Northeast Wood Markets Retention and New Market Recruitment Initiative

North East *State* Foresters Association

REPORT Section I: FIA, Timber Projections & Supply Chain

July 29, 2020

Produced by the North East *State* Foresters Association for the Northern Forest Center, U.S. Department of Commerce Economic Development Administration and the U.S. Endowment for Forestry & Communities.

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I. Timber and Timberland Data for New Hampshire, New York and Vermont

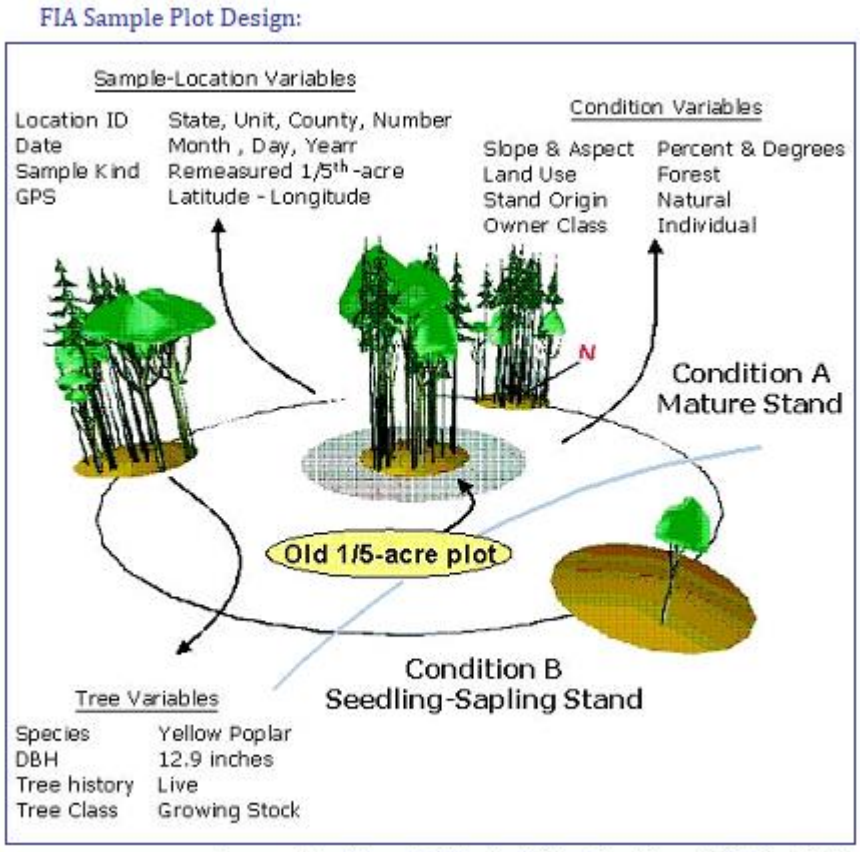
To understand the timber resources of New Hampshire, New York and Vermont we have used data available through the USDA Forest Service Forest Inventory and Analysis (FIA). The FIA data is the most robust and continuous set of forest and timberland data available in the U.S. These data are developed from on-the-ground measurements on fixed plots throughout most of the U.S. forestland. Each plot represents approximately 6,000 acres of forest. FIA is a national program of the Forest Service that has been operating since 1930, collecting, analyzing, and reporting information on the status and trends of America's forests since then. The FIA data collection program includes:

Phase 1 – Remote sensing using satellite image data (of forest and non-forest cover);

Phase 2 – one field sample site for every (approximately) 6,000 acres. Field crews collect data on forest type, site attributes, tree species/size/overall condition on accessible forestland;

Phase 3 – Subset of the sample plots measured for forest health attributes.

The following diagram shows the FIA field plot design.



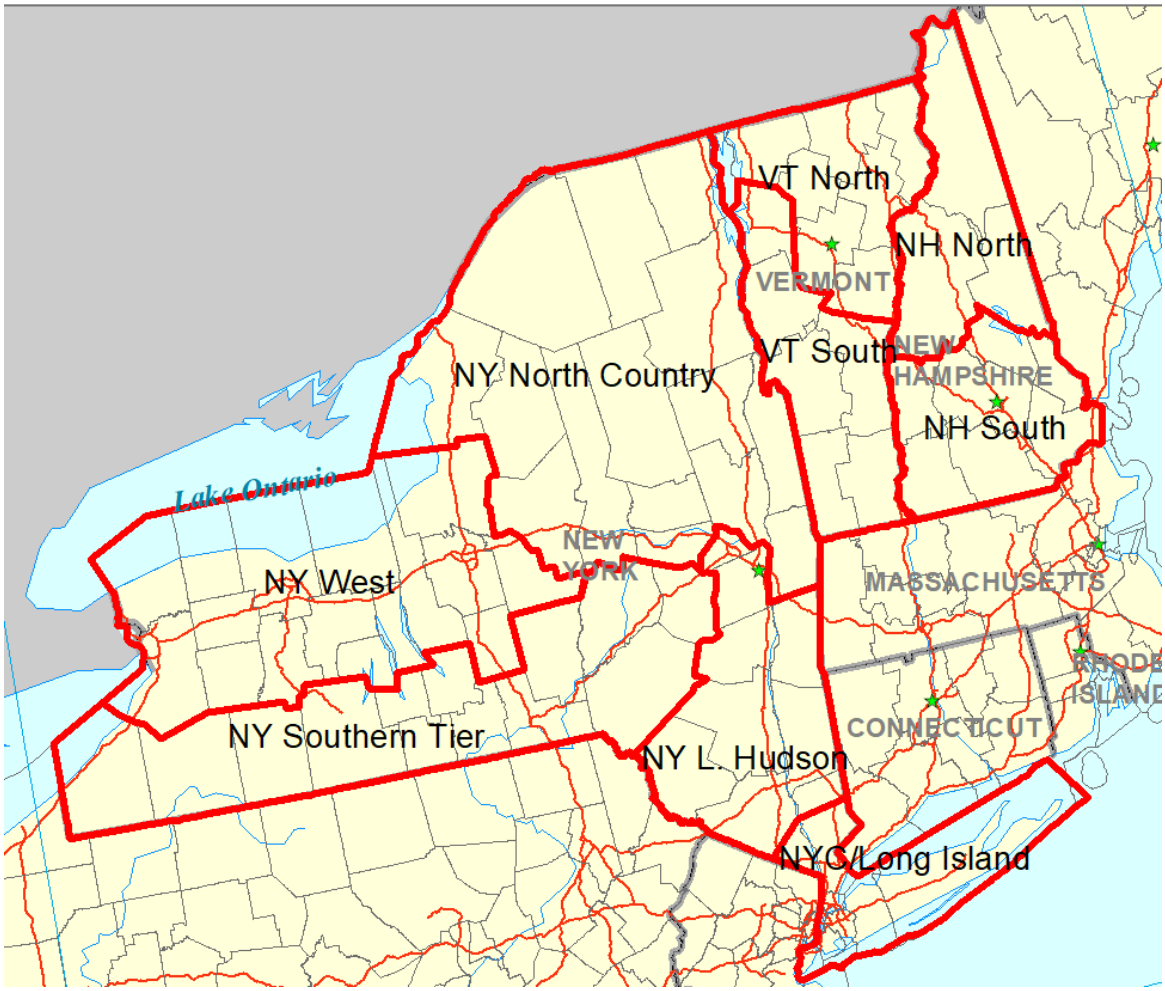
Source: http://www.fs.fed.us/ne/fia/methodology/p2/design2.html

Timberland – the land designation for virtually all the data later found in this report - is defined as forest land capable of producing in excess of 20 cubic feet per acre per year and not legally withdrawn from timber production, with a minimum area classification of 1 acre. Forestland includes these lands and also forested land that does not meet the timberland definition, such as congressionally dedicated Wilderness areas. For this report, we have chosen to display and

analyze only timberland acres. For practical purposes, the vast majority of forested lands in the three-state region meet the timberland definition.

For the purposes of this analysis, we have parceled the three-state region into eight (8) different sub-regions, following county lines, as seen in Figure 1 below. This analysis does not include the southern-most counties in New York State including and surrounding New York City.

Figure 1 Forest Inventory and Analysis Data Sub-Regions



These sub-regions were chosen for two reasons: first, the regions are generally large enough to allow the data statistics to be accurate enough for analysis; secondly, the regions are logical from a forest products supply chain perspective.

Below are data displays and analyses for each of the nine sub-regions.

1. Sub-Region NH – North

Overview - This three-county area is very rural and its economy has traditionally been based in large part on the forests of the region through forest products and recreation. Forests dominate the landscape of this sub-region. These three counties are the most forested counties in New Hampshire. The northern county, Coos, borders the Canadian province of Quebec. This area contains over 750,000 acres of the White Mt. National Forest.

Forest types are dominated by Northern Hardwood species: American Beech, Sugar Maple, Yellow Birch and Spruce-Fir in this sub-region. Other species groups are found in the region such as White Pine and Red Oak but are minor components of the landscape compared to Northern Hardwood and Spruce-Fir.

The population of all three counties has been increasing since 2000. In 2000, the population of the sub-region was 158,284 while in 2010 it was 169,777[1]. In 2018, the estimate is 173,415. That represents a 9.6% increase from 2000 to 2018.

Timber data major findings for the NH – North Sub-region - The Northern NH sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 1.4:1, meaning that for every unit of timber harvested, 1.4 units are grown. On public land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 3.7:1. On private lands, the ratio is 1.2:1 for all species but is less than 1 for the Maples and Eastern White and Red Pine species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 22 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across certain species groups, particularly the Spruce-Fir group.

Lastly, the natural mortality in the forest of this sub-region at 35,900,927 cubic feet per year, is 60% of the annual removals at 58,709,442 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

The Northern NH sub-region is heavily forested and well stocked with standing timber. Forests are growing timber at rates higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

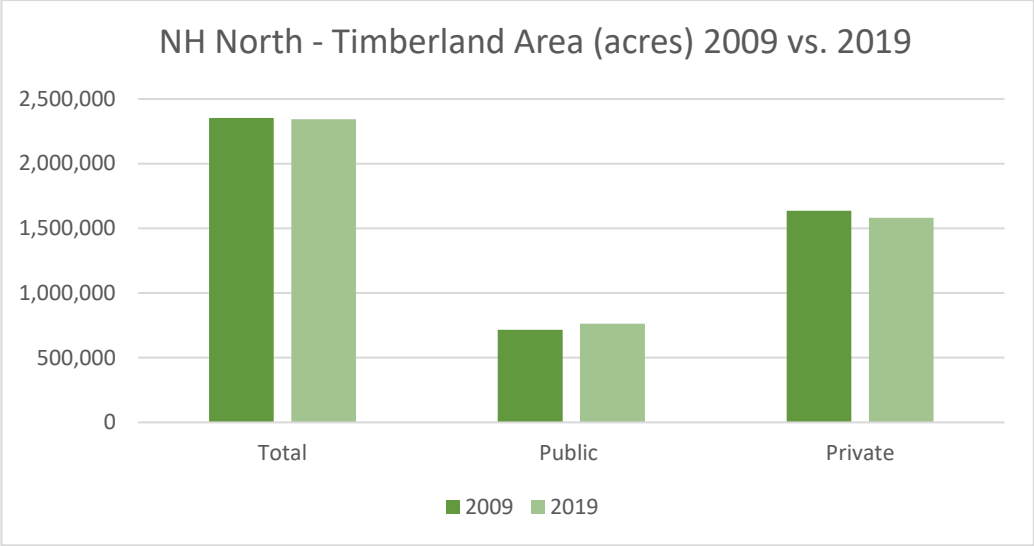
This region includes Coos, Carroll and Grafton Counties in New Hampshire and represents approximately 2,342,555 acres of timberland As a percentage of land and water area in the sub-region, the area is 80% forested. The sub-region has over twice the timberland acreage in private land as it does in public land (1,580,761 acres private vs. 761,794 acres public) – see Figure 2. Comparing the area using 2009 and 2019 data[2], the sub-region lost 10,703 acres of timberland over the 10-year period (approximately .5 % of the forests in the sub-region). The area gained 44,842 acres of public land during that period and lost 55,545 acres of private land (from the public land gained plus additional acreage that changed to developed or agricultural uses). Little of this loss was to non-forest uses. The loss of timberland results from a

[1] Data for 2000 and 2010 are from U.S. Decennial Census. The 2018 data is an estimate from State of NH Office of Strategic Initiatives.

[2] 2009 FIA data actually represents a series of years of data collection which includes 2003-2009. FIA plot re-measurement occurs at approximately 20% per year so the 2009 year represents the average data for the plots in the region over the 2003-2009 period with the most recent 20% re-measurement of plots in 2009. 2019 data represents plot data collected from 2013-2019.

combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests).

Figure 2 Northern NH Timberland Area



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Volume and Changes 2009-2019

Overall, on all timberlands in the three-county region, standing timber volume in 2019 for all species was 4,192,568,604[3] cubic feet. This represents 1,789.7 cubic feet/acre or 22.4 cords[4] per acre – 21.0 cords/ac private land and 26.0 cords/acre on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides[5], created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

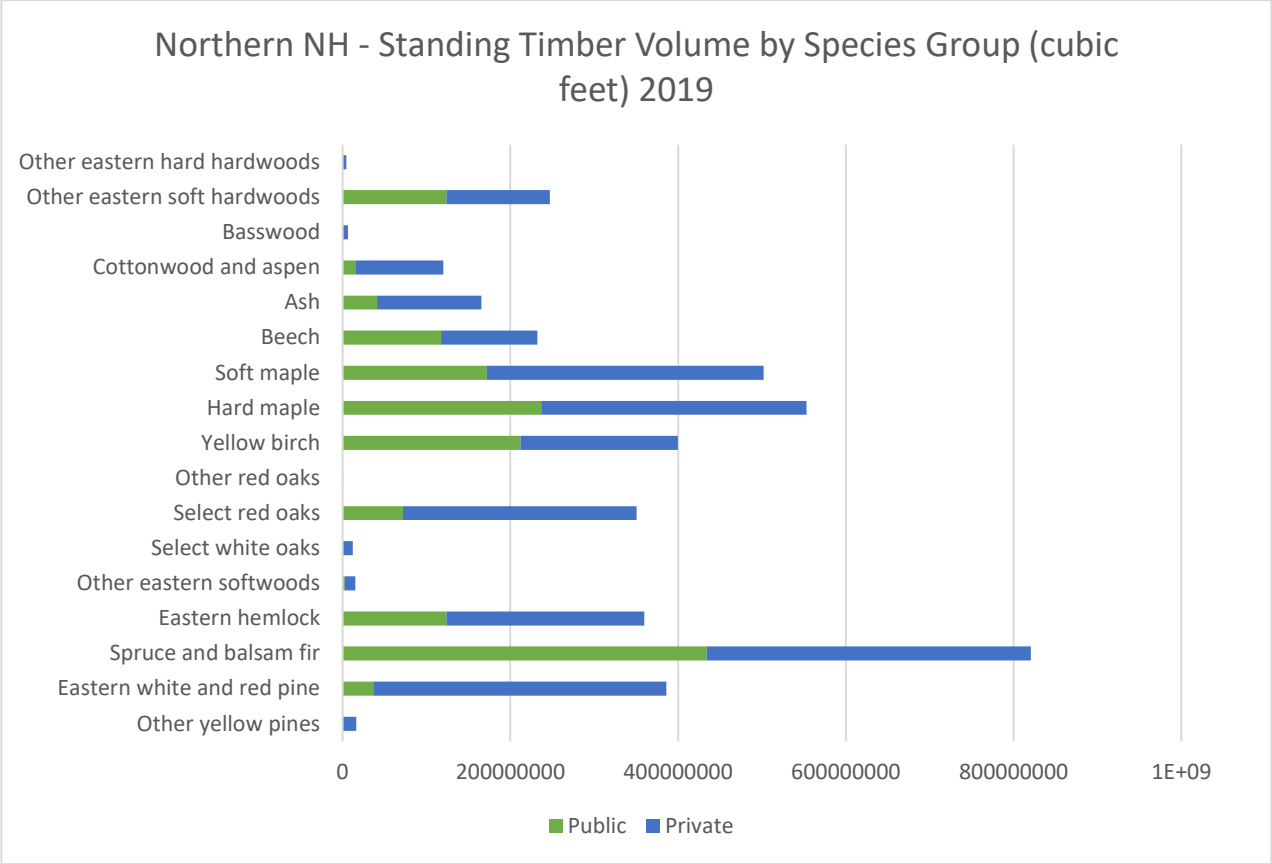
The breakdown of standing volume by species groups for the NH North sub-region can be seen in Figure 3. Spruce-Fir and the Northern Hardwood species (maple, birch and beech) are the dominant species groups in terms of volume in the sub-region. Other substantial species groups include White Pine, Hemlock and Oaks.

[3] The Forest Inventory and Analysis data is based upon sampling, and not a full inventory of all land and timber. As a result, there are sampling errors associated with the use of this data; INRS reports here using the mid-point of each estimate.

[4] Conversion factor used was 80 cubic feet per cord.

[5] Timber stocking guides use basal area – a measurement of the cross-sectional area of the trees as if they were severed at 4.5 feet – and number trees per acre in a two-axis diagram (see Appendix for more detail). The guide typically has 3 levels: A, B and C. Desired stocking level to fully occupy the site with trees is between the A and B lines.

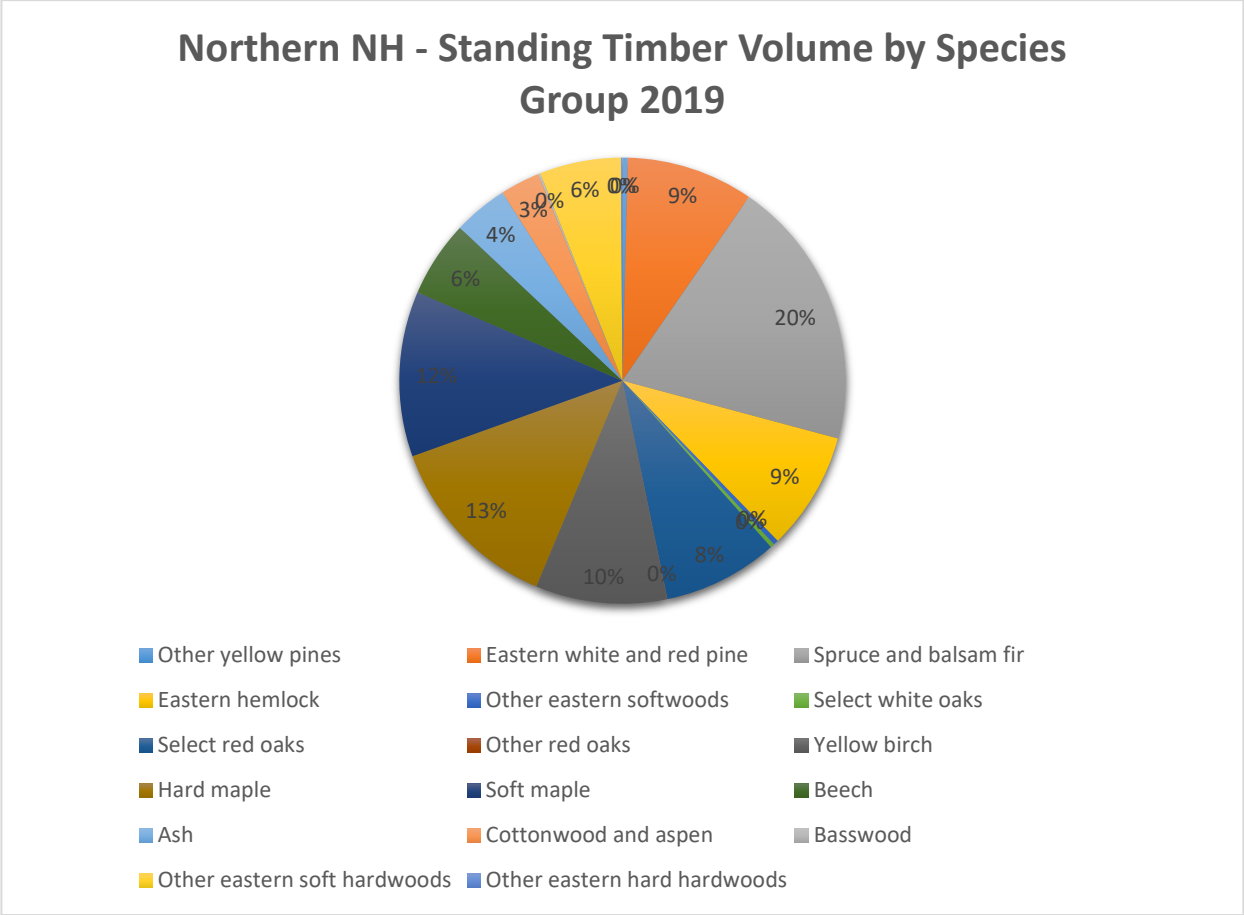
Figure 3 Northern NH Standing Timber Volumes



Source: USDA Forest Service, Forest Inventory and Analysis[6]

[6] All volume data in the charts and graphs in the report section are from net merchantable bole volume of growing stock trees (at least 5" in diameter at 4.5 feet)

Figure 4 Northern NH Timber Volume by Species



Source: USDA Forest Service, Forest Inventory and Analysis

Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber reduced by 9,832,372 cubic feet or .2% of standing volume, roughly in line with the loss of timberland over this time period. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 5) but it must be understood as a current snapshot in time.

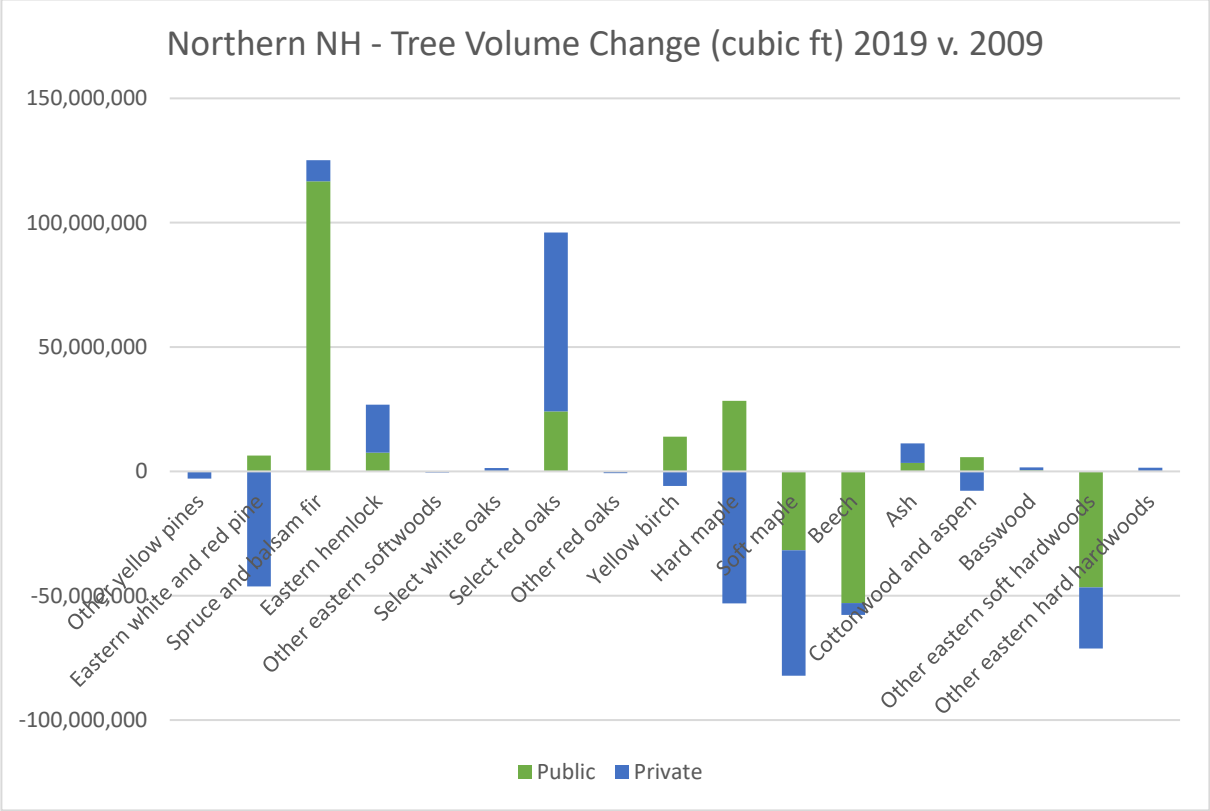
Figure 5 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber occurred on private land in the sub-region where most of the timber is harvested. Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 5, notable changes in species volume from 2009-2019 include large increases in Spruce-Fir, Hemlock and Oak. Reductions in standing volume during the 10-year time period

include White Pine and Maples. It is important to note that overall standing timber stocking, i.e. the amount of timber that is standing per acre at over 22 cords, is considered good or even overstocked.

Just because standing timber volumes in a geographic region are reduced from one time period to another does not necessarily mean that this is problematic trend if the current forest is still adequately stocked. The most recent timber volume data for this sub-region indicates that it is, on average, stocked adequately.

Figure 5 Northern NH Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

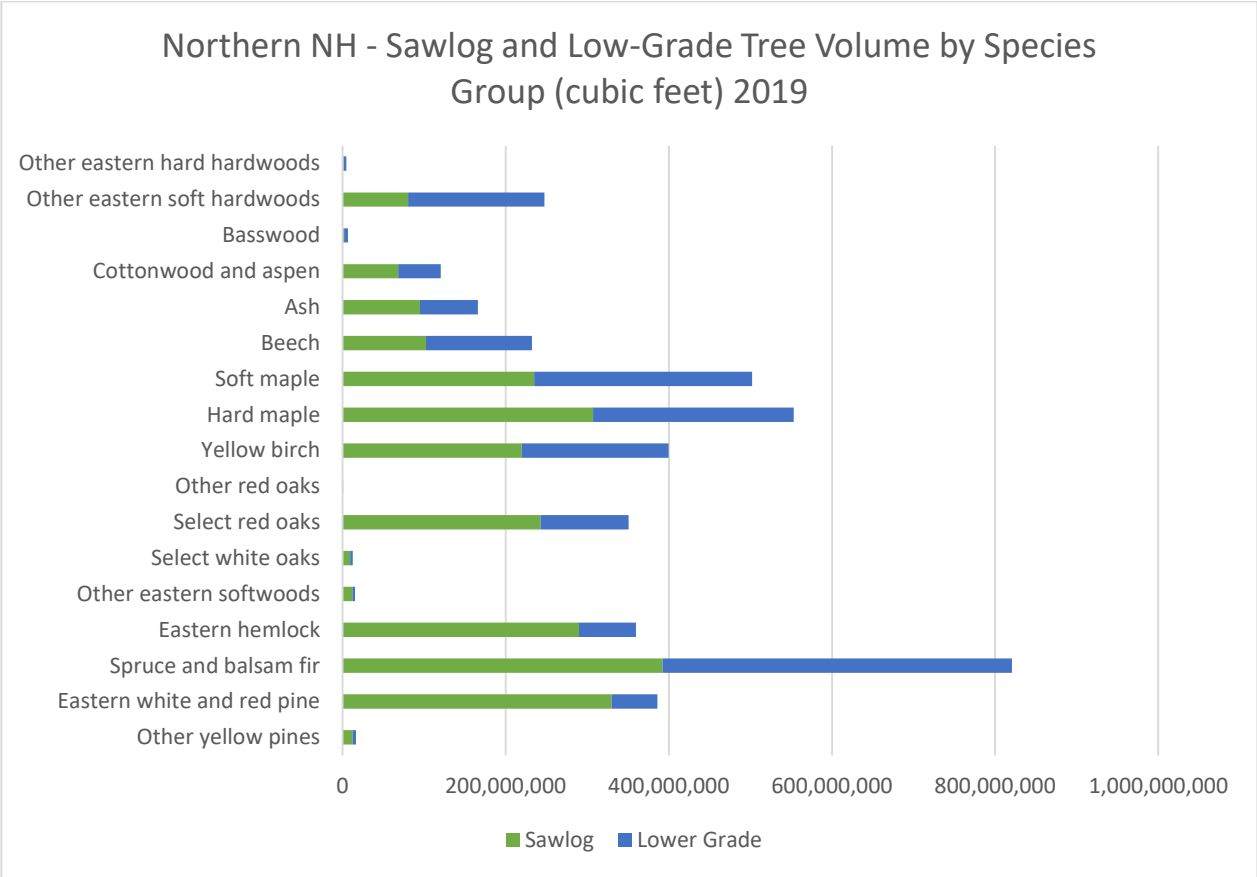
Note on Figure 5 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 6 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Maples, Yellow Birch, Spruce and Fir and White Pine all show sawlog volumes at over half of standing volumes. Hard maple is over 60% sawlog as is Yellow Birch. White Pine is over 85% sawlog volume. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 6 Northern NH Sawlog vs. Low-Grade Volume[7]



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number in Figure 7 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 7. Net growth for the year was 82.9 million cubic feet and removals 60.1 million cubic feet. The important result (growth less removals) is a net increase of 22.8 million cubic feet (285,154 cords) of standing timber volume per year in the sub-region.

[7] Sawlog volume = net merchantable sawlog volume; low-grade volume – total merchantable volume minus merchantable sawlog volume.

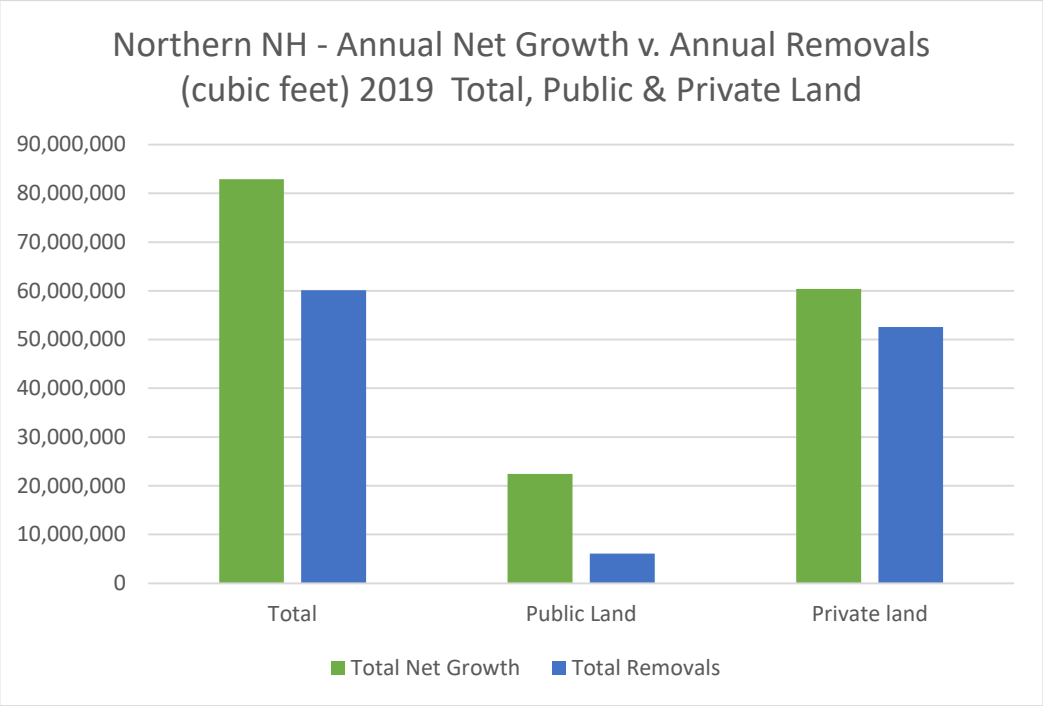
Figure 7 Northern NH Summary Table – Net Growth V. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Northern NH			
2019	***Net Growth***	cubic feet	
	all	82,935,275	
	public	22,407,446	
	private	60,402,270	
	Removals		**Removals from Harvest**
	all	60,122,928	57,356,242
	public	6,065,591	
	private	52,560,109	
	Growth less Removals		
	all	22,812,347	
	public	16,341,855	
	private	7,842,161	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 8. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

Figure 8 Northern NH Net Growth V. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

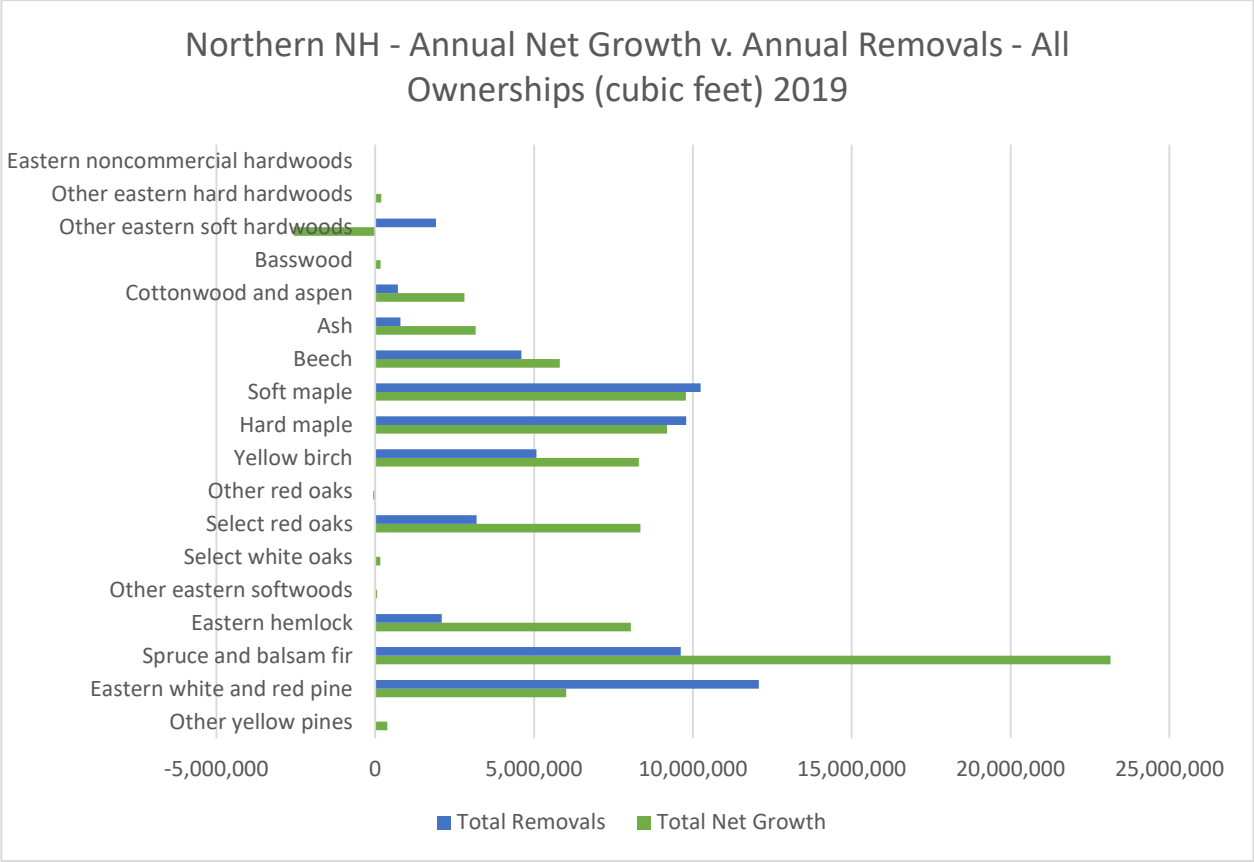
Figures 9 through 11 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all but the Eastern White and Red Pine groups show a positive net growth to removals ratio. This means that all but the pine group are increasing in volume over time. A particular bright spot is that Spruce-Fir is showing a wide ratio of net growth to removals.

The Eastern White and Red Pine group data, which shows more removals than annual net growth, is of concern simply because more annual removals than net growth means reduced standing volume over time. The net growth to removals ratio is not significant, however, and also, this species group is not considered a major species group in this sub-region.

By ownership type, in the private land category (Figure 10), negative net growth to removals ratios in the Maples and Eastern White and Red Pine species groups is of concern.

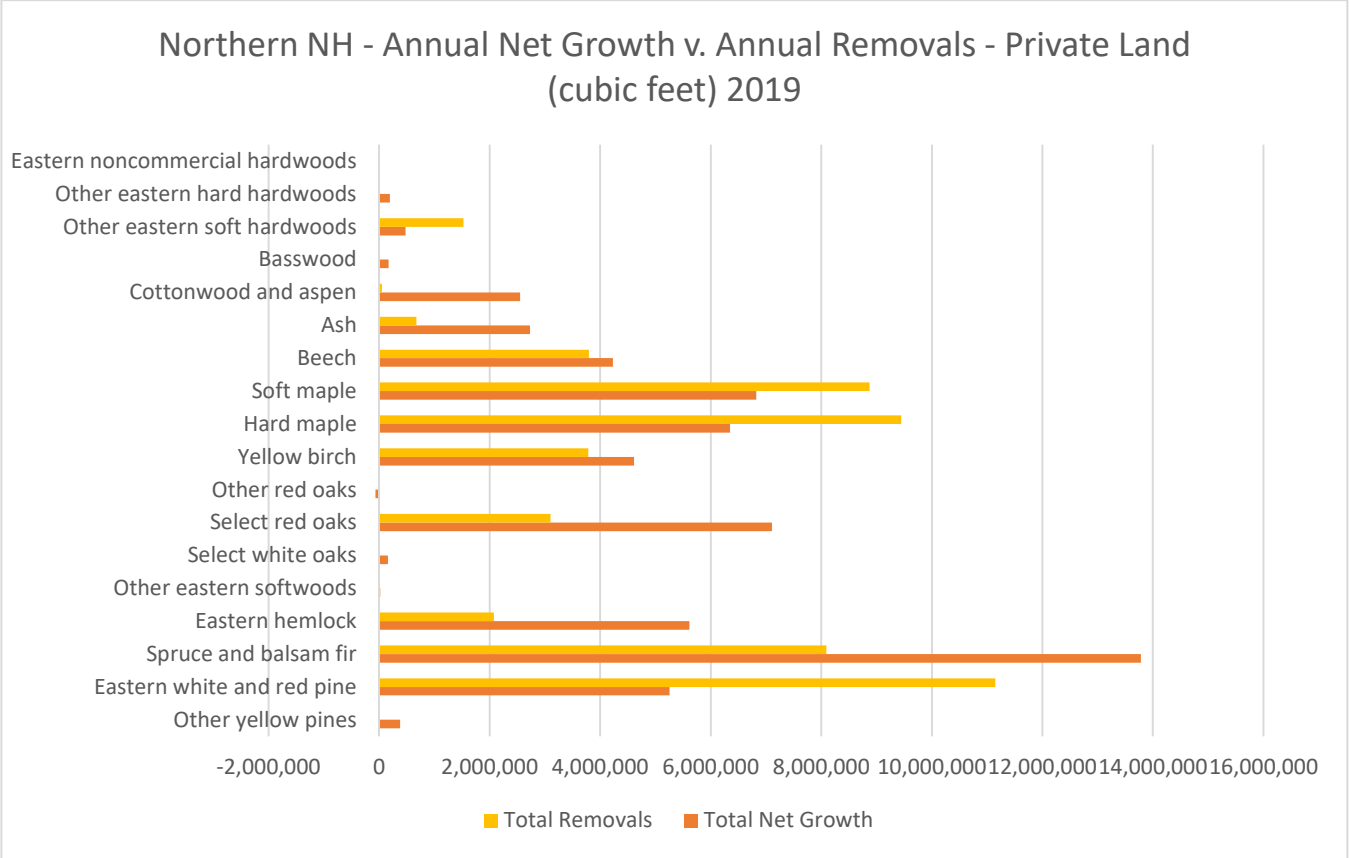
Public land category ratios (Figure 11) are all positive, however, these lands do not produce substantial volumes of harvested timber per acre as compared to private lands.

Figure 9 Northern NH Net Growth v. Removals by Species Group



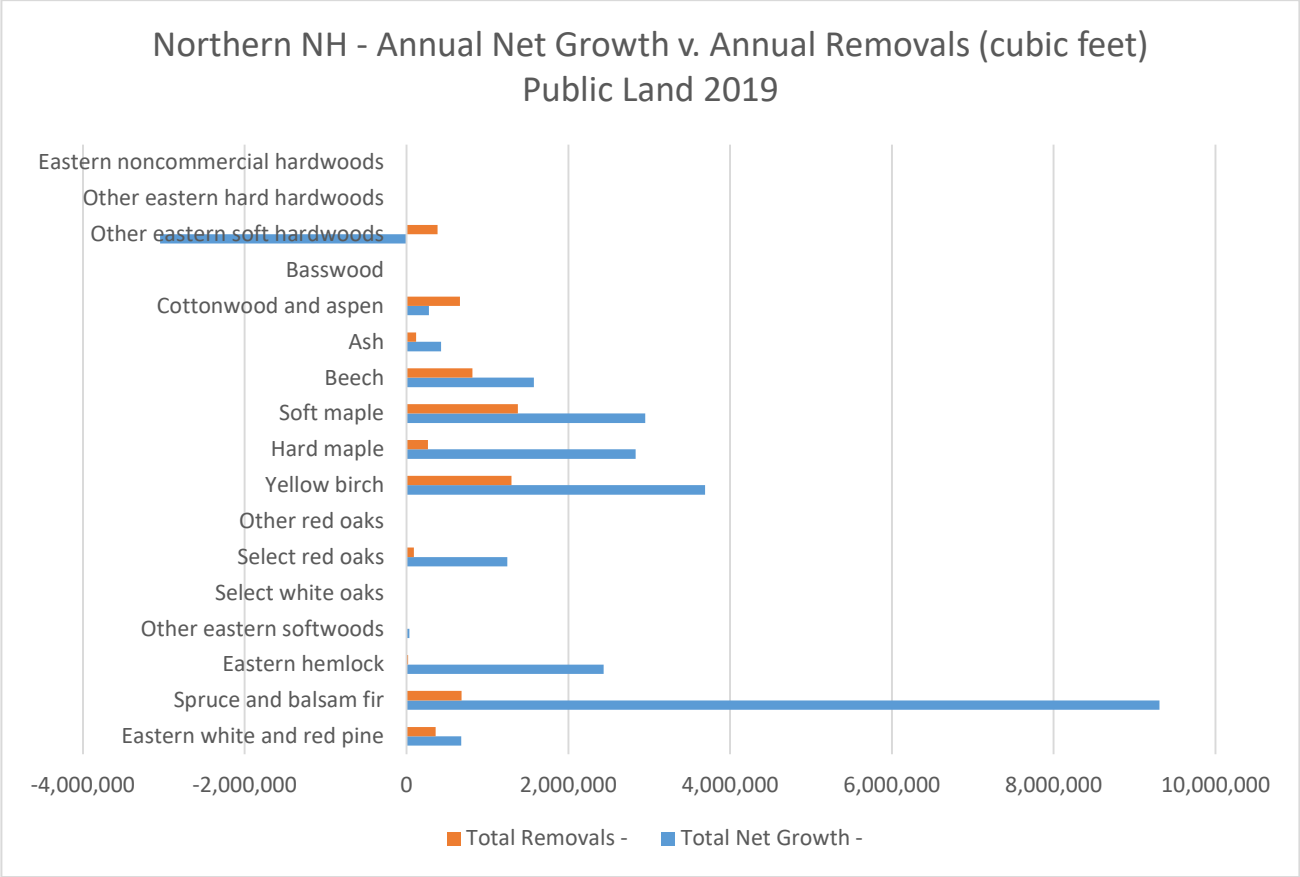
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 10 Northern NH Net Growth v. Removals Private Land



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 11 Northern NH Net Growth v. Removals Public Land



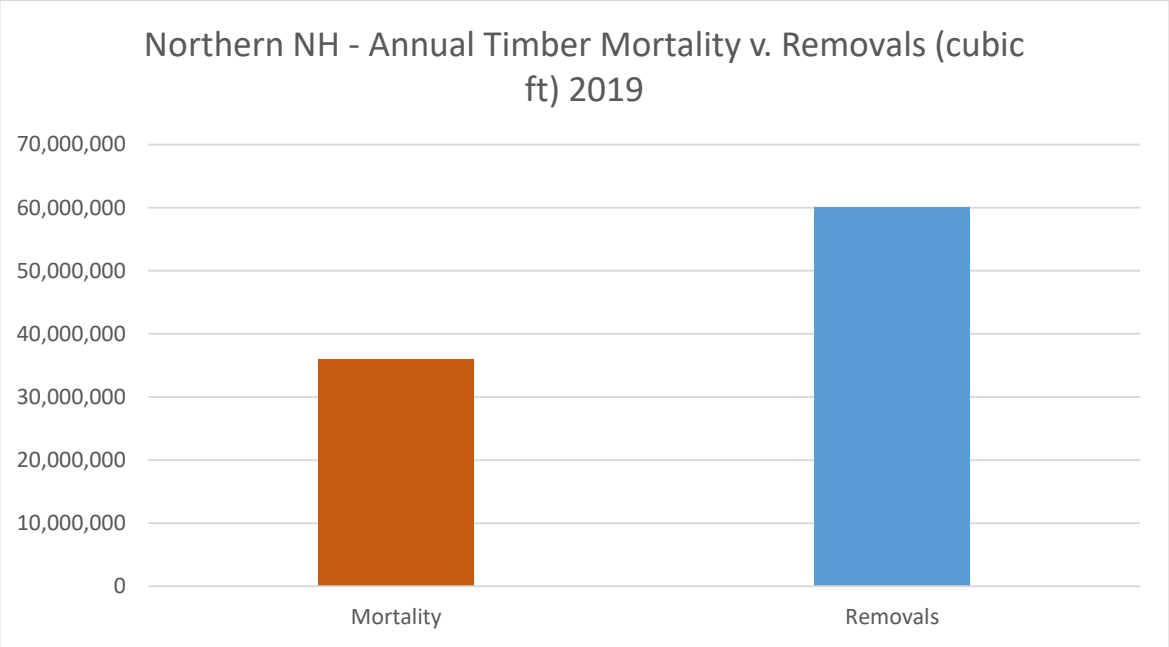
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

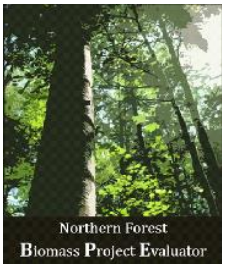
Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees several hundred years. As forests grow and age, their rate of annual mortality grows with it. Older forests have greater mortality, measured in volume, compared to young forests. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 12 below shows the annual mortality in volume for Northern NH trees vs. the amount harvested. With 2019 data, annual mortality is 60% of annual removals.

