,335,219 timberland acres.

Data Sources

Forest Resource

Forest inventory data was obtained from the USDA Forest Service Forest Inventory and Analysis (FIA) system. From the FIA inventory data (2002-2006), there are 298 million green tons of growing stock (for definition see Appendix I) in this study area, of which 78% is from private timberland (Table 3).

Table 3. Estimated growing stock within the study area

	Growing Stock (Green Ton)	Growing Stock Proportion	Top and Branches (Green Ton)
Federal	42,756,583	15%	12,514,122
State	21,715,386	7%	6,355,723
Private	233,586,225	78%	68,366,700
Total	298,058,194	100%	87,236,545

The study area forest is dominated by hardwood species. It consists of about 60% hardwood and 40% softwood in terms of the growing stock volume. The FIA growing stock data represents only the roundwood and it does not include stump, root, topwood and branches. Studies show that the roundwood is about 41% of standing tree biomass in

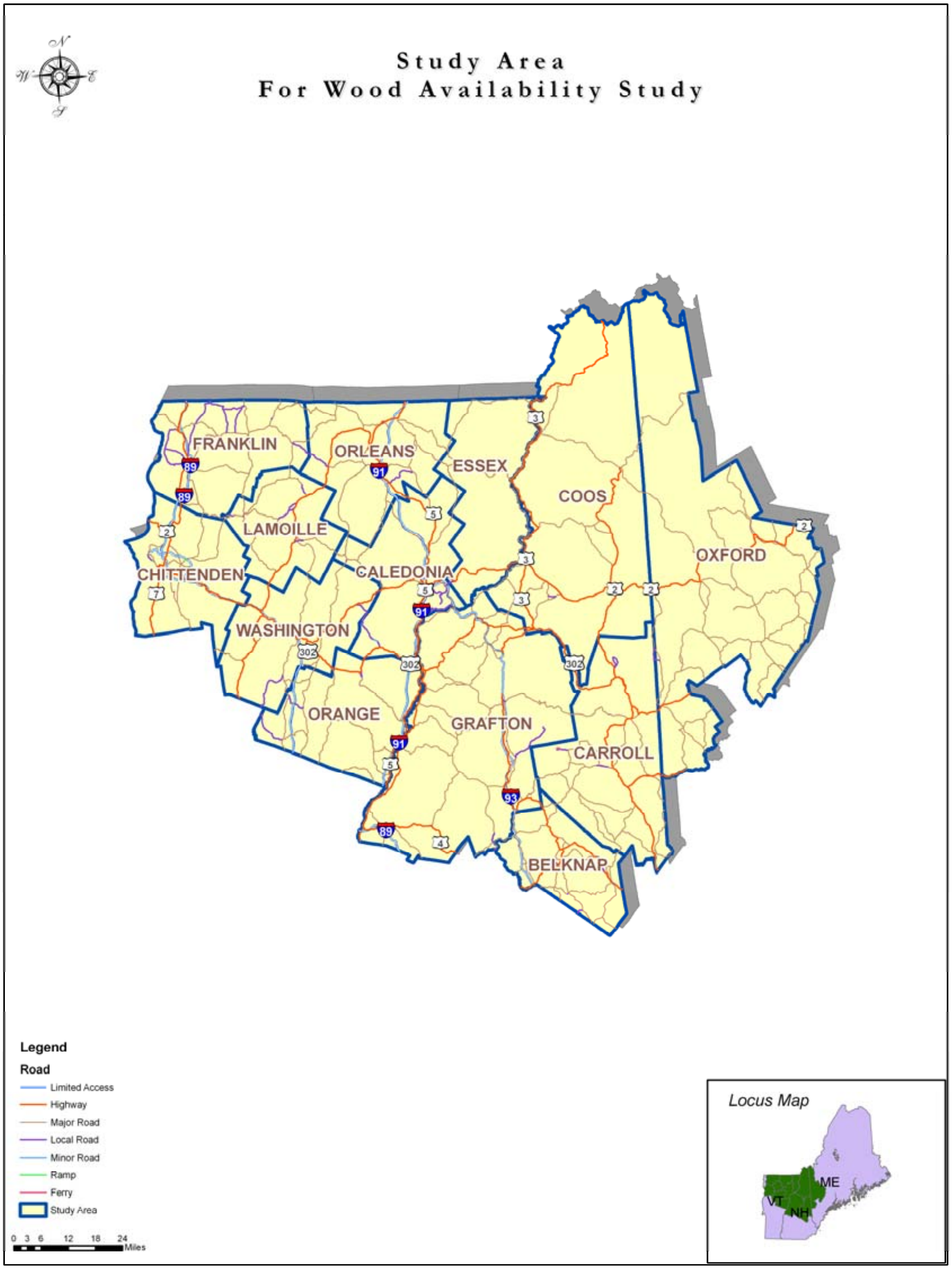

Figure 2. Map of the study area

a typical northeastern forest (NEFA 2002, INRS 2007 and 2008). Since no studies (or operations we know of) use the stumps and roots, only the tops and branches are used in the projections and modeling contained in this report. Their proportion is estimated to be about 12%. Therefore, in addition to the growing stock, it is estimated there are 87 million green tons of usable biomass available from the tops and branches (Table 3).

After we defined the wood basket, we next went about the task of estimating growth and potential removals. In order to get to actual availability we broke the ownership pattern into classes of ownership. The FIA data obtained from querying the FIA online database (http://fia.fs.fed.us/tools-data/other/default.asp) was helpful in delineating the major ownership classes (i.e., federal, state and private ownerships). We describe the further breakdown in the "private" sector and other specifics below (see Land Ownership).

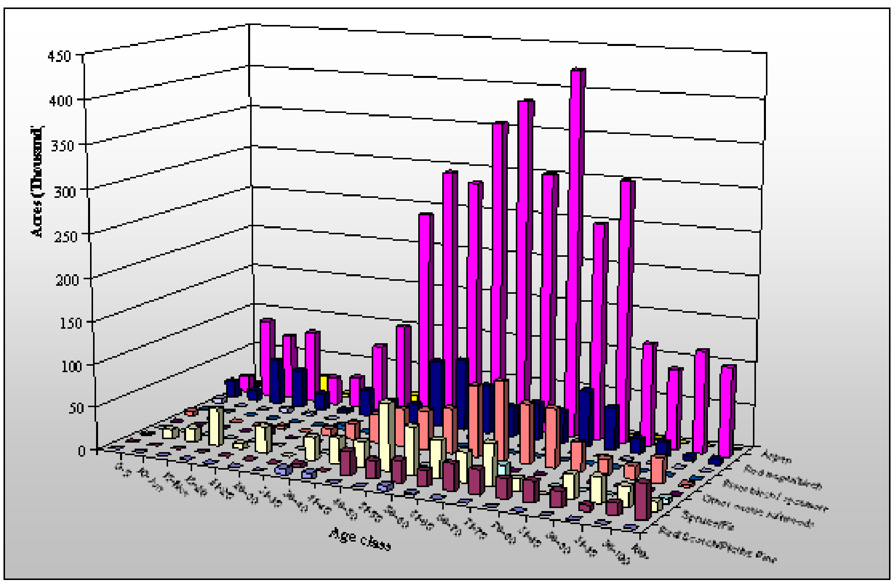

Figure 3. Year 2005 acres by habitat type and age class

Our next step was to estimate results by ownership class, by forest type, and to get that information. We grouped the plot data into the six habitat types which are used in the FlexFiber program. These six habitat types are sugar maple/ash, beech/red maple, oak/white pine, hemlock/red spruce, spruce/fir, and cedar/black spruce (Brann and Solomon 2001, Solomon et al. 1995). They are classified in terms of ecological, physical boundaries and biological characteristics. The 2005 FIA inventory data was used to create growth and yield curves for these six habitat types, which we used in the model simulations (see Timber Projection Model section). Basically, the growth is determined by these growth and yield curves.

The sugar maple/ash type dominates the overall study area forest (Figure 3) with an estimated 3.8 million acres in the study area. The second, third and fourth most common types are red maple/beech, pine/oak and spruce/fir types, respectively. Most of the stands are between 30 and 90 years old (about 5.1 million acres). About 0.17 million acres of stand are older than 100 years.

Land Ownership

The timberland in the study area is primarily owned by non-industrial private forest (NIPF) landowners (Figure 4) and summarized from the ownership maps which have been compiled by the James W. Sewall Company. Their timberland may range from one acre to hundreds of thousands of acres and their management objectives vary widely. Despite their differences in management regime and ownership structure, however, they are the primary timber supplier to forest product industries adjacent to or in the study area.

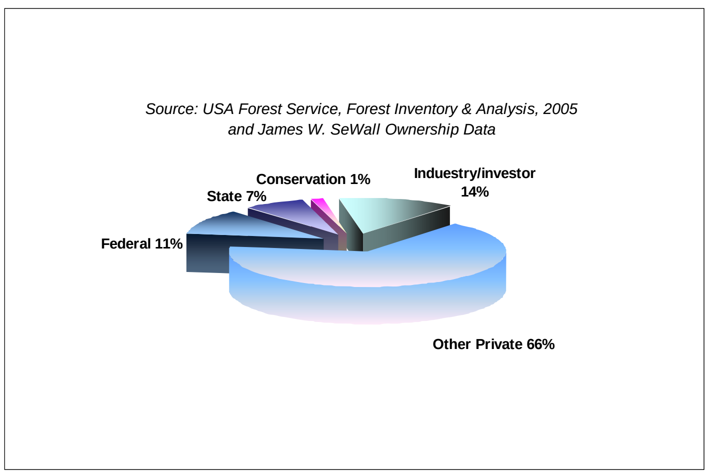

Figure 4. Timberland ownership types

Forest industry and investment groups own approximately 14% of the timberland within the wood basket. Timber from their land is either supplied to their own manufacturing facilities or sold to other forest product manufacturers. There are about 726,039 acres of timberland which the federal government owns, most of which belongs to the White Mountain National Forest. The federal timberland does not supply a lot of timber due to its multiple uses, such as recreation, water and wildlife protection - the harvest has declined significantly from the White Mountain National Forest since 1995

(Figure 5)[4]. In recent years, the WMNF harvest has averaged about 75,000 green tons per year and there is no particular reason to expect that to change. State owned timberland accounts for approximately 462,898 acres (including county and municipal owned acres), supplying about 423,000 green tons per year (Forest Service FIA data, 2002-2006).

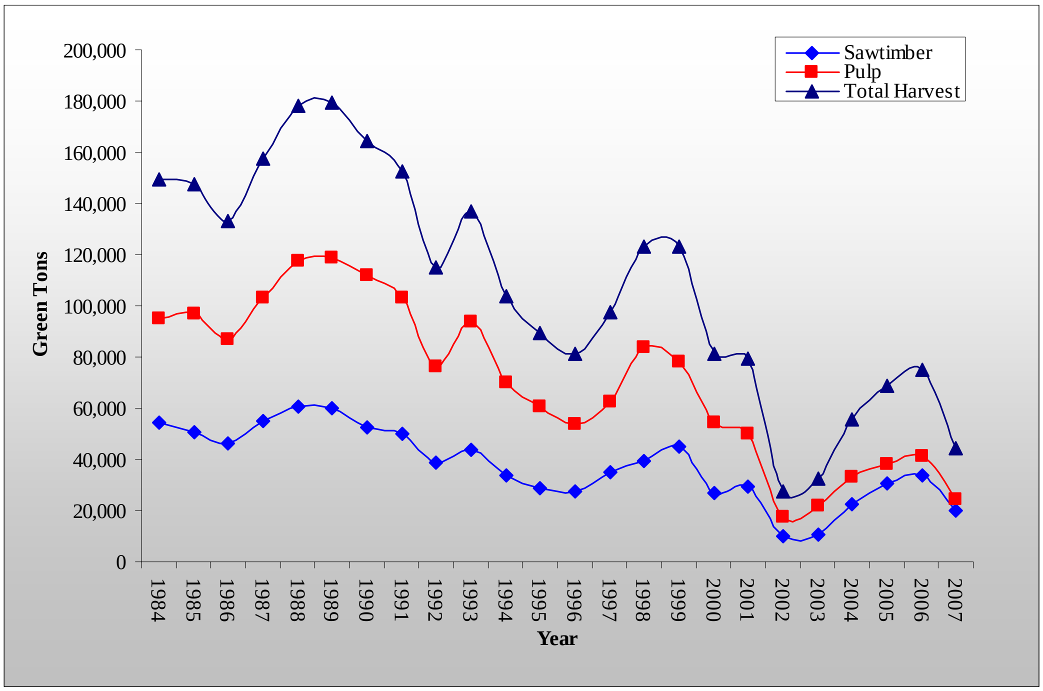

Figure 5. White Mountain National Forest timber harvesting

As discussed, the management objective for the NIFP sector is diverse and difficult to predict. Some owners may just want to preserve the land in its current state, without the harvesting of timber, while others manage their lands with great intensity. Recognizing this diversity in management regimes by ownership type, we have created five ownership groups for use in the model. These are: federal, state, industry/investment, conservation, and other private (e.g., family, individual) ownerships. All the forest acres are assigned to these five ownerships and then they are further distributed to the six habitat types (Table 4).

[4] The data is provided by NH Division of Forests and Lands.

Recent Harvest

The roundwood supply has been changing over the years throughout the study area[5] (Figure 6). The sawtimber supply has not changed significantly since 2001, but overall pulpwood supply changed dramatically from 2003 to 2005. The overall pulpwood supply appears to be declining due to a number of possibilities. Market conditions in the US have changed over the last decade or so. Regionally, regulations have constricted supply to some degree. For example, the State of Vermont enacted harvest regulations that applied to heavy cuts and clearcuts. The Groveton and Berlin pulp mills were closed in 2005 and 2006 respectively, removing a major consumer of pulpwood from the system. It would appear that as the demand for pulpwood declined, the supply became a little less too (Figure 6). After the closure of the above two pulp mills, the wood possibly went to nearby wood using facilities, for example, Newpage, Sappi. While the amount of whole tree chips increased from 2003 to 2006 and there are also about 230,000 green tons of wood harvested for energy fuel.

Table 4. Timberland acres and volume by ownership and habitat type (Unit: Acre and Million Green Ton[6])

Ownership		SM/ASH	BE/RM	OK/WP	HE/RS	SP/FR	CE/BS	Total
Federal	Acre	476,197	108,190	7,734	30,390	103,521		726,032
	Volume	26.88	5.20	0.60	3.50	6.57		42.76
State	Acre	294,214	92,324	20,285	1,768	54,311		462,902
	Volume	15.60	3.19	0.62	0.13	2.18		21.72
Private Conservation	Acre	48,835	11,981	9,813	4,164	6,558	524	81,875
	Volume	2.09	0.38	0.69	0.39	0.13	0.03	3.72
Private Industry/ Investment	Acre	519,478	127,462	104,408	44,308	69,756	5,570	870,982
	Volume	22.24	4.03	7.37	4.12	1.40	0.37	39.53
Private Other	Acre	2,501,074	613,689	502,674	201,655	347,511	26,814	4,193,417
	Volume	107.08	19.42	35.50	19.83	6.73	1.79	190.34
Total	Acre	3,839,798	953,646	644,914	280,517	583,425	32,908	6,335,208
	Volume	173.89	32.22	44.78	30.02	4.83	2.32	298.06

Inoperable/Inaccessible Timberland

We believe it is also important in estimating available timber to understand that not all timberland acres are available for harvest. We consider the following factors in the analysis of inoperable/inaccessible timberland acres:

[5] The harvest data is provided by VT Department of Forests, Parks and Recreation, NH Division of Forests and Lands, and Maine Forest Service.
[6] The sum may be different due to rounding

- Probably the most common constraints on harvests in this area are steep slopes and mountain tops along with fragile or sensitive areas which are often excluded from harvest operations.
- Some timberland acres are classified as wildlife habitat, such as a deer yard and through regulation may not be available for harvests or have the allowable cut sharply reduced.
- Acreage within watersheds and/or riparian areas may not be available.
- Some areas may be too remote to be economically reached by the current road system.
- Some areas are prohibited from harvesting due to easements and other encumbrances.