Figure 12 Northern NH Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis



Future Timber Projections

As with the FIA analysis in the section above, an analysis was conducted for all the sub-regions using the *Northern Forest Biomass Project Evaluator* (BPE) model[8]. The intent is to give, using key assumptions which we include below, a set of possible timber resource futures for the area. The BPE model runs use the FIA dataset for the sub-region as with the FIA analysis for each sub-region. The BPE model also uses the most recent complete FIA information with data collected ending in 2019.

The BPE model was created by INRS on behalf of the North East *State* Foresters Association through grant support from the USDA Forest Service. The BPE tool is intended to be used as a decision support tool for analyses of wood supply under different conditions for a geographic area. Using FIA data as its core dataset, BPE estimates available timber volumes over time for a specific geographic area based on a series of parameter assumptions. The tool's interface allows for a large number of different model runs. For this project, we have chosen a small number of likely potential futures given certain parameter choices further described in the next section.

[8]The *Northern Forest Biomass Project Evaluator* model was developed by Innovative Natural Resource Solutions, LLC for the North East *State* Foresters Association with funding from the USDA Forest Service. See Appendix for more detail on the model.

Given the robust nature of timber stocks in this three-state region and the very modest timber harvesting that currently takes place in these states relative to growth and mortality in its forests, the possible future timber scenarios modeled all show substantial increases in standing timber over the next 20 years ending in 2040.

The key assumptions used for the model runs is described below. If these assumptions have been changed for a sub-region, it is noted in the model run explanation.

Scenario Name: Northern NH

General

% of total standing bolewood volume that is low grade:	75%
% of total sawtimber harvest that is high-value (sawlog quality):	50%
% of tops and limbs inventory that is suitable/sustainable to extract for chipping:	75%

Private Timberland Ownership Proportions

% Corporate	15.0%		
% Far	2.0%		
% Other Private	83.0%	% Other Private: 1-50acre parcels	30.0%
		% Other Private: 50+acre parcels	70.0%

Physical Factors Limiting Access

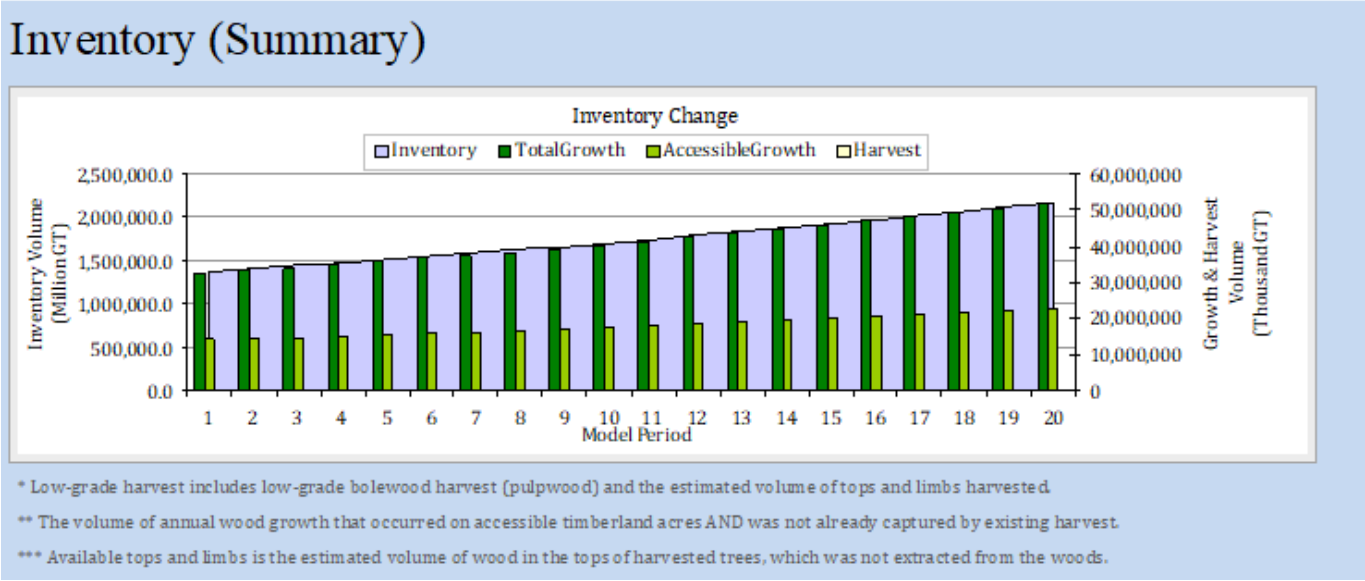
Slope	2.0%
Elevation	2.0%
Wetlands	0.5%
Distance to Roads	2.0%
Deer Yards	0.2%
Stream Buffers	1.0%
Easements	0.5%
Other	0.0%
Total % Physically Inaccessible Acres:	**8.20%**

Ownership Impact on Accessibility

Federal	15.0%
State	30.0%
Municipal	10.0%
Farmer	50.0%
Corporate	90.0%
Private Parcels 1-50 acres	50.0%
Private Parcels 50+ acres	70.0%

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

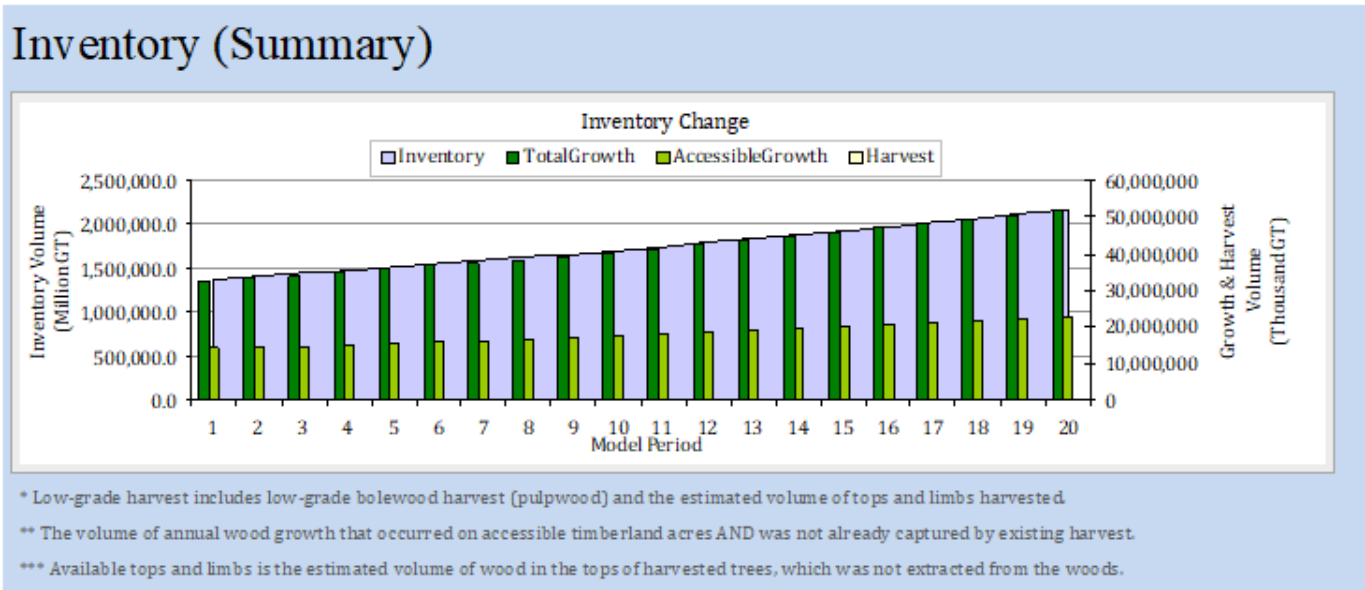


Available timber volume per year (Accessible Growth) in 2020 – 11,418,168 green tons

Available timber volume per year in year 2040 – 18,277,066 green tons

Approximately 57% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

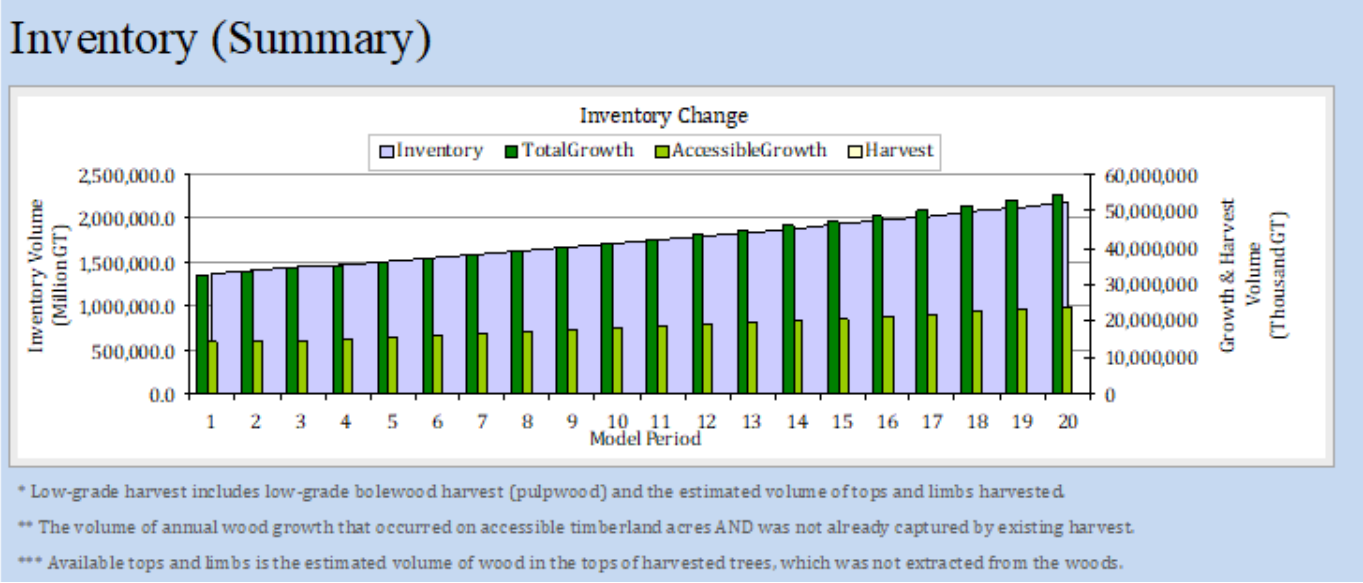


Available timber volume per year (Accessible Growth) in 2020 – 11,418,168 green tons

Available timber volume per year in year 2040 – 18,276,914 green tons

Approximately 57% of ending standing available volume in 2040 is in higher value quality timber.

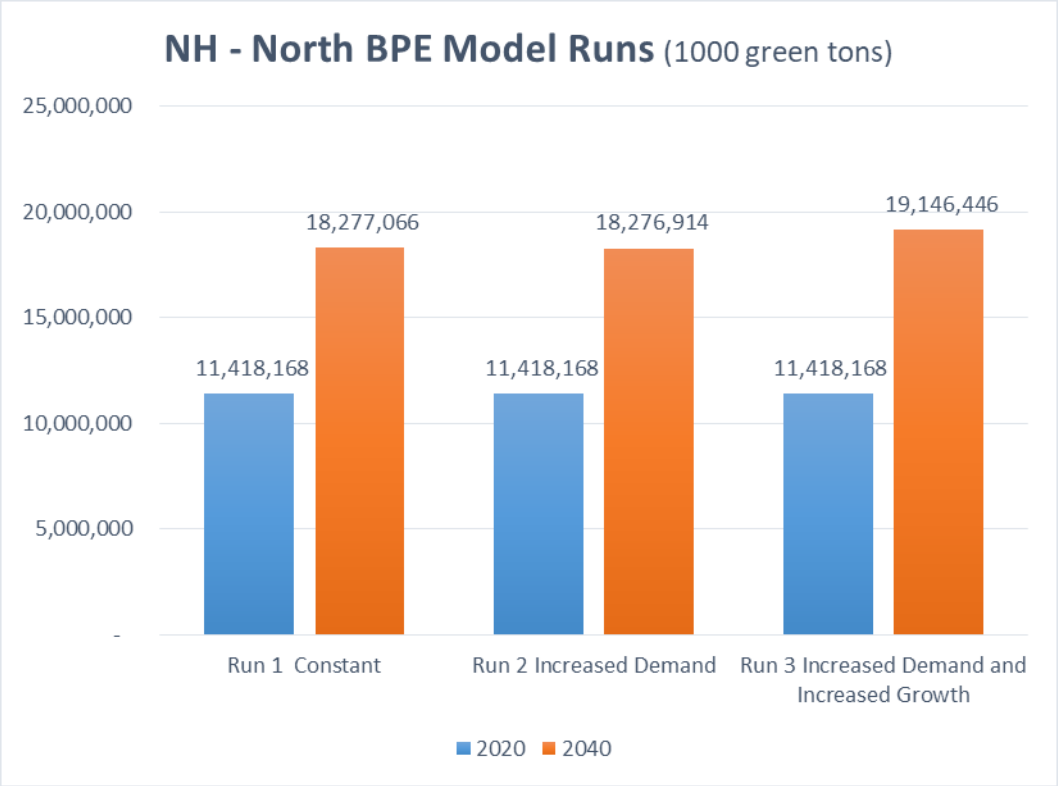
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 11,418,168 green tons

Available timber volume per year in year 2040 – 19,146,446 green tons

Approximately 57% of ending standing available volume in 2040 is in higher value quality timber.


NH - North BPE Model Runs (1000 green tons)
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
-
11,418,168
18,277,066
11,418,168
18,276,914
11,418,168
19,146,446
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

2. Sub-Region NH – South

Overview - This seven-county sub-region is a mix of rural and urban population densities. The southern and southeastern part of the sub-region is primarily urban with the balance of the sub-region predominantly rural.

The forest industry is well-established. There is sufficient logging workforce to meet the demands of new forest-based manufacturing facilities, and there is proven access to diverse local, regional and international markets. There is also adequate transportation infrastructure and transportation logistics options due to the high population centers in the greater region.

This sub-region is dominated by hemlock-hardwood-pine forest type (transition hardwood species). Dominant species include eastern white pine, northern red oak, soft maple, and eastern hemlock. Other hardwoods are commonly found in the region such as American beech, white ash, sugar maple, and the birch species.

Population trends throughout the sub-region are stable showing a modest increase in the last decade. In 2010, the population was 1,146,479 and is estimated to be 1,173,933 in 2018.

Timber data major findings for the NH – South Sub-region - The Southern NH sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 2.9:1, meaning that for every unit of timber harvested, 2.6 units are grown. On public land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 5.4:1. On private lands, the ratio is 2.8:1 for all species and that is also true of all major species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 31.8 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for White Pine is nearly 2:1 for both public and private lands.

Lastly, the natural mortality in the forest of this sub-region at 36,184,775 cubic feet per year, is close to 100% of the annual removals at 34,742,315 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

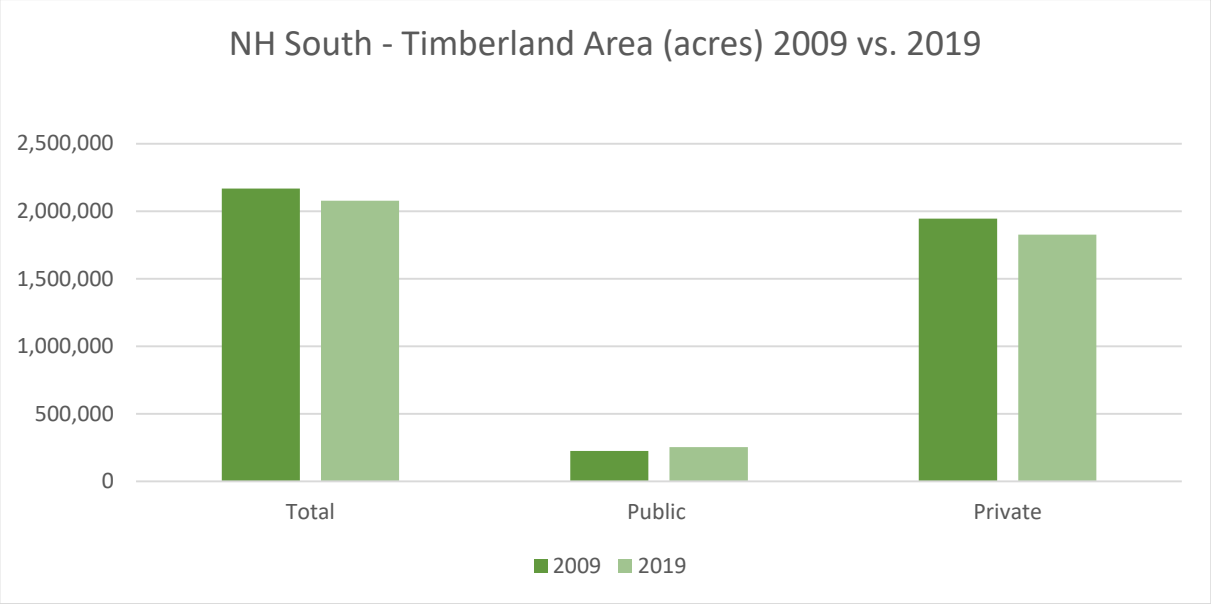
The Southern NH sub-region is heavily forested and well stocked with standing timber. Forests are growing timber at rates higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users, especially the western and northern portions which are more rural than the southeastern area.

Timberland Area

This region includes Belknap, Cheshire, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties in New Hampshire and represents approximately 2,077,449 acres of timberland As a percentage of land and water area in the sub-region, the area is 69% forested. The sub-region has over seven times the timberland acreage in private land as it does in public land

(1,824,849 acres private vs. 252,600 acres public) – see Figure 13. Comparing the area using 2009 and 2019 data, the sub-region lost 91,007 acres of timberland over the 10-year period (approximately 4 % of the forests in the sub-region). The area gained 29,201 acres of public land during that period and lost 119,908 acres of private land (from the public land gained plus additional acreage that changed to developed or agricultural uses). Most of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests).

Figure 13 Southern NH Timberland Area



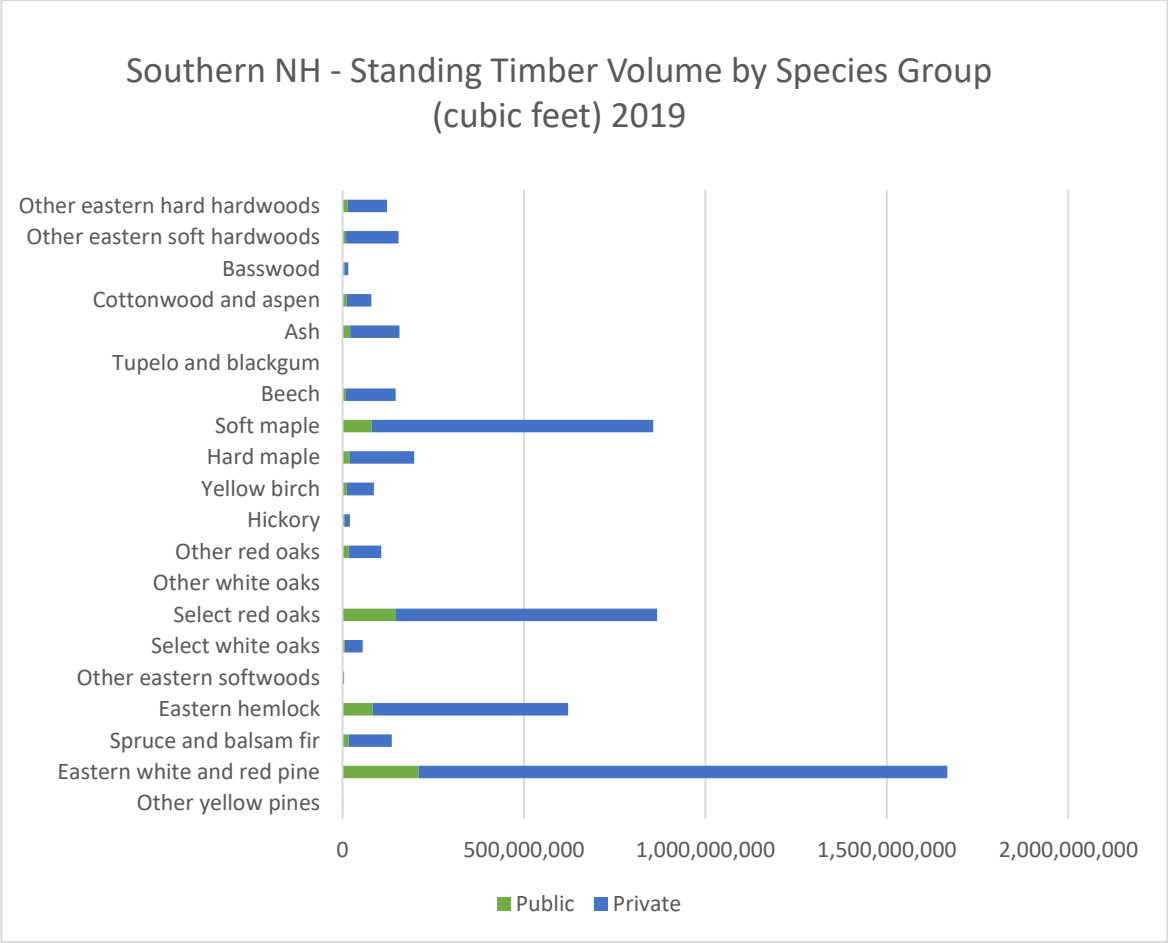
Source: USDA Forest Service, Forest Inventory and Analysis

Timber Volume and Changes 2009-2019

Overall, on all timberlands in the seven-county region, standing timber volume in 2019 for all species was 5,292,029,092 cubic feet. This represents 2,547.4 cubic feet/acre or 31.8 cords per acre – 31.7 cords/ac private land and 32.7 cords/ac on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

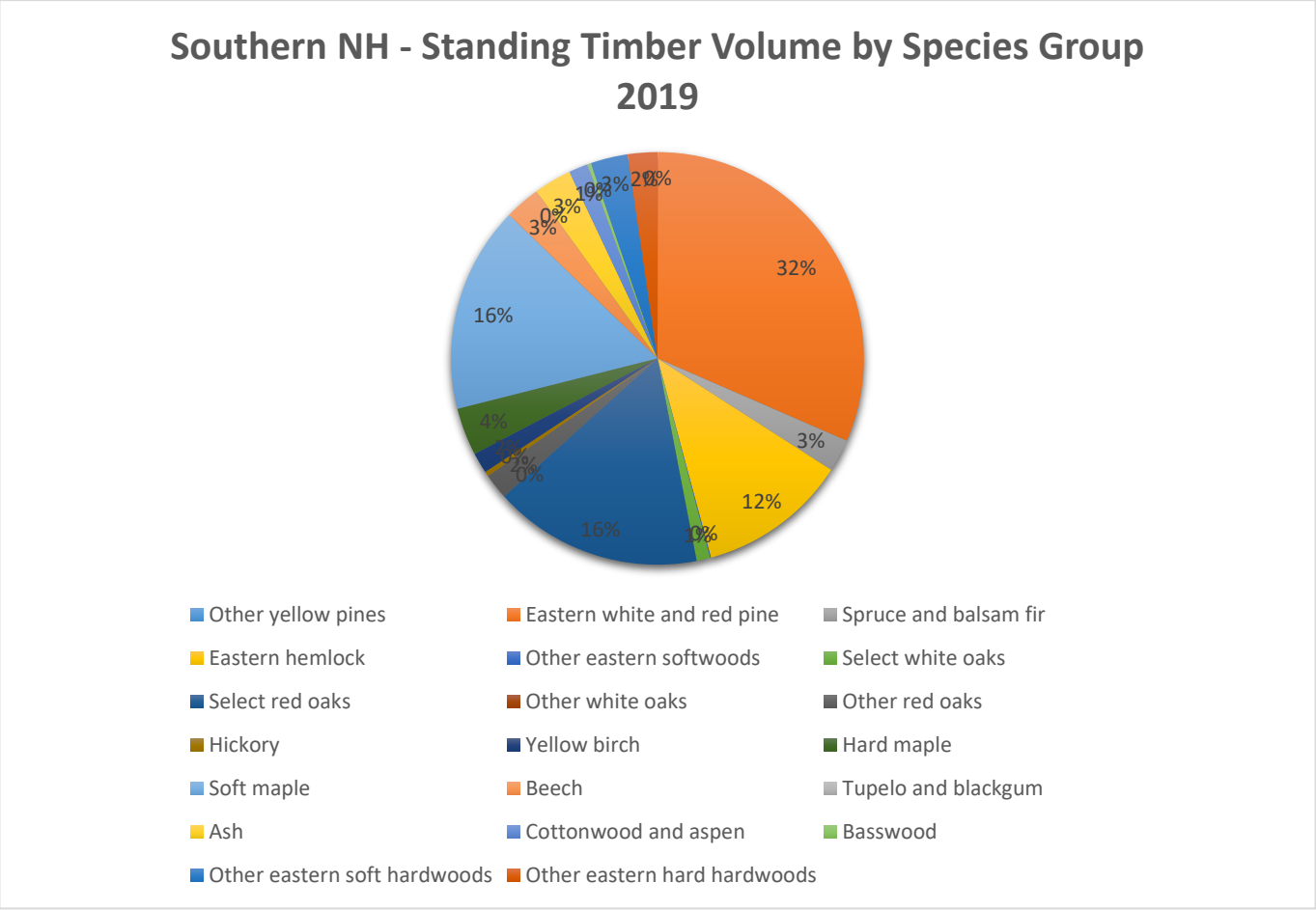
The breakdown of standing volume by species groups for the NH South sub-region can be seen in Figure 14. Eastern White Pine, Red Oaks and Soft Maple are the dominant species groups in terms of volume in the sub-region. Another substantial species group is Eastern Hemlock.

Figure 14 Southern NH Standing Timber Volumes



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 15 Southern NH Timber Volume by Species



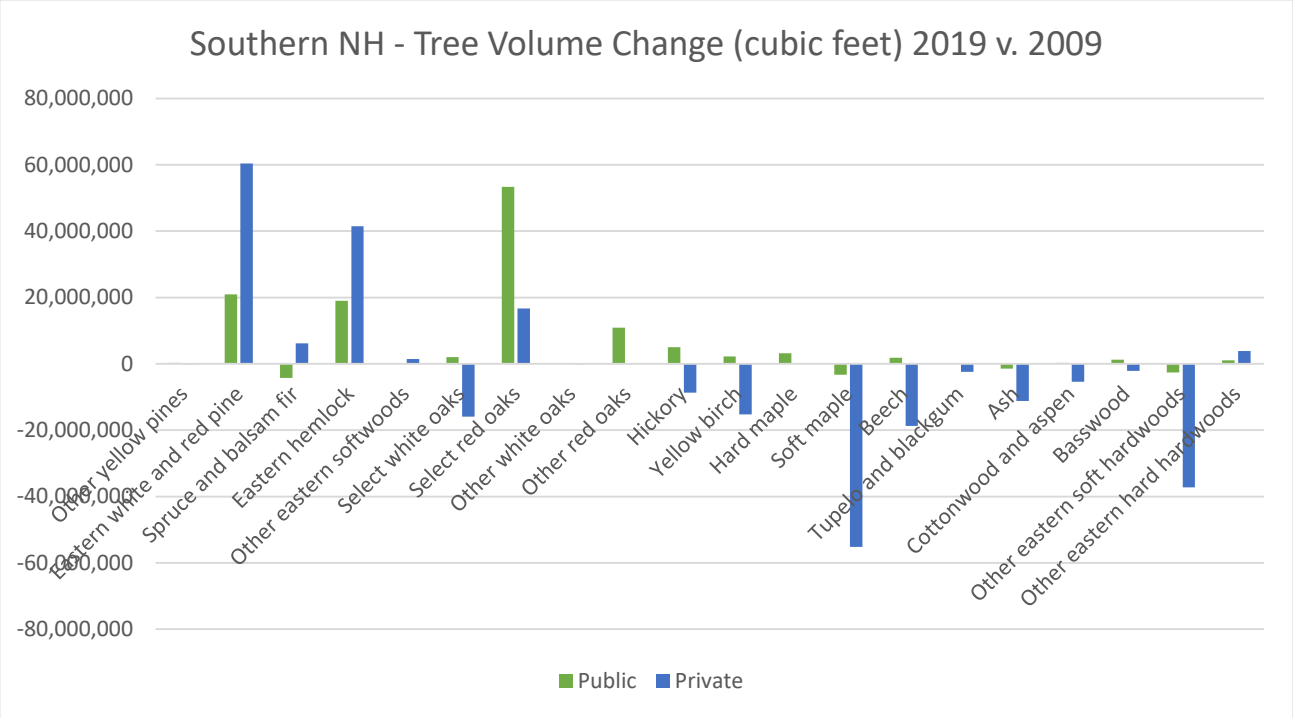
Source: USDA Forest Service, Forest Inventory and Analysis

Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber increased by 67,436,406 cubic feet or 1.3% of standing volume. This occurred despite a loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 16) but it must be understood as a current snapshot in time.

Figure 16 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups occurred on private land in the sub-region where most of the timber is harvested. Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 16, notable changes in species volume from 2009-2019 include large increases in White Pine, Hemlock and Oak. Reductions in standing volume during the 10-year time period include White Pine and Maples. It is important to note that overall standing timber stocking, i.e. the amount of timber that is standing per acre at over 22 cords, is considered good or even overstocked.

Figure 16 Southern NH Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

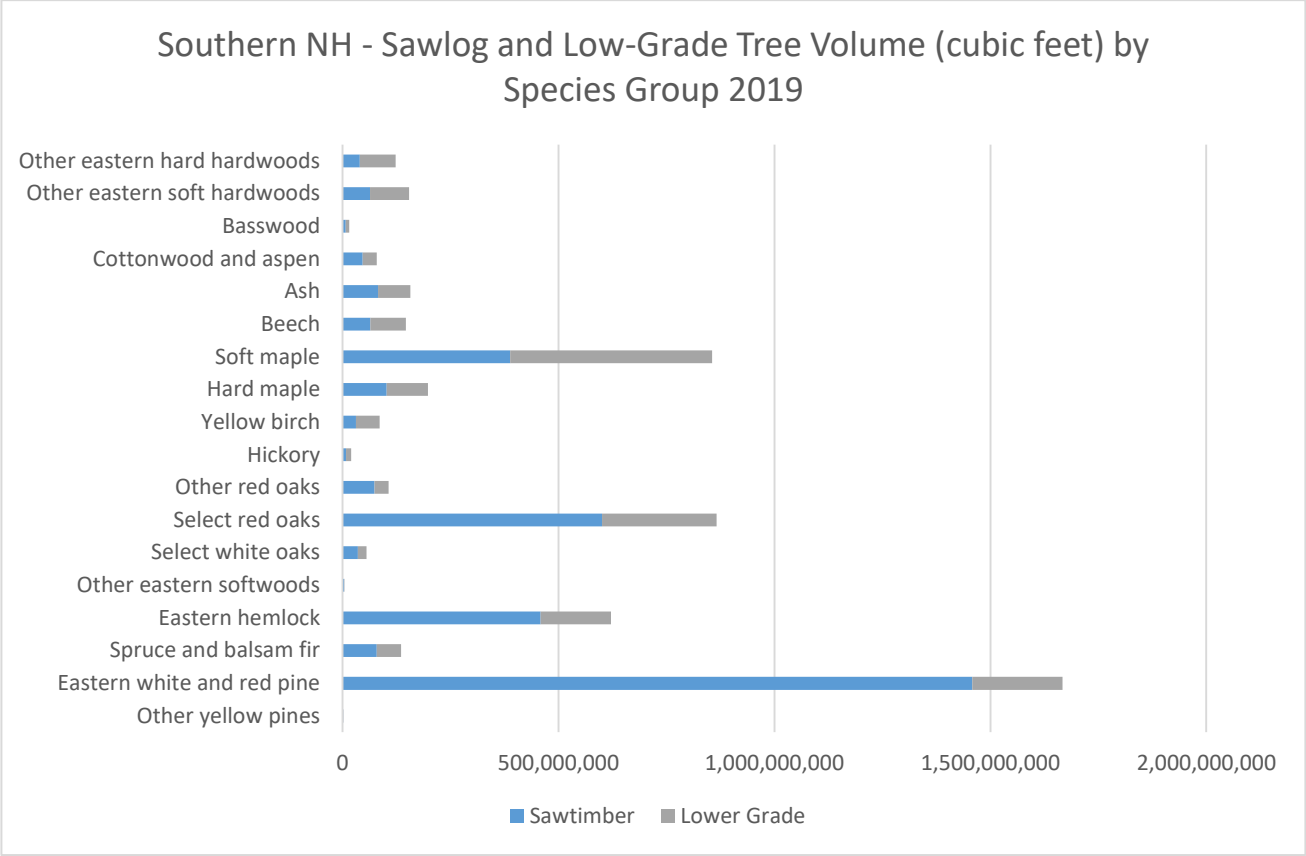
Note on Figure 16 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 17 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Maples, Red Oaks, Eastern Hemlock and White Pine all show sawlog volumes at or over half of standing volumes. Red oak is over 70% sawlog as is Eastern Hemlock. White Pine is over 85% sawlog volume. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 17 Southern NH Sawlog vs. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number in Figure 18 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 18. Net growth for the year was 91.0 million cubic feet and removals 34.7 million cubic feet. The important result (growth less removals) is a net increase of 56.3 million cubic feet (703,509 cords) of standing timber volume per year in the sub-region.

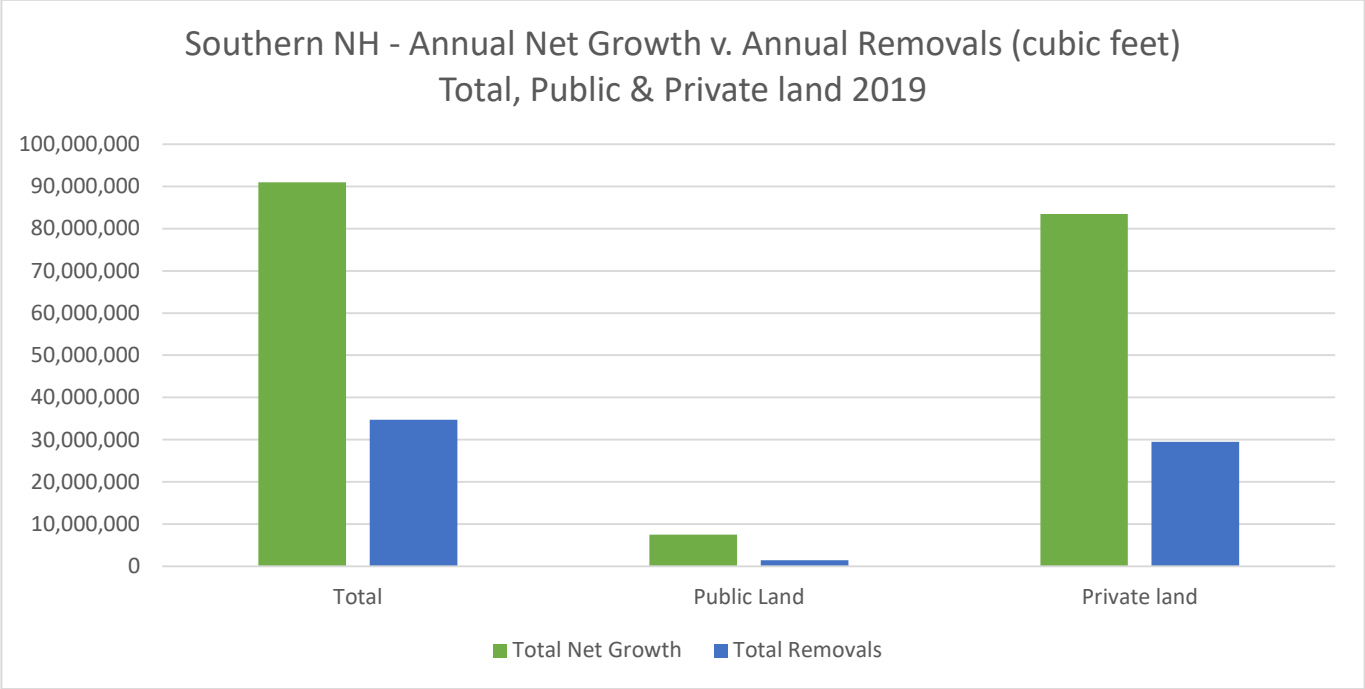
Figure 18 Southern NH Summary Table - Net Growth V. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Southern NH			
2019	***Net Growth***	cubic feet	
	all	90,948,195	
	public	7,457,125	
	private	83,491,070	
	Removals		**Removals from Harvest**
	all	30,858,407	32,845,677
	public	1,384,825	
	private	29,473,582	
	Growth less Removals		
	all	60,089,788	
	public	6,072,300	
	private	54,017,488	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 19. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

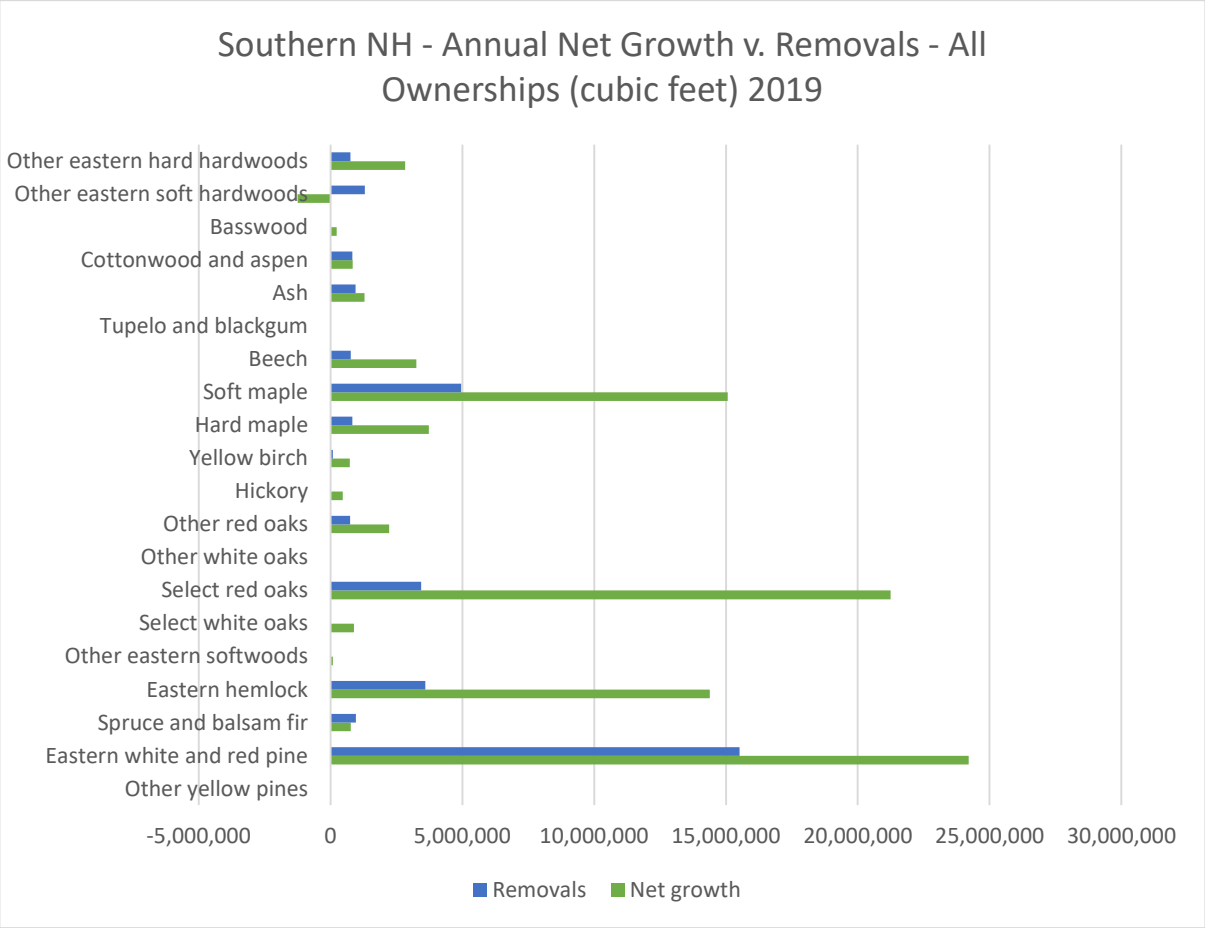
Figure 19 Southern NH Net Growth V. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

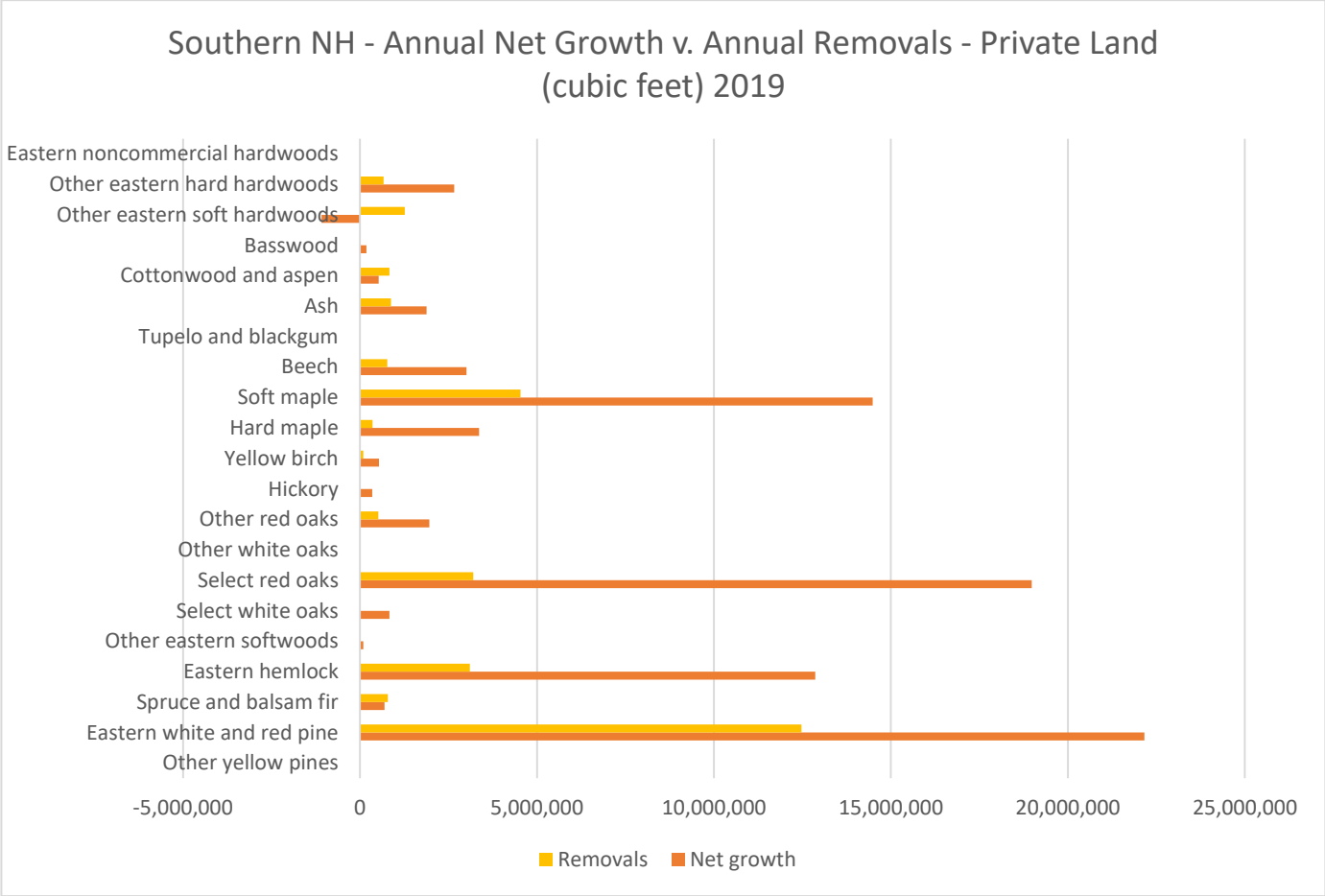
Figures 20 through 22 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Red Oaks and White Pine, the two dominant species groups in the sub-region, are showing a wide ratio of net growth to removals.