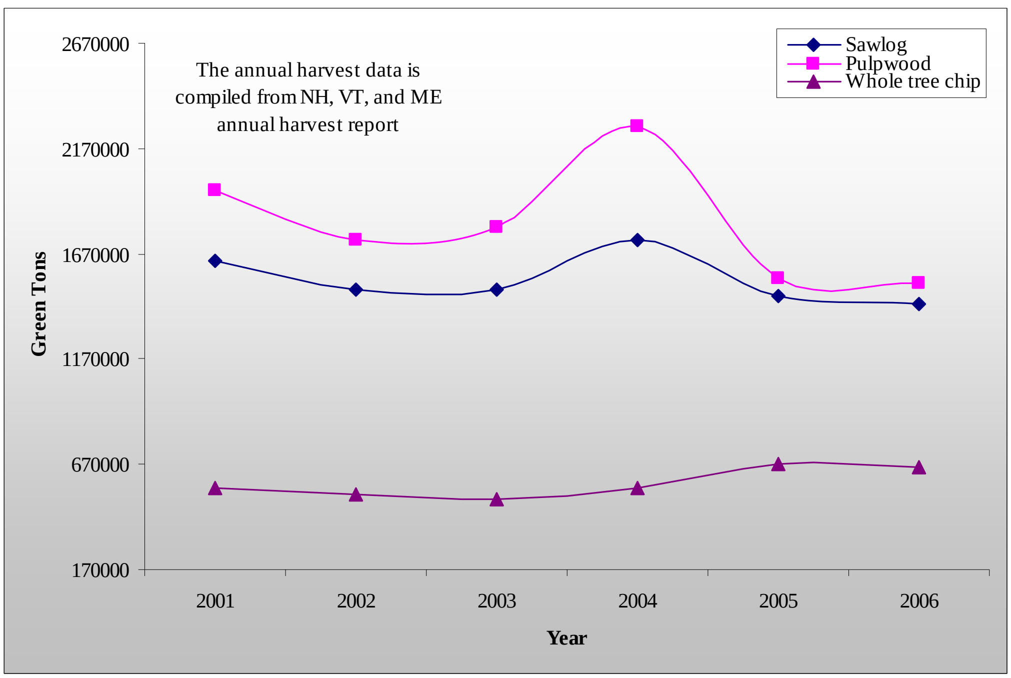

Figure 6. Sawlog and pulpwood harvests and whole tree chip from 2001 to 2006

Our analysis is based on personal interview, current spatial data, and historical documentation. We interviewed LandVest's regional foresters and the consensus was that the maximum operable slope percent is usually around 50%, though some acres are still operable with slope percent of 60% or even 70%. So we decided to use 55% as the threshold, if the slope was greater than 55%, we assumed that no harvest operations can be done. After querying the FIA database, there are about 132,071 acres which are located on slopes > 55% (similar acres can be derived from the topographical analysis using ArcGIS). For the wetlands and riparian, we sampled our management plans over 1 million acres, we found that generally, it is about 3% of the total acreage. Taking all of the above factors into account, the result is a 6% reduction of the timberland area. The inoperable/inaccessible acres are taken out from the six habitat types and grouped into one inventory unit named NO/OP within each ownership group (Figure 7).

Management Options

Four management options are applied to each of the six habitat types in each ownership group (Table 5). The estimates of volume harvested per ownership are based on the FIA removals, net growth, and the annual harvest report from NH, VT and ME (Figure 6) for the base model. The White Mountain National Forest (WMNF) is the primary federal timberland ownership in the study area along with a small amount of acres associated with the Green Mountain National Forest located in the study area. According to the land and resource management plan for WMNF, the annual harvest for the following 10 to 15 year is 120,000 green tons of forest products. Considering the declining level of harvest volumes from federal timberland, the initial estimated harvest is set up to be 112,000 green tons per year. For the state owned land, the harvest is almost equal to growth (personal communication with Philip Bryce, Director of NH Division of Forests and Lands), hence the initial estimated harvest is approximately 352,000 green tons.

Table 5. Management options

Treatment		Partial Cut		Clearcut
Removal (%)	0-30%	31-50%	51-80%	81-100%

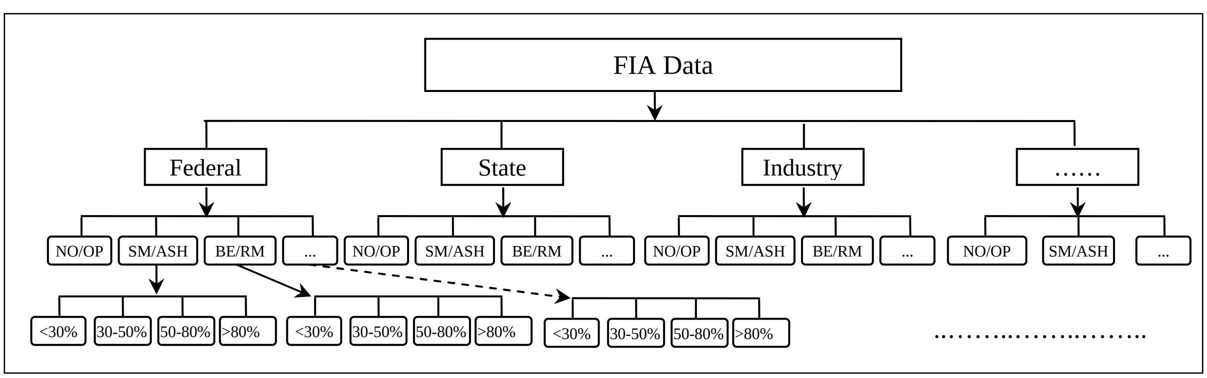

Figure 7. Conceptual structure of ATLAS

We had to make some general assumption as to harvest intensity for the private ownership type. We assumed that private owners would cut about 65%-85% of their growth, that conservation owners would harvest 20%-40% of the growth, while the industry/investor owners would cut about 85%-120% of growth. No harvest treatment is applied to the inoperable/inaccessible inventory units in each ownership group. These assumptions are based on the analysis of FIA inventory data and our knowledge and experience about common forest practices in the study area. With these assumptions, the initially estimated harvests are 2.88, 0.02, and 0.71 million green tons for the "private other", "private conservation", and "private industry/investment" groups respectively. Therefore the harvest is 4.07 million green tons for the initial model period (2005-2015) which are based on the FIA growth, removal and the state harvest reports.

Land Use Conversion

The change in land use from productive timberland to an alternative use would obviously have an impact on the timber supply. However, we believe land development is not a significant issue for this study area. The population is decreasing in northern NH (Table 1), therefore the housing development and agricultural land conversion has almost no influence on the timberland productivity. Northeast State Forester Association (NEFA) study indicates that there might be 33,000 acres converted to housing development or farmland in northern NH over a 50-year projection (Turner and Caldwell 2001), while there would be about 24,000 acres which is reverted from agricultural land to timberland in VT. Therefore, we assume that there is no land use change in this study.

Timber Projection Model

Model Choice

The aggregate timber assessment system (ATLAS) is the primary modeling framework for this study. The ATLAS model has been used in the Maine Forest Service (Gadzik et al. 1998), Northeast State Foresters Association (Turner and Caldwell 2001) and New Hampshire Wood Supply (Caldwell 2005) projects. One of the attractive aspects of ATLAS is that it can directly employ FIA data in the specifications of most model parameters. It is an integration of forest inventory, growth, regeneration of timber stands, and forestland change (for more information about the ATLAS model see the research proposal). ATLAS is one kind of the "accounting" models which have the ability to integrate various strata of forest types, ownerships, management, and associated actions. In order to obtain reasonable yield of each iteration with ATLAS, FlexFiber is used rather than empirical yield tables (Gadzik et al. 1998; Turner and Caldwell 2001; Sendak et al. 2003).

ATLAS and FlexFiber are models used for stand projections; however, they are not well suited for dealing with economic issues. As mentioned in the Introduction, Sendak et al (2003) have integrated SRTS and ATLAS, so the timber supply and demand can be simulated and the influence of price change accommodated in the following simulation experiment. Another advantage of using SRTS is to allow the wood to flow freely in the study area. It is accomplished by meeting the harvest request through sharing the available timber among management units (Turner and Caldwell 2001).

Model Verification

Any model can be run if the data it requires (input parameters) is provided, however the veracity of the model's outputs must be verified. In an effort to gauge the accuracy of the model outputs, two tests were conducted by assuming (1) demand is constant and (2) there is no harvest over the 50-year simulation. The constant demand test can verify the sustainability under the current management. It can also be used to check any potential mistakes in the model. If there is no harvest during the simulation, *what would the growth be?* This test can tell us whether the growth can meet our expectation. If it is either too high or too low, there must be something unreasonable in the model. These simulation results would testify whether the assumptions used in constructing the model are reasonable. A positive outcome occurs when the projections are falling into our expected range of values and the overall growth rate is consistent with other studies.

Results of model verification

Under the constant demand assumption, the overall net growth is more than the harvest, so the inventory tends to increase over the 50-year simulation (Figure 8). The merchantable volume[7] is 47.05 green tons/acre in 2005. There is a total of 399.37 million green tons of timber in 2055 (63.04 green tons/acre, Figure 8). The net growth rate is 0.97 green tons/acre/year. Because the removal is less than the annual growth, the average stocking increases from 2005 to 2055.

[7] The merchantable volume just refers to the roundwood including bother sawlog and pulpwood, see definition in the appendix II. The tops, branches, leave, root, and stump are not included.

If the forest grows naturally over 50 years under the no harvest assumption, there would be 597.27 million green tons of timber (i.e., 94.28 green tons/acre) in 2055 (Figure 9). However, the net growth rate is 0.93 green tons/acre/year without any harvest. It seems that the growth rate is unreasonable because it is just 4% lower than that from the constant demand simulation. The comparison between the 2005 and 2055 stocking level indicates the growth is still not out of our expectation. Most stands were understocked in 2005, while they are likely fully stocked in 2055. The forest has gone through a re-stocking process for the first 35 years. After 2040, the net growth declines rapidly (Figure 9). It is 3.8 million green tons per year at 2050. Compared with the net growth (5.5 million green tons per year) at 2050 from the constant demand model simulation, the forest grows slowly after 2050.

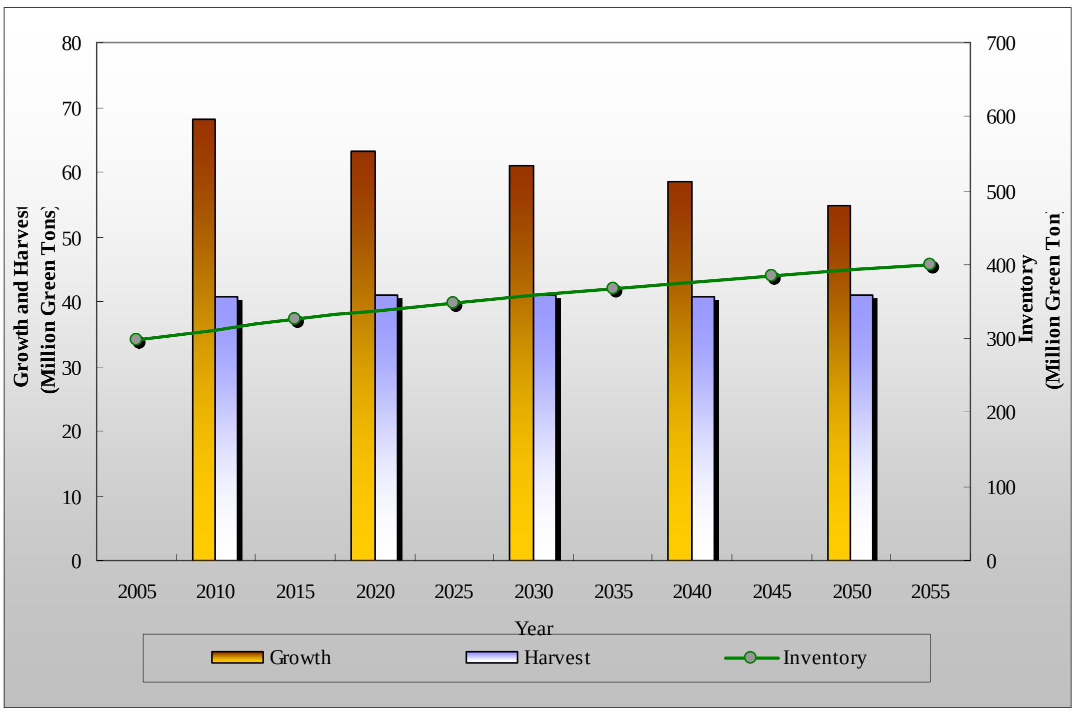

Figure 8. Constant demand run: inventory, growth and harvest

Discussion about the model verification

The two verification tests indicate that the stocking and growth rates seem reasonable. From the northern hardwood stocking guide, the highest stocking can be more than 110 green tons/acre (Leak. 1983). The model verification shows the stock level is within

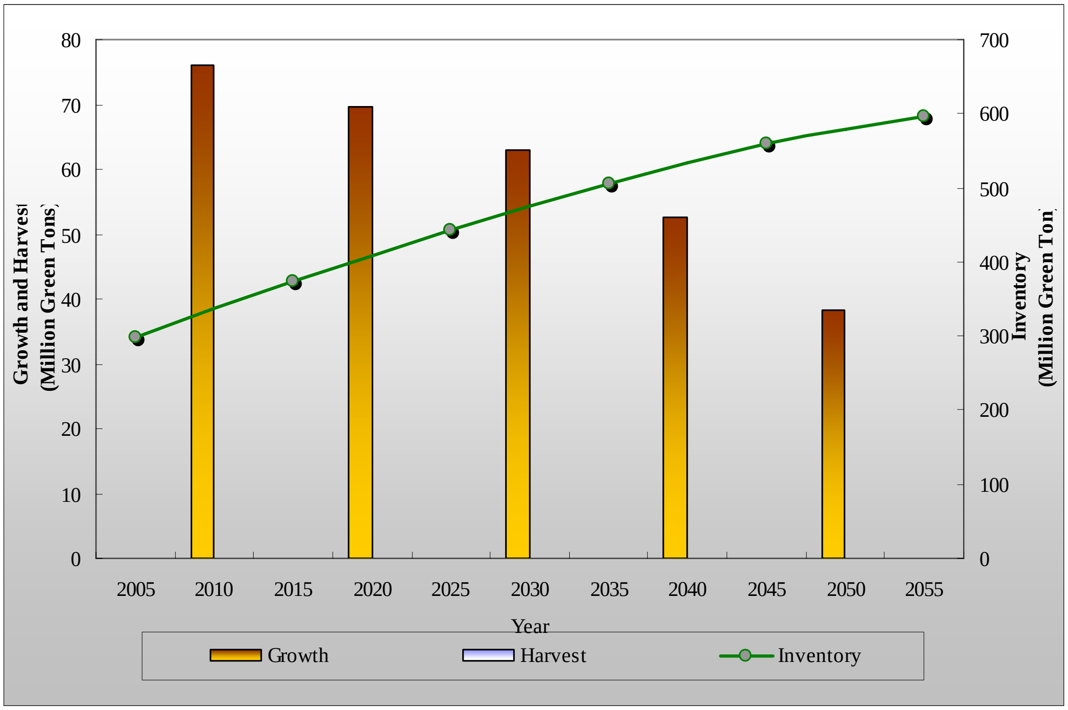

Figure 9. No harvest: inventory and growth

the acceptable range. Compared with the growth rate with other studies, there is no significant difference - for example, the net growth rate is 1 green ton/acre/year from Turner and Caldwell's study (2001). In the case of the no harvest simulation, the growth rate decreases quickly after most stands are fully stocked, which is consistent with the theoretical growth pattern. No outcomes are out of our expectation, so we conclude that the assumptions used to construct the model is fair and the model works properly.

Base Model

The base model is used to study the possible timber supply from the wood basket under normal conditions. Timber supply responds to demand change and is managed under the suitable management regime.

In the base model, we still use basic assumptions mentioned in the above sections, however they are listed here again to emphasize the major details of these assumptions.

- The timber price and logging infrastructures were not investigated and projected in the model simulation.

- There is no land use change.
- The initial inventory for the year 2005, including forest type, stocking level, acreage, and percent slope, is based on the most recent FIA data.
- The management option is either partial cut or clearcut with the designed cutting intensity (Table 5).
- The simulation just focuses on timberland.
- The removal is different for different ownerships (see *Management Option* section).
- We assume the demand is determined by the market, which is accomplished through the SRTS program at 10-year periods in the model simulation.

In the SRTS program, the parameter estimates were set up the same as the study done by Sendak et al (2003). In other words, the supply price elasticity is set to be 0.31 and 0.26 for softwood-dominated and hardwood-dominated habitat types respectively and the demand-price elasticity is set to be 0.5 (see Sendak et al 2003 for more information).

Results

Comparison of the beginning and ending inventory volume revealed that overall stocking increases by about 0.26 million green tons per year (Figure 10). Over the 50 year period, net growth exceeds harvest, thus the overall inventory does not decline. The harvest increased from 40.76 million green tons (2005-2015) to 49.31 million green tons (2045-2055). The average growth was 0.96 green tons/acre/year. The harvest averages 4.62 million green tons/year. This is just the total harvest for the roundwood, so the timber which can be used for other purposes, such as biomass, is not included. The biomass estimation is described in details in the late sections.