Figure 20 Southern NH Net Growth v. Removals by Species Group



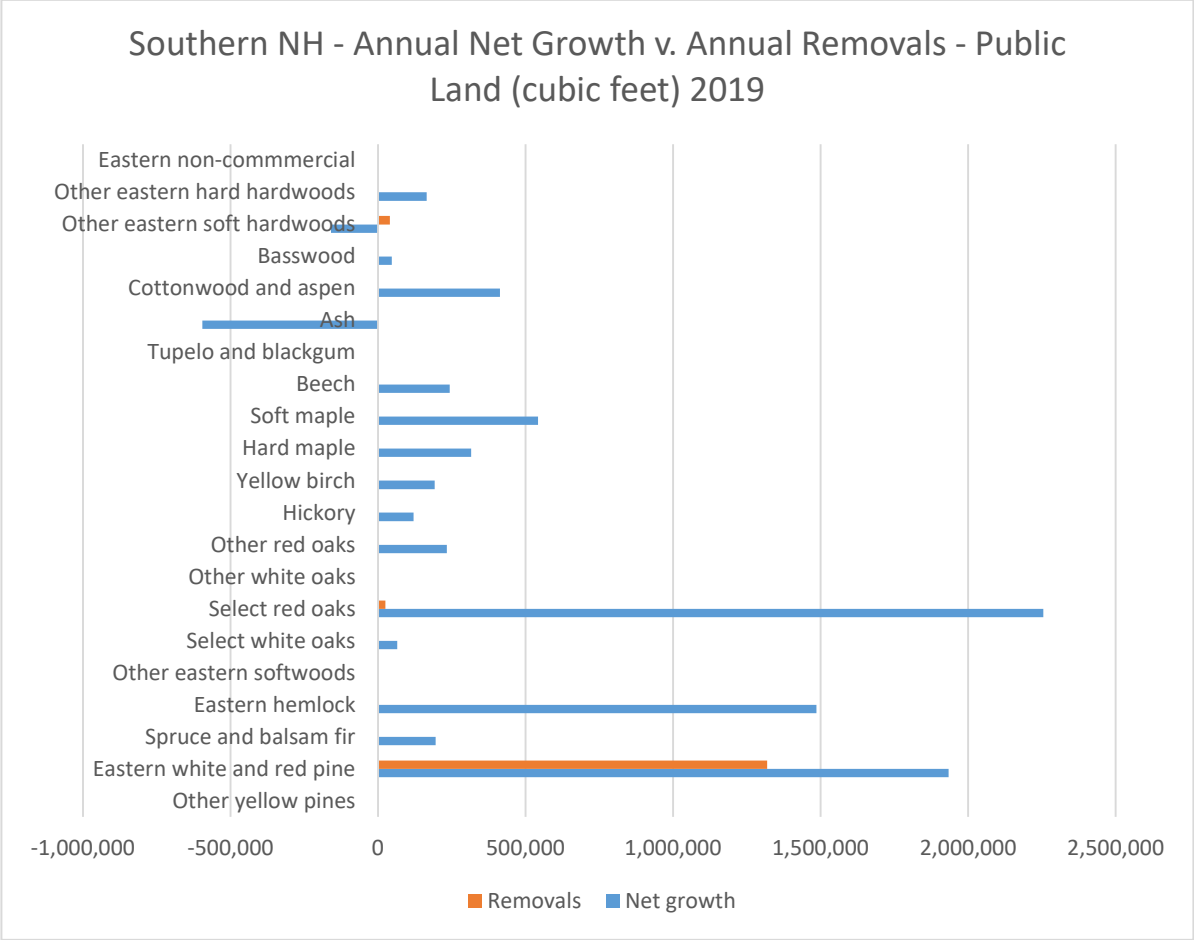
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 21 Southern NH Net Growth v. Removals Private Land



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 22 Southern NH Net Growth v. Removals Public Land



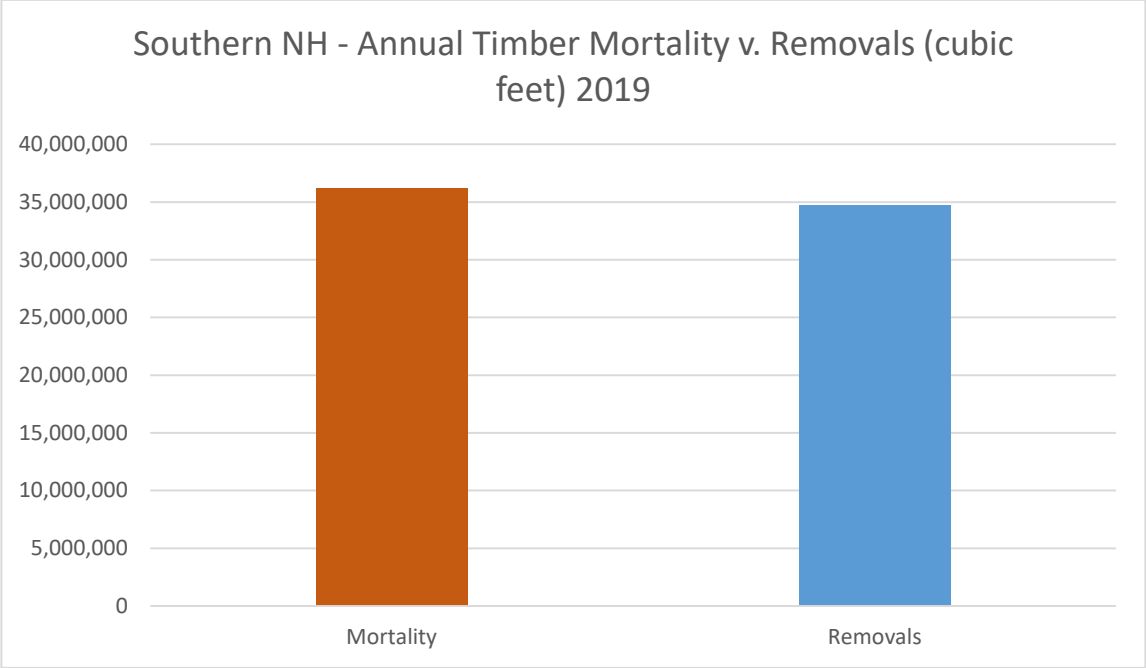
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 23 below shows the annual mortality in volume for Southern NH trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 105% of annual removals.

Figure 23 Southern NH Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

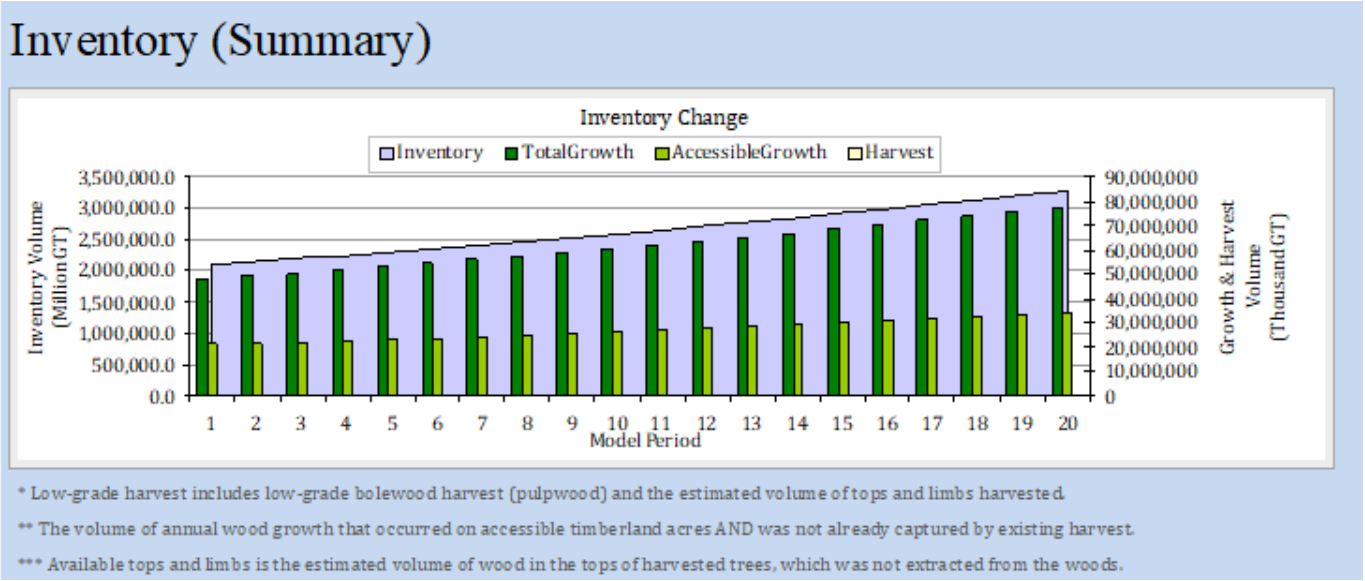
Future Timber Projections

Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the NH South sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

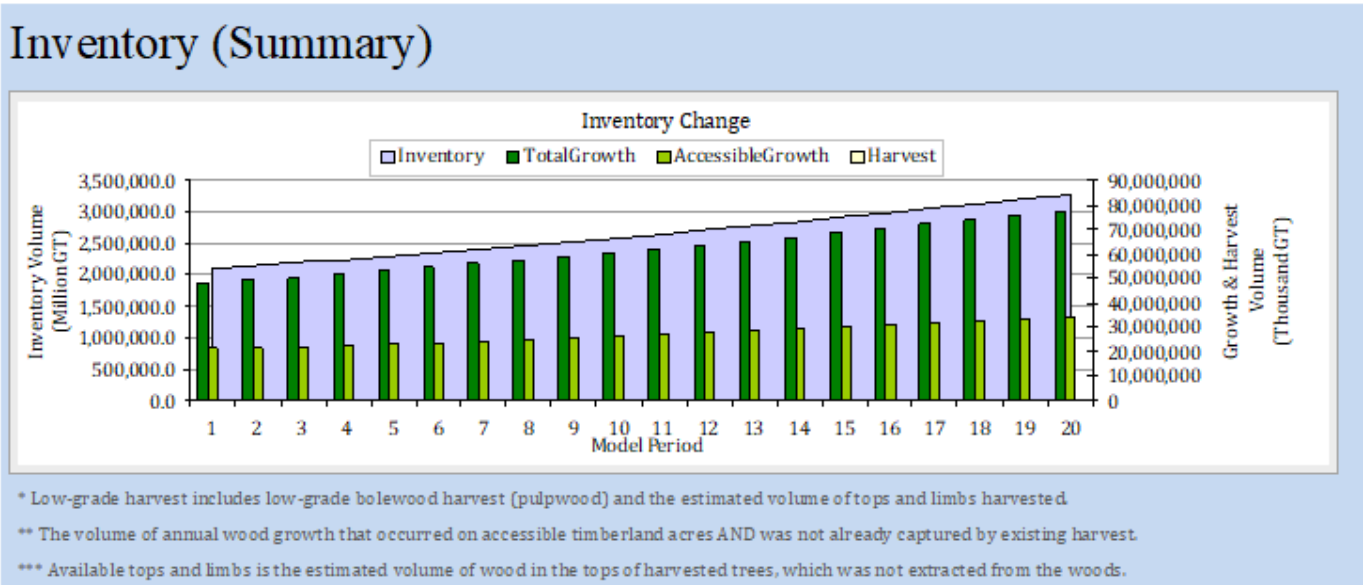


Available timber volume per year (Accessible Growth) in 2020 – 17,140,057green tons

Available timber volume per year in year 2040 – 27,679,572 green tons

Approximately 67% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

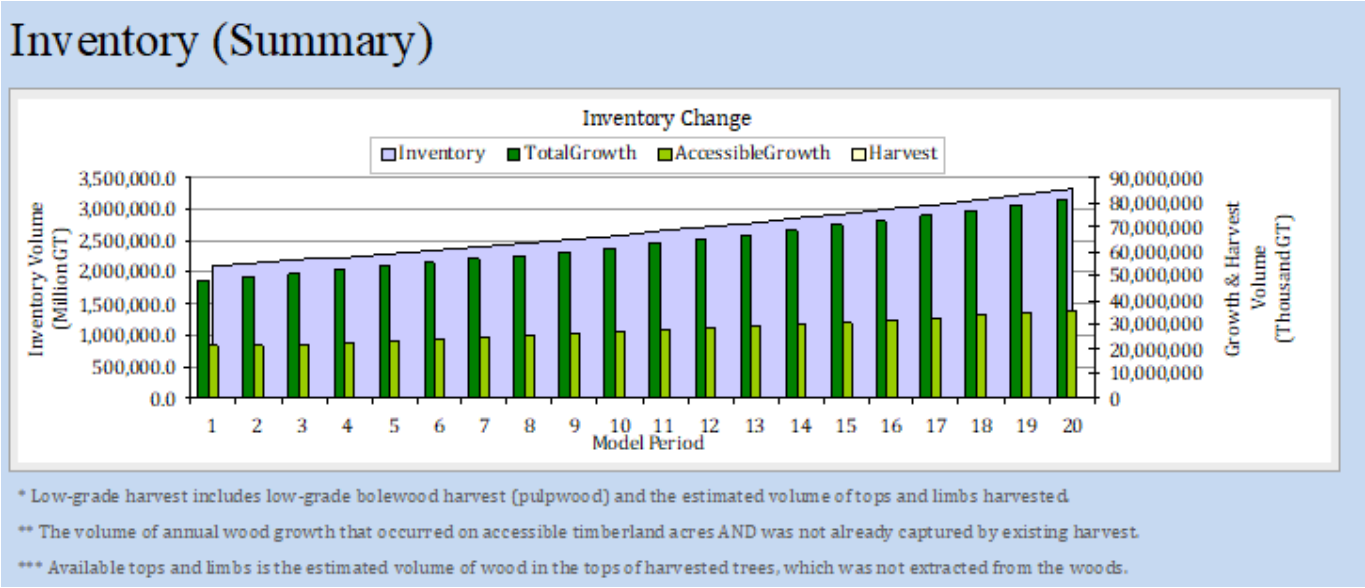


Available timber volume per year (Accessible Growth) in 2020 – 17,140,057 green tons

Available timber volume per year in year 2040 – 27,679,455 green tons

Approximately 67% of ending standing available volume in 2040 is in higher value quality timber.

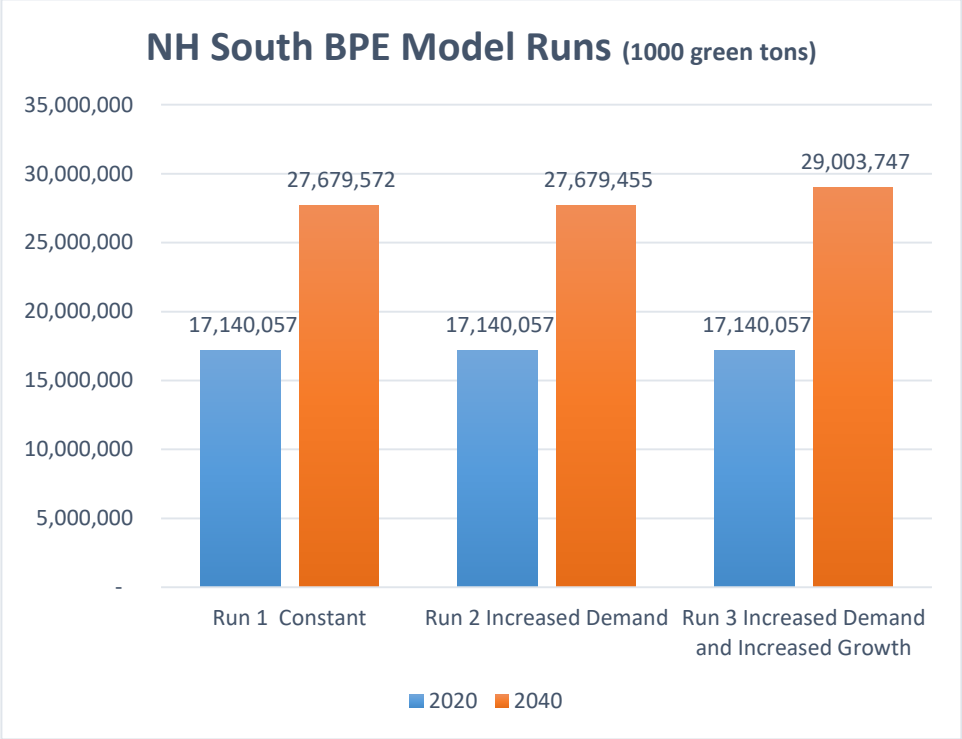
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 17,140,057 green tons

Available timber volume per year in year 2040 – 29,003,747 green tons

Approximately 67% of ending standing available volume in 2040 is in higher value quality timber.


NH South BPE Model Runs (1000 green tons)
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
-
17,140,057
27,679,572
17,140,057
27,679,455
17,140,057
29,003,747
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

3. Sub-Region VT – North

Overview - Vermont's northern 9 counties include some of the most rural parts of the state as well as three of the four most forested counties. The region includes over 3 million acres, with 73% classified as timberland. Eighty-seven percent is privately owned with roughly 48,000 acres under working forest conservation easements.

The region includes the "Northeast Kingdom" counties of Orleans, Caledonia and Essex which have a rich working land culture of farming and forestry. There is a legacy of large industrial forestry ownerships in the area with many large parcels now owned as long-term, private, working forest investments. The state's single largest parcel of industrial forestland (56,000+ acres) is also located in the region. Forest management is well accepted and valued by the residents and the sub-region is home to some of the state's largest and most productive harvesting contractors.

Merchantable bole volume of growing stock trees across the region averages 23 cords/acre. On a volume basis, the most abundant species groups are (in descending order): hard maple; soft maple; spruce/balsam fir; eastern hemlock; and yellow birch. Species groups with the highest standing sawtimber volumes are hard maple; eastern hemlock; spruce/balsam fir; eastern white pine; and soft maple. Net growth to removals ratio averages 2.0 with the largest positive ratios in ash, yellow birch, eastern hemlock, beech, soft maple and hard maple.

Population within the region has remained stable, with a net population increase of just 615 people between 2008 and 2018. Population has generally increased in the counties nearest the state's major population center in Chittenden County (where Burlington is located) and has fallen in counties farther to the east. Population increased by 5.5% in Lamoille County and just over 4% in Franklin County. Population decreased by nearly 3% in Caledonia County.

The region's labor force (as of May 2020) totaled just over 125,000 with the labor force mirroring population trends.

Forest product processing capacity in the region is limited with most markets for sawlogs clustered along the international border in Quebec or in southern Vermont or New Hampshire and Maine. Pulpwood markets for the region are found primarily in western Maine. Biomass electric markets are located in Caledonia County and Coos County in adjacent New Hampshire.

Timber data major findings for the VT – North Sub-region - The Northern VT sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 2.0:1, meaning that for every unit of timber harvested, 2.0 units are grown. On public land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 6.5:1. On private lands, the ratio is 2.0:1 for all species and that is also true of all major species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 22.9 cords per acre for both public and private land. This indicates substantial standing timber in the sub-

region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for the Maples, Yellow Birch and Eastern Hemlock is nearly 3:1 for both public and private lands.

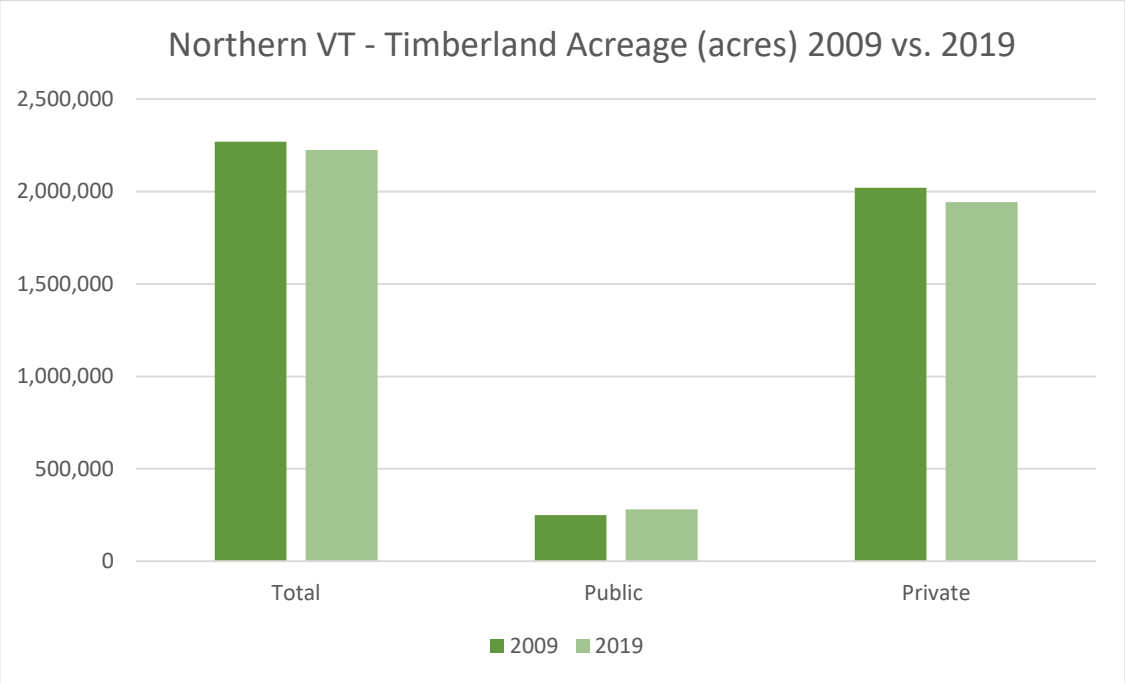
Lastly, the natural mortality in the forest of this sub-region at 40,067,808 cubic feet per year, is close to 100% of the annual removals at 40,148,109 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

The Northern VT sub-region is heavily forested and well stocked with standing timber. Forests are growing timber at rates higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

This region includes Caledonia, Essex, Franklin, Grand Isle, Lamoille, Orange, Orleans and Washington Counties in Vermont and represents approximately 2,223,811 acres of timberland. As a percentage of land and water area in the sub-region, the area is 73% forested. The sub-region has almost seven times the timberland acreage in private land as it does in public land (1,943,182 acres private vs. 280,629 acres public) – see Figure 24. Comparing the area using 2009 and 2019 data, the sub-region lost 46,274 acres of timberland over the 10-year period (approximately 2 % of the forests in the sub-region). The area gained 30,723 acres of public land during that period and lost 76,997 acres of private land (from the public land gained plus additional acreage that changed to developed or agricultural uses). Much of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests).

Figure 24 Northern VT - Timberland Area



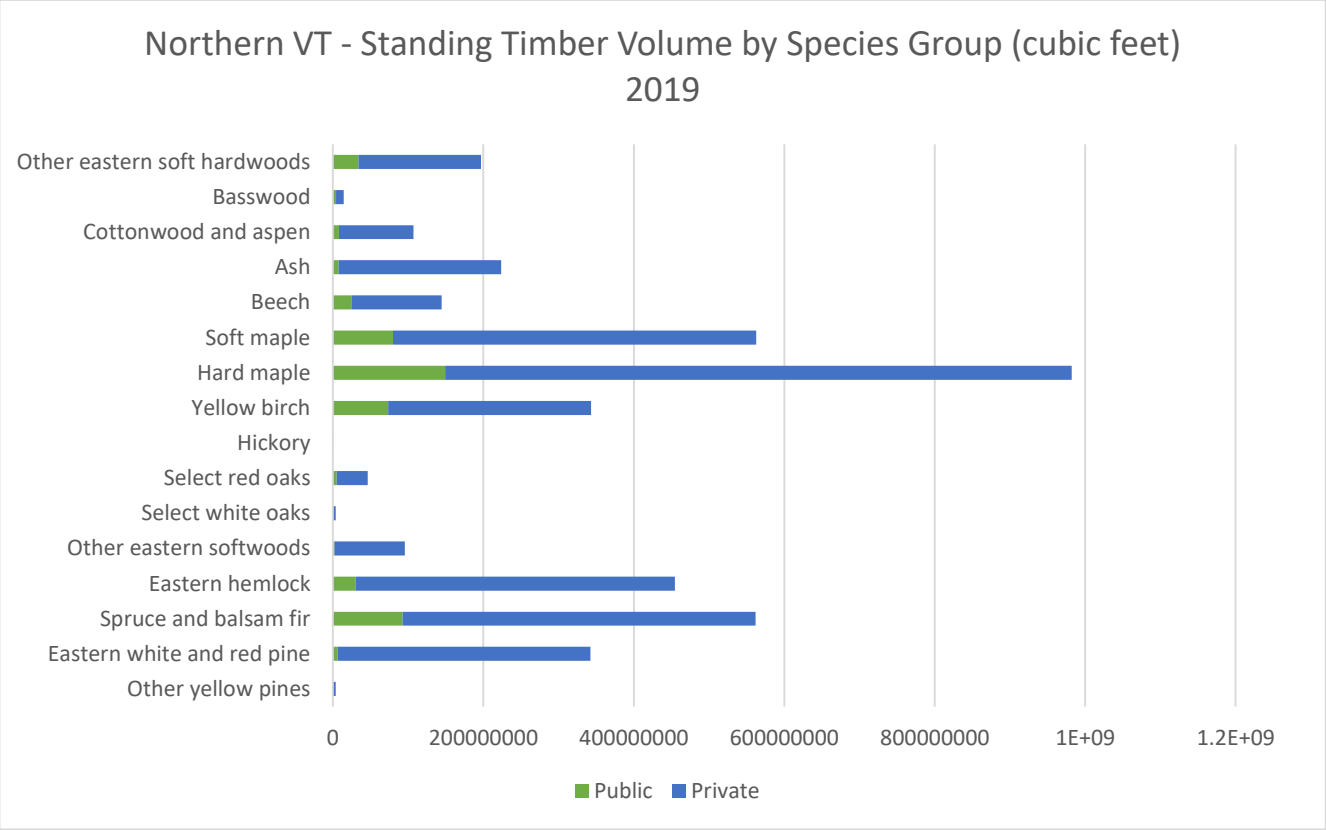
Source: USDA Forest Service, Forest Inventory and Analysis

Timber Volume and Changes 2009-2019

Overall, on all timberlands in the nine-county region, standing timber volume in 2019 for all species was 4,081,985,098 cubic feet. This represents 1,835.6 cubic feet/acre or 22.9 cords per acre – 22.9 cords/ac private land and 23.0 cords/ac on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

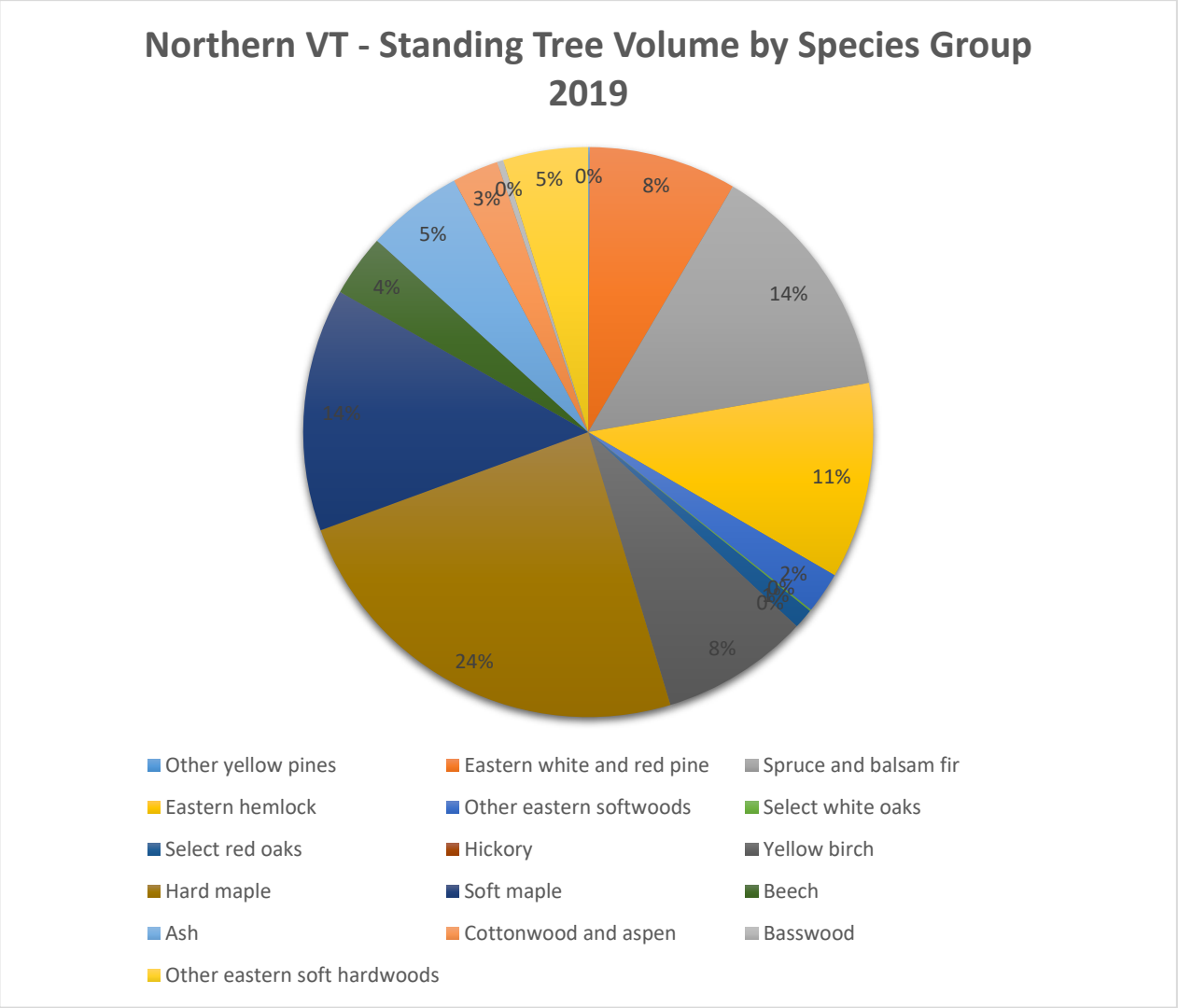
The breakdown of standing volume by species groups for the VT North sub-region can be seen in Figure 25. The Maples, Birch, Eastern Hemlock and Spruce/Fir are the dominant species groups in terms of volume in the sub-region. Another substantial species group is Eastern White Pine.

Figure 25 Northern VT Standing Timber Volumes



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 26 Northern VT Timber Volume by Species



Source: USDA Forest Service, Forest Inventory and Analysis

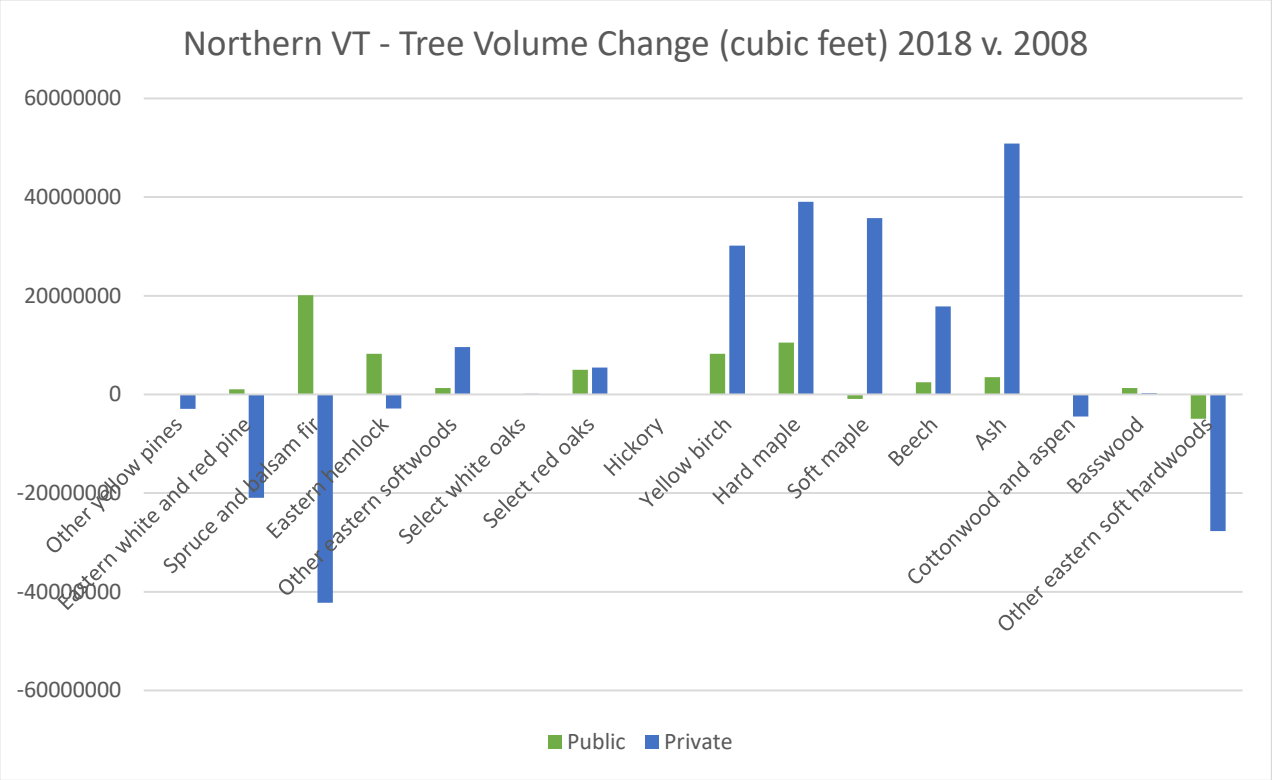
Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber increased by 143,929,726 cubic feet or 3.7% of standing volume. This occurred despite a loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 27) but it must be understood as a current snapshot in time.

Figure 27 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups occurred on private land in the sub-region where most of the timber is harvested. Generally

speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 27, notable changes in species volume from 2009-2019 include large increases in the Maples, Birch, Beech and Ash. Reductions in standing volume during the 10-year time period include White Pine on private land (increase on public) and Spruce/Fir. It is important to note that overall standing timber stocking, i.e. the amount of timber that is standing per acre at nearly 23 cords, is considered good or even overstocked.

Figure 27 Northern VT Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

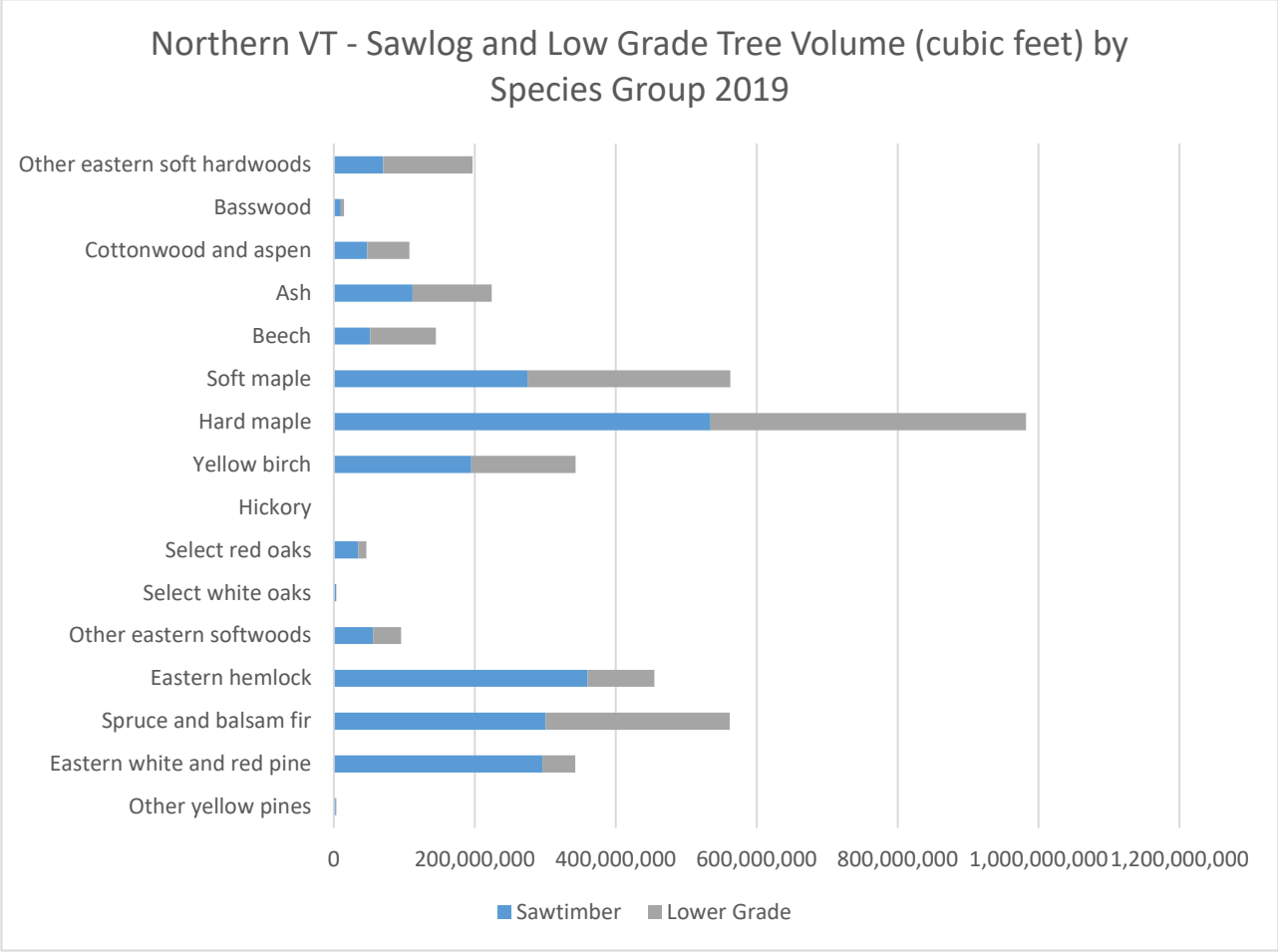
Note on Figure 27 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 28 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Maples, Birch, Eastern Hemlock, Spruce/Fir and White Pine all show sawlog volumes at or over half of standing volumes. Eastern Hemlock & White Pine is over 80% sawlog volume. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 28 Northern VT Sawlog vs. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number in Figure 29 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 29. Net growth for the year was 82.1 million cubic feet and removals 40.1 million cubic feet. The important result (growth less removals) is a net increase of 41.9 million cubic feet (523,880 cords) of standing timber volume per year in the sub-region.

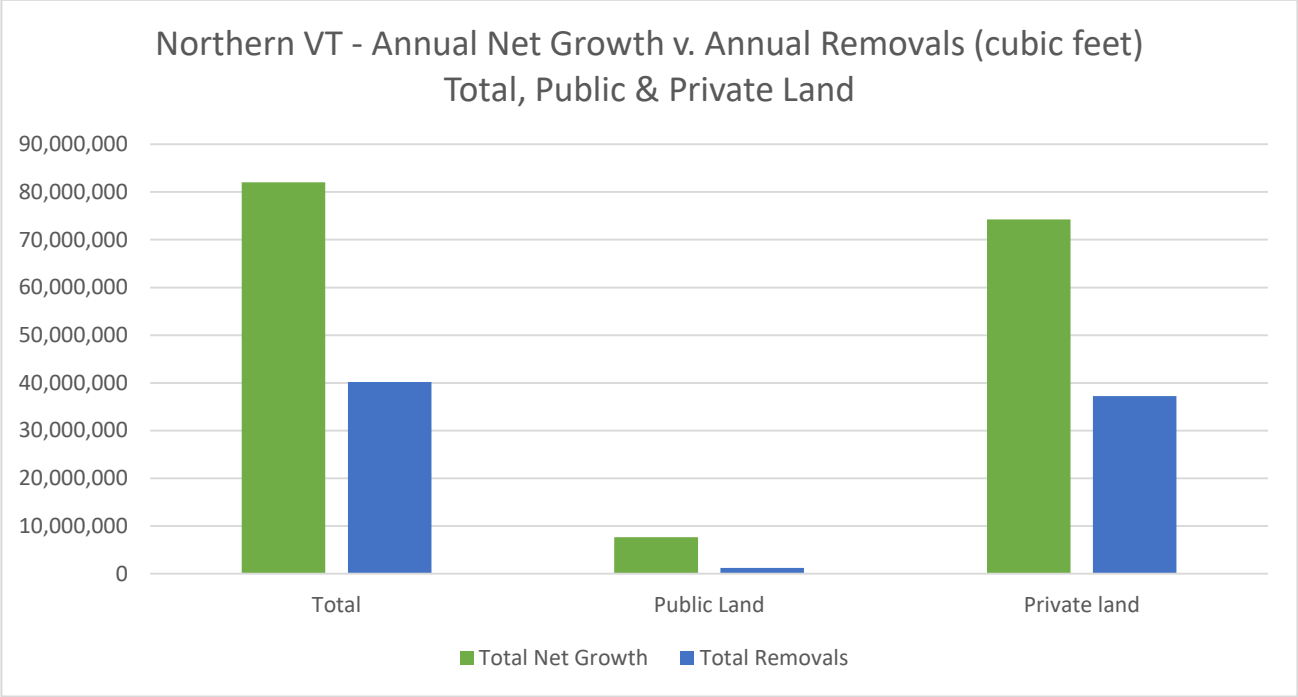
Figure 29 Northern VT Summary Table - Net Growth v. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Northern VT			
2019	***Net Growth***	cubic feet	
	all	82,058,538	
	public	7,638,883	
	private	74,243,183	
	Removals		**Removals from Harvest**
	all	40,148,109	40,126,726
	public	1,182,887	
	private	37,218,325	
	Growth less Removals		
	all	41,910,429	
	public	6,455,996	
	private	37,024,858	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 30. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

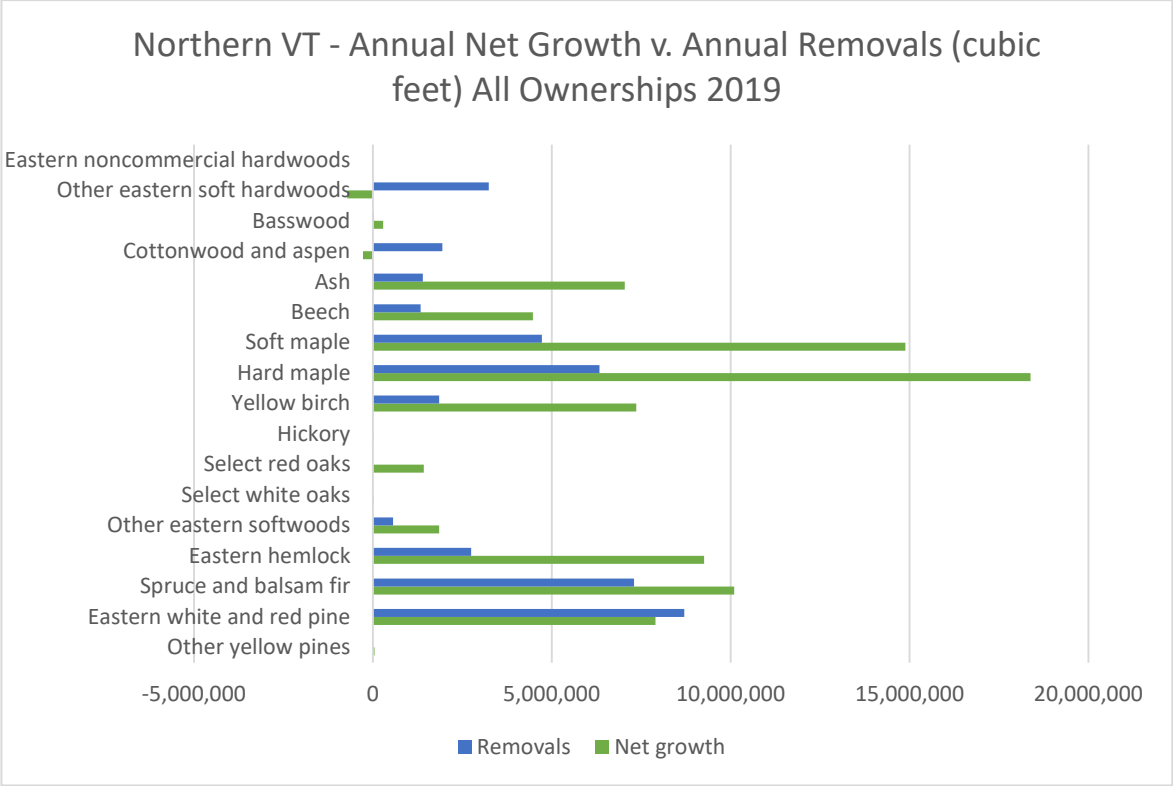
Figure 30 Northern VT Net Growth v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

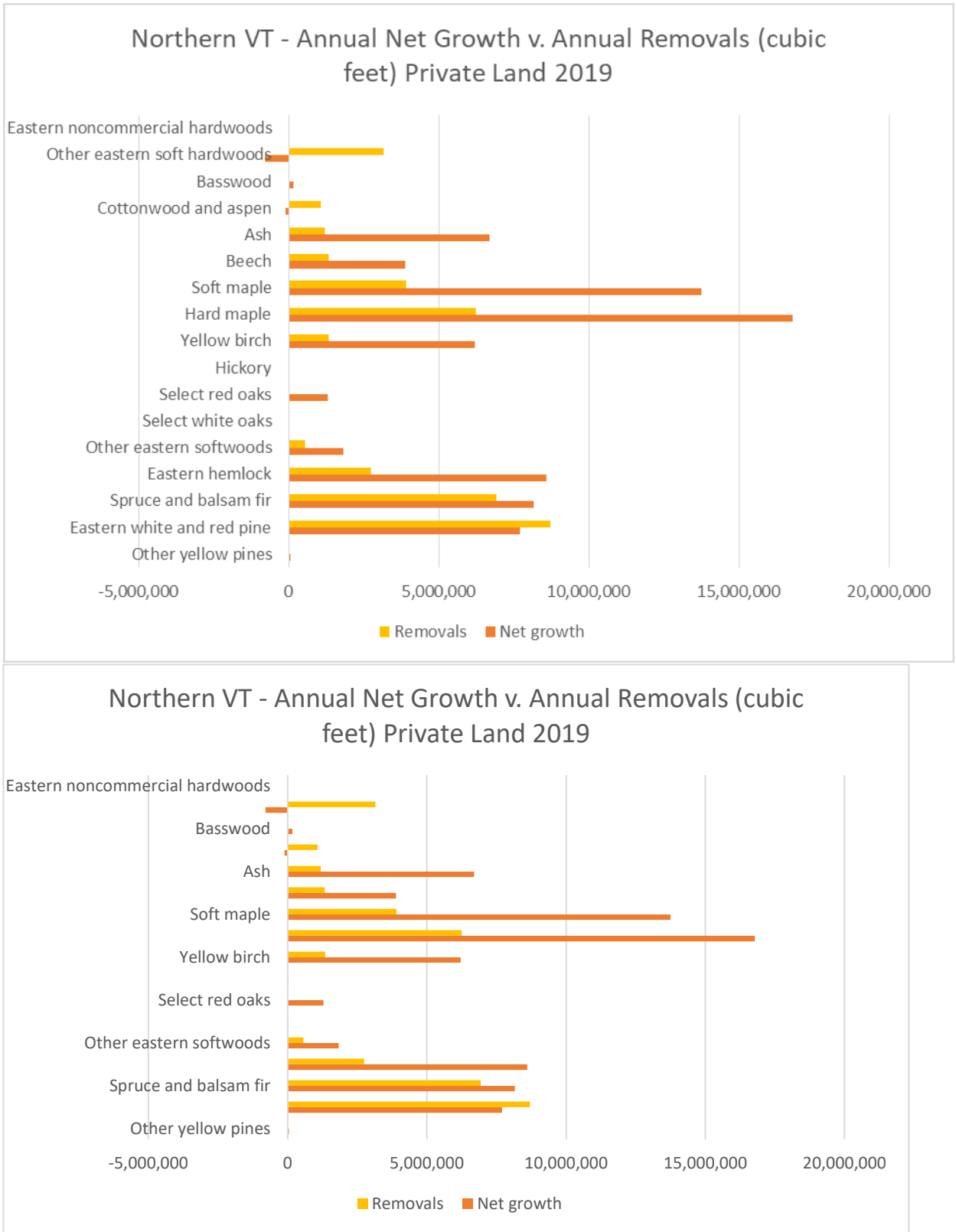
Figures 31 through 33 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Red Oaks and White Pine, the two dominant species groups in the sub-region, are showing a wide ratio of net growth to removals.

Figure 31 Northern VT Net Growth v. Removals by Species Group



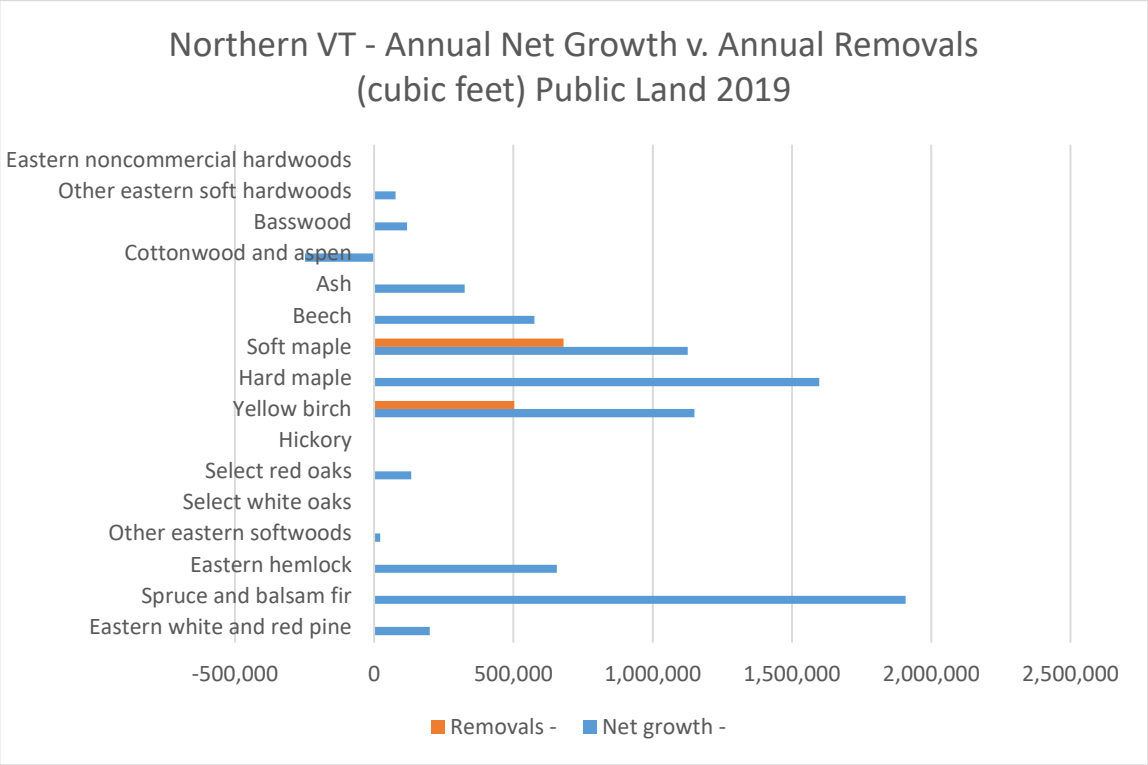
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 32 Northern VT Net Growth v. Removals Private Land



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 33 Northern VT Net Growth v. Removals Public Land



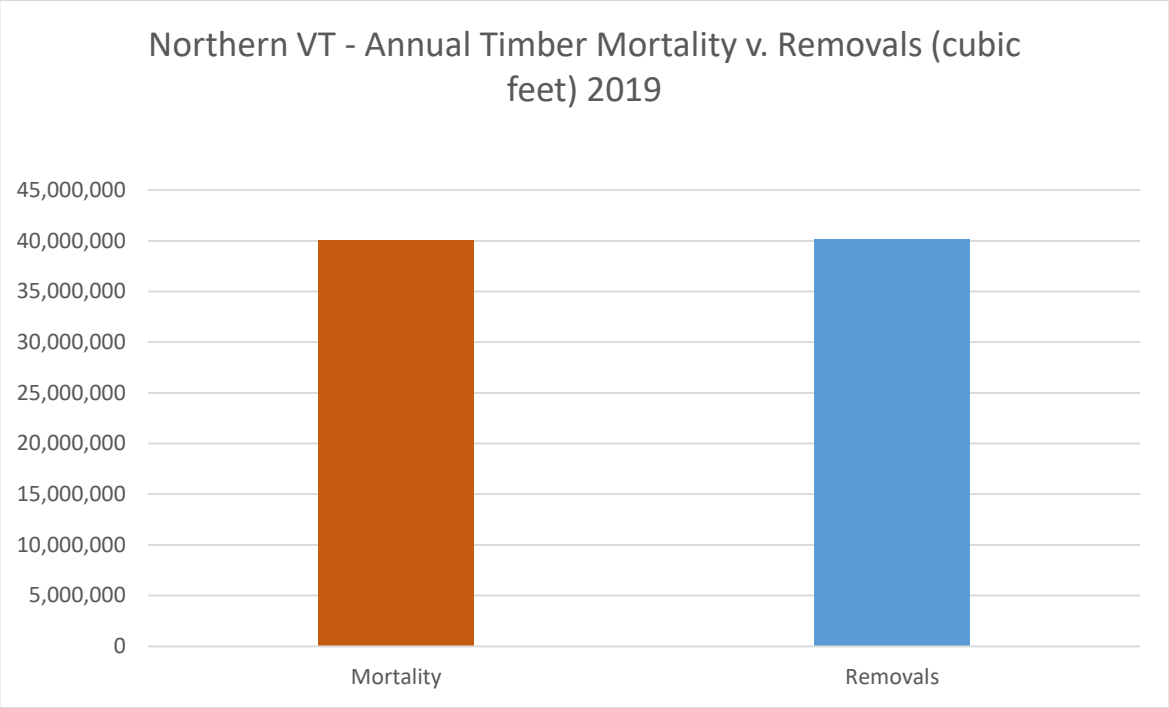
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 34 below shows the annual mortality in volume for Northern VT trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 105% of annual removals.

Figure 34 Northern VT Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

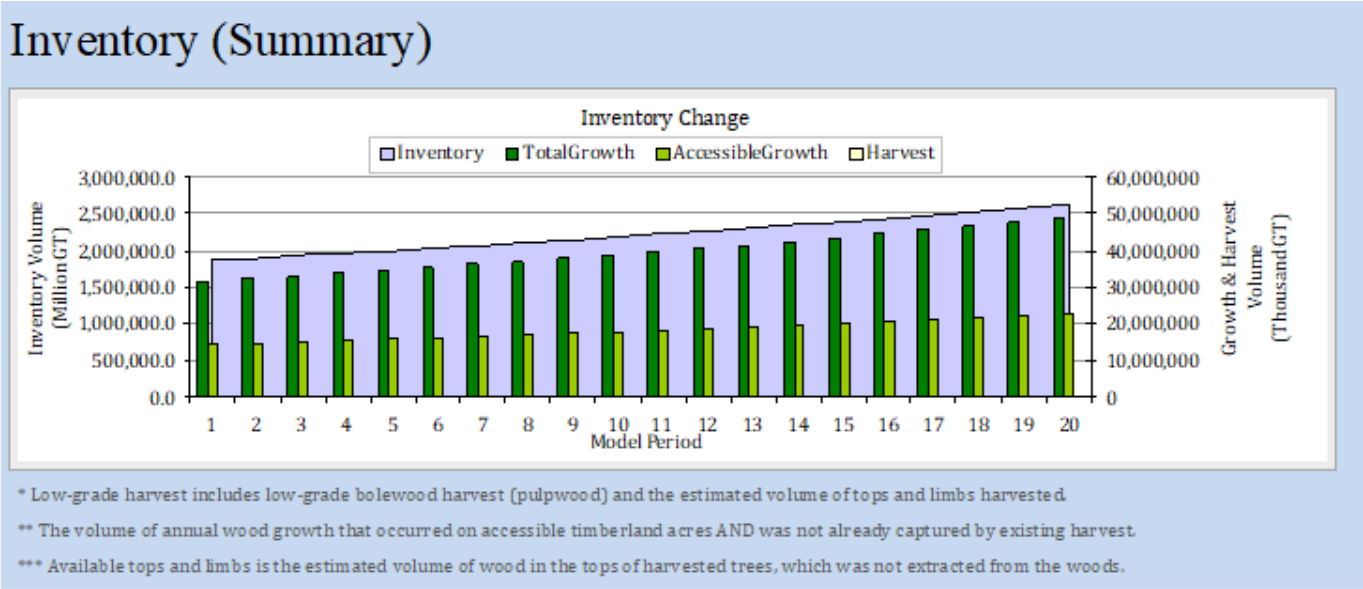
Future Timber Projections

Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the VT North sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

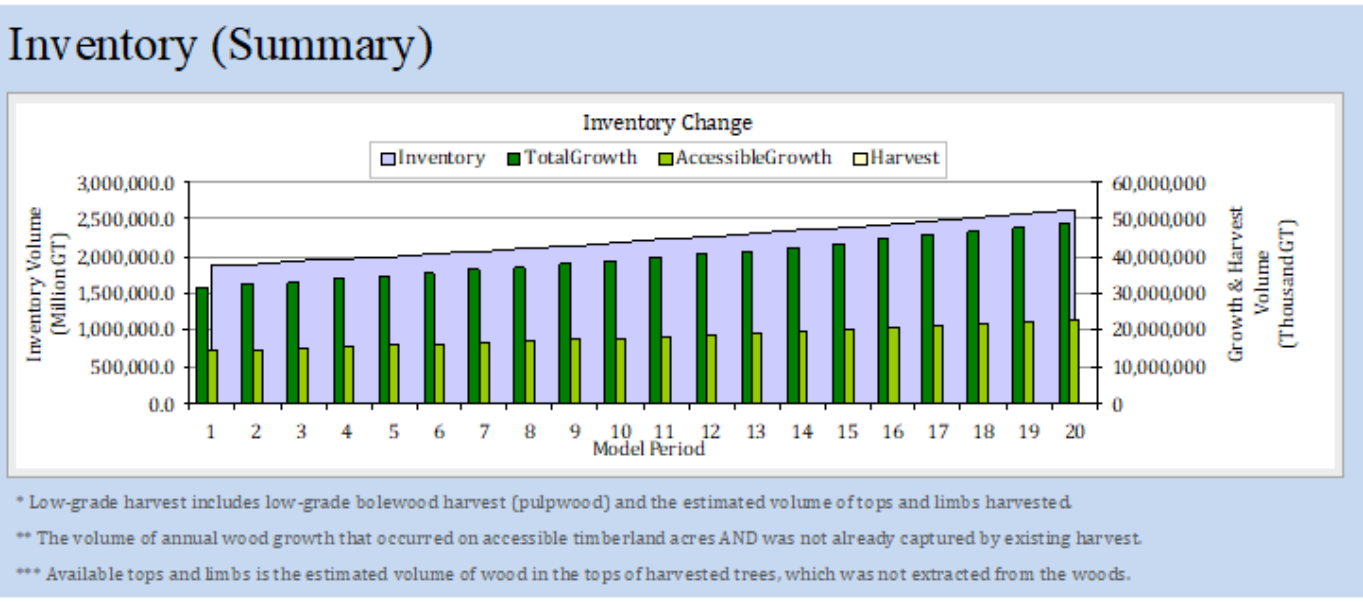


Available timber volume per year (Accessible Growth) in 2020 – 11,685,248 green tons

Available timber volume per year in year 2040 – 18,124,147 green tons

Approximately 58% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

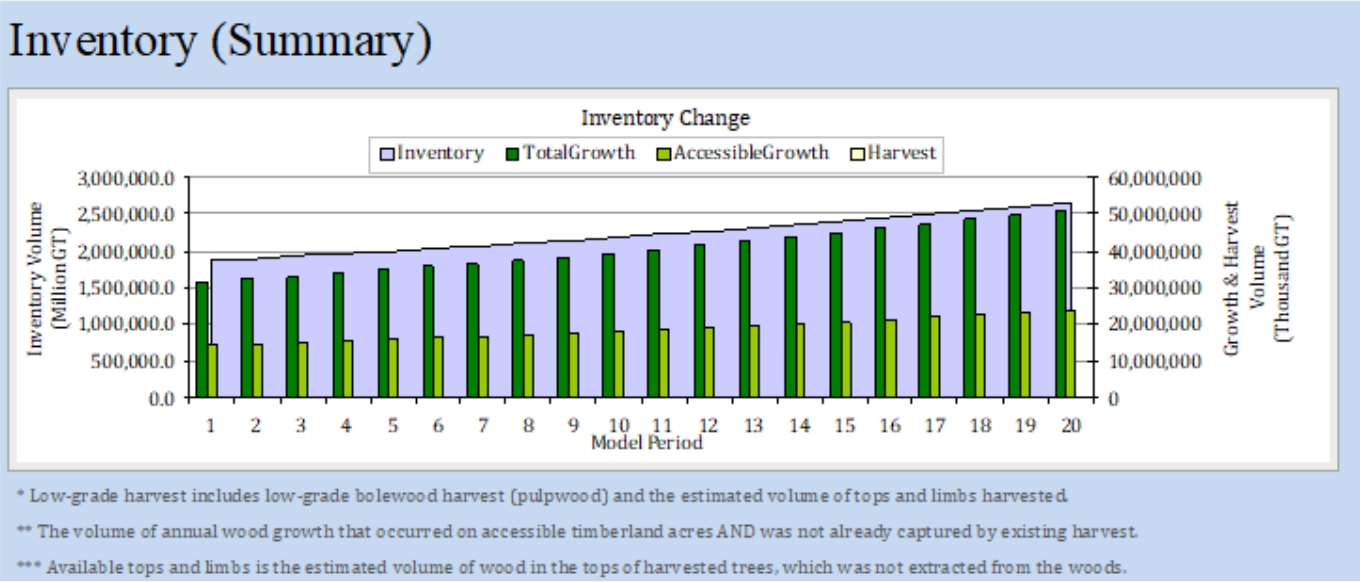


Available timber volume per year (Accessible Growth) in 2020 – 11,685,248 green tons

Available timber volume per year in year 2040 – 18,124,004 green tons

Approximately 58% of ending standing available volume in 2040 is in higher value quality timber.

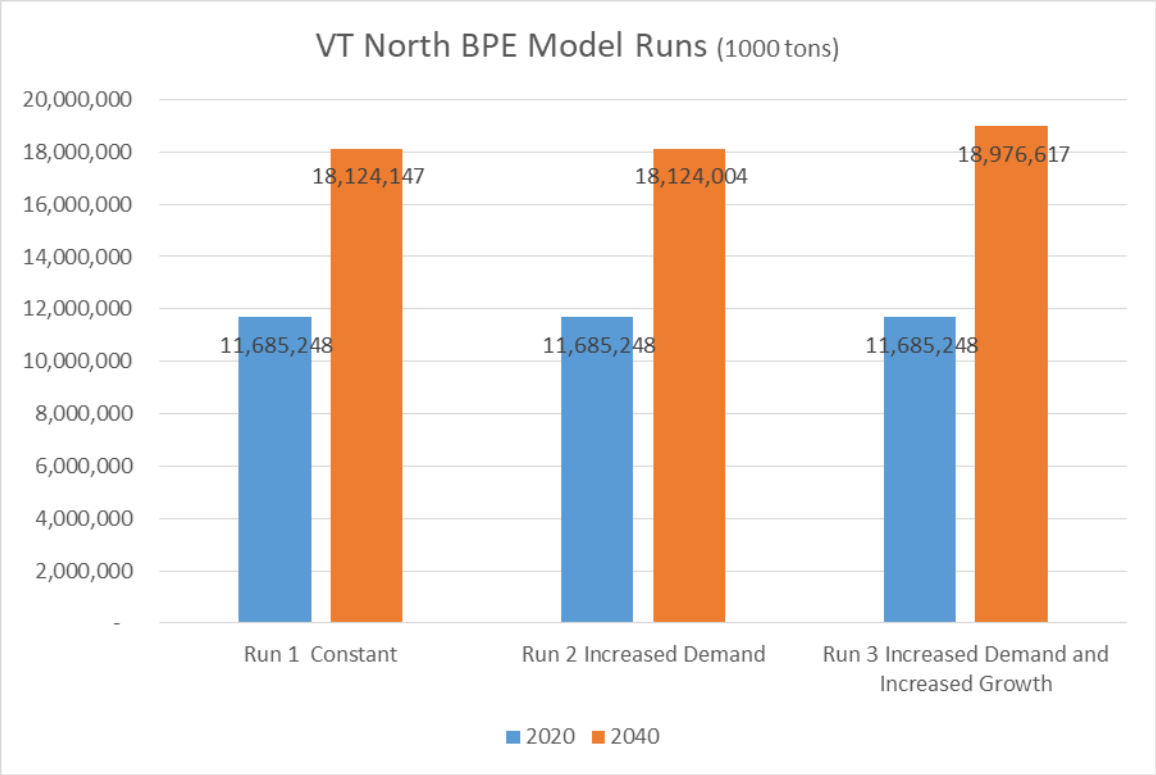
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 11,685,248 green tons

Available timber volume per year in year 2040 – 18,976,617green tons

Approximately 58% of ending standing available volume in 2040 is in higher value quality timber.


VT North BPE Model Runs (1000 tons)
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
18,124,147
18,124,004
18,976,617
11,685,248
11,685,248
11,685,248
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

4. Sub-Region VT – South

Overview - Vermont's "Southern" sub-region includes the four southern-most counties in the state as well as the "Champlain Valley" counties of Addison and Chittenden. The region includes over 3 million acres and 67% is classified as timberland. Eighty percent of the timberland is privately owned. Public ownership includes the Green Mountain National Forest at over 400,000 acres.

This region is quite diverse in terms of both demographics and land use. It includes Vermont's most urban county (Chittenden), as well as some of the state's most productive farmland (Addison County) and the second most heavily forested county (Windham County) in the state.

Merchantable bole volume of growing stock trees across the region averages 29 cords/acre. On a volume basis, the most abundant species groups are (in descending order): Hard (sugar) Maple; Soft (red) Maple; Eastern White Pine; Eastern Hemlock; and Ash. Species groups with the highest standing sawtimber volumes are Hard Maple; Eastern White Pine; Eastern Hemlock; Soft Maple; and Red Oak. Net growth to removals ratio averages 2.2 with the largest positive ratios in Yellow Birch, Hickory, Hard Maple, Beech and select White Oaks.

Overall population within the region increased by a total of 1,533 people between 2008 and 2018. Chittenden county's population grew by 9900 (over 6%) while population decreased in all four of the southernmost counties with Rutland County declining the most at 6%.

The region's labor force (as of May 2020) totaled just over 216,500 with the labor force mirroring population trends.

The majority of Vermont's forest product processing capacity is located in the region. Sawmill capacity is greatest in Windham, Addison, Rutland and Chittenden Counties or New Hampshire. Pulpwood markets closest to this region are located in adjacent New York State. In addition, Chittenden County is home to a biomass electric generating station.

Timber data major findings for the VT – South Sub-region - The Southern VT sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 2.2:1, meaning that for every unit of timber harvested, 2.2 units are grown. On public land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 3.4:1. On private lands, the ratio is 2.0:1 for all species and that is also true of all major species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 29.4 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for the Maples, Yellow Birch, and Beech is nearly 3:1 for both public and private lands.

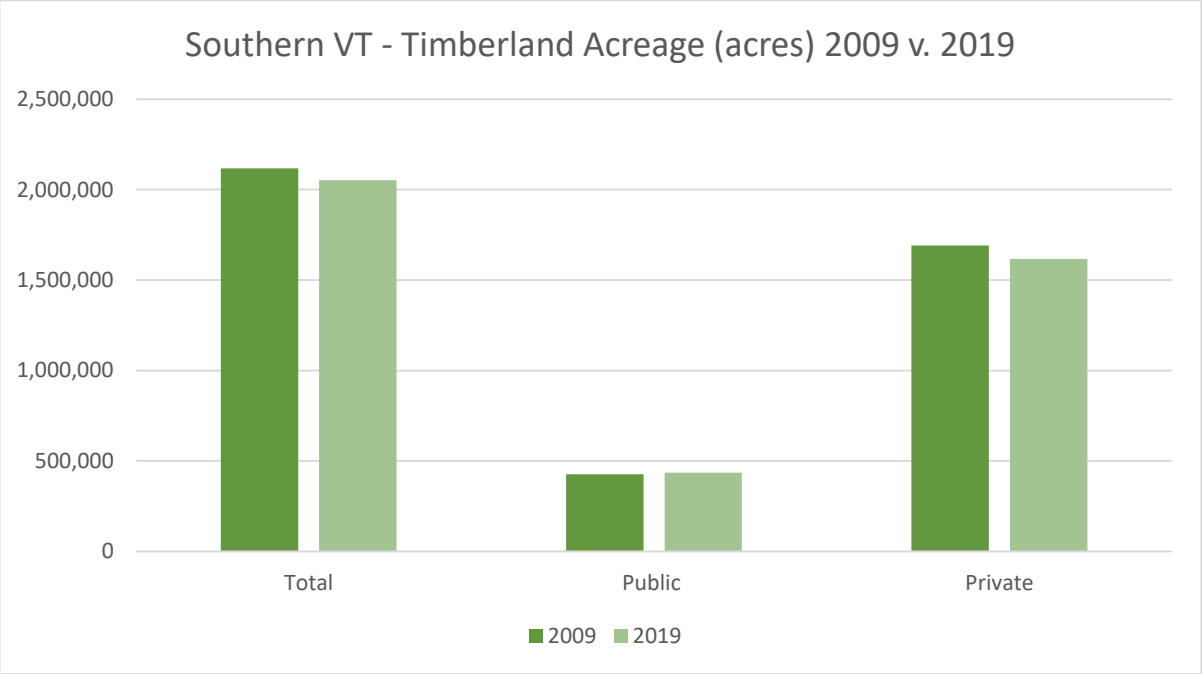
Lastly, the natural mortality in the forest of this sub-region at 34,316,740 cubic feet per year, is over 91% of the annual removals at 37,667,452 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

The Southern VT sub-region is heavily forested and well stocked with standing timber. Forests are growing timber at rates higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

This region includes Addison, Bennington, Chittenden, Rutland, Windham and Windsor Counties in Vermont and represents approximately 2,051,841 acres of timberland. As a percentage of land and water area in the sub-region, the area is 67% forested. The sub-region has almost four times the timberland acreage in private land as it does in public land (1,616,550 acres private vs. 435,291 acres public) – see Figure 35. Most of the public land is in the Green Mt. National Forest. Comparing the area using 2009 and 2019 data, the sub-region lost 65,752 acres of timberland over the 10-year period (approximately 3 % of the forests in the sub-region). The area gained 8,824 acres of public land during that period and lost 74,576 acres of private land (from the public land gained plus additional acreage that changed to developed or agricultural uses). Much of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests).

Figure 35 Southern VT - Timberland Area



Source: USDA Forest Service, Forest Inventory and Analysis

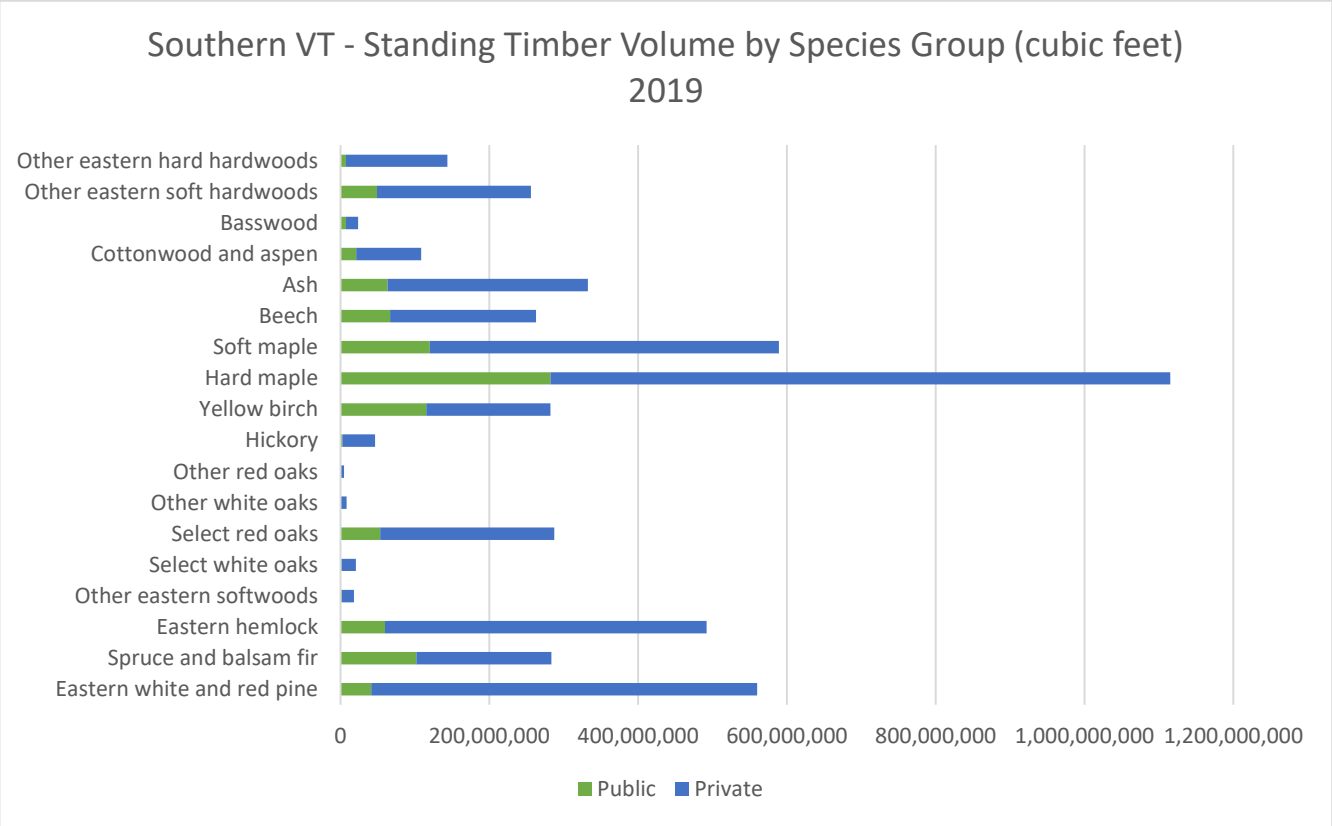
Timber Volume and Changes 2009-2019

Overall, on all timberlands in the six-county region, standing timber volume in 2019 for all species was 4,832,837,347 cubic feet. This represents 2,355.4 cubic feet/acre or 29.4 cords per acre –

29.7 cords/ac private land and 28.5 cords/ac on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

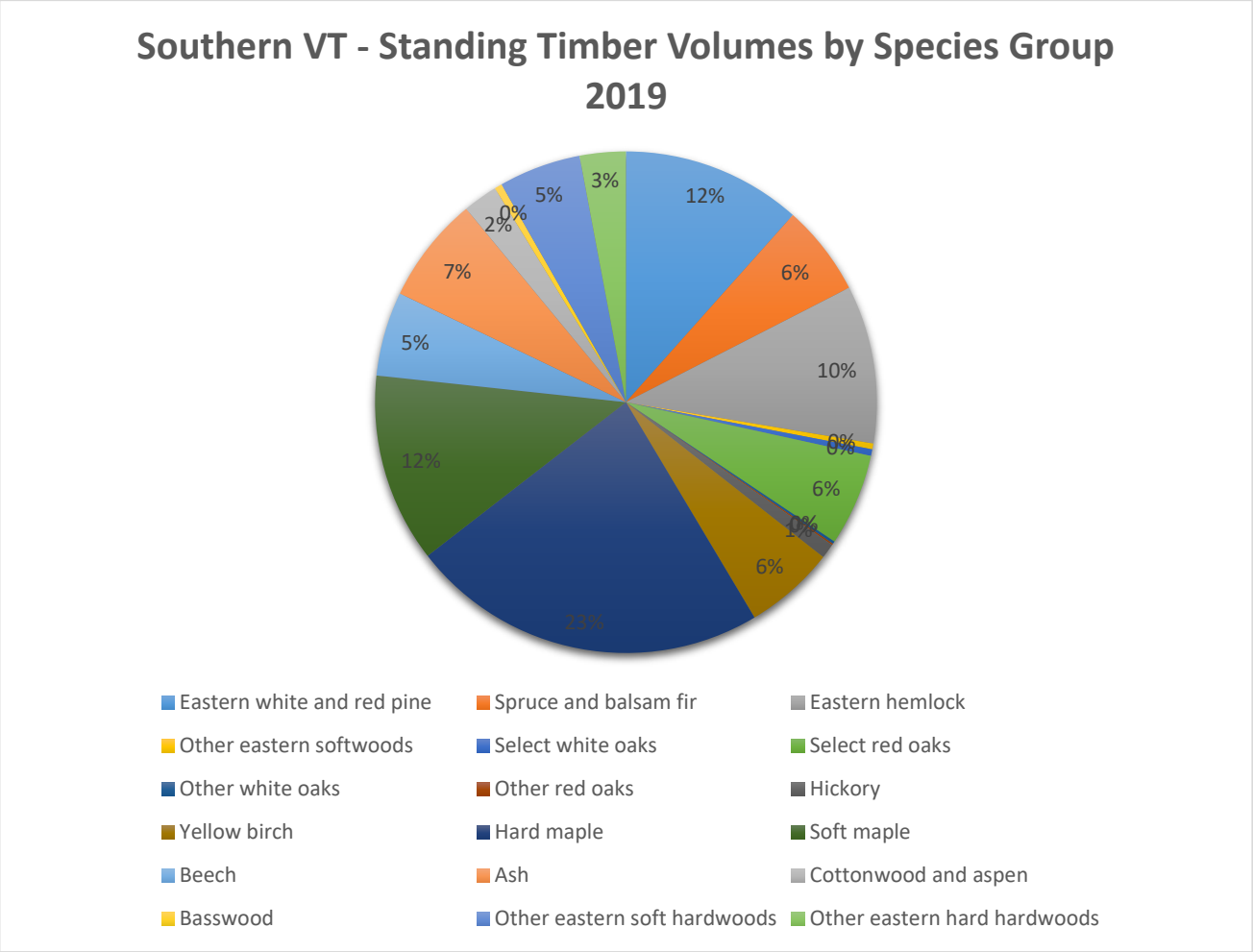
The breakdown of standing volume by species groups for the VT South sub-region can be seen in Figure 36. The Maples, Birch, Beech, Ash, Eastern Hemlock and Eastern White Pine are the dominant species groups in terms of volume in the sub-region.

Figure 36 Southern VT Standing Timber Volumes



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 37 Southern VT Timber Volume by Species



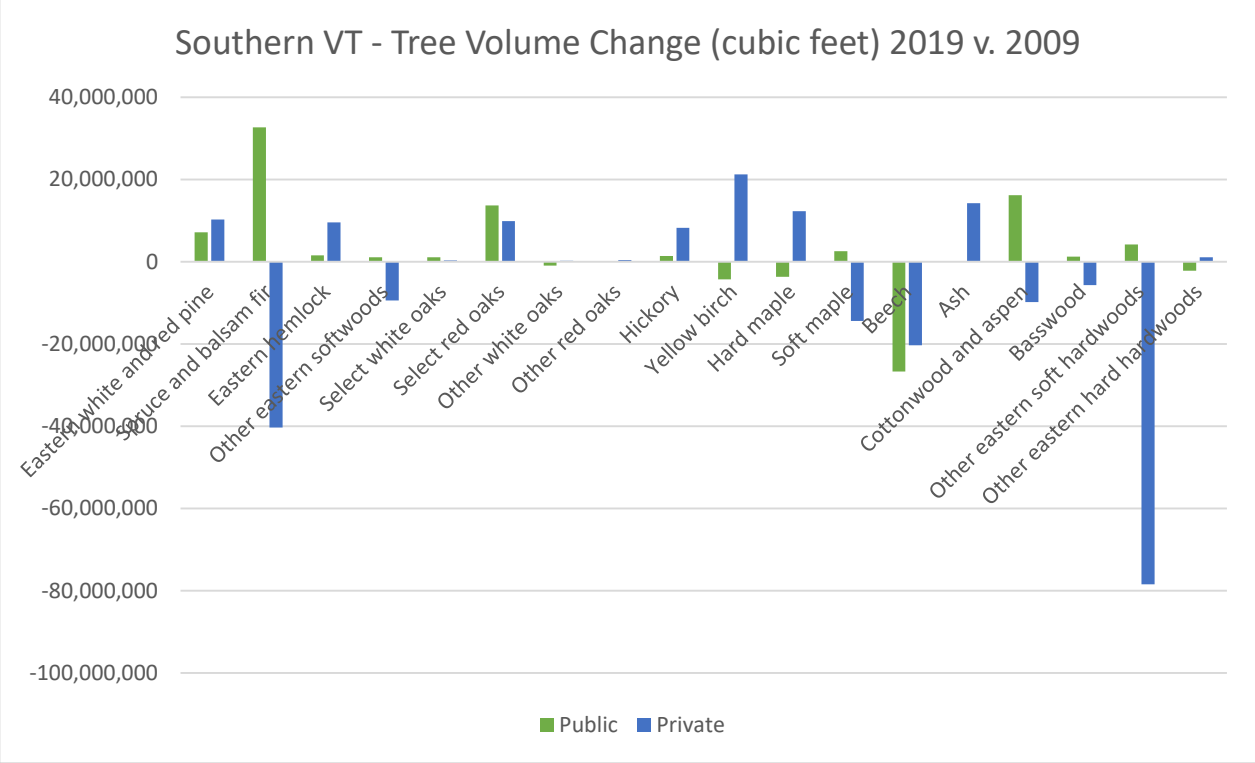
Source: USDA Forest Service, Forest Inventory and Analysis

Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber decreased by 45,774,044 cubic feet or .9 % of standing volume – not a significant amount. This occurred partly as a result of loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 38) but it must be understood as a current snapshot in time.

Figure 38 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups occurred on private land in the sub-region where most of the timber is harvested. Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 38, notable changes in species volume from 2009-2019 include large increases in the Maples, Birch, Red Oaks, Eastern White Pine and Ash. Reductions in standing volume during the 10-year time period include Spruce/Fir on private land (increase on public), Beech (on both private and public land) and Other Eastern Soft Hardwoods (this is on private lands). It is important to note that overall standing timber stocking, i.e. the amount of timber that is standing per acre at over 29 cords, is considered good or even overstocked.

Figure 38 Southern VT Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

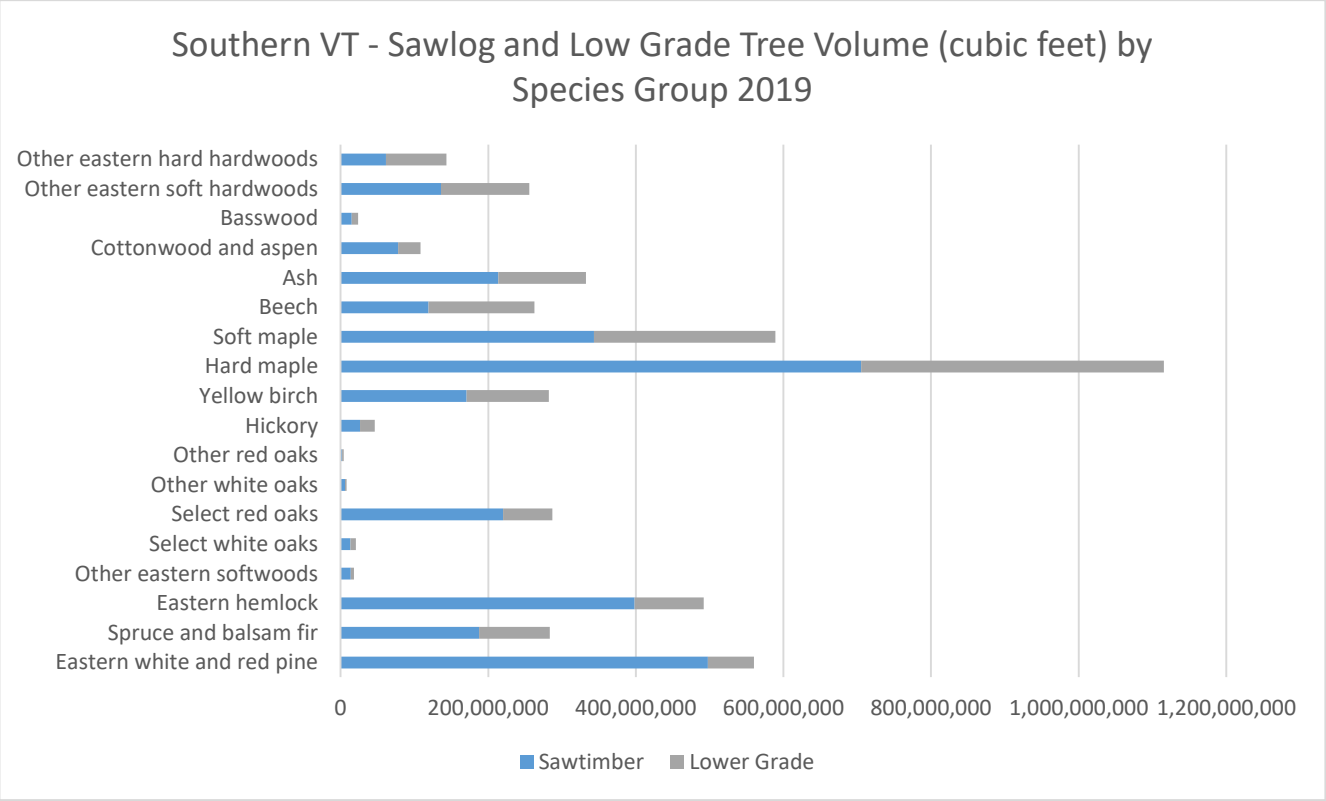
Note on Figure 38 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 39 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Maples, Birch, Ash, Eastern Hemlock, Spruce/Fir and Eastern White Pine all show sawlog volumes at or over half of standing volumes. Eastern Hemlock & White Pine is over 80% sawlog volume. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 39 Southern VT Sawlog v. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number in Figure 40 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 40. Net growth for the year was 81.8 million cubic feet and removals 37.7 million cubic feet. The important result (growth less removals) is a net increase of 44.2 million cubic feet (552,673 cords) of standing timber volume per year in the sub-region.