The largest increase in inventory volume comes from the “other private” group (Figure 11). The federal timberland ranks the second place. The inventory increase is not significant from the other three groups. Both the hardwood and the softwood inventories increased from 2005 to 2055, however the softwood inventory is growing

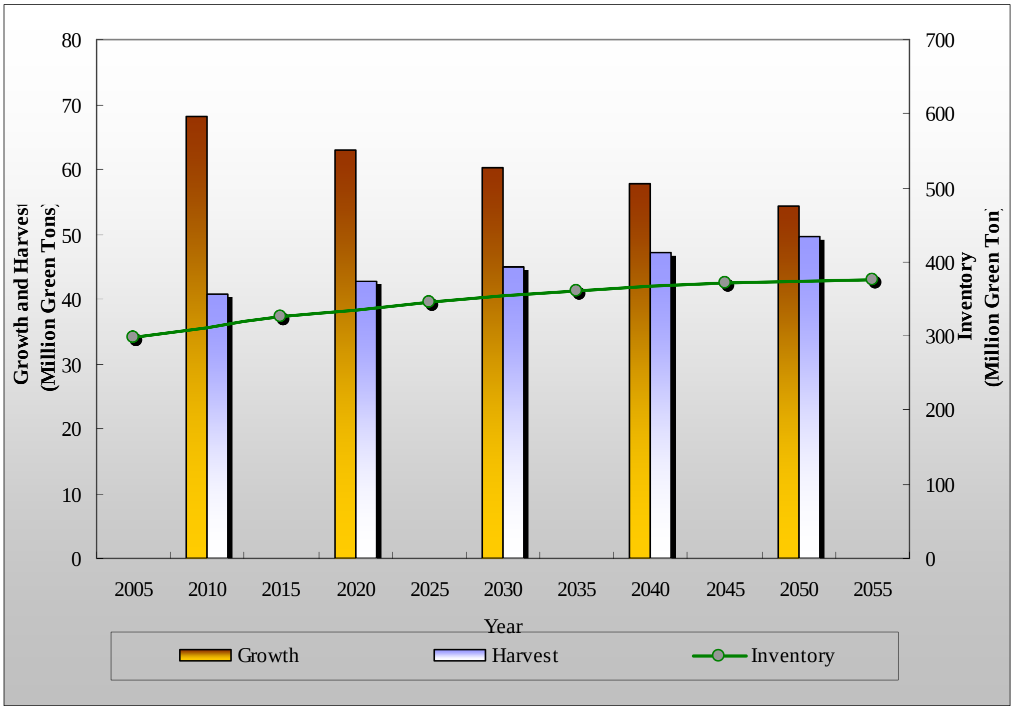

Figure 10. Base model run: Inventory, Growth and Harvest

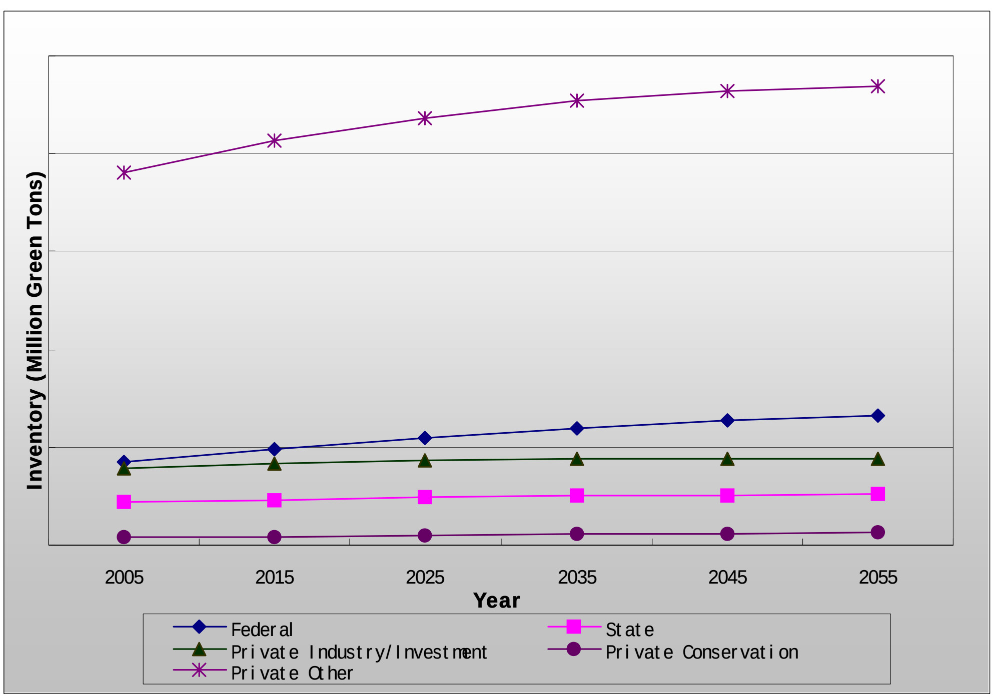

Figure 11. Base model run: inventory by ownership.

faster (Figure 12). In 2005, the softwood had 65.57 million green tons, while it was 99.45 million green tons in 2055, translating to a 52% increase, while the hardwood increased 21%. Most harvest volume for this run comes from the sugar maple/ash habitat type of the "private other" group, contributing a total of 101.25 million green tons over the 50 years. Conversely, the harvest from the "private conservation" group is quite negligible (1.40 million green tons). The public timberland total removal is 25.15 million green tons (Table 6).

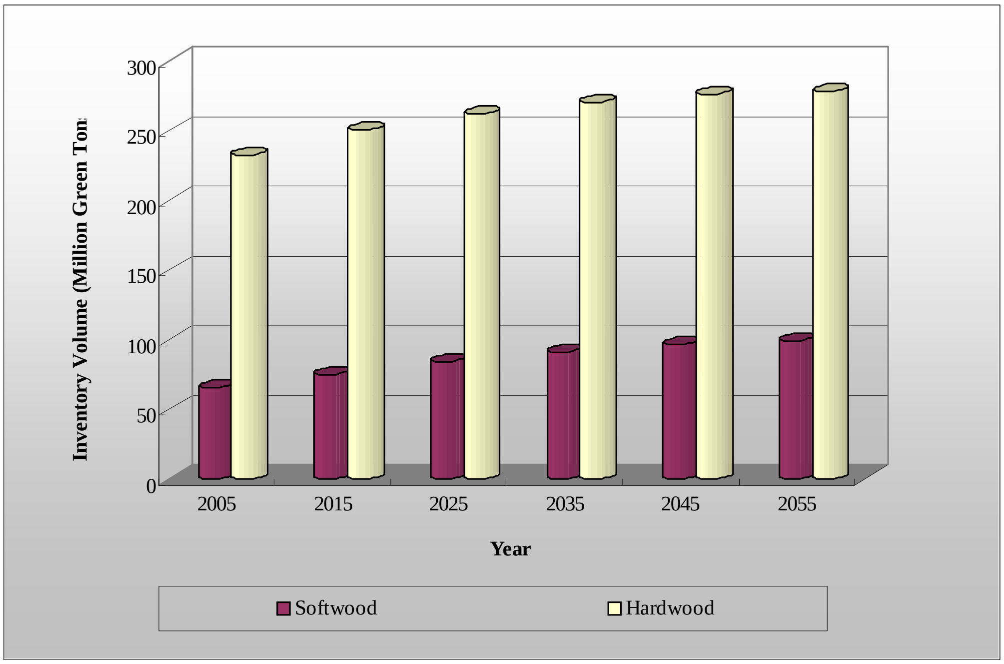

Figure 12. Base model run: softwood and hardwood inventory

Sensitivity analysis

The sensitivity analysis is used to test how a model's output responds to small changes in the components of interest (Jørgensen 1986; Pulliam et al. 1992; Shi et al. 2006). It can help us to understand and identify the factors which have significant impact on stocking levels and growth. These factors may further influence the timber supply. Twelve model runs were performed to see the effect of one factor change on the other two factors (Table 7). Each factor changes once at a model run. For example, if the harvest is increased by 20%, what is the response of growth and inventory? What if the FIA inventory does not represent the actual stocking level, the actual inventory is 10% lower than the FIA estimate. What would the change be for harvest and growth?

Table 6. Base model run: harvest by ownership and habitat types (Unit: million green ton)

HABITAT	2010	1020	2030	2040	2050	Total
Fed_SM_ASH	0.78	0.76	0.85	0.96	1.06	4.41
Fed_BE_RM	0.14	0.15	0.17	0.20	0.24	0.89
Fed_OK_WP	0.02	0.02	0.02	0.03	0.03	0.12
Fed_HE_RS	0.07	0.05	0.05	0.05	0.05	0.27
Fed_SP_FR	0.14	0.09	0.11	0.12	0.13	0.58
State_SM_ASH	2.82	2.71	2.65	2.64	2.71	13.54
State_BE_RM	0.61	0.69	0.77	0.83	0.86	3.77
State_OK_WP	0.14	0.16	0.18	0.18	0.18	0.84
State_HE_RS	0.02	0.02	0.02	0.02	0.02	0.11
State_SP_FR	0.07	0.10	0.13	0.15	0.17	0.62
PRInv_SM_ASH	4.50	4.58	4.68	4.83	5.01	23.60
PRInv_BE_RM	1.01	1.03	1.07	1.11	1.15	5.37
PRInv_OK_WP	0.95	0.97	1.01	1.06	1.09	5.07
PRInv_HE_RS	0.32	0.33	0.34	0.34	0.36	1.68
PRInv_SP_FR	0.50	0.53	0.56	0.59	0.63	2.82
PRInv_CE_BS	0.00	0.00	0.00	0.00	0.00	0.02
PRCon_SM_ASH	0.12	0.14	0.16	0.18	0.20	0.81
PRCon_BE_RM	0.02	0.03	0.03	0.04	0.04	0.16
PRCon_OK_WP	0.04	0.05	0.05	0.06	0.06	0.25
PRCon_HE_RS	0.01	0.01	0.02	0.02	0.02	0.08
PRCon_SP_FR	0.01	0.02	0.02	0.02	0.02	0.09
PRCon_CE_BS	0.00	0.00	0.00	0.00	0.00	0.01
PROth_SM_ASH	18.36	19.29	20.22	21.17	22.21	101.25
PROth_BE_RM	4.12	4.44	4.76	5.06	5.35	23.73
PROth_OK_WP	3.86	4.04	4.25	4.51	4.70	21.36
PROth_HE_RS	1.31	1.36	1.42	1.47	1.54	7.10
PROth_SP_FR	2.03	2.25	2.45	2.64	2.83	12.20
PROth_CE_BS	0.02	0.02	0.02	0.02	0.02	0.09
Grand Total	42.00	43.85	46.01	48.29	50.68	230.83

This sensitivity analysis indicates that the harvest change has more influence on inventory than the inventory change on harvest. The response of growth is relatively small from the harvest change. For example, when the harvest change is up by 10%, the inventory sensitivity is –35.93%, while the growth sensitivity is just -3.47%. The comparison among these three factors shows that harvest has the most impact on the simulation outcomes. Put into practice, that yields the obvious conclusion that harvest activities significantly affect inventory and growth. Conversely, growth and inventory have less effect on the harvest although the fast growth and high inventory imply more harvest.

Table 7. Matrix for sensitivity analysis

Factor	Change	Factor	Change	Factor	Change
	+20%		+20%		+20%
	+10%		+10%		+10%
Harvest		Inventory		Growth	
	-10%		-10%		-10%
	-20%		-20%		-20%

Simulation Experiment

With sensitivity analysis, we know that harvesting is the major component in the model. In order to obtain the most likely available timber over a long time period, it is necessary to incorporate the possible changes of all factors into the model. Therefore, two simulation scenarios are carefully chosen from all combinations of factors and two additional simulations were run as follows:

- Growth is up by 10%, inventory is up by 5% and the demand is down by 10%. All other assumptions are the same as the base model. The implied assumption is to keep high level stocking and provide the timber which the market needs.
- Growth is down by 10%, inventory is down by 5%, and the demand is up by 10%. The implied assumption is that there may be more supply to the market and the stocking level may be low due to intense harvest.

All assumptions used in the based model are still valid in these two additional simulations except above changes to the inventory, growth and harvest.

Low supply model simulation

This simulation is used to show what is the lowest possible limit of timber supply if the inventory and the growth increase while the demand decreases. In other words, the actual inventory is assumed to be more than the FIA inventory estimate and the growth is also more than that projected from the base model.

Results

Stocking levels increase dramatically due to the increase of growth, inventory and less harvest. In 2055, the average stocking is 69.14 green tons/acre (Figure 13). It is a 16.5% increase compared with the base model. The average harvest is 4.15 million green tons per year. The softwood reaches almost 115 million green tons in 2055, and is approximately 26% of the overall inventory volume. The overall trend of hardwood tends to increase from 2005 to 2055. The average growth rate is 1.03 green tons/acre/year, which is a 7% increase compared with the base model. The difference results from the low supply assumptions (i.e., the increase of inventory, growth and less harvest). The first ten-year harvest is 36.69 million green tons, or 3.67 million green tons per year. The last ten-year harvest is 44.38 million green tons. The harvest request grows by about 0.39% annually.

High supply model simulation

This simulation is used to show how much timber would be available if the inventory and the growth decrease as the demand increases. The implied assumption is that the 2005 inventory did not reflect the actual volume on the ground, and that management does not improve growth rates.

Results

The simulation indicates that the inventory keeps increasing from 2005 to 2045 (Figure 14). After 2045, the inventory volume tends to decrease because of less growth and more harvest. The initial stocking is 44.69 green tons/acre, while the average stocking is 49.54 green tons/acre in 2055, therefore the inventory increases little. The annual harvest is 5.08 million green tons. The average net growth is 0.87 green tons/acre/year. This represents a 9% reduction compared with the base model.

Discussion

The annual harvest is 4.15 million green tons per year and 5.08 million green tons

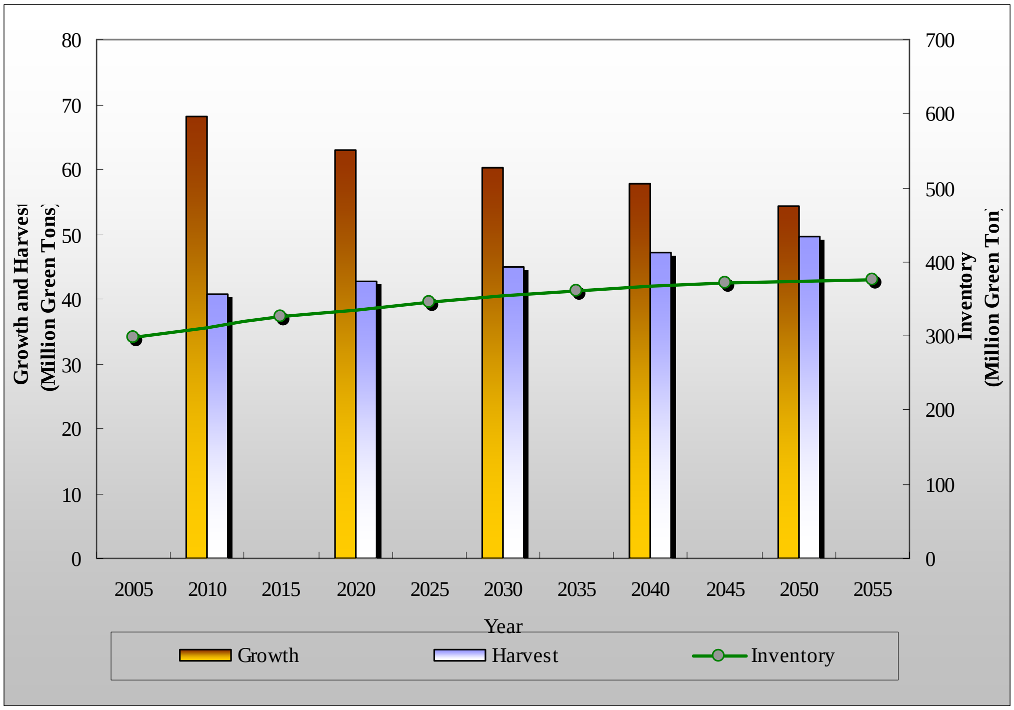

Figure 13. Low supply model run: Inventory, Growth and Harvest

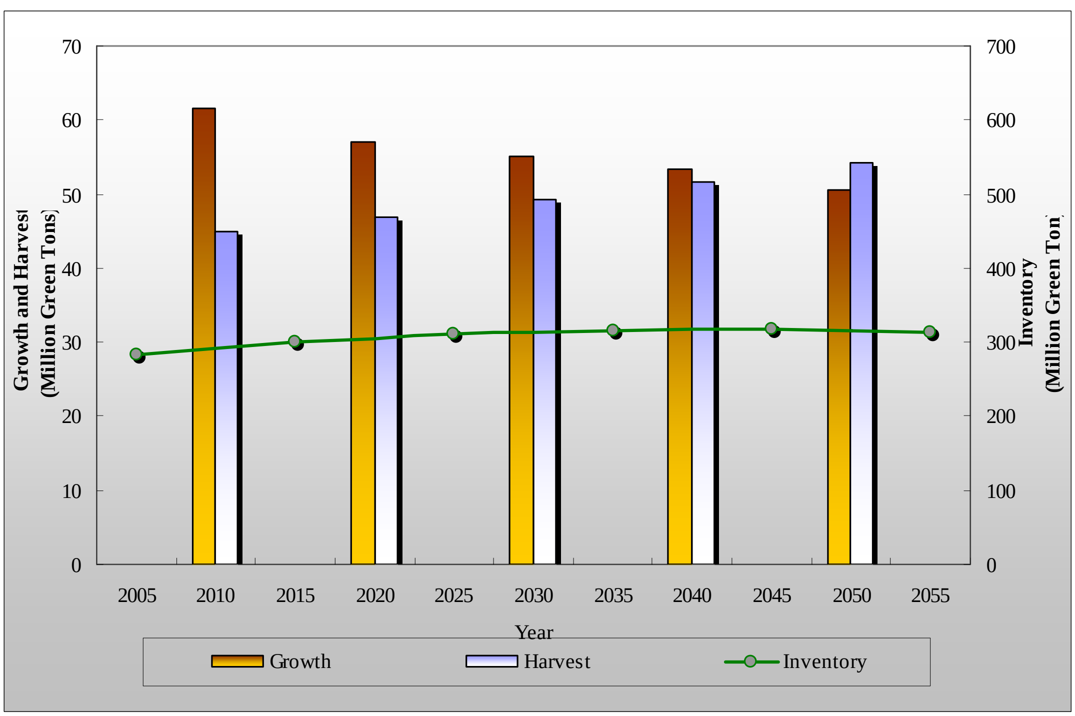

Figure 14. High supply model run: inventory, growth and harvest.