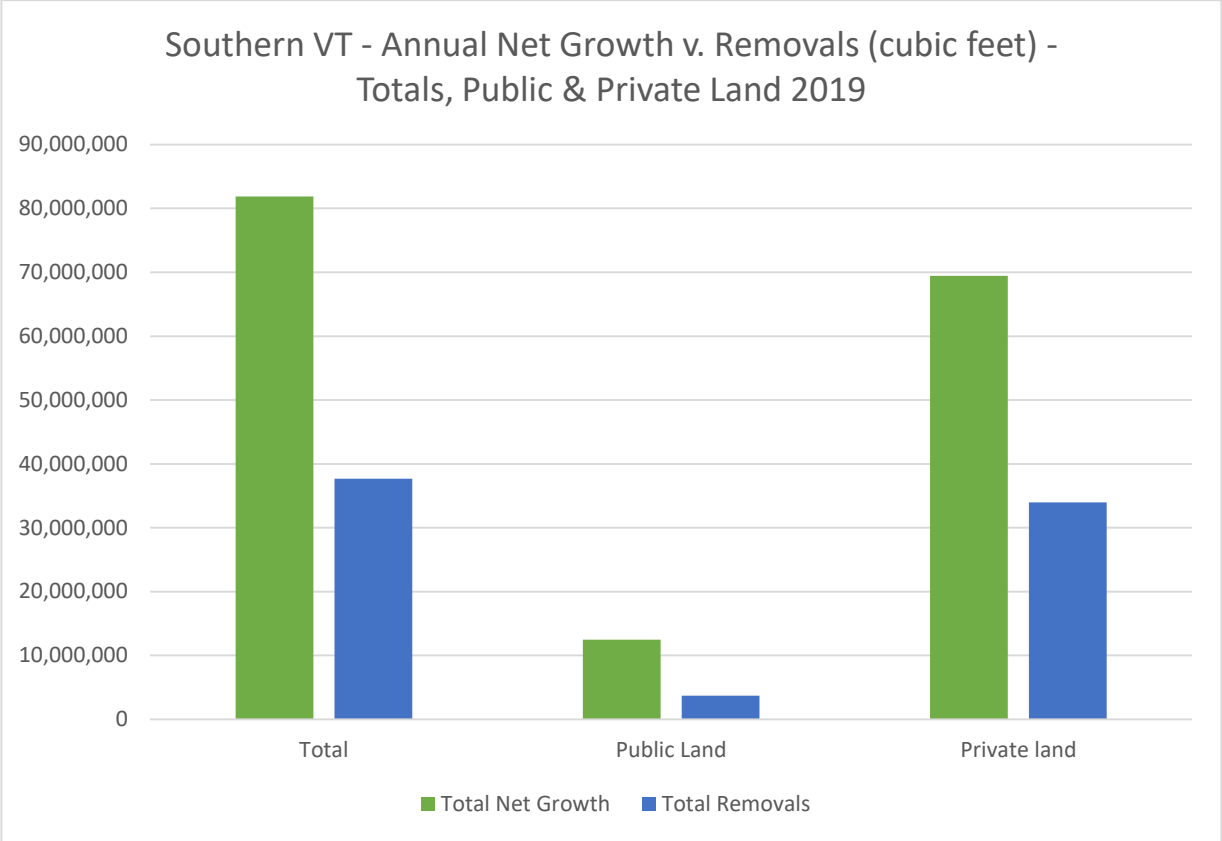
Figure 40 Southern VT Summary Table - Net Growth v. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Southern VT			
2019	***Net Growth***	cubic feet	
	all	81,881,269	
	public	12,444,892	
	private	68,953,481	
	Removals		**Removals from Harvest**
	all	37,667,452	33,232,246
	public	3,713,203	
	private	24,319,105	
	Growth less Removals		
	all	44,213,817	
	public	8,731,689	
	private	44,634,376	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 41. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

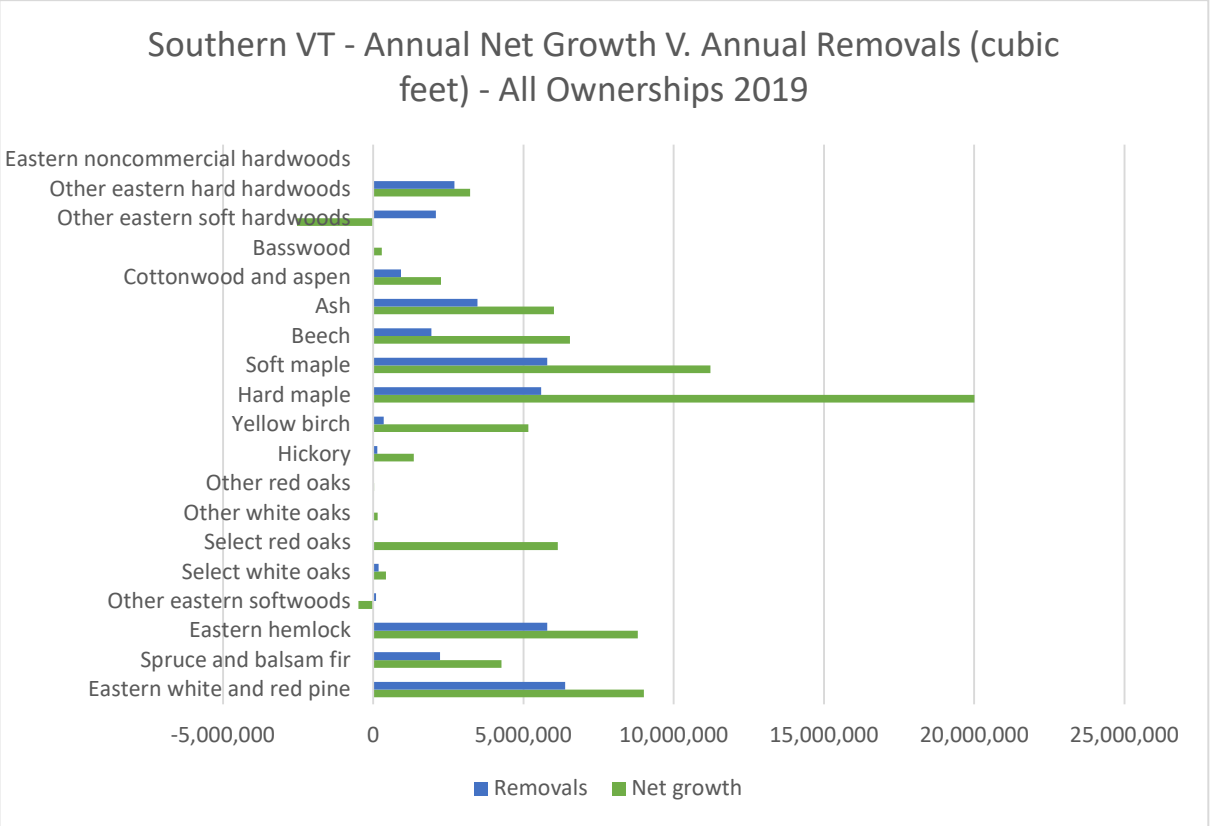
Figure 41 Southern VT Net Growth v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

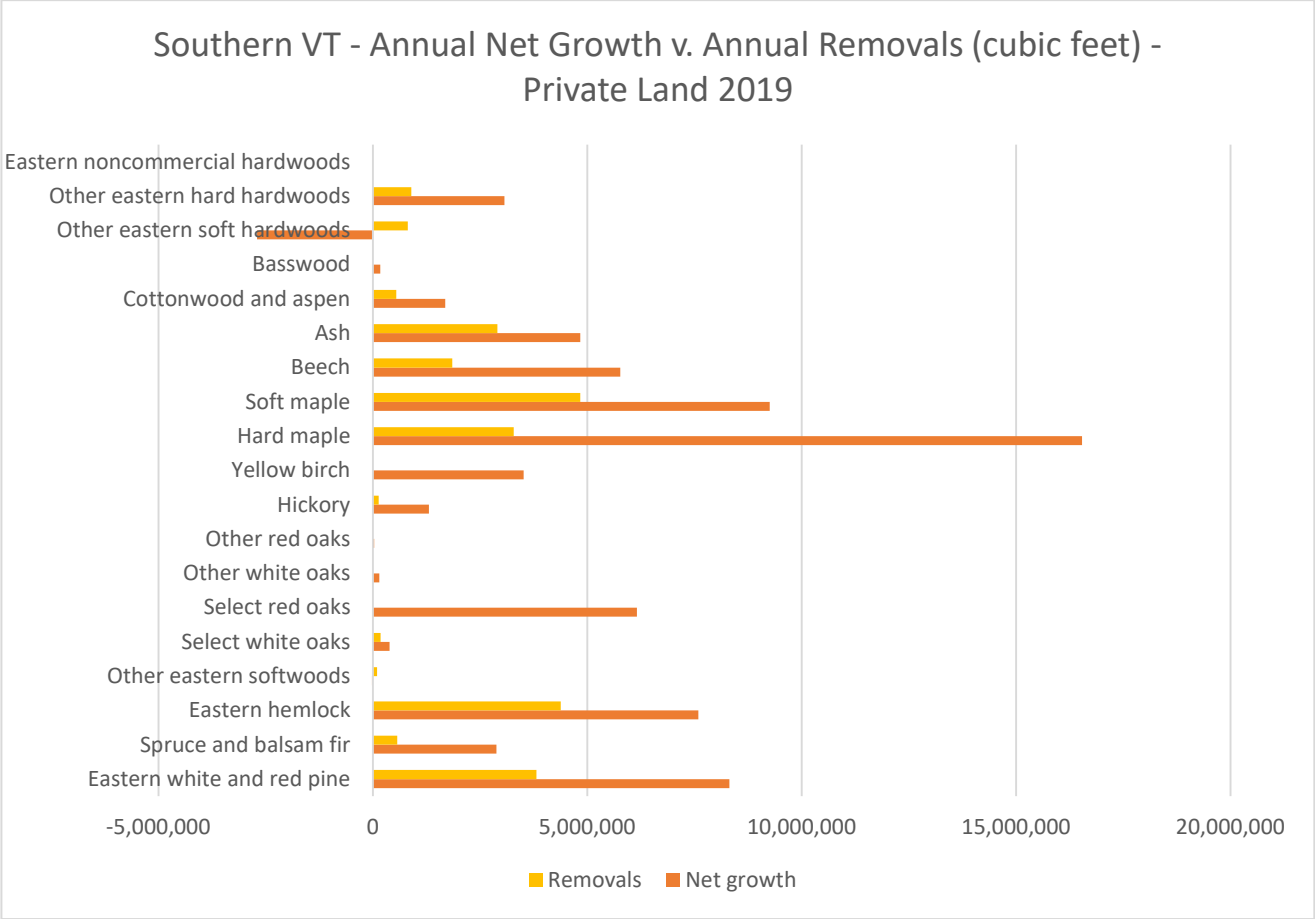
Figures 42 through 44 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Maples and Birch are showing a wide ratio of net growth to removals.

Figure 42 Southern VT Net Growth v. Removals by Species Group



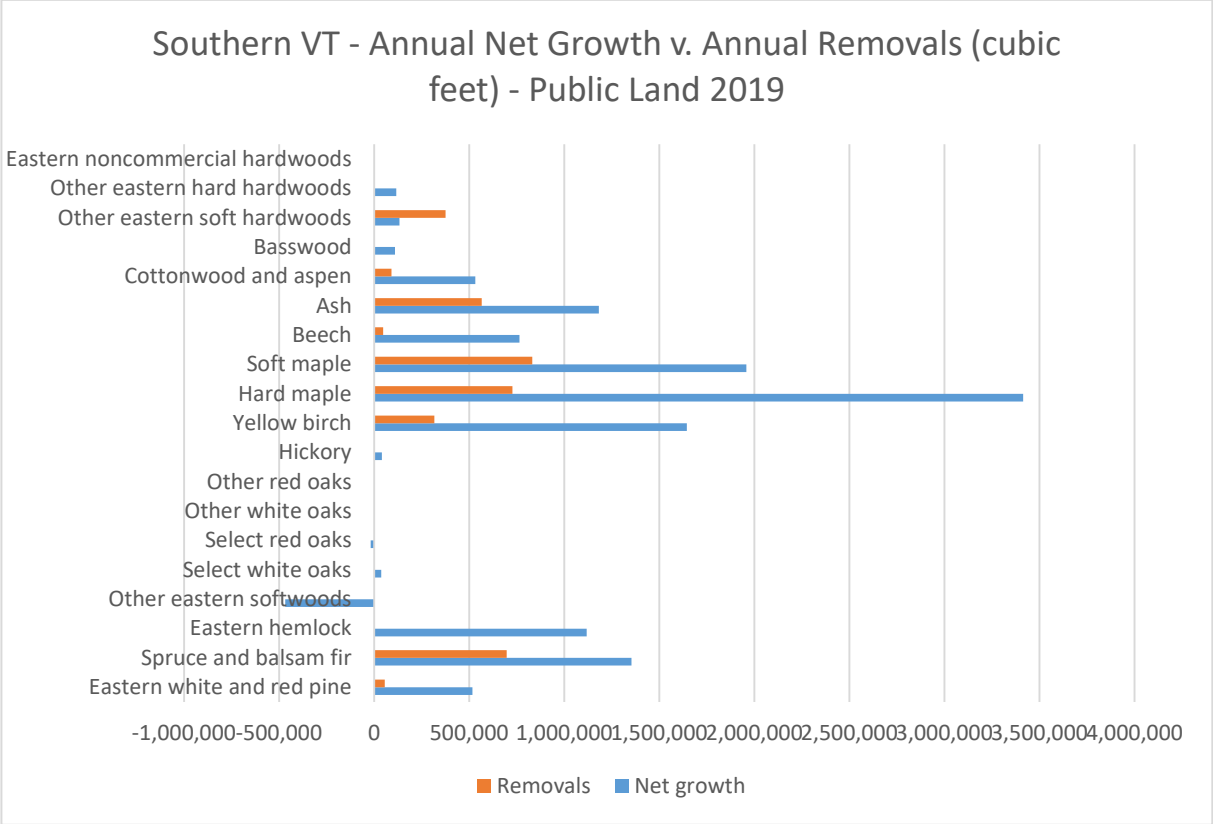
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 43 Southern VT Net Growth v. Removals Private Lands



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 44 Southern VT Net Growth v. Removals Public Land



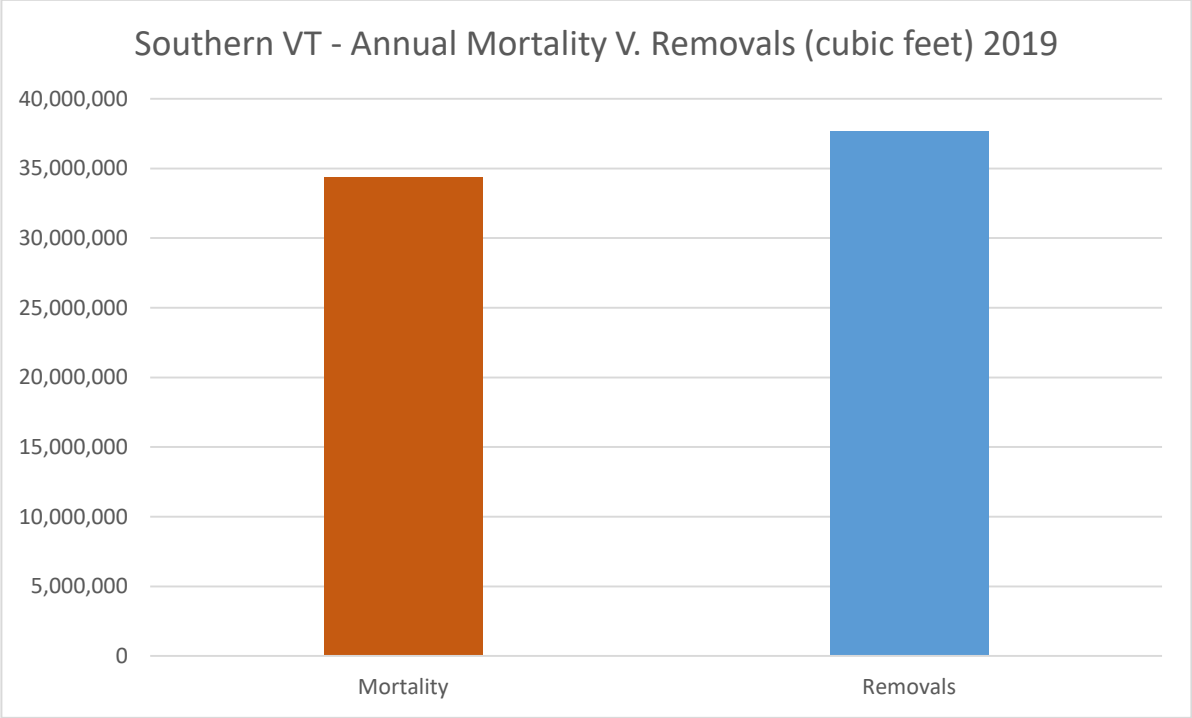
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 45 below shows the annual mortality in volume for Southern VT trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 91% of annual removals.

Figure 45 Southern VT Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

Future Timber Projections

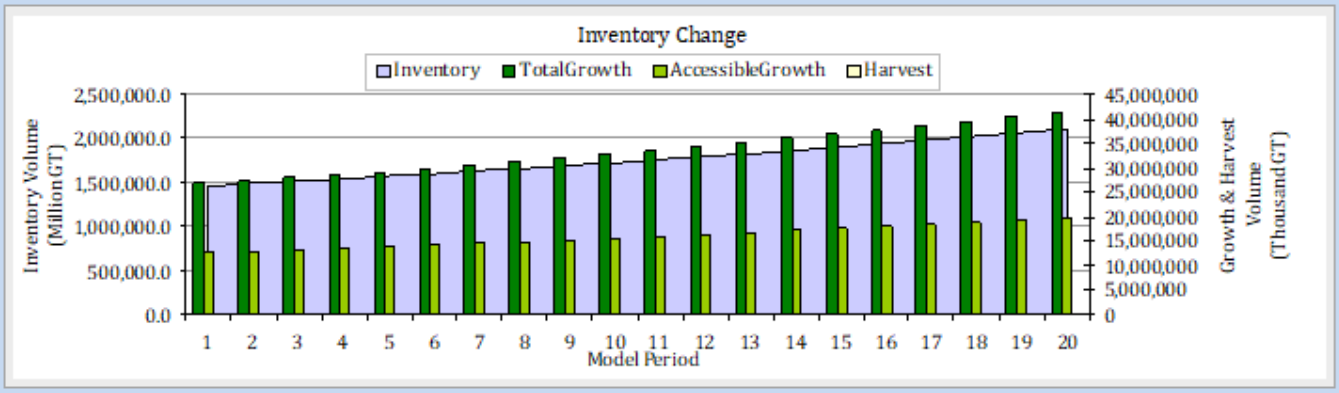
Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the VT South sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

Inventory (Summary)



* Low-grade harvest includes low-grade bolewood harvest (pulpwood) and the estimated volume of tops and limbs harvested.

** The volume of annual wood growth that occurred on accessible timberland acres AND was not already captured by existing harvest.

*** Available tops and limbs is the estimated volume of wood in the tops of harvested trees, which was not extracted from the woods.

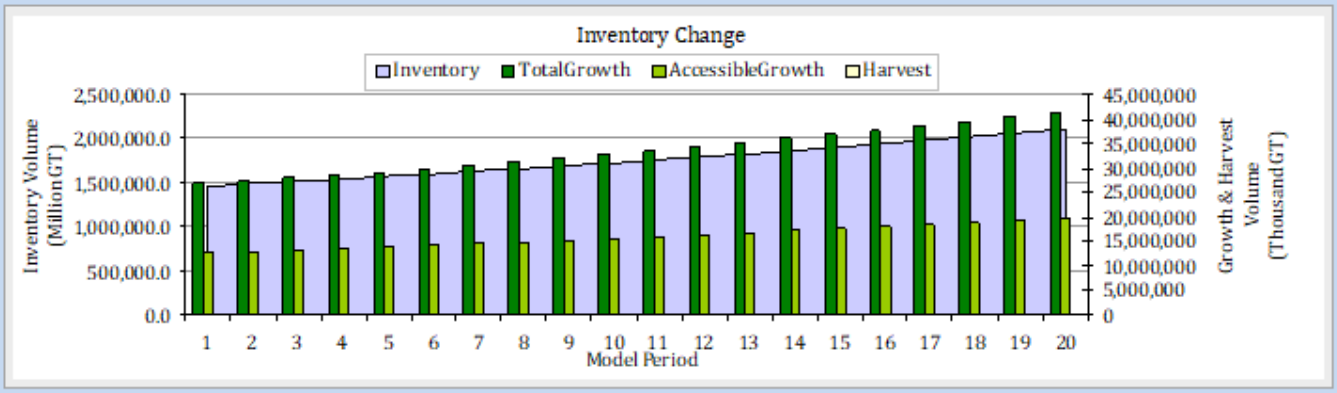
Available timber volume per year (Accessible Growth) in 2020 – 10,361,138 green tons

Available timber volume per year in year 2040 – 16,036,763 green tons

Approximately 66% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

Inventory (Summary)



* Low-grade harvest includes low-grade bolewood harvest (pulpwood) and the estimated volume of tops and limbs harvested.

** The volume of annual wood growth that occurred on accessible timberland acres AND was not already captured by existing harvest.

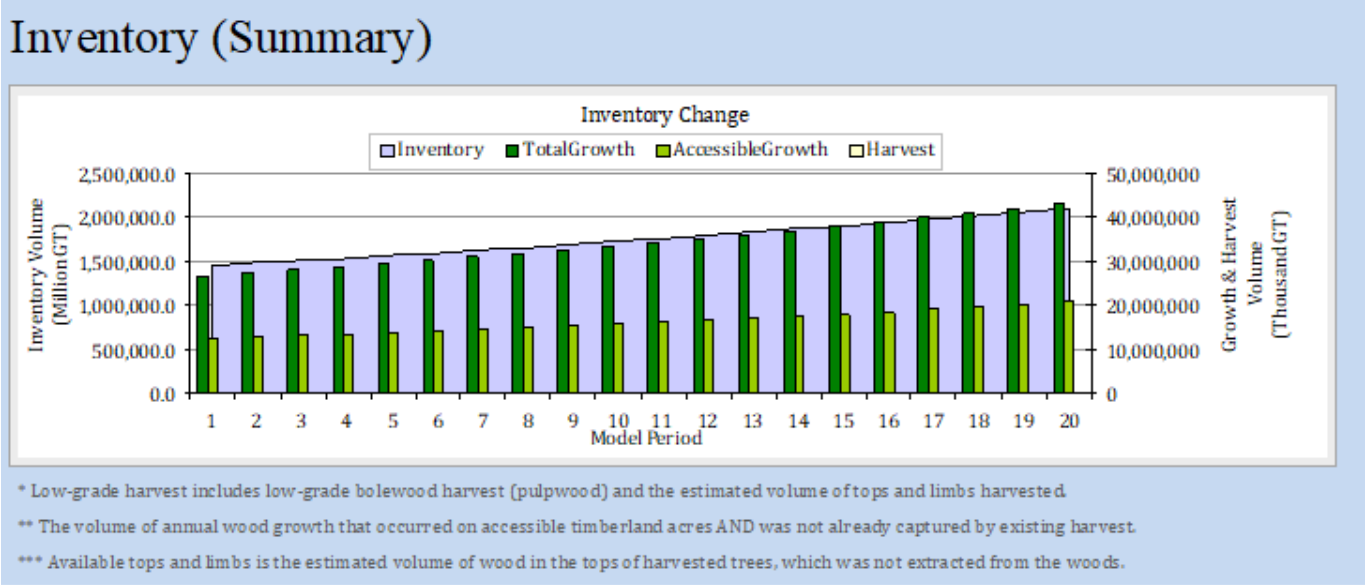
*** Available tops and limbs is the estimated volume of wood in the tops of harvested trees, which was not extracted from the woods.

Available timber volume per year (Accessible Growth) in 2020 – 10,361,138 green tons

Available timber volume per year in year 2040 – 16,036,641 green tons

Approximately 66% of ending standing available volume in 2040 is in higher value quality timber.

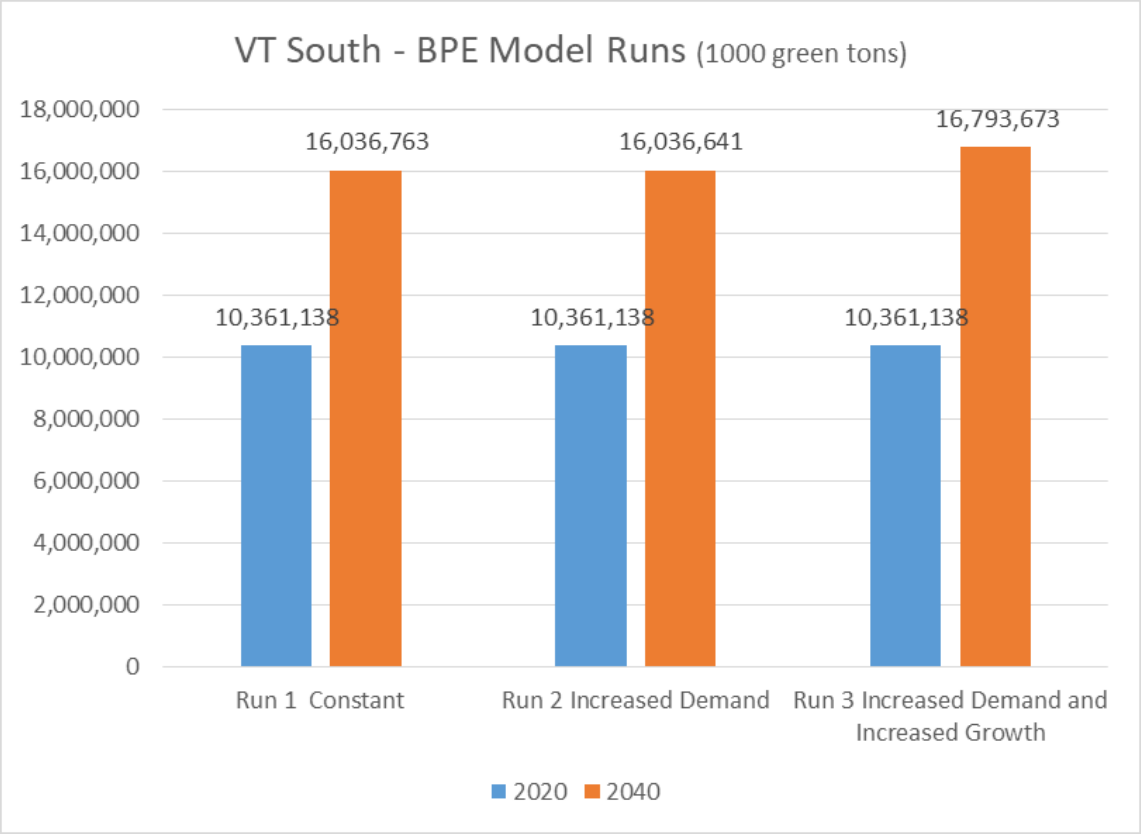
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 10,361,138 green tons

Available timber volume per year in year 2040 – 16,793,673 green tons

Approximately 66% of ending standing available volume in 2040 is in higher value quality timber.


VT South - BPE Model Runs (1000 green tons)
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
16,036,763
16,036,641
16,793,673
10,361,138
10,361,138
10,361,138
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

5. Sub-Region NY – North Country

Overview - The Adirondack Mountains and Tug Hill Plateau are the main features in this sub region. The 13-county area is the most forested region in the state and a major forest recreation destination for the Northeast. Traditionally, forest industry has played a large role in the sub-region's economy and most of the industrial forest land in the state is located here. In total, there are nearly 6 million acres of privately owned timberland in this sub region.

The sub-region's forest types are dominated by Northern Hardwoods - mainly Red Maple and Sugar Maple. Other species include White Pine, Eastern Hemlock, and Beech. Much of the growing stock here is of lower grade material due to poorer growing conditions and past harvesting practices.

A substantial forest products manufacturing infrastructure is found in this sub-region.

The population of this are increased between 2000 and 2010 from 1,308,027 million people to 1,346,299 million people, a 2.9% increase. This increase is driven by mainly Saratoga and Rensselear Counties, which are bedroom counties of the tri-cities of Albany, Schenectady and Troy. The core areas located in the Adirondacks and Tug Hill continue to see an overall decrease in population.

Timber data major findings for the NY – North Country Sub-region - The North Country NY sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 1.8:1, meaning that for every unit of timber harvested, 1.8 units are grown. On private land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 2.0:1. On public lands, the ratio is 1:1 for all species and that is also true of all major species groups. The reason for this is likely that the State of NY timberlands is within this sub-region are not harvested heavily and they are an older, slower growing forest where mortality can be very high. Not much timber is being harvested on State timberlands in this sub-region[9].

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 22.1 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for the Ash, Yellow Birch, Eastern Hemlock and Red Oak is over 2:1 for both public and private lands. It is over 3:1 for Eastern White Pine and almost 2:1 for Spruce/Fir.

Lastly, the natural mortality in the forest of this sub-region at 109,696,434 cubic feet per year, is over 84% of the annual removals at 130,812,739 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

The North Country NY sub-region is heavily forested and well stocked with standing timber. Forests are growing timber at rates higher than is being removed annually. From a timber supply

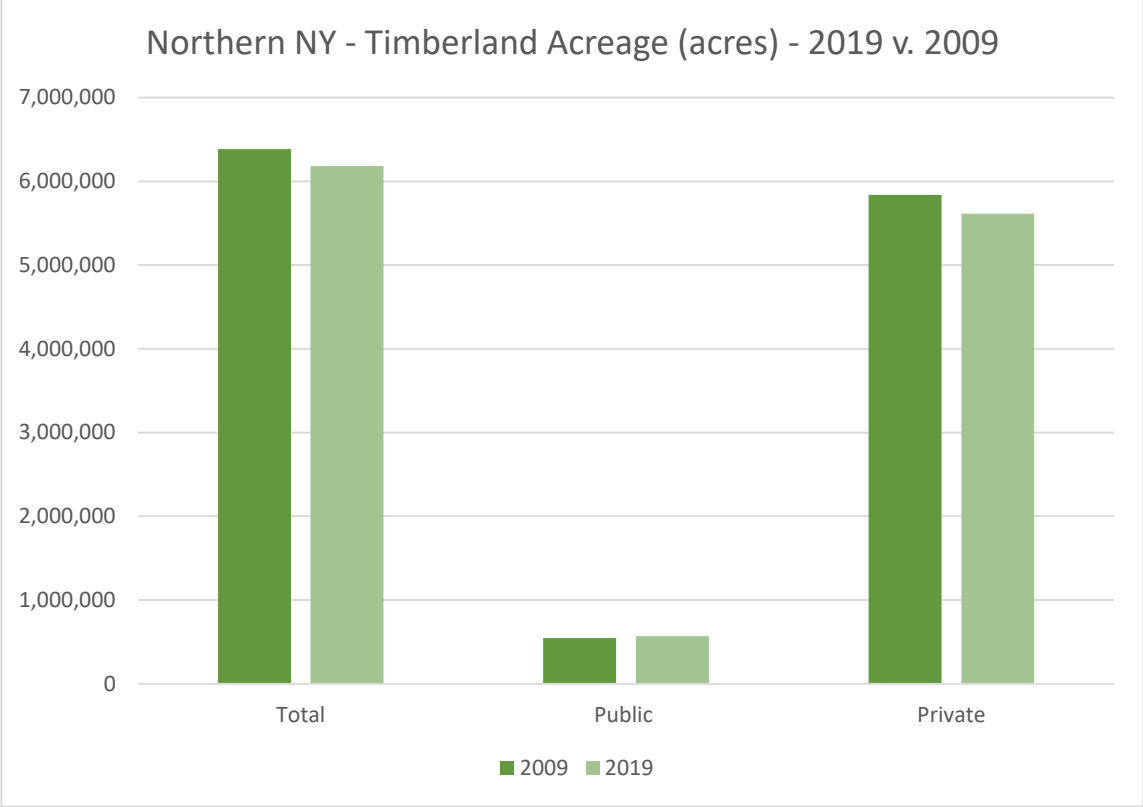
[9] An important note – even though there are over 3 million acres of forestland in public ownership in the Adirondack Park area, because these acres are off limits to harvesting by order of the State Constitution, those acres do not show as timberland.

perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

This region includes Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Jefferson, Lewis, Montgomery, Oneida, Rensselaer, St. Lawrence, Saratoga, Warren and Washington Counties in New York and represents approximately 6,180,290 acres of timberland. As a percentage of land and water area in the sub-region, the area is 51% forested. The sub-region has almost nearly ten times the timberland acreage in private land as it does in public land (5,613,182 acres private vs. 567,108 acres public) – see Figure 46. Comparing the area using 2009 and 2019 data, the sub-region lost 65,752 acres of timberland over the 10-year period (approximately 3 % of the forests in the sub-region). The area gained 8,824 acres of public land during that period and lost 74,576 acres of private land (from the public land gained plus additional acreage that changed to developed or agricultural uses). Much of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests or State land in the Adirondack Park area).

Figure 46 North Country NY - Timberland Area



Source: USDA Forest Service, Forest Inventory and Analysis

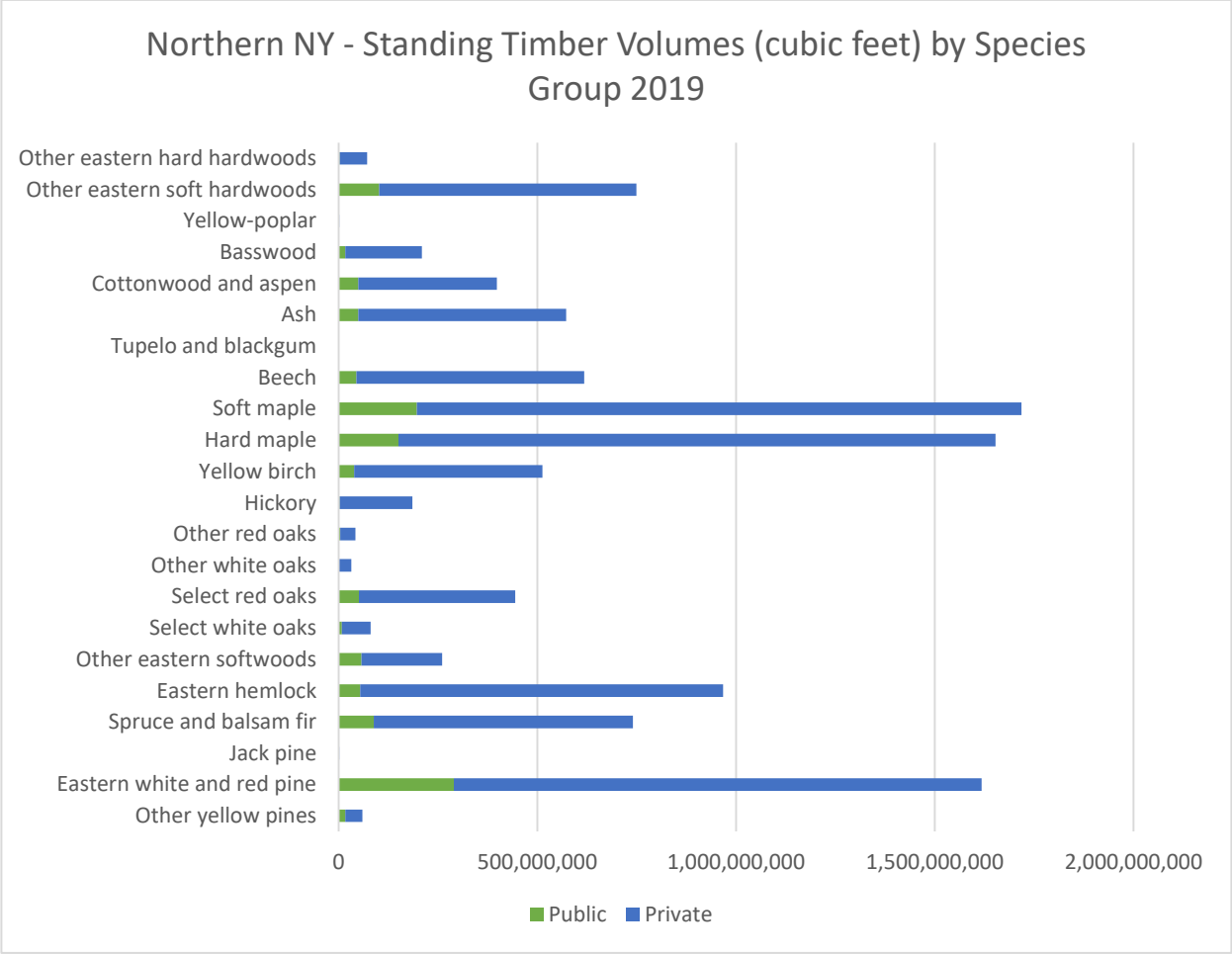
Timber Volume and Changes 2009-2019

Overall, on all timberlands in the fifteen-county region, standing timber volume in 2019 for all species was 10,933,706,173 cubic feet. This represents 1,769.1 cubic feet/acre or 22.1 cords per acre – 21.6 cords/ac private land and 26.9 cords/ac on public land. This represents standing

volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

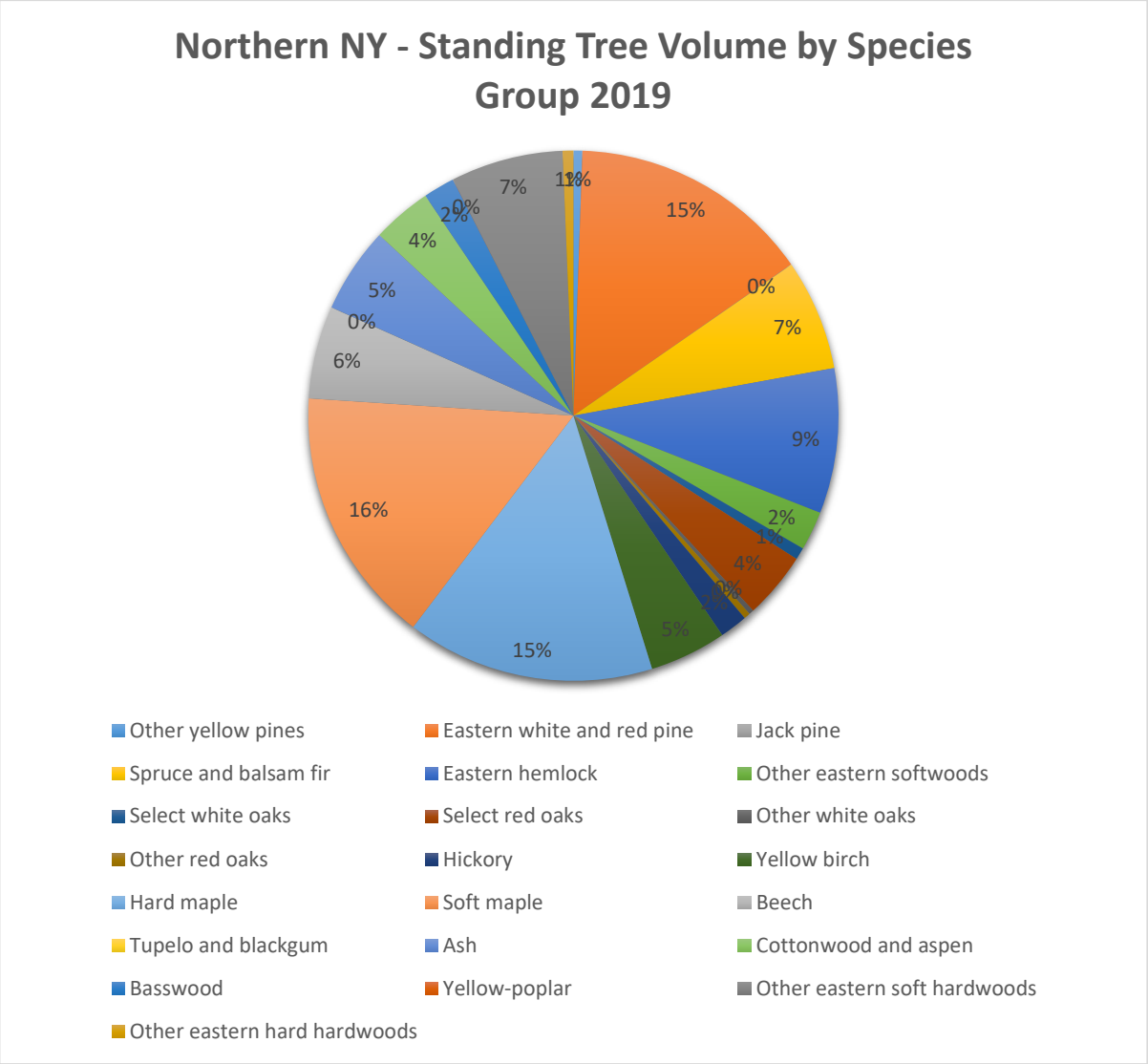
The breakdown of standing volume by species groups for the North Country NY sub-region can be seen in Figure 47. The Maples, Birch, Beech, Eastern Hemlock, Spruce/Fir and Eastern White Pine are the dominant species groups in terms of volume in the sub-region.

Figure 47 North Country NY Standing Timber Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 48 North Country NY Timber Volume by Species



Source: USDA Forest Service, Forest Inventory and Analysis

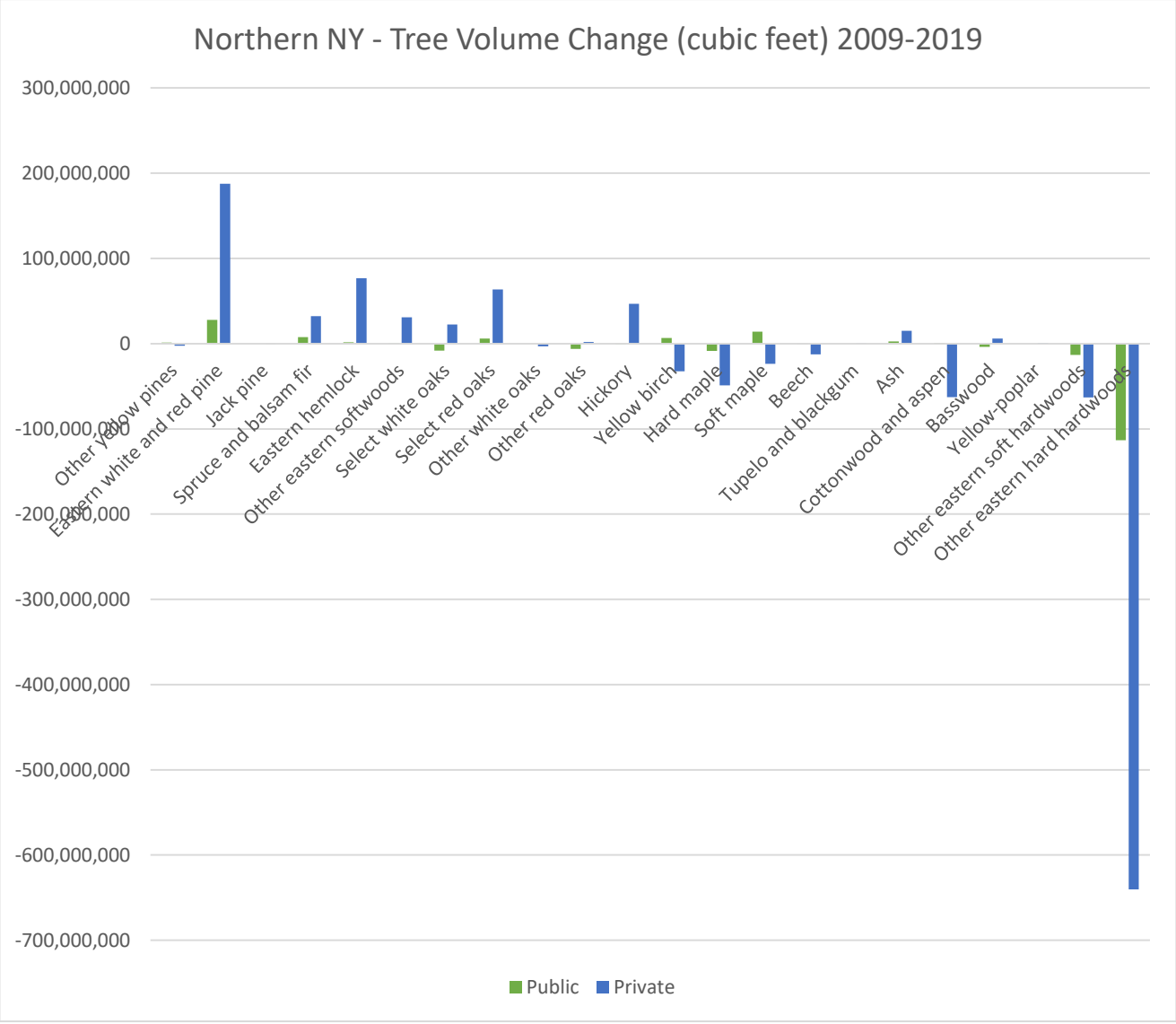
Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber increased by 266,956,523 cubic feet or 2.5 % of standing volume. This occurred despite a loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 49) but it must be understood as a current snapshot in time.