per year for the low and supply model simulations respectively. For the high supply model simulation, the harvest is the highest levels among these simulations, however its' ending inventory volume is less than the base model. Although we cannot tell whether the forest is sustainable, the declining inventory volume is not a good sign. The low supply model simulation has the highest growth rate, while its annual harvest level is the lowest. In summary, the lowest limit that the timberland can annually supply is at least 4.15 million green tons of timber and the highest limit may be 5.08 million cords (Table 8). Therefore, the base model may give us the possible amount of timber available in the study area. There would be at least 4.62 million green tons of roundwood.

Table 8. Annual harvest from the model simulations

Simulation	Low Supply Model	Base Model	High Supply Model
Annual Harvest (Million Green Tons)	4.15	4.62	5.08
Net Growth Rate (Green Tons/Acre/Year)	1.03	0.96	0.87

Available Timber

Our primary objective is to estimate how much wood is available in the study area. To derive this information, and using our simulations above, we have estimated the annual harvest volumes coming off of the study area. Then having estimates of annual wood supply consumed by those wood using facilities within or close to the study area through subtraction, we can estimate the available unused timber that is available for a potential new facility.

Low grade wood

After a tree is cut, the roundwood is either delivered to saw mills or pulp mills. The rest can be chipped and delivered to power plants, though usually not all of the tops and branches can be utilized. Studies suggest that 50% of this material can be chipped or used as fuel wood (INRS 2001, 2007). The same approach is adopted in this study.

In above model simulation, the projected harvest includes both sawlogs and pulpwood. Recent harvest reports indicate that the sawlog percentage is around 38% of the total roundwood volume (Figure 7), and we have not assumed any change in this as we ran the 50-year simulation. Therefore the proportion of low grade wood is 3.58 million green tons (Table 9). For the low and high supply cases, it is 3.22 and 3.94 respectively.

Table 9. Available timber volume (Unit; Million Green Tons)

Simulation	Roundwood		Top and Branch	Low Grade Wood
	Sawlog	Pulpwood		(Pulpwood + 50% of Top and Branch)
Low Supply	1.54	2.62	1.2	3.22
Base Model	1.71	2.91	1.34	3.58
High Supply	1.88	3.2	1.47	3.94

Composition of wood delivered to pulp mills and power plants

We know a certain volume of supply to pulp and fuel producers is in the form of sawmill residue, but we don't count that volume in this projection because it is already deducted from the wood basket as sawlog volume. The Maine annual harvest report indicates this low grade sawlog volume at about 10.6%[8] of the total pulpwood production. In addition, the power plants generally buy sawdust[9] as part of their supply. The sawdust usually accounts for about 10% of the total sawtimber volume (Wakefield 2007). Since these volumes will be drawn off to alternative users, we deducted them from the pulp mills' annual consumption. After the deduction, the rest would be the wood which these facilities actually procure from the study area.

Wood consumption estimation

The wood product facilities included in this study do not only buy wood from the study area, but also procure wood from outside this area. Therefore geographical analysis is conducted to estimate how much timber they likely procure from the study area. A circle was drawn around each facility with different radius, determined according to their annual consumption (Table 10). The assumption is that the higher the consumption, the bigger the radius meaning they can procure wood from further out. In each circle, the timberland acres in and out of the study area are obtained from the FIA online database. Then the consumption is adjusted by the ratio of the timberland acres in

[8] This percentage is just the clean chips and may vary by tree species and region
[9] It includes tree bark

the study area versus the timberland acres in the circle, which was drawn using the radius defined in Table 10.

This analysis indicates that the total consumption of these facilities is 2,889,000 green tons and from that analysis we estimate about 690,000 green tons of low grade wood remain unspoken for. With the approach applied to the low and high timber harvest from the model simulations, the timberland can supply at least 330,000 green tons and at most 1,050,000 green tons of low grade wood.

Growth Removal Approach

Besides using the geographical analysis to obtain the available low grade wood, the growth removal approach is used for further verification. We assumed that the demand would be the same as the average from recent harvests, therefore these existing wood using facilities consumed 3.92 million green tons of roundwood per year. Our model simulation indicates that this study area can provide 4.62 million green tons per year in the following 50 years, therefore the difference is 700,000 green tons. Using the conversion factors mentioned above, there is 540,000 green tons of low grade wood[10]. As Figure 6 showed, the 2004 harvest is an exceptional case. If we did not count it in the average of recent harvests, the available low grade wood would be 620,000 green tons using the growth removal approach. Therefore, we believe that our geographical analysis gives us a fair prediction of the available low grade wood.

Discussion

Above two methods to estimate the low grade wood already take into account the wood flow in and out of the study area. The wood flow to Canada is an exception we did not consider because we did not consider any inventory or supply either, in part because that has been the historic case and Canadian timberland acres are not available from FIA database. However we do know that wood has historically flowed to Canada, Domtar's Windsor mill is the major Canadian company that bought/is buying low grade wood from NH, and we have been told this mill annually imports about 40,000-50,000 green tons of pulpwood from Coos County[11]. We have also been informed that nearly all timber

[10] After taking the export to Canada into account (see the follow discussion), the available low grade wood would be similar.
[11] Personal communication with their procureman.

exported from VT and Oxford County, ME to Canada is sawtimber in recent years. There is no import from Canada to VT, but there are about 27,000 green tons of low grade wood imported from Canada to Oxford, ME in 2005. We also believe that in recent years the overall export to Canada from NH has been between 120,000 – 140,000 green tons, with perhaps as much as two-thirds coming from our study area. Thus we think the Canadian draw is in the 40,000 ton – 85,000 green tons range. We also think that projecting this over a 50-year simulation period, with no assumption of supply from adjacent Canadian land (while perhaps the way things have been) is not necessarily the way things will be – hence would be an overreach. So for the purposes of this report we are using a net annual export of 50,000 green tons from our study area to Canada. With that adjustment downward we think that the available low grade wood would be around 640,000 green tons per year. Correspondingly, the low and high limits of the available low grade wood are 280,000 and 1,000,000 green tons for the low and high supply model simulations respectively.

Table 10. Analysis of low grade wood available to existing wood using facilities.

Plant Name	State	Location	Type	Radius	Consumption (Green Ton)	Adjutsted consumption	Geographical Analysis	Wood Assigned
Androscoggin Mill	Operating	Jay, ME	Pulp	125	1,645,000	1,470,630	34.36%	505,281
Madison Paper Industries	Operating	Madison, ME	Pulp	50	250,000	223,500	11.19%	25,004
Masonite Corp.	Operating	Lisbon Falls, ME	Pulp	50	100,000	89,400	4.44%	3,971
Newpage Corp.	Operating	Rumford, ME	Pulp	125	1,300,000	1,162,200	37.00%	430,025
Sappi Fine Paper	Operating	Skowhegan, ME	Pulp	125	2,300,000	2,056,200	25.53%	524,990
Bridgewater Power	Operating	Bridgewater, NH	Power plant	75	225,000	202,500	46.43%	94,011
Whitefield Power and Light	Operating	Whitefield, NH	Power plant	50	187,000	168,300	99.54%	167,522
Pine Tree Power	Operating	Bethlehem, NH	Power plant	75	230,000	207,000	73.85%	152,869
Hemphill Power	Operating	Springfield, NH	Power plant	75	208,000	187,200	37.21%	69,660
PSNH Schiller Station	Operating	Portsmouth, NH	Power plant	75	450,000	405,000	23.72%	96,085
Finch, Pruyn, & Co., Inc.	Operating	Glens Falls, NY	Pulp	100	638,000	570,372	11.24%	64,122
International Paper Co.	Operating	Ticonderoga, NY	Pulp	100	750,000	670,500	12.53%	84,003
Joseph C. McNeil Station	Operating	Burlington, VT	Power plant	75	380,000	342,000	44.69%	152,841
Ryegate Power Station	Operating	Ryegate, VT	Power plant	75	260,000	234,000	72.65%	170,010
Pine Tree - Tamworth	Operating	Tamworth,NH	Power plant	75	300,000	270,000	58.35%	157,558
Alexandria - Power	Operating	Alexandria, NH	Power plant	75	200,000	180,000	44.66%	80,380
Borelex - Livermore Falls	Operative	Livermore Falls, ME	Power plant	75	350,000	315,000	35.28%	111,135
Total					9,773,000	8,753,802		2,889,467
Available wood					3,577,913			688,446

There are several proposed facilities are or will be likely built in the study area. If we take their annual wood consumptions into account, they would pull about 1.1 million green tons of wood from our study area (Table 11). The available low grade wood would not be enough to supply these facilities after these proposed facilities are built and run at their capacity unless the timberland owners increase their harvest or the facility owners purchase wood from other areas.