Figure 49 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups

occurred mostly on private land in the sub-region where most of the timber is harvested. Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 49, notable changes in species volume from 2009-2019 include large increases in the Eastern Hemlock, Eastern White Pine and Red Oak. Reductions in standing volume during the 10-year time period include Maple, Aspen and Other Eastern Hard Hardwoods – an aberration because this species group is a small part of the standing volume in the sub-region. It is important to note that overall standing timber stocking, i.e. the amount of timber that is standing per acre at over 22 cords, is considered good or even overstocked.

Figure 49 North Country NY Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

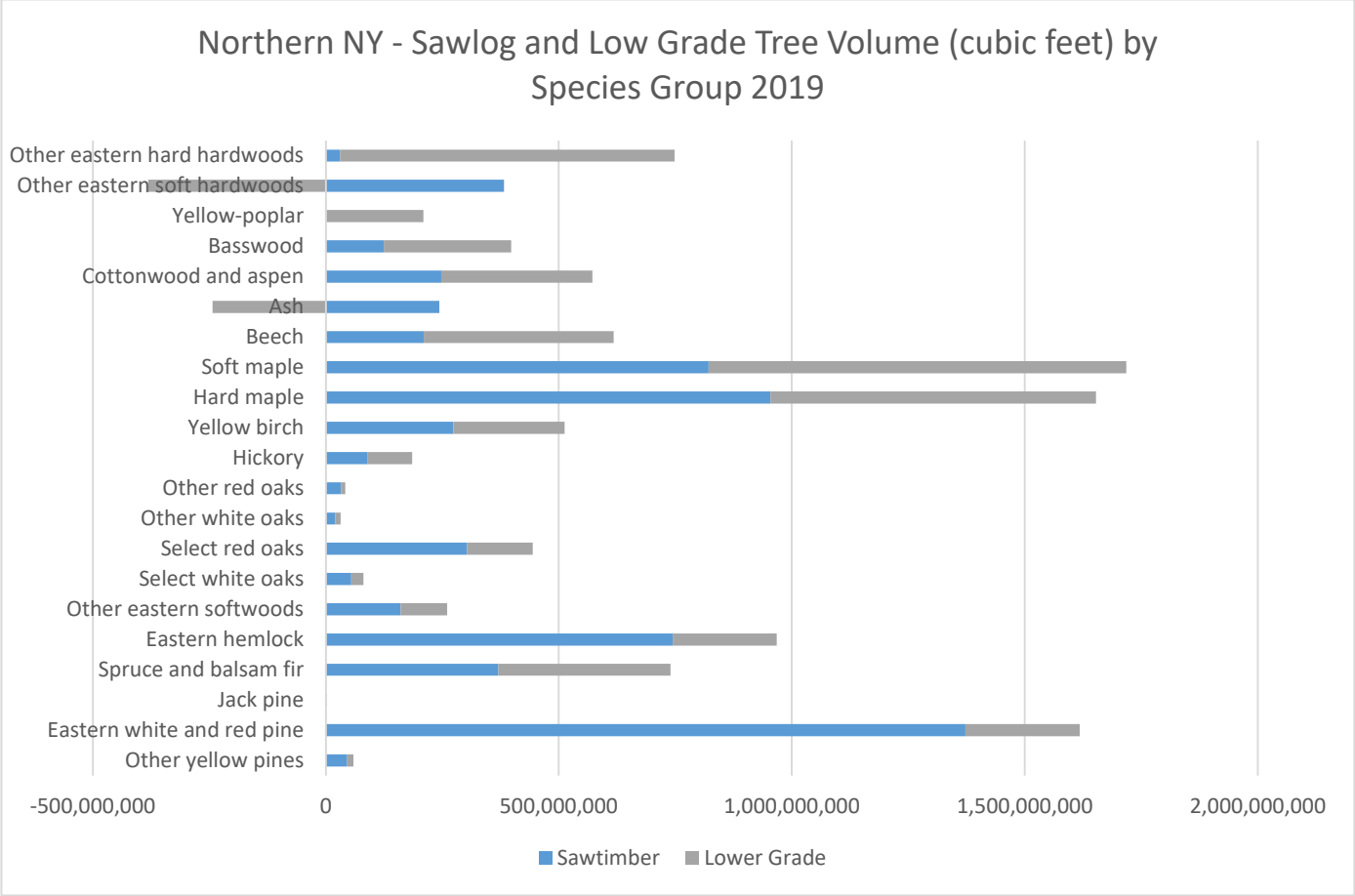
Note on Figure 49 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 50 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Maples, Birch, and Spruce/Fir all show sawlog volumes at or over half of standing volumes. Eastern Hemlock & White Pine is over 80% sawlog volume. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 50 North Country NY Sawlog v. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as

opposed to land management policy changes. The Removals from Harvest number in Figure 51 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 51. Net growth for the year was 230.1 million cubic feet and removals 130.8 million cubic feet. The important result (growth less removals) is a net increase of 99.3 million cubic feet (1,241,590 cords) of standing timber volume per year in the sub-region.

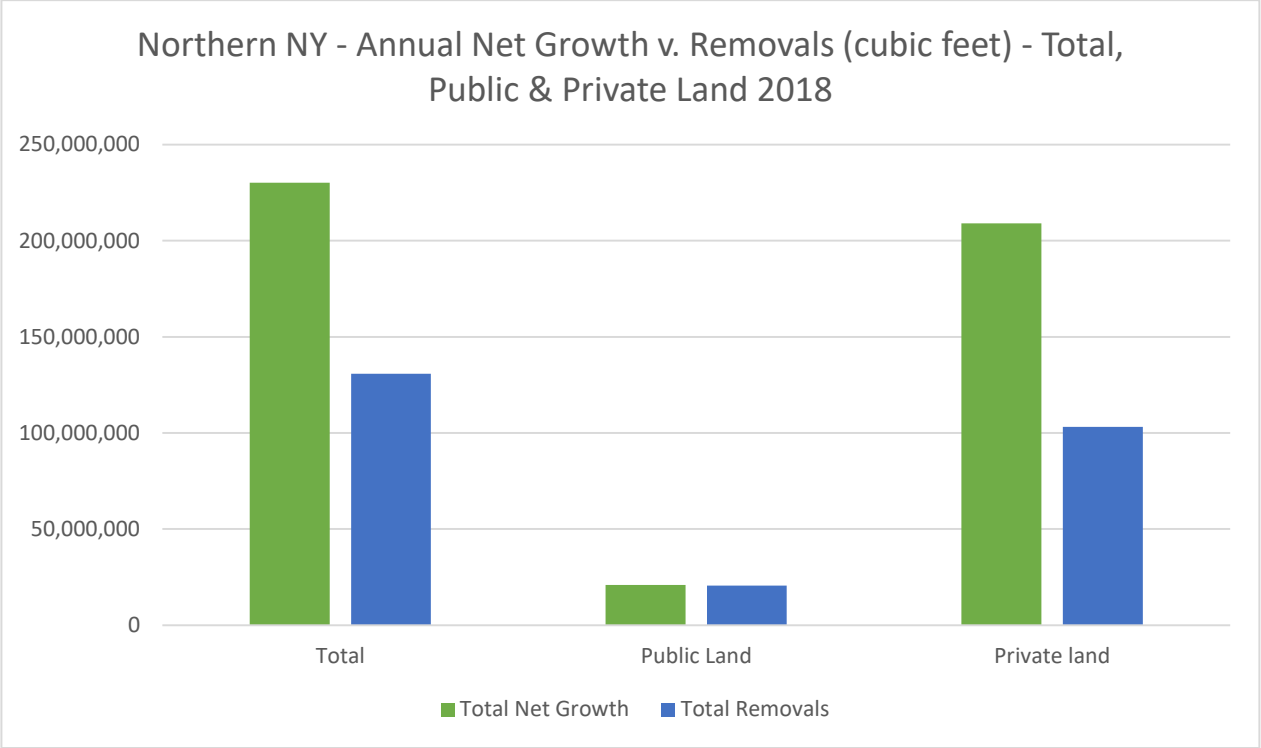
Figure 51 North Country NY Summary Table - Net Growth v. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Northern NY			
2019	***Net Growth***	cubic feet	
	all	230,139,907	
	public	20,921,500	
	private	208,987,289	
	Removals		**Removals from Harvest**
	all	130,812,739	109,280,572
	public	20,640,025	
	private	103,101,469	
	Growth less Removals		
	all	99,327,168	
	public	281,475	
	private	105,885,820	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 52. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

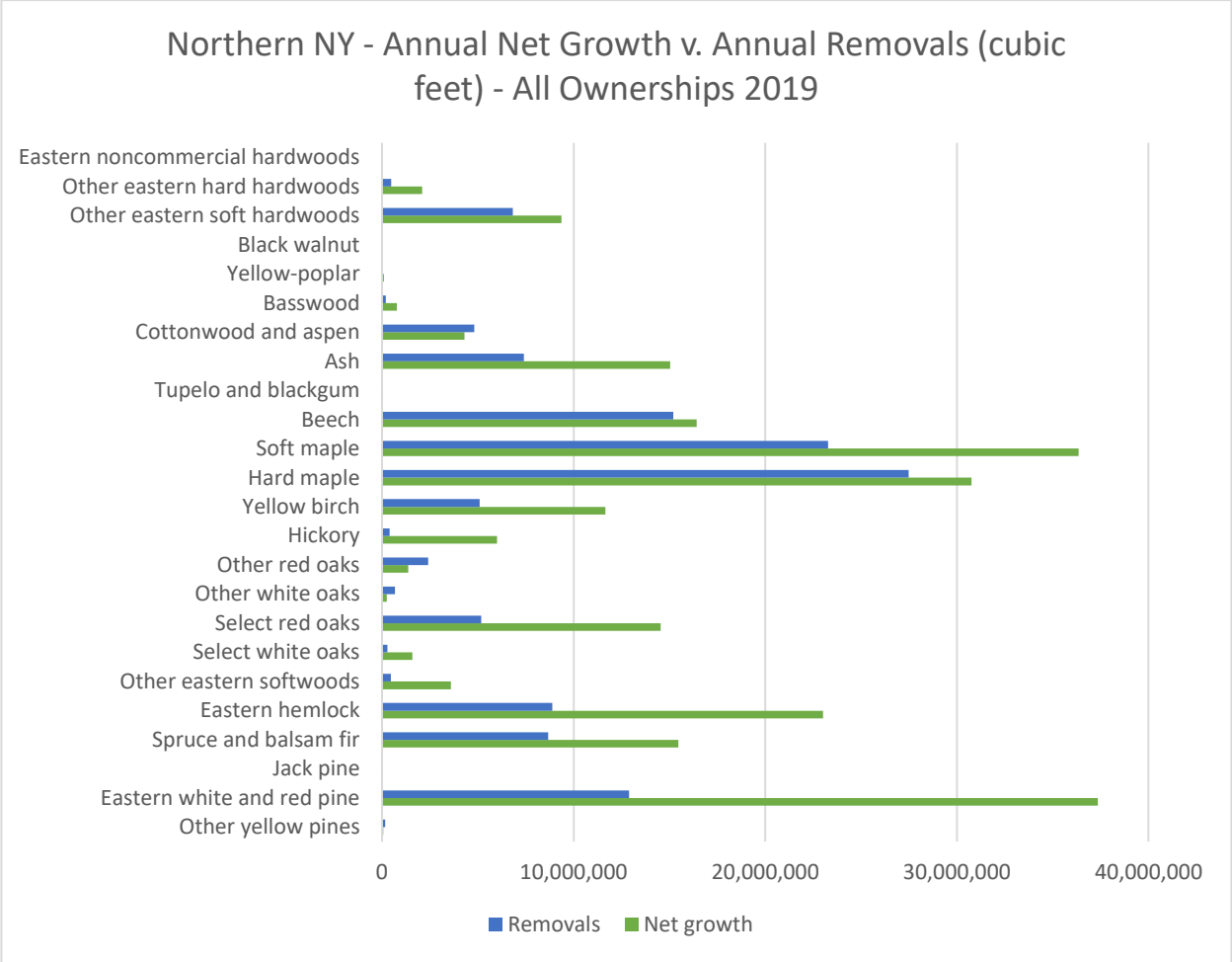
Figure 52 North Country NY Net Growth v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

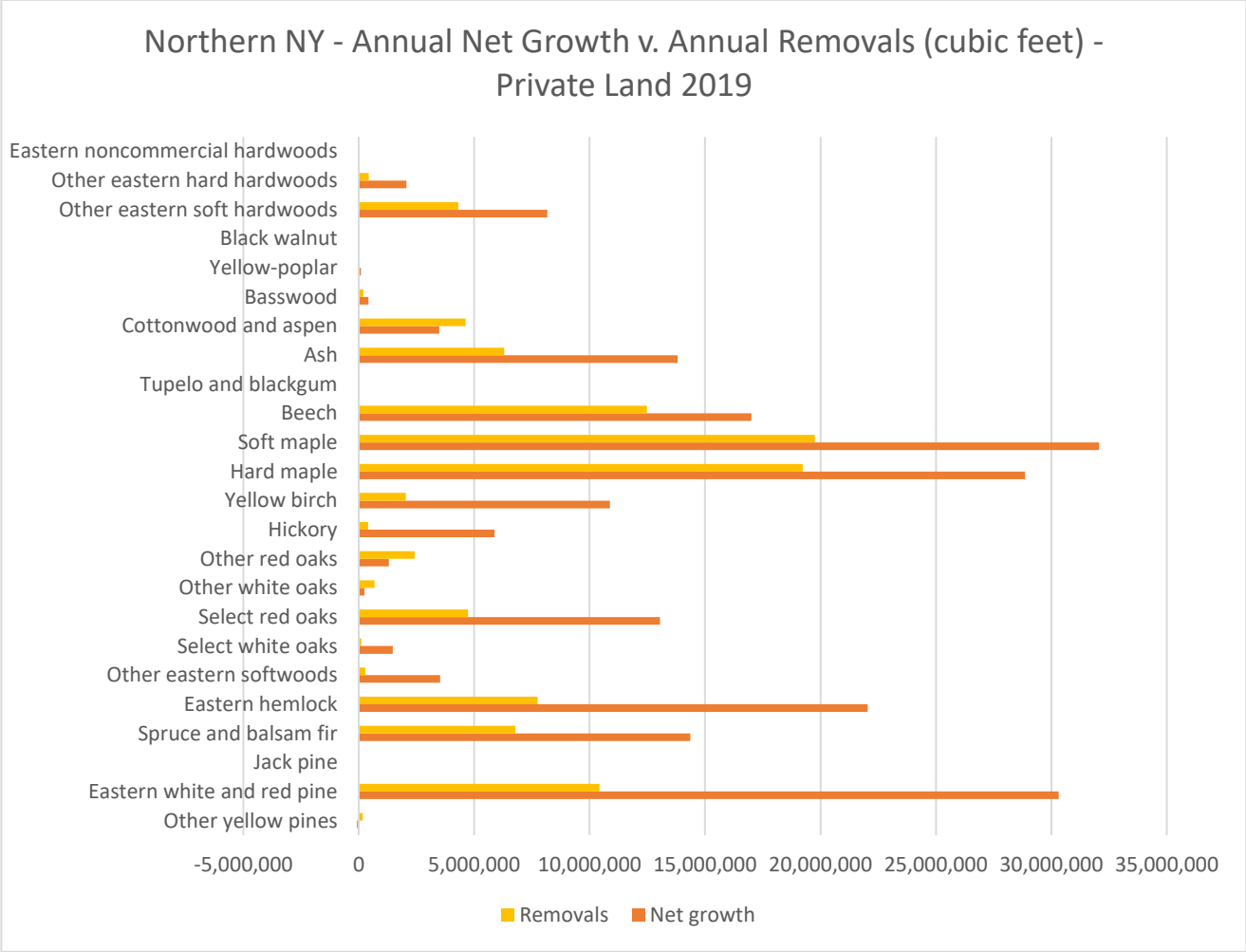
Figures 53 through 55 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Birch, Red Oak, Eastern Hemlock, Spruce/Fir and Eastern White Pine are showing a wide ratio of net growth to removals.

Figure 53 North Country Net Growth v. Removals by Species Group



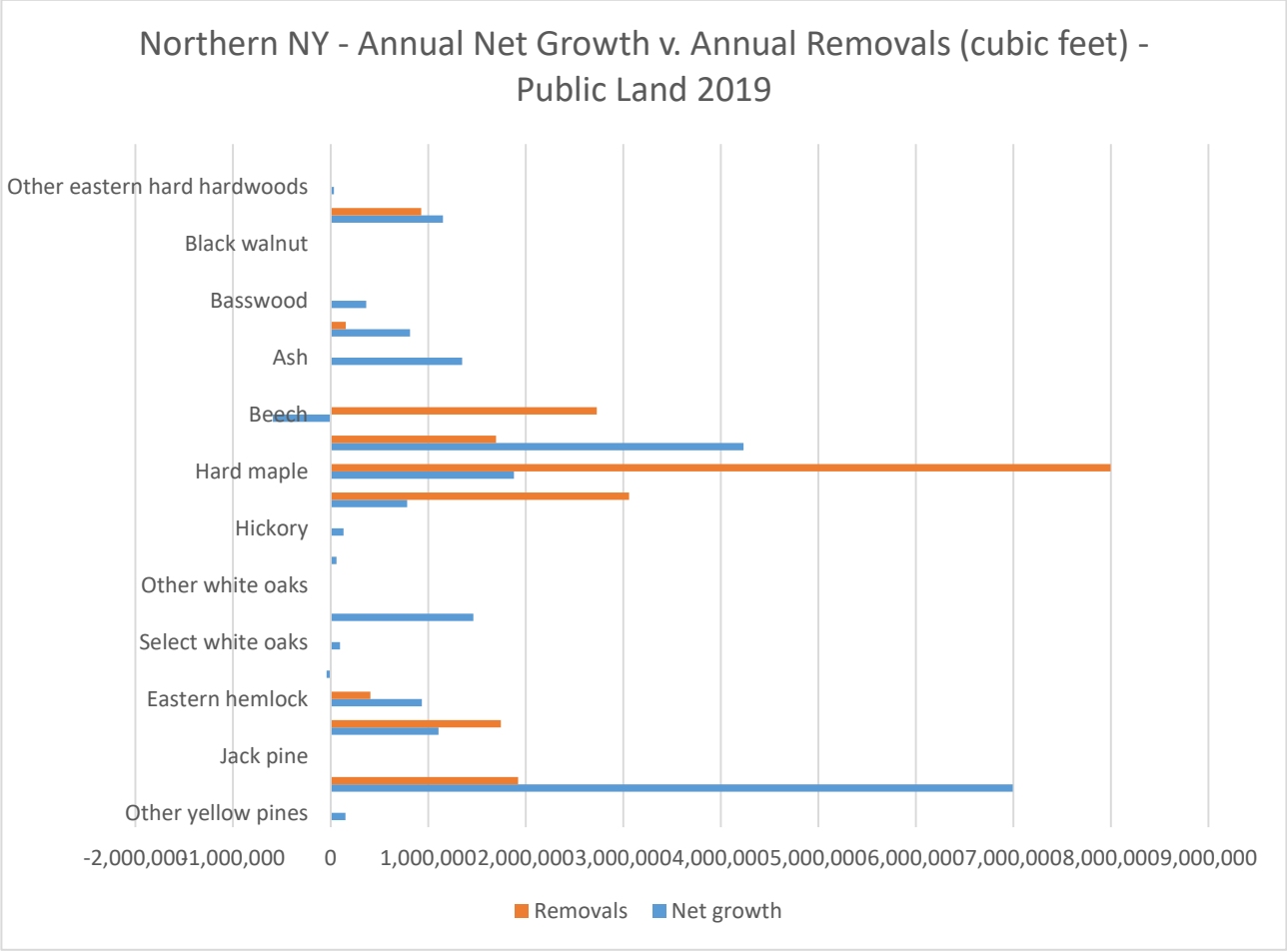
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 54 North Country Net Growth v. Removals Private Lands



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 55 North Country NY Net Growth v. Removals Public Land



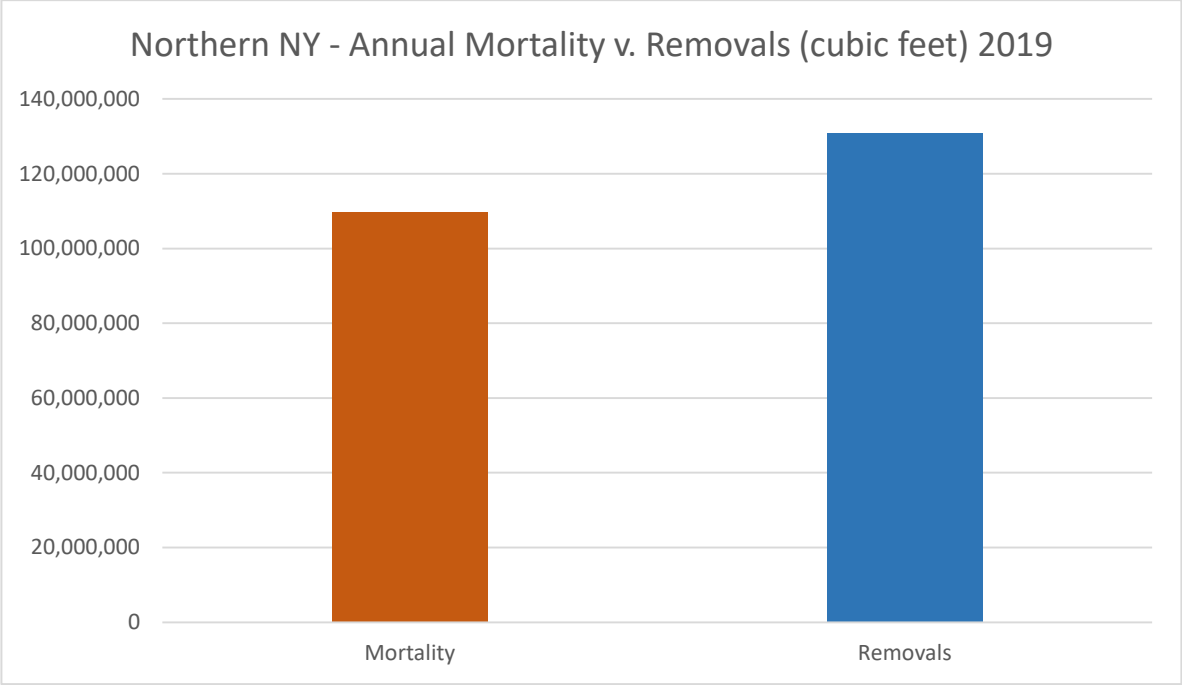
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 56 below shows the annual mortality in volume for North Country NY trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 84% of annual removals.

Figure 56 North Country NY Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

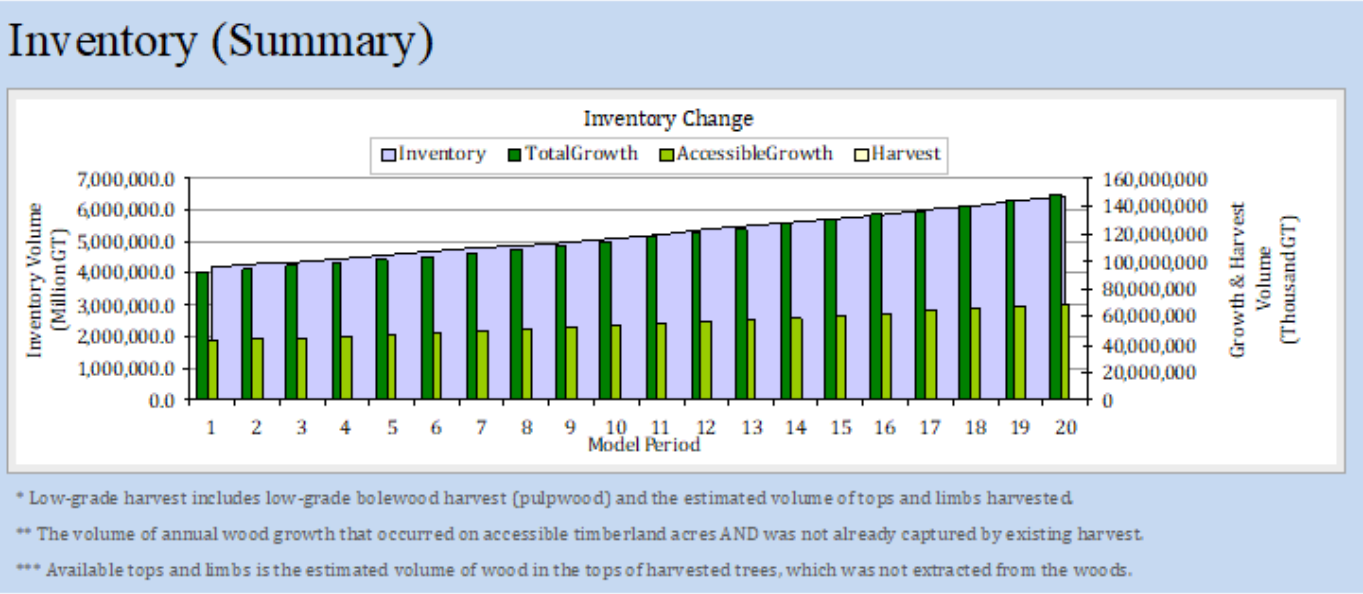
Future Timber Projections

Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the NY North Country sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

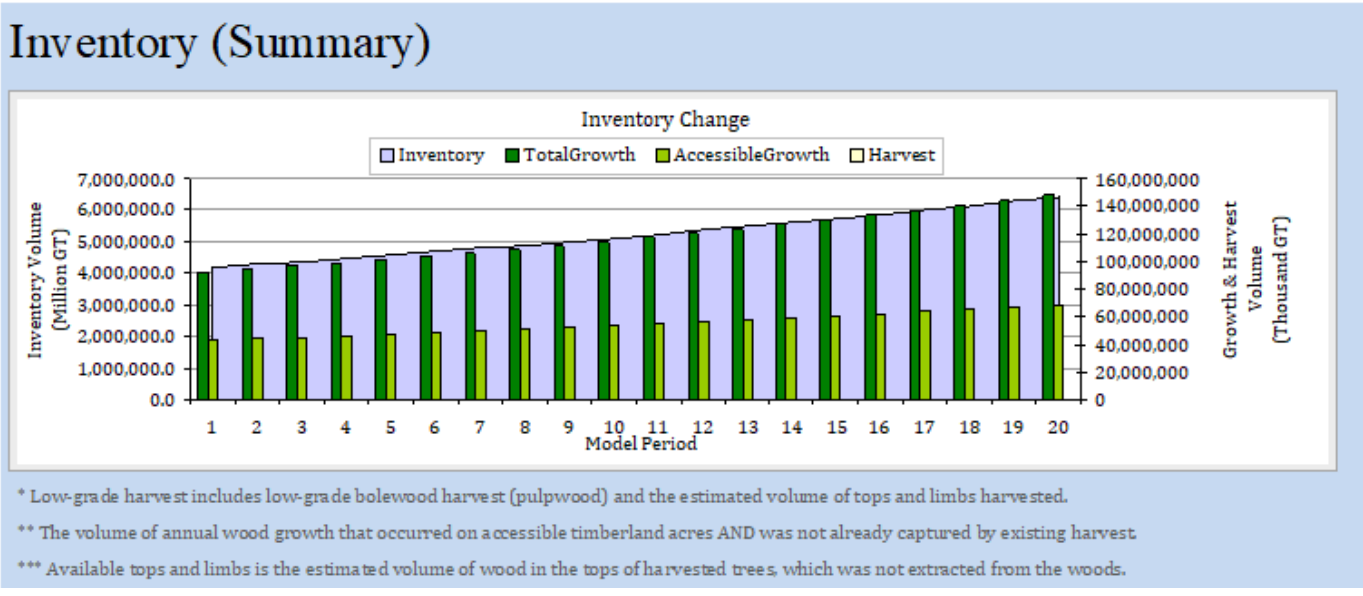


Available timber volume per year (Accessible Growth) in 2020 – 34,607,808 green tons

Available timber volume per year in year 2040 – 55,343,362 green tons

Approximately 60% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

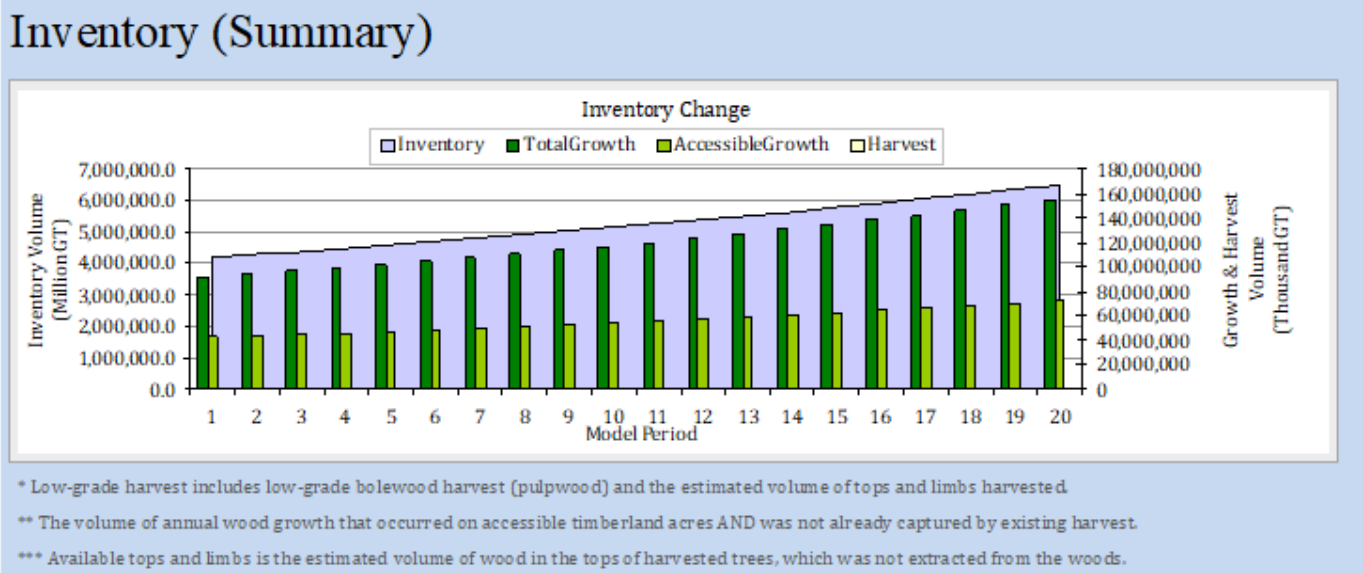


Available timber volume per year (Accessible Growth) in 2020 – 34,607,808 green tons

Available timber volume per year in year 2040 – 55,342,905 green tons

Approximately 60% of ending standing available volume in 2040 is in higher value quality timber.

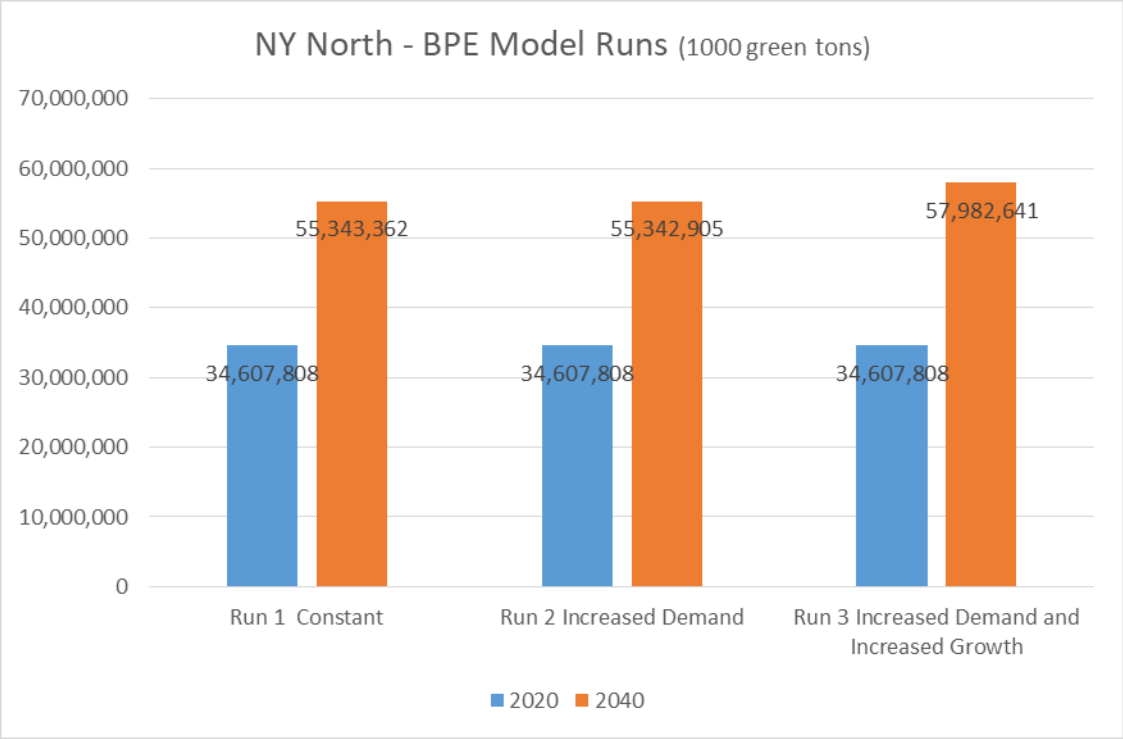
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 34,607,808 green tons

Available timber volume per year in year 2040 – 57,982,641green tons

Approximately 60% of ending standing available volume in 2040 is in higher value quality timber.


NY North - BPE Model Runs (1000 green tons)
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
55,343,362
55,342,905
57,982,641
34,607,808
34,607,808
34,607,808
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

6. Sub-Region NY – Southern Tier

Overview - The New York Southern Tier sub-region is a 13-county area bordering Pennsylvania that stretches from Chautauqua County on the shores of Lake Erie in the west to Schoharie County in the foothills of the Catskill Mountains to the east. The area is known for having some of the highest quality hardwoods in the country and is the heart of New York's hardwood industry. The sub-region also has parts of two important watersheds: The Chesapeake Bay and NYC Watersheds. Also, located throughout this region is the majority of New York's State Forest system, which is managed on a multiple use basis for recreation and timber products.

The main forest types in the area include Northern Hardwoods and Allegheny Hardwoods. The trees that are dominated include by Red Maple, Sugar Maple, Red Oak, and White Ash. Other species include Eastern White Pine and Eastern Hemlock. This region also has a substantial volume of Norway Spruce – planted - located on State forest lands in this sub-region,

The population of this sub-region decreased between 2000 and 2010 from 1,004,000 million people to 998,742 million people, a .5% decrease.

Timber data major findings for the NY – Southern Tier Sub-region - The Southern Tier NY sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 3.1:1, meaning that for every unit of timber harvested, 3.1 units are grown. On private land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 3.5:1. On public lands, the ratio is 3.8 for all species and that is also true of all major species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 26.8 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for the Maples, Red Oak, Eastern Hemlock and Eastern White Pine is over 2:1 for both public and private lands. It is over 4:1 for Eastern White Pine and Eastern Hemlock.

Lastly, the natural mortality in the forest of this sub-region at 57,765,388 cubic feet per year, is over 86% of the annual removals at 66,875,378 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

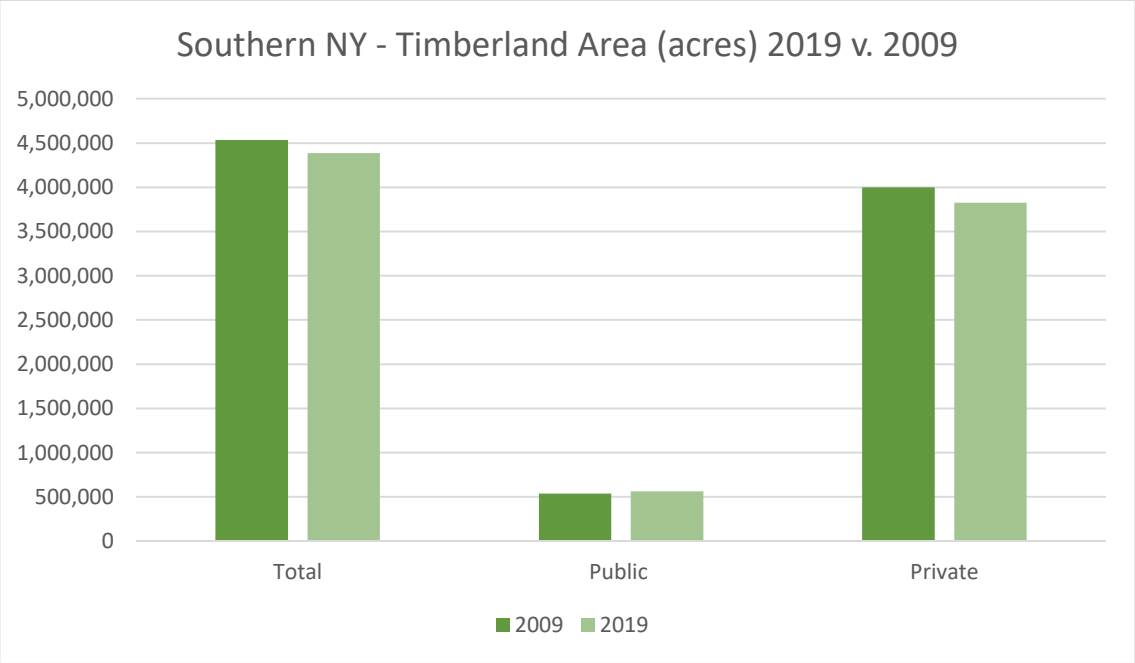
The Southern Tier NY sub-region is heavily forested and well stocked with standing timber. Forests are growing timber at rates higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

This region includes Allegany, Broome, Cattaraugus, Chautauqua, Chemung, Chenango, Delaware, Otsego, Schoharie, Schuyler, Steuben, Tioga and Tompkins Counties in New York and represents approximately 4,387,314 acres of timberland. As a percentage of land and water area in the sub-region, the area is 61% forested. The sub-region has almost nearly seven times the timberland acreage in private land as it does in public land (3,825,778 acres private vs.

561,536 acres public) – see Figure 57. Comparing the area using 2009 and 2019 data, the sub-region lost 147,382 acres of timberland over the 10-year period (approximately 3 % of the forests in the sub-region). The area gained 25,860 acres of public land during that period and lost 173,242 acres of private land (from the public land gained plus additional acreage that changed to developed or agricultural uses). Much of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests or State land in the Adirondack Park area).