The low and high limit of available timber is based on the assumptions used in the model. Compared with other studies related to this area, the estimate is not out of the reasonable range. The INRS study suggests that approximately 300,000 green tons of wood is available within 30 mile radius around Berlin, NH. Their wood basket is about 25% of the wood basket we defined. If we compare the biomass between these two studies, the different is approximately 10%[12]. If similar comparison was made with the VT biomass study (Sherman 2007), we can reach the similar conclusion. In addition, many factors caused the closure of Groveton and Berlin pulp mills, but one of them is likely due to the competition for low grade wood which causes less low grade wood available in this region. Many wood using facilities have been procuring wood from Coos County. As we know, these two mills consumed approximately 1 million green tons per year. That implies the low grade wood supply is likely less than 1 million green tons, which supports our estimate for the low grade wood in the study area. On the other hand a facility that could be aggressively competitive with pricing could likely command a higher proportion of wood in our study area.

Table 11. Analysis of low grade wood available to proposed wood using facilities.

Plant Name	State	Location	Type	Radius	Consumption (Green Ton)	Adjutsted consumption	Geographical Analysis	Wood Assigned
Clean Power Plant	Proposed	Berlin, NH	Power Plant	75	368,500	331,650	69.86%	231,681
Frazer Papers-Vision Power	Proposed	Gorham, NH	Wood Boiler	75	220,000	198,000	67.35%	133,350
Vermont Fuel Co.	Proposed	Island Pond, VT	Wood Pellets	50	100,000	90,000	100.00%	90,000
Presby Environmental, Inc.	Proposed	Whitefield, NH	Wood Pellets	100	660,000	594,000	51.58%	306,414
Laidlaw EcoPower	Proposed	Berlin, NH	Power plant	100	750,000	675,000	50.90%	343,582
Total					9,773,000			1,105,027

Summary

In order to come up with an estimate of available low grade wood supply that could be used by a new or potential facility in Coos County, NH, we came up with a multi-phase plan. The first order of business was to analyze the annual wood consumption within the study area, deriving harvest by product and quantity. This was done by

[12] Using INRS (2007) method to calculate biomass, which is different from the definition of our low grade wood. INRS takes 15% of roundwoods which cannot be used for higher value products plus 50% of the tops and branches as biomass.

interviewing contractors within the pulp and paper industry as well as reviewing public information from company websites, state harvest records and other sources such as previous wood supply studies.

The information obtained in the first phase of the study was used to project harvests and growths over the next 50 year period. Using the ATLAS-SRTS model, and running a number of simulations, an estimate of annual harvest was calculated 4.62 million green tons per year, which means there are 3.58 million green tons of low grade wood. Then using our analysis of the current and historical demand by existing pulp mills and biomass energy plants, we subtract that from annual timber supply. **We estimate the available low grade timber for a new facility in Coos County to be somewhere around 640,000 green tons from the study area. The lower and upper limits would 280,000 and 1,000,000 green tons respectively.**

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Appendix I. Terms

Average annual gross growth. Average annual increase in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting and mortality. Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.

Average annual mortality. Average annual volume of trees 5.0 inches d.b.h. and larger that died from natural causes during the intersurvey period.

Average annual net growth: Average annual net change in volume of trees 5.0 inches d.b.h and larger in the absence of removals during the intersurvey period. Average annual net growth is equal to average annual gross growth minus average annual mortality.

Average annual removals: Average volume of trees removed from growing stock each year due to timber harvests and land use changes.

Average annual mortality: Average volume of trees that died each year due to insects, diseases and other natural causes.

Biomass: Aboveground weight of live trees 5-inch d.b.h. and larger including buck, top and branches.

Growing stock: All live trees 5.0 inches DBH or larger that meet regional merchantability requirements in terms of sawlog length, grade, and cull deductions. Excludes rough and rotten cull trees.

DBH: Diameter at breast height. The diameter for tree stem, located at 4.5 feet (1.37 m) above the ground (breast height) on the uphill side of a tree. The point of diameter measurement may vary on abnormally formed trees.

Forest Type: A classification of forest land based upon and named for the tree species that forms the plurality of live-tree stocking. A forest type classification for a field location indicates the predominant live-tree species cover for the field location; hardwoods and softwoods are first grouped to determine predominant group, and Forest Type is selected from the predominant group

Ownership: A legal entity having an ownership interest in land, regardless of the number of people involved. An ownership may be an individual; a combination of persons; a legal entity such as corporation, partnership, club, or trust; or a public agency. An ownership has control of a parcel or group of parcels of land.

Poletimber: Softwood trees 5-9 inches d.b.h.; Hardwood trees 5-11 inches d.b.h.

Hardwood: tree species belonging to the botanical subdivision Angiospermae, class Dicotyledonous, usually broad-leaved and deciduous.

Sawtimber: Softwood trees greater than 9 inches d.b.h.; Hardwood trees greater than 11 inches d.b.h.

Seedlings-saplings: Trees less than 5 inches in diameter at breast height (d.b.h.).

Softwoods: Coniferous trees, usually evergreen having needles or scale-like leaves.

Stand Age: A stand descriptor that indicates the average age of the live dominant and codominant trees in the predominant stand size-class of a condition.

Stocking: 1) At the tree level, stocking is the density value assigned to a sampled tree (usually in terms of numbers of trees or basal area per acre), expressed as a percent of the total tree density required to fully utilize the growth potential of the land. 2) At the stand level, stocking refers to the sum of the stocking values of all trees sampled.

Appendix II. Definitions for Table of harvest by habitat types and ownership

Habitat Type	Definition
Fed_Non	**Federal inoperable**
Fed_BE_RM	Federal owned beech/red maple type
Fed_HE_RS	Federal owned hemlock/red spruce type
Fed_OK_WP	Federal owned oak/white pine type
Fed_SM_ASH	Federal owned sugar maple/ash type
Fed_SP_FR	Federal owned spruce/fir type
State_Non	State inoperable
State_BE_RM	State owned beech/red maple type
State_HE_RS	State owned hemlock/red spruce type
State_OK_WP	State owned oak/white pine type
State_SM_ASH	State owned sugar maple/ash type
State_SP_FR	State owned spruce/fir type
PRInv_non	Private industry/investment inoperable
PRInv_BE_RM	Private industry/investment owned beech/red maple type
PRInv_CE_BS	Private industry/investment owned cedar/black spruce type
PRInv_HE_RS	Private industry/investment owned hemlock/red spruce type
PRInv_OK_WP	Private industry/investment owned oak/white pine type
PRInv_SM_ASH	Private industry/investment owned sugar maple/ash type
PRInv_SP_FR	Private industry/investment owned spruce/fir type
PRCon_non	Private conservation inoperable
PRCon_BE_RM	Private conservation owned beech/red maple type
PRCon_CE_BS	Private conservation owned cedar/black spruce type
PRCon_HE_RS	Private conservation owned hemlock/red spruce type
PRCon_OK_WP	Private conservation owned oak/white pine type
PRCon_SM_ASH	Private conservation owned sugar maple/ash type
PRCon_SP_FR	Private conservation owned spruce/fir type
PROth_non	Private other inoperable
PROth_BE_RM	Private other owned beech/red maple type
PROth_CE_BS	Private other owned cedar/black spruce type
PROth_HE_RS	Private other owned hemlock/red spruce type
PROth_OK_WP	Private other owned oak/white pine type
PROth_SM_ASH	Private other owned sugar maple/ash type
PROth_SP_FR	Private other owned spruce/fir type

Appendix III. Conversion factors

SM/ASH: 1 Cord = 2.65 Green Tons

BE/RM: 1 Cord = 2.45 Green Tons

OK/WP: 1 Cord = 2.77 Green Tons

HE/RS: 1 Cord = 2.25 Green Tons

SP/FR: 1 Cord = 2.15 Green Tons

CE/BS: 1 Cord = 2.10 Green Tons

1 MBF = 2 Cords