Figure 57 Southern Tier NY - Timberland Area



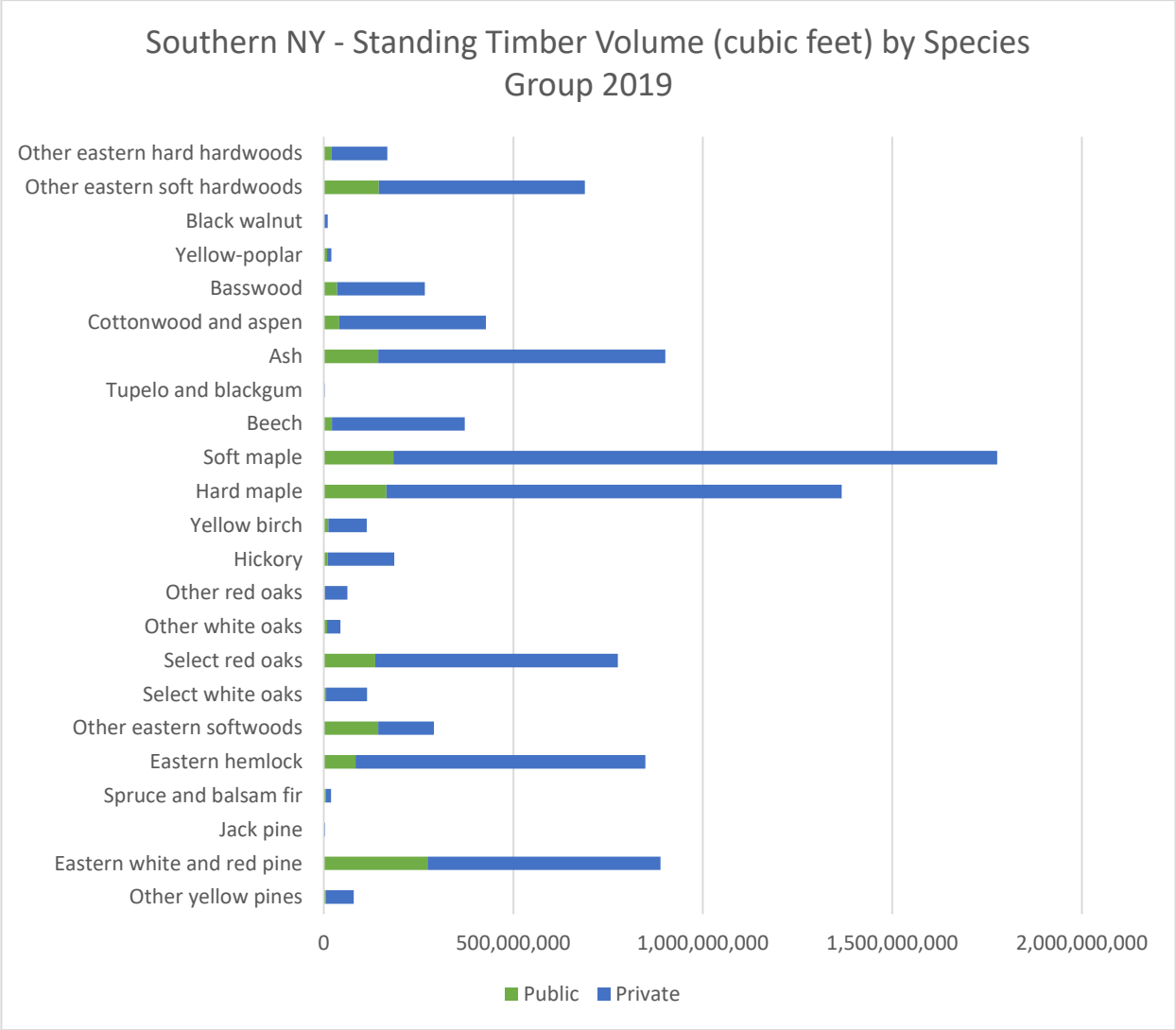
Source: USDA Forest Service, Forest Inventory and Analysis

Timber Volume and Changes 2009-2019

Overall, on all timberlands in the fifteen-county region, standing timber volume in 2019 for all species was 9,420,902,222 cubic feet. This represents 2,147.3 cubic feet/acre or 26.8 cords per acre – 26,0 cords/ac private land and 32.3 cords/ac on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

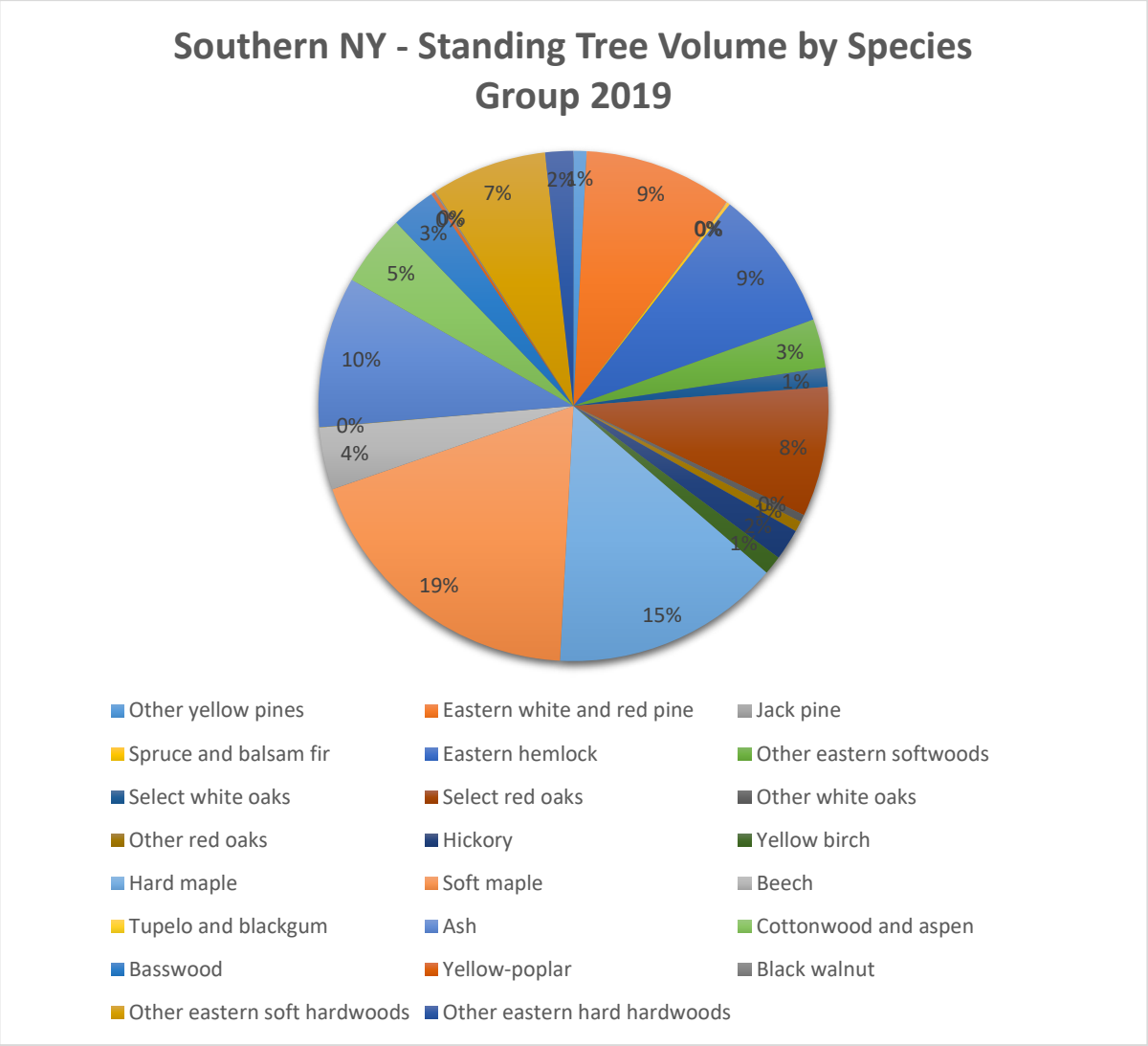
The breakdown of standing volume by species groups for the North Country NY sub-region can be seen in Figure 58. The Maples, Ash, Red Oak, Eastern Hemlock and Eastern White Pine are the dominant species groups in terms of volume in the sub-region.

Figure 58 Southern Tier NY Standing Timber Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 59 Southern Tier NY Timber Volume by Species



Source: USDA Forest Service, Forest Inventory and Analysis

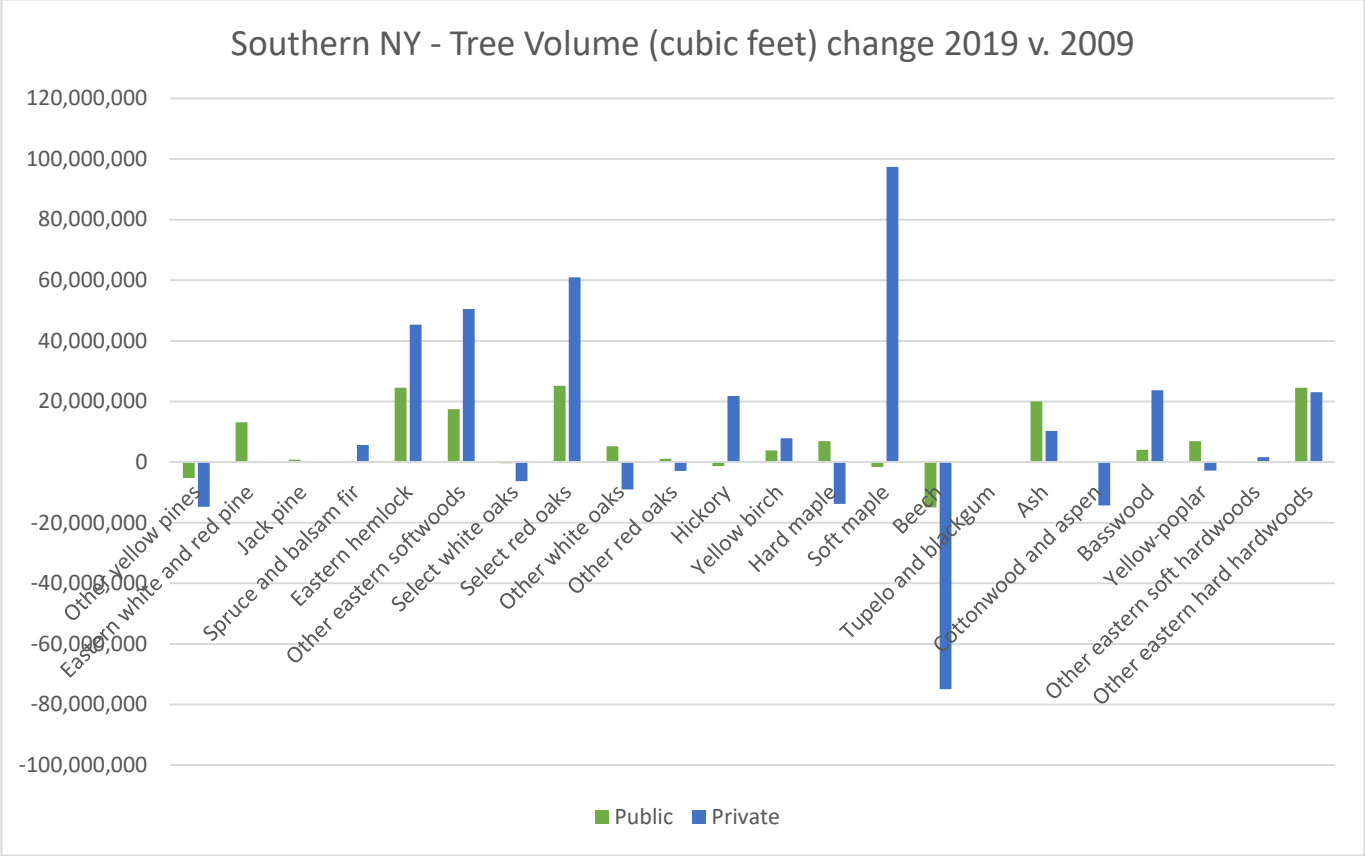
Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber increased by 374,536,138 cubic feet or 4.1 % of standing volume. This occurred despite a loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 60) but it must be understood as a current snapshot in time.

Figure 60 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups occurred mostly on private land in the sub-region where most of the timber is harvested.

Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 60, notable changes in species volume from 2009-2019 include large increases in the Maples, Eastern Hemlock, Eastern White Pine and Red Oak. Reductions in standing volume during the 10-year time period include mostly just Beech which is a good trend given the lack of economic value of this species which has been devastated by the Beech scale complex disease.

Figure 60 Southern Tier NY Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

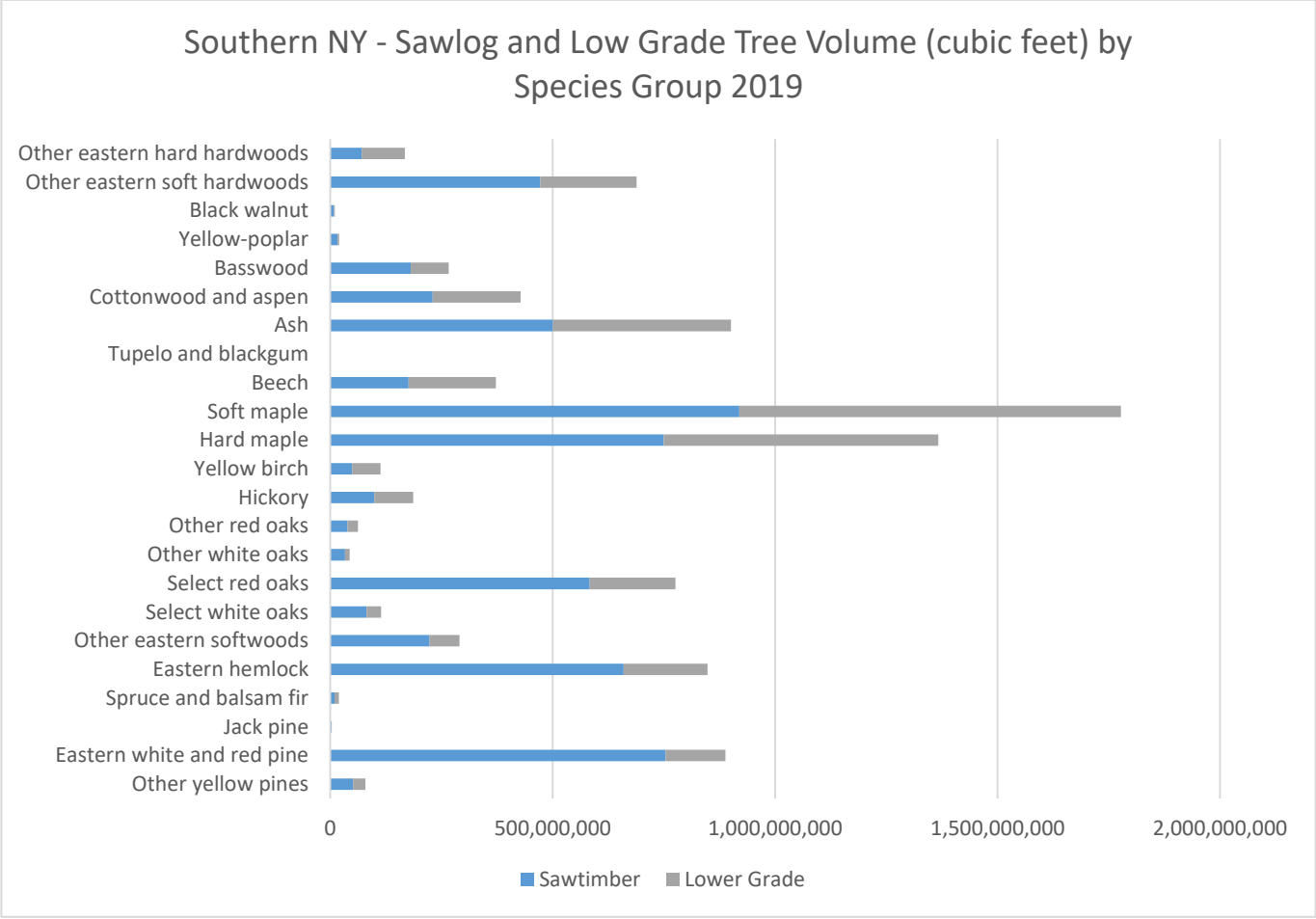
Note on Figure 60 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 61 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Maples, Ash, Red Oak, Eastern Hemlock and Eastern White Pine all show sawlog volumes at or over half of standing volumes. Red Oak, Eastern Hemlock & White Pine is over 80% sawlog volume. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 61 Southern Tier NY Sawlog v. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number in Figure 62 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 62. Net growth for the year was 206.0 million cubic feet and removals 66.9 million cubic feet. The important result (growth less removals) is a net increase of 139.1 million cubic feet (1,738,533 cords) of standing timber volume per year in the sub-region.

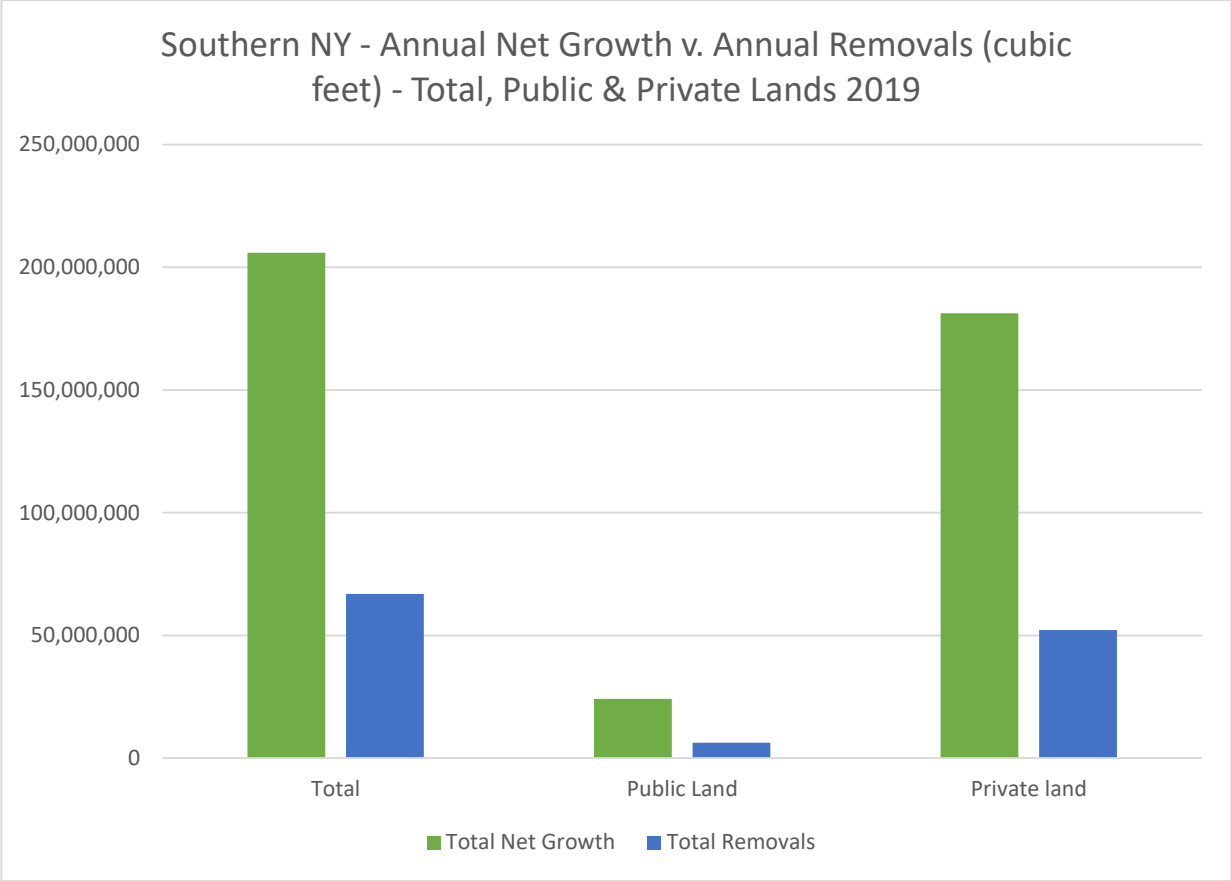
Figure 62 Southern Tier Summary Table - Net Growth v. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Southern NY			
2019	***Net Growth***	cubic feet	
	all	205,957,986	
	public	24,228,815	
	private	181,264,983	
	Removals		**Removals from Harvest**
	all	66,875,378	65,897,067
	public	6,340,234	
	private	52,137,859	
	Growth less Removals		
	all	139,082,608	
	public	17,888,581	
	private	129,127,124	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 63. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

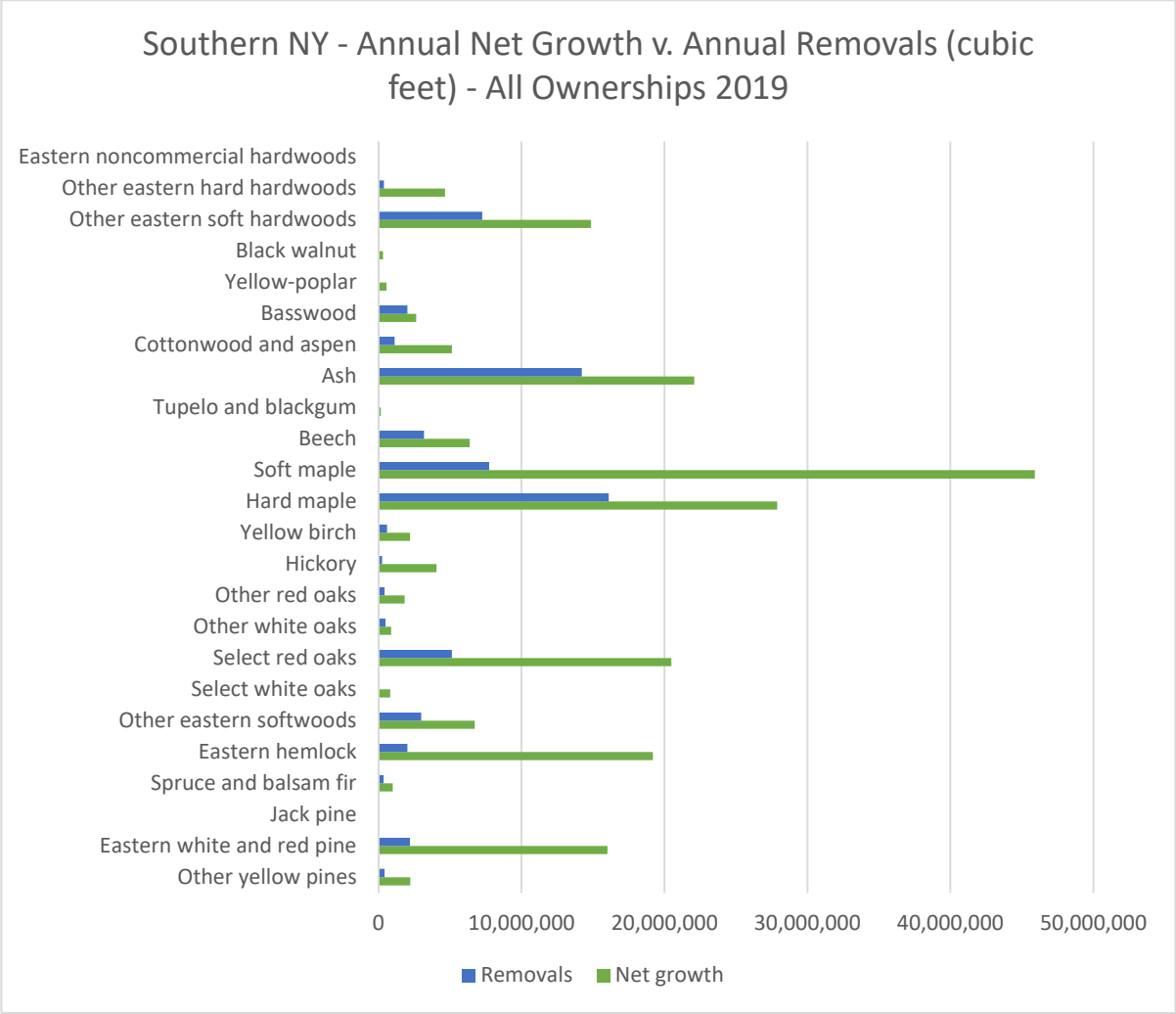
Figure 63 Southern Tier NY Net Growth v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

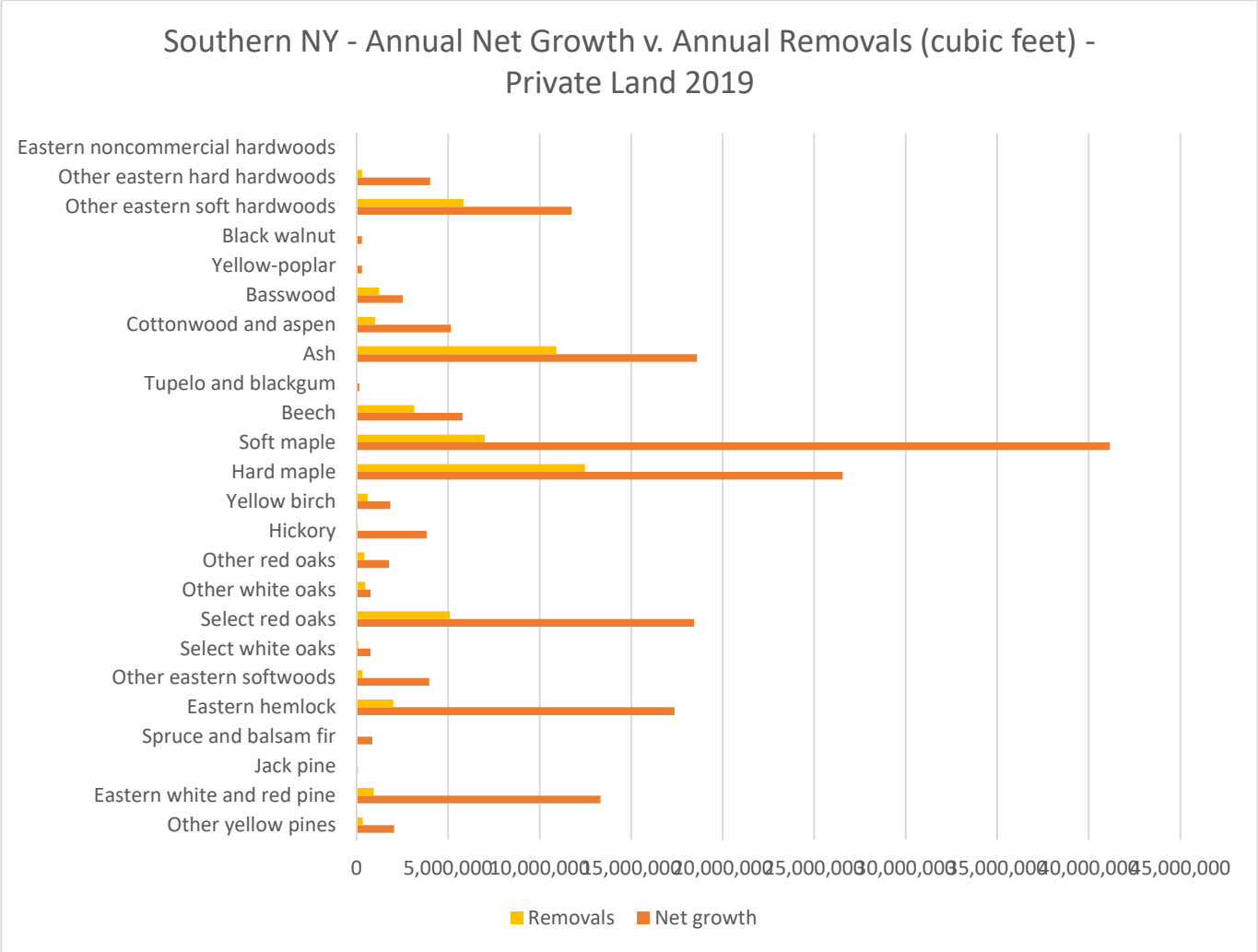
Figures 64 through 66 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Birch, Ash, Maples, Red Oak, Eastern Hemlock, and Eastern White Pine are showing a wide ratio of net growth to removals.

Figure 64 Southern Tier NY Net Growth v. Removals by Species Group



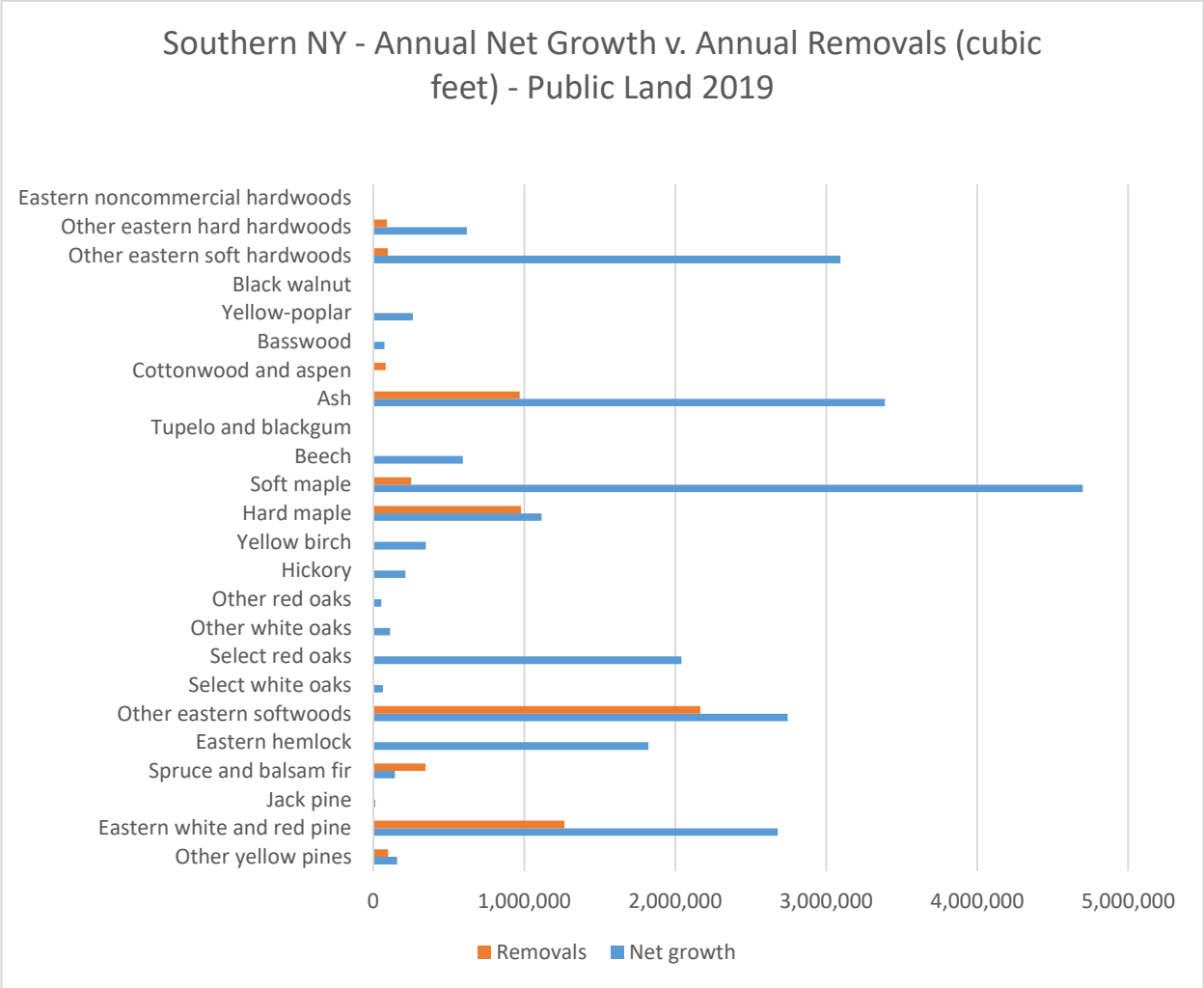
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 65 Southern Tier NY Net Growth v. Removals Private Land



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 66 Southern Tier NY Net Growth v. Removals Public Land



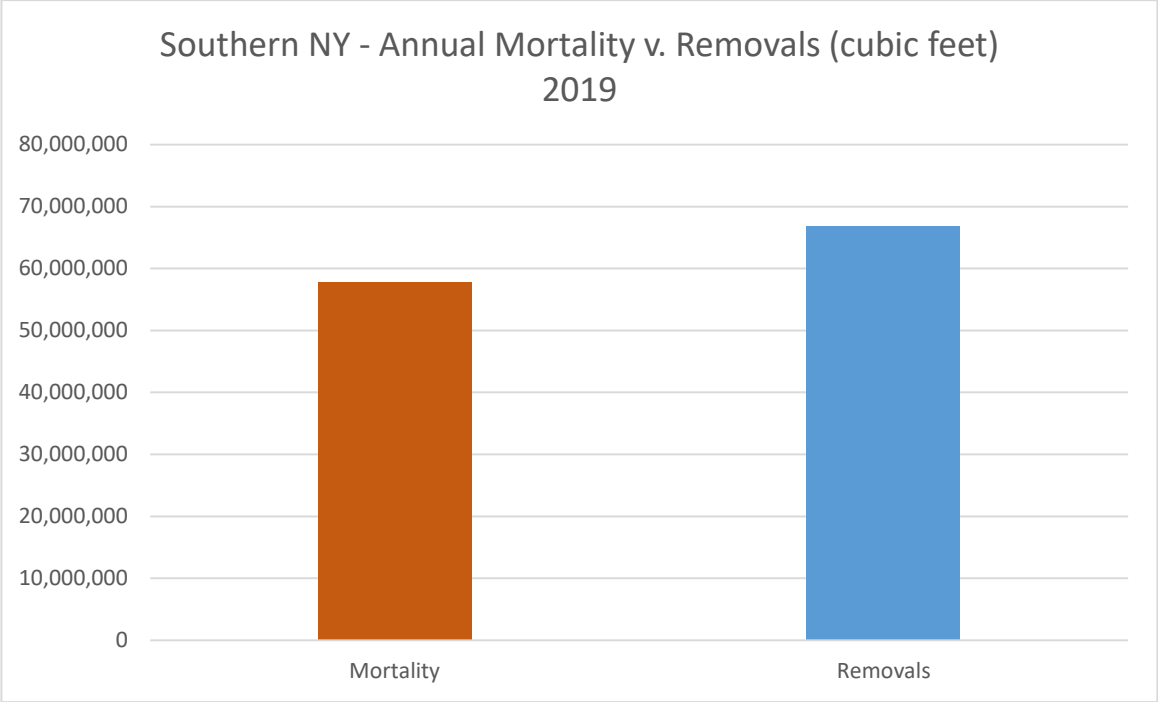
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 67 below shows the annual mortality in volume for the Southern Tier NY trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 86% of annual removals.

Figure 67 Southern Tier NY Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

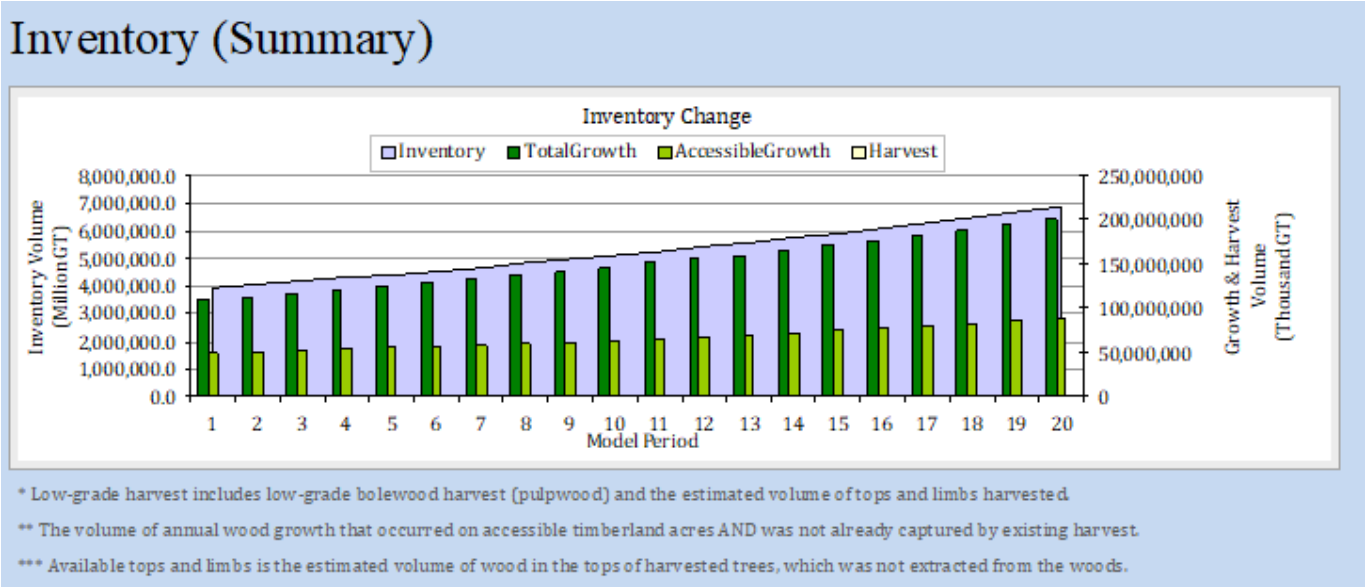
Future Timber Projections

Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the NY Southern Tier sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

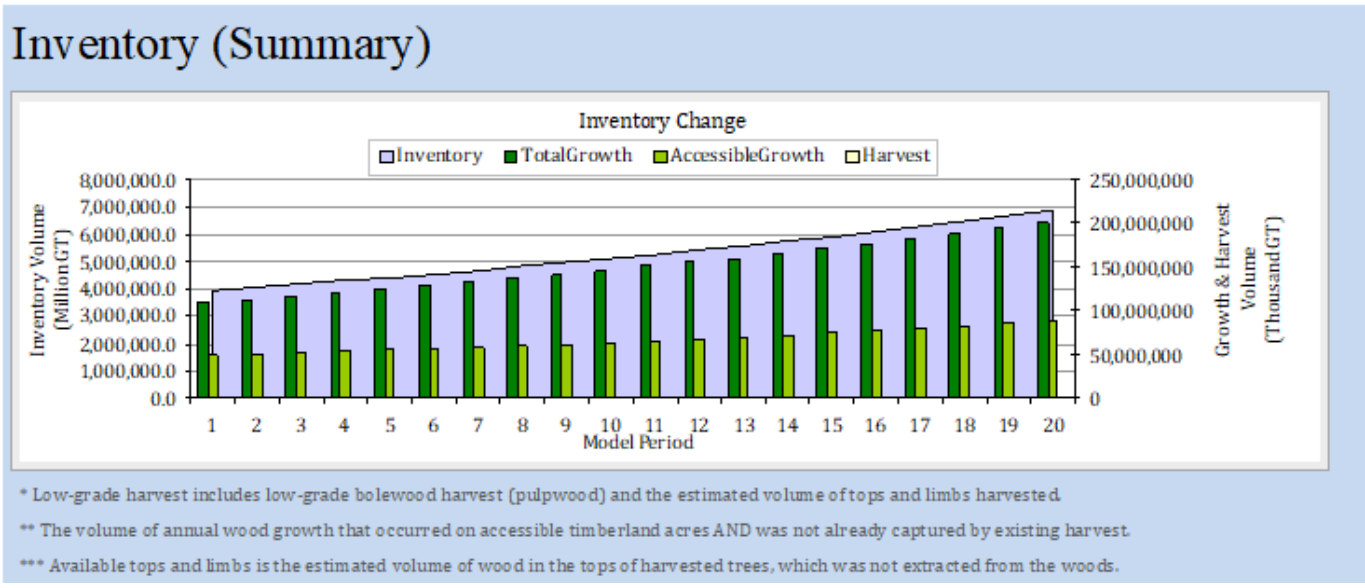


Available timber volume per year (Accessible Growth) in 2020 – 38,742,590 green tons

Available timber volume per year in year 2040 – 70,534,911 green tons

Approximately 63% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

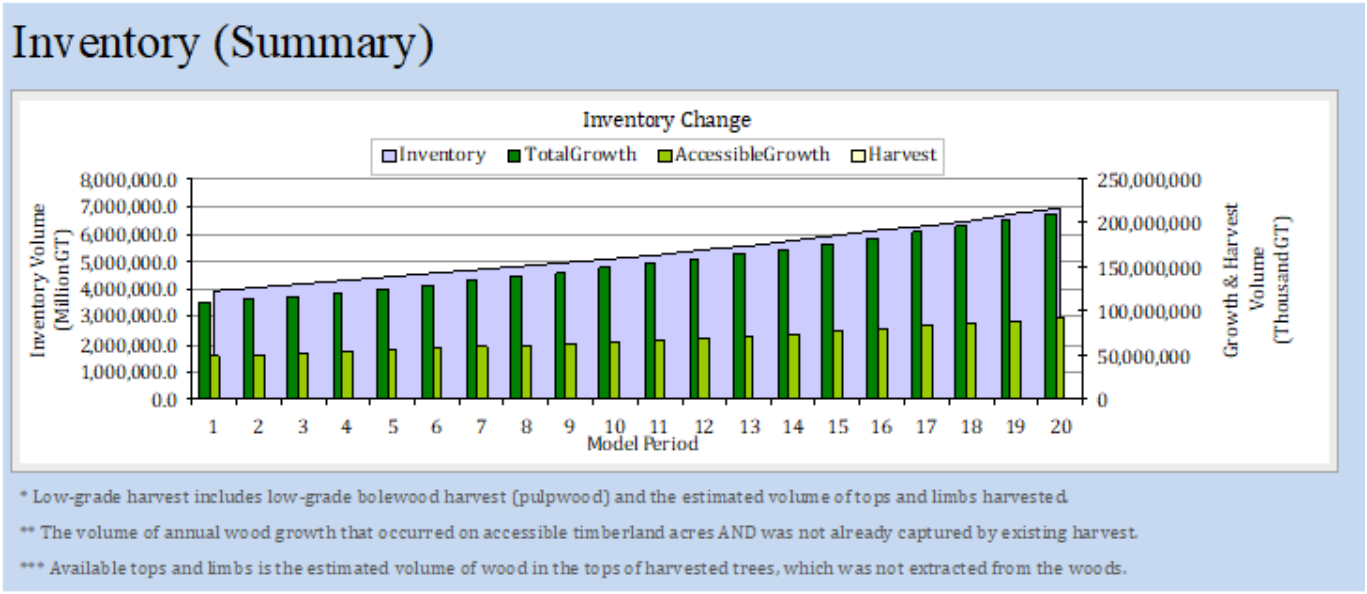


Available timber volume per year (Accessible Growth) in 2020 – 38,742,590 green tons

Available timber volume per year in year 2040 – 70,534,661 green tons

Approximately 63% of ending standing available volume in 2040 is in higher value quality timber.

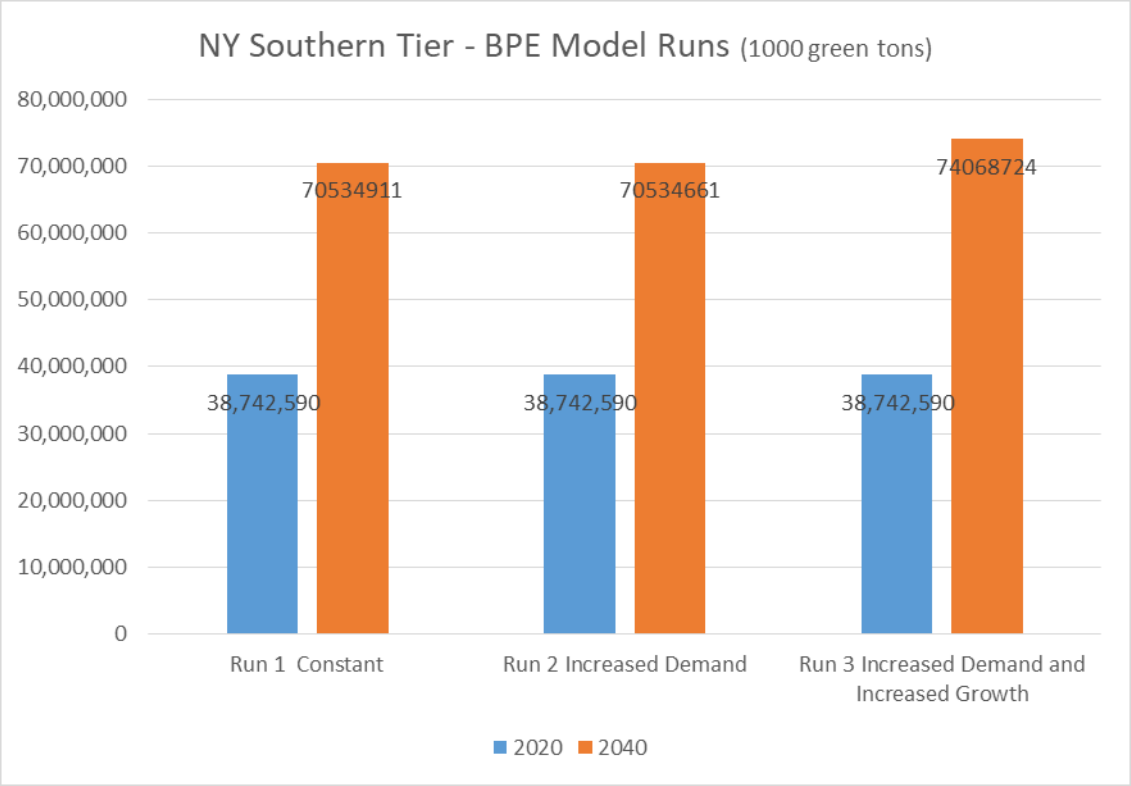
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 38,742,590 green tons

Available timber volume per year in year 2040 – 74,068,724 green tons

Approximately 63% of ending standing available volume in 2040 is in higher value quality timber.


NY Southern Tier - BPE Model Runs (1000 green tons)
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
70534911
70534661
74068724
38,742,590
38,742,590
38,742,590
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

7. Sub-Region NY – West

Overview - The 16-county New York West sub-region is the least forested region compared to the other New York sub-regions. The landscape is mostly dominated by agriculture, the Finger Lakes and urban centers such as Buffalo, Rochester, Syracuse and Utica are located in this geography. This sub-region includes parts of the Lake Erie and Lake Ontario Watersheds. A highlight of the area is existing manufacturing infrastructure with easy access to shipping lanes via Lake Erie, Lake Ontario and the St. Lawrence Seaway.

The forest types here are Northern Hardwoods dominated Red Maple, Sugar Maple and White Ash. Other minor species include Eastern White Pine, Hickory and Red Oak.

The population of this sub region decreased between 2000 and 2010 from 3,150,620 million people to 3,144,604 million people, a .2% decrease.

Timber data major findings for the NY – West Sub-region - The Western NY sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 2.6:1, meaning that for every unit of timber harvested, 2.6 units are grown. On private land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 3.0:1. On public lands, the ratio is 2.0 for all species and that is also true of all major species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 26.3 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for the Ash, Maples, Hickory, Red Oak, Eastern Hemlock and Eastern White Pine is over 2:1 for both public and private lands. It is over 3:1 Maples, Hickory and Eastern Hemlock.

Lastly, the natural mortality in the forest of this sub-region at 35,847,068 cubic feet per year, is over 79% of the annual removals at 45,143,277 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

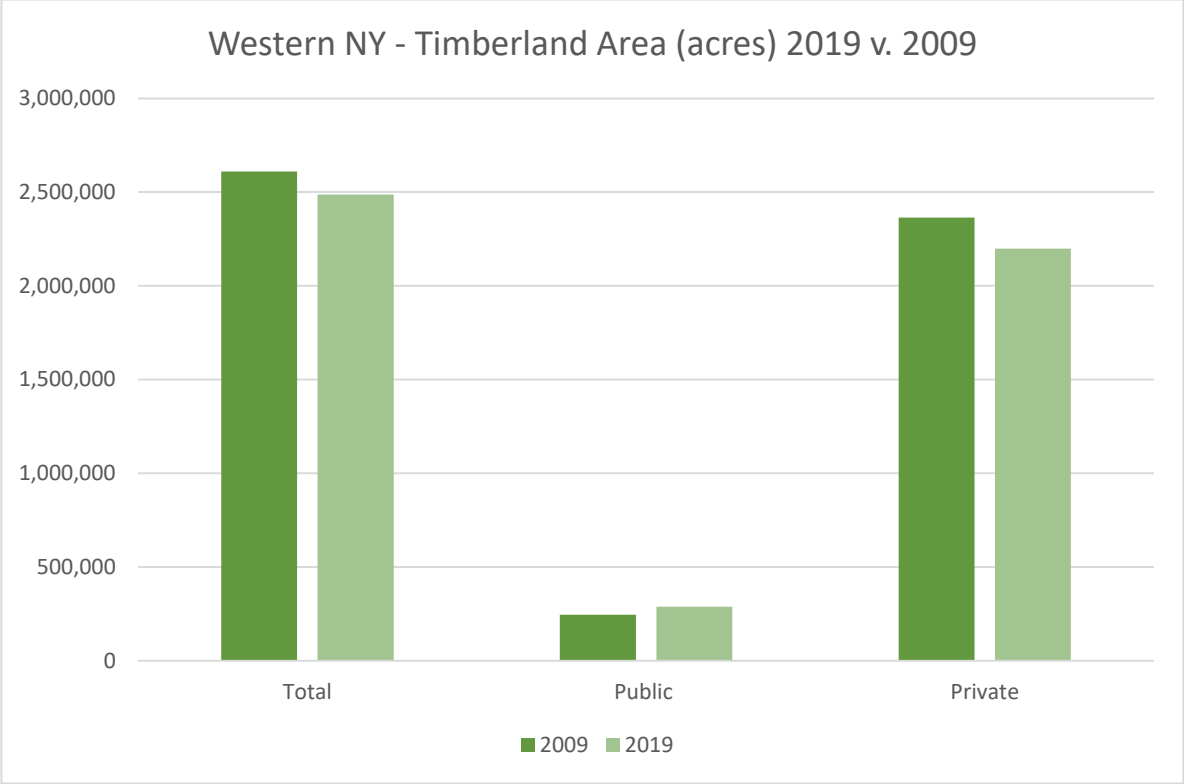
The Western NY sub-region is less than half forested but well stocked with standing timber in the forested areas. Forests are growing timber at rates higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

This region includes Cayuga, Cortland, Erie, Genesee, Livingston, Madison, Monroe, Niagara, Onondaga, Ontario, Orleans, Oswego, Seneca, Wayne, Wyoming, and Yates Counties in New York and represents approximately 6,531,382 acres of timberland. As a percentage of land and water area in the sub-region, the area is 38% forested – a very heavy to agriculture land region. The sub-region has almost nearly eight times the timberland acreage in private land as it does in public land (2,199,137 acres private vs. 287,112 acres public) – see Figure 68. Comparing the area using 2009 and 2019 data, the sub-region lost 123,442 acres of timberland over the 10-year period (approximately 5 % of the forests in the sub-region). The area gained 42,155 acres of

public land during that period and lost 165,596 acres of private timberland (from the public land gained plus additional acreage that changed to developed or agricultural uses). Much of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests or State land in the Adirondack Park area).

Figure 68 West NY - Timberland Area



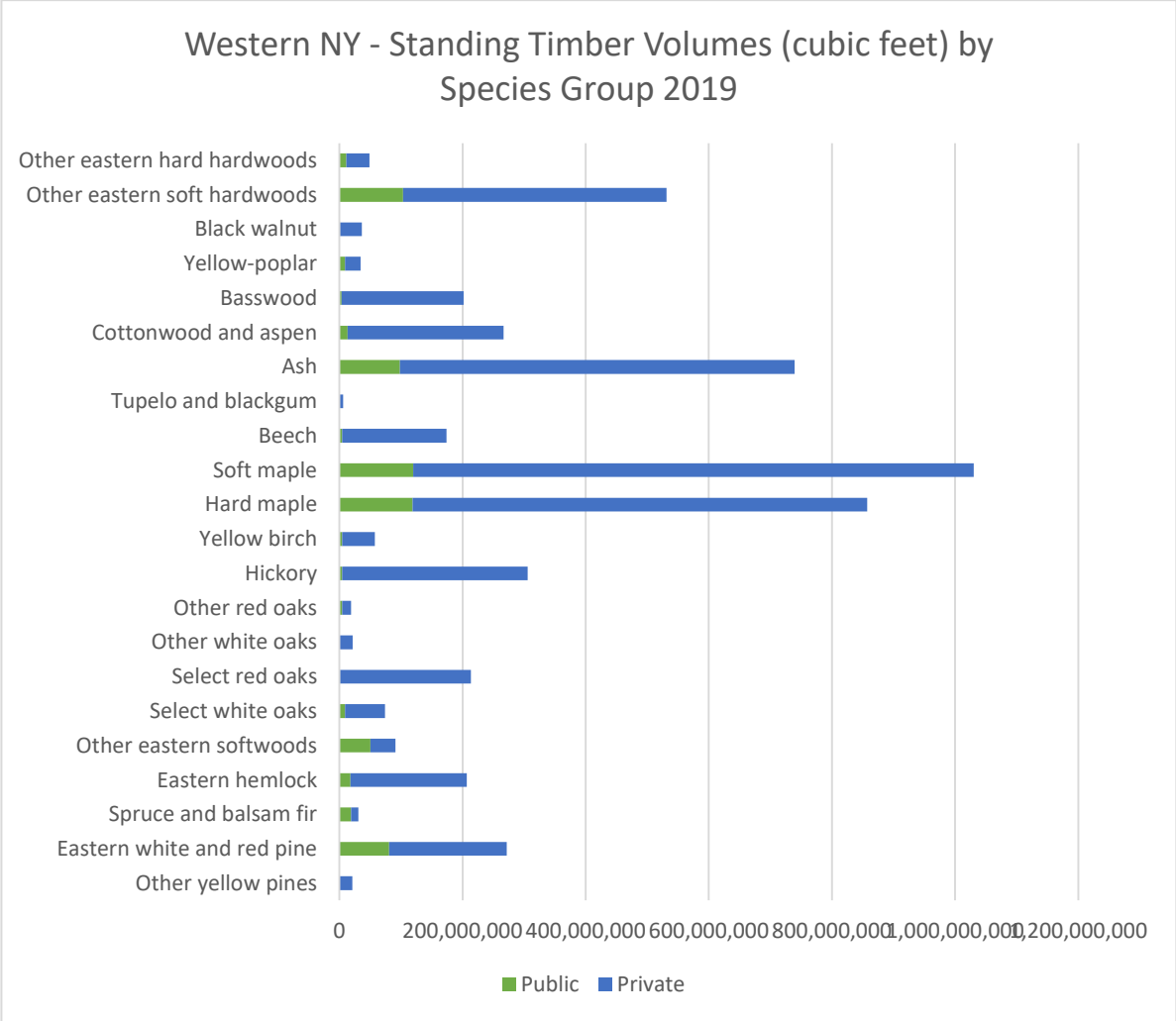
Source: USDA Forest Service, Forest Inventory and Analysis

Timber Volume and Changes 2009-2019

Overall, on all timberlands in the sixteen-county region, standing timber volume in 2019 for all species was 5,237,662,801 cubic feet. This represents 2,106.7 cubic feet/acre or 26.3 cords per acre – 26,0 cords/ac private land and 29.4 cords/ac on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

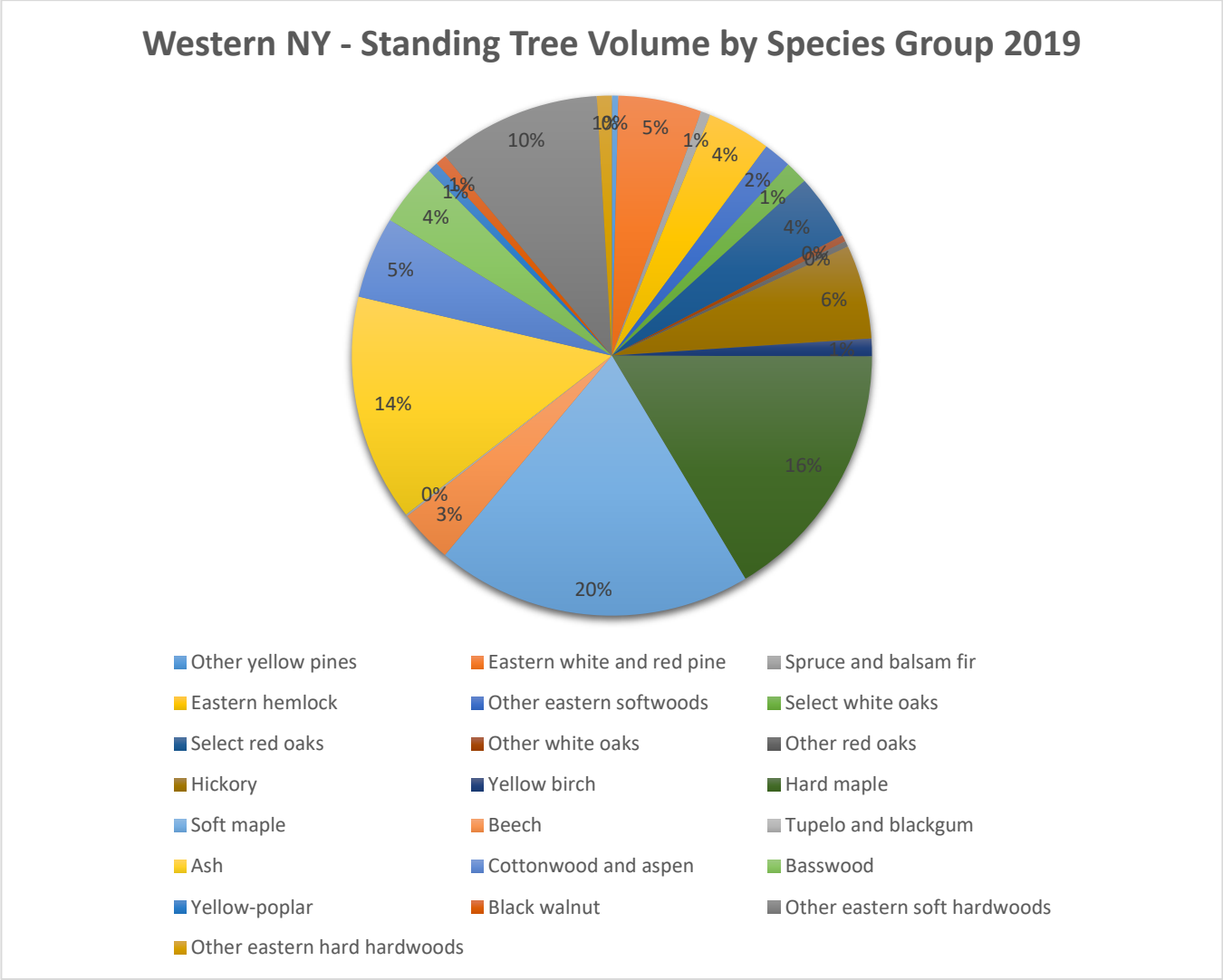
The breakdown of standing volume by species groups for the Lower Hudson NY sub-region can be seen in Figure 69. Ash, the Maples, Ash, and Hickory are the dominant species groups in terms of volume in the sub-region.

Figure 69 Southern Tier NY Standing Timber Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 70 West NY Timber Volume by Species



Source: USDA Forest Service, Forest Inventory and Analysis

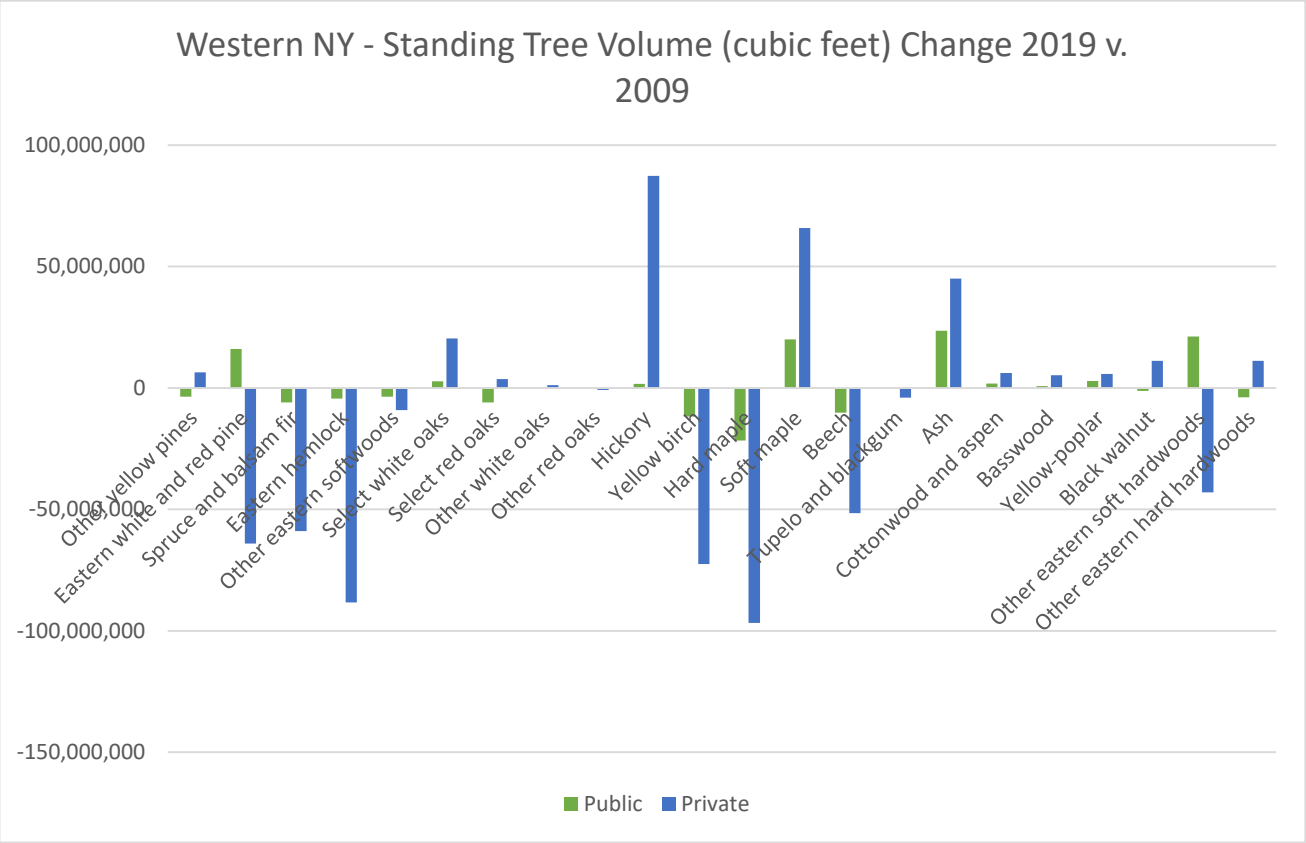
Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber decreased by 201,888,004 cubic feet or 3.7 % of standing volume. This occurred partly because of the loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 71) but it must be understood as a current snapshot in time.

Figure 71 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups occurred mostly on private land in the sub-region where most of the timber is harvested.

Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 71, notable changes in species volume from 2009-2019 include large increases in Hickory, Soft (red) Maple, and Ash. Reductions in standing volume during the 10-year time period include Eastern White Pine, Spruce/Fir, Eastern Hemlock, Yellow Birch, Hard (sugar) Maple and Beech.

Figure 71 West NY Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

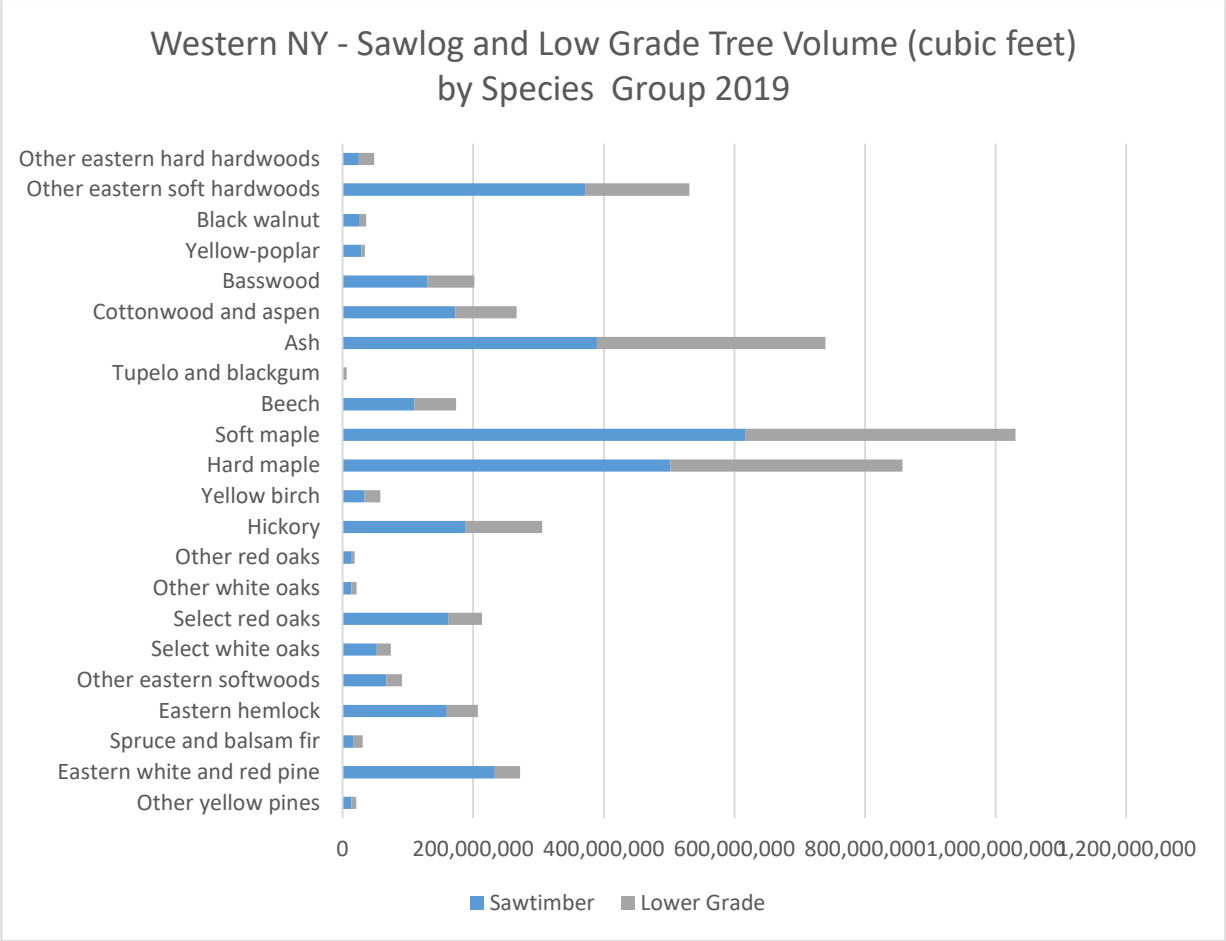
Note on Figure 71 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 72 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Ash, the Maples and Hickory all show sawlog volumes nearly at or over half of standing volumes. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 72 West NY Sawlog v. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number is Figure 73 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 73. Net growth for the year was 117.9 million cubic feet and removals 45.1 million cubic feet. The important result (growth less removals) is a net increase of 72.8 million cubic feet (909,680 cords) of standing timber volume per year in the sub-region.

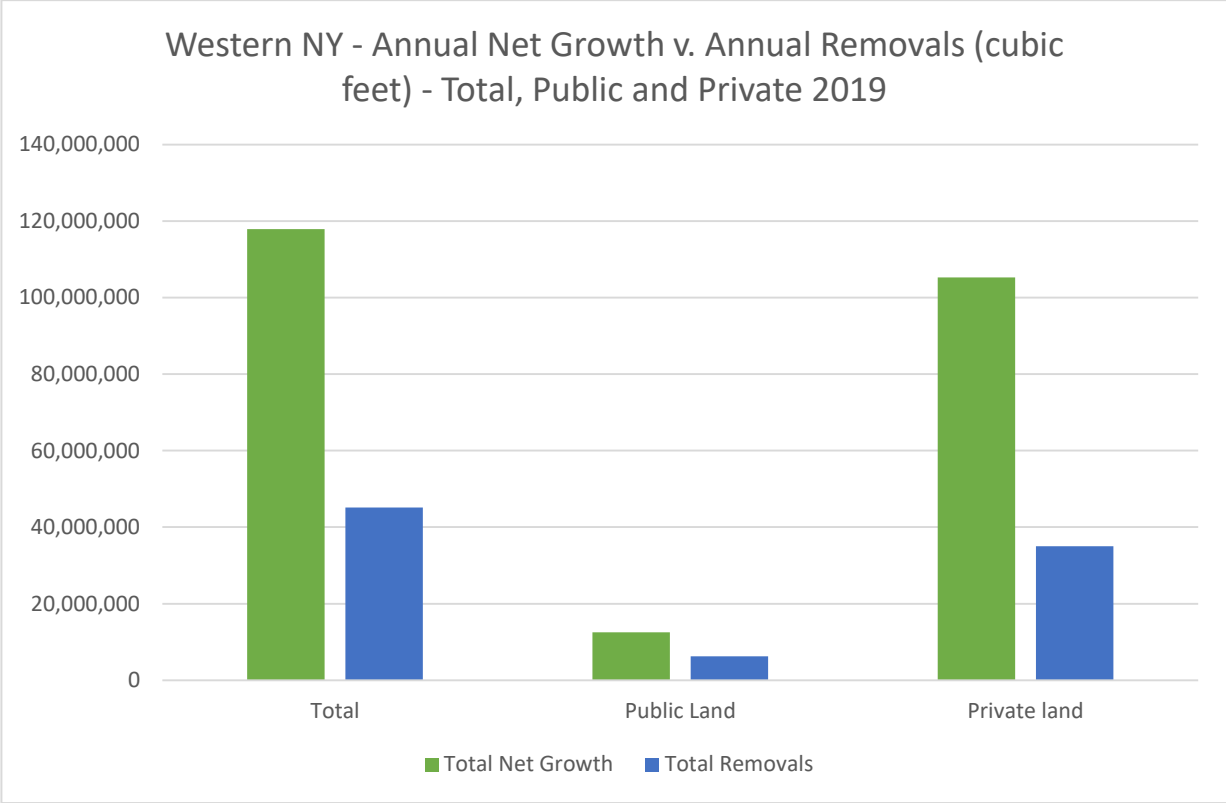
Figure 73 West NY Summary Table - Net Growth v. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Western NY			
2019	***Net Growth***	cubic feet	
	all	117,917,695	
	public	12,478,488	
	private	105,320,327	
	Removals		**Removals from Harvest**
	all	45,143,277	44,116,871
	public	6,245,285	
	private	35,016,857	
	Growth less Removals		
	all	72,774,418	
	public	6,233,203	
	private	70,303,470	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 74. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

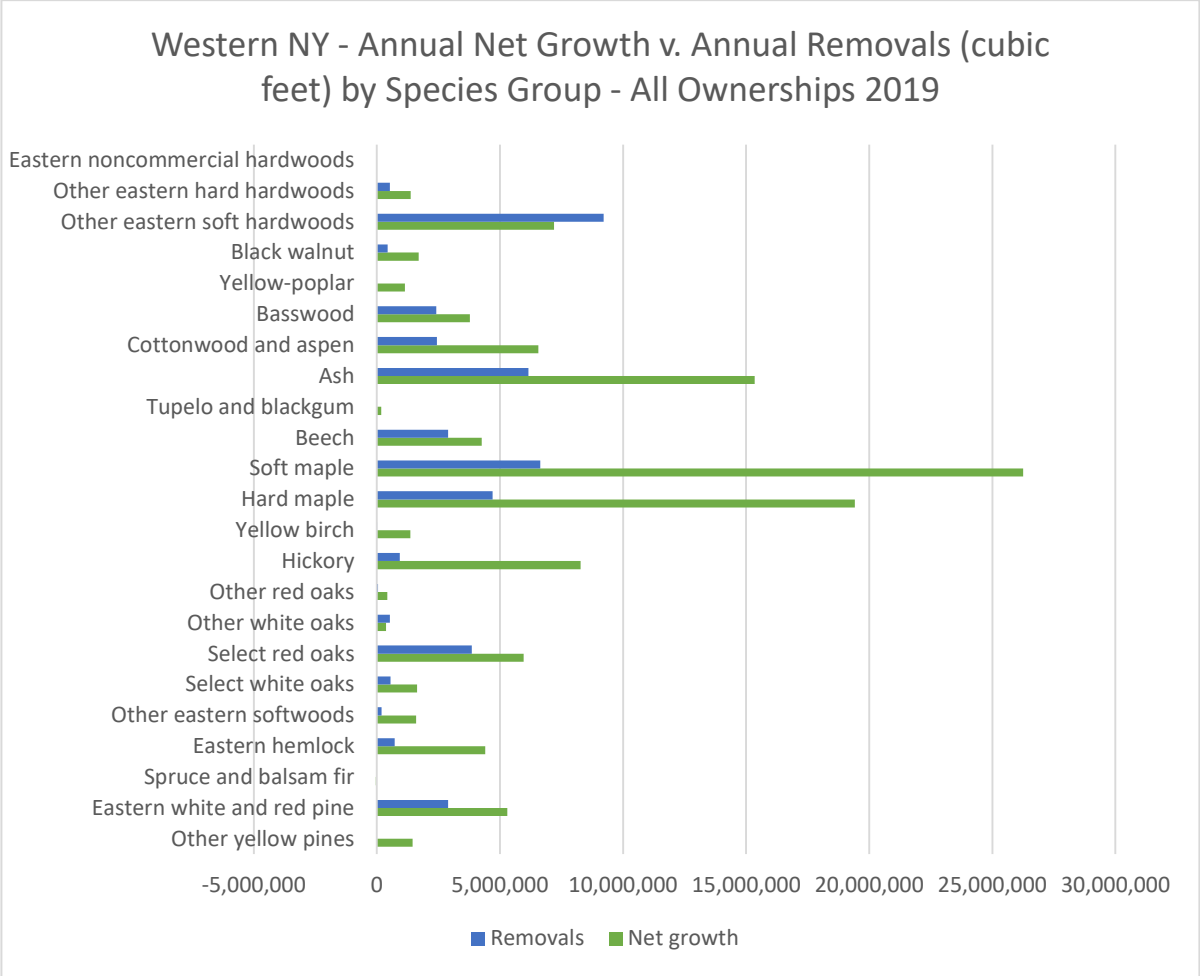
Figure 74 Southern Tier NY Net Growth v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

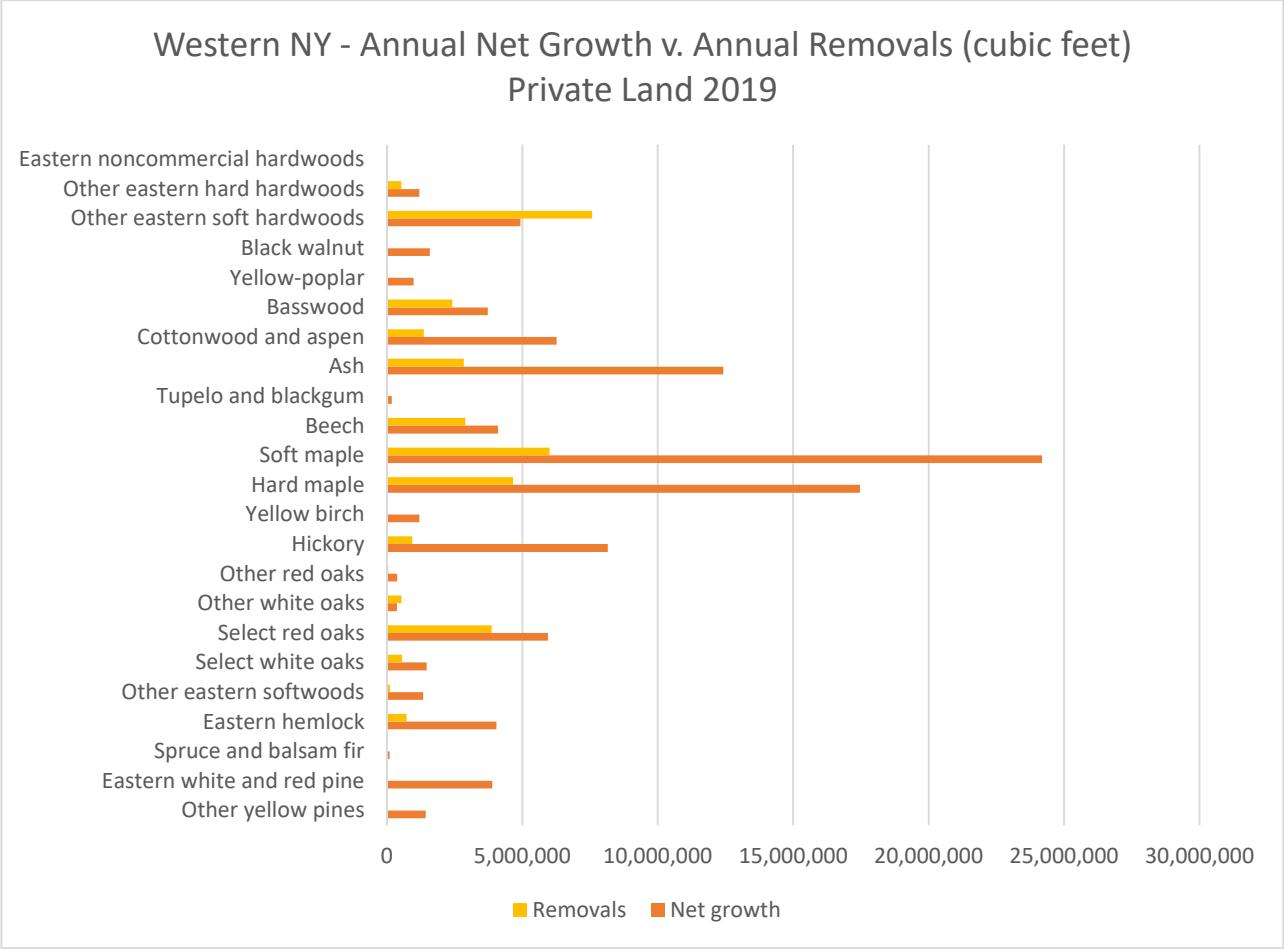
Figures 75 through 77 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Ash, Maples, and Hickory are showing a wide ratio of net growth to removals.

Figure 75 West NY Net Growth v. Removals by Species Group



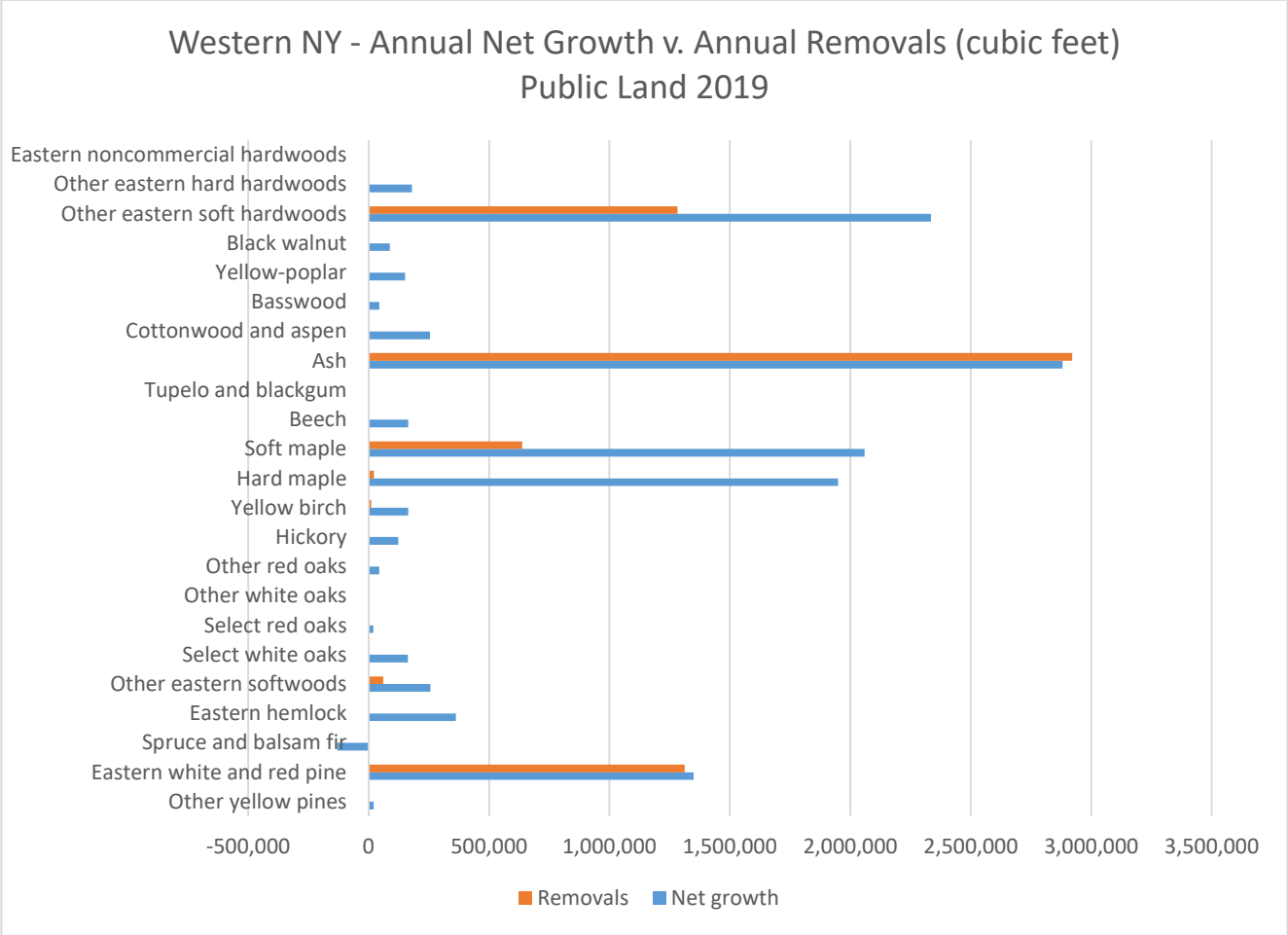
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 75 West NY Net Growth v. Removals Private Land



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 76 West NY Net Growth v. Removals Public Land



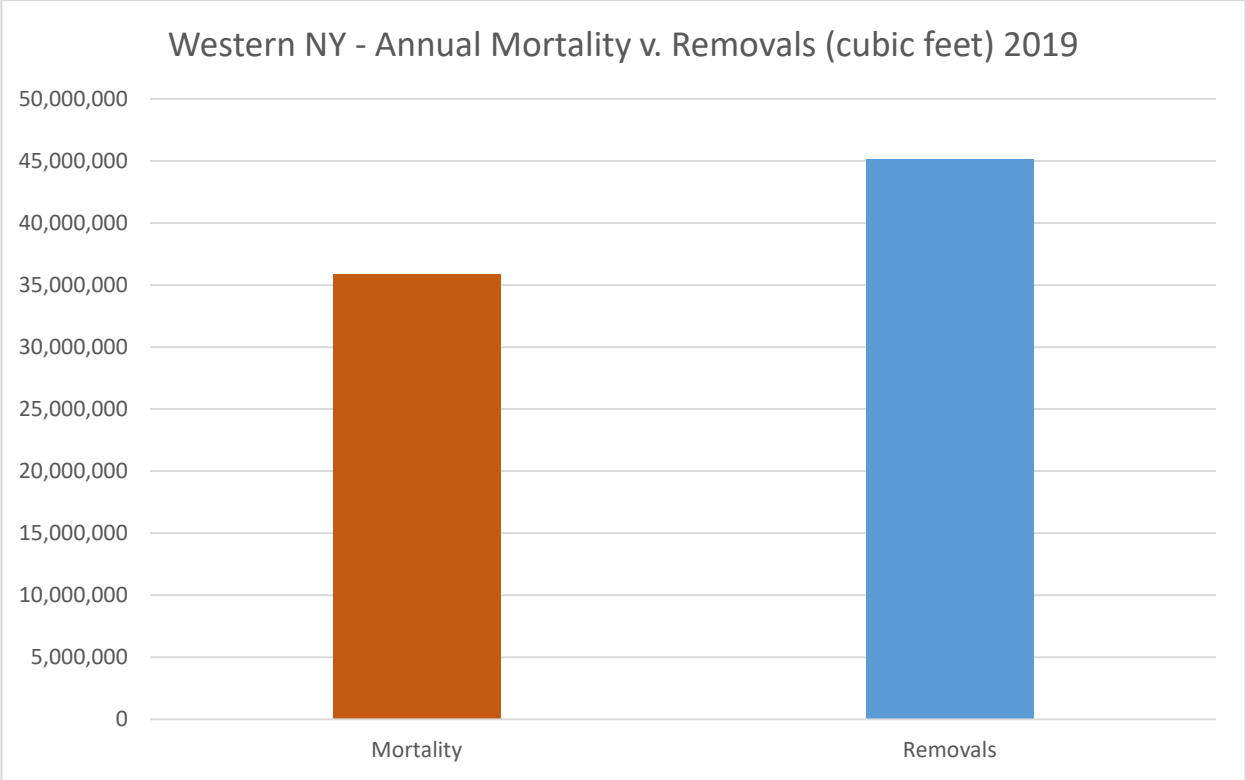
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 78 below shows the annual mortality in volume for the West NY trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 79% of annual removals.

Figure 77 West NY Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

Future Timber Projections

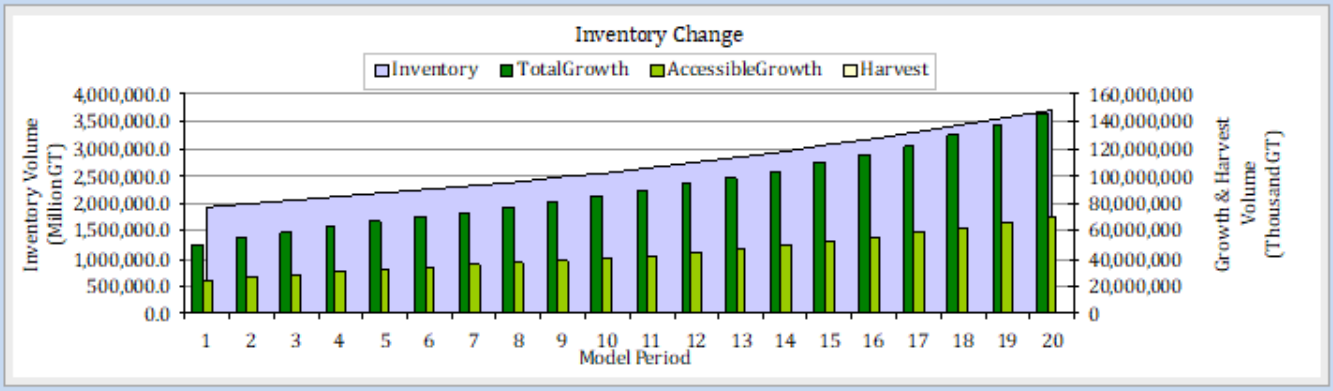
Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the NY West sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

Inventory (Summary)



* Low-grade harvest includes low-grade bolewood harvest (pulpwood) and the estimated volume of tops and limbs harvested.

** The volume of annual wood growth that occurred on accessible timberland acres AND was not already captured by existing harvest.

*** Available tops and limbs is the estimated volume of wood in the tops of harvested trees, which was not extracted from the woods.

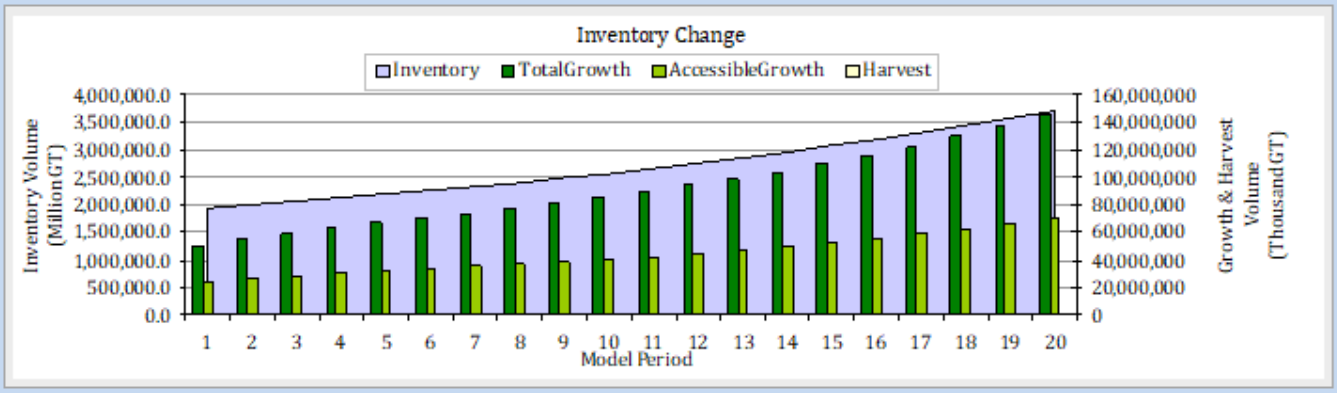
Available timber volume per year (Accessible Growth) in 2020 – 18,663,630 green tons

Available timber volume per year in year 2040 – 55,686,503 green tons

Approximately 64% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

Inventory (Summary)



* Low-grade harvest includes low-grade bolewood harvest (pulpwood) and the estimated volume of tops and limbs harvested.

** The volume of annual wood growth that occurred on accessible timberland acres AND was not already captured by existing harvest.

*** Available tops and limbs is the estimated volume of wood in the tops of harvested trees, which was not extracted from the woods.

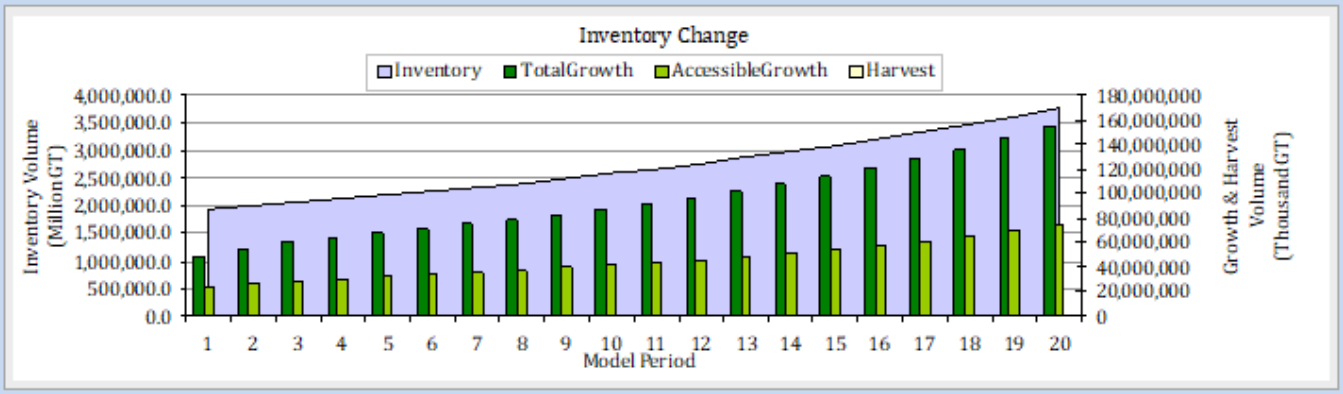
Available timber volume per year (Accessible Growth) in 2020 – 18,663,630 green tons

Available timber volume per year in year 2040 – 55,686,352 green tons

Approximately 64% of ending standing available volume in 2040 is in higher value quality timber.

Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.

Inventory (Summary)



* Low-grade harvest includes low-grade bolewood harvest (pulpwood) and the estimated volume of tops and limbs harvested.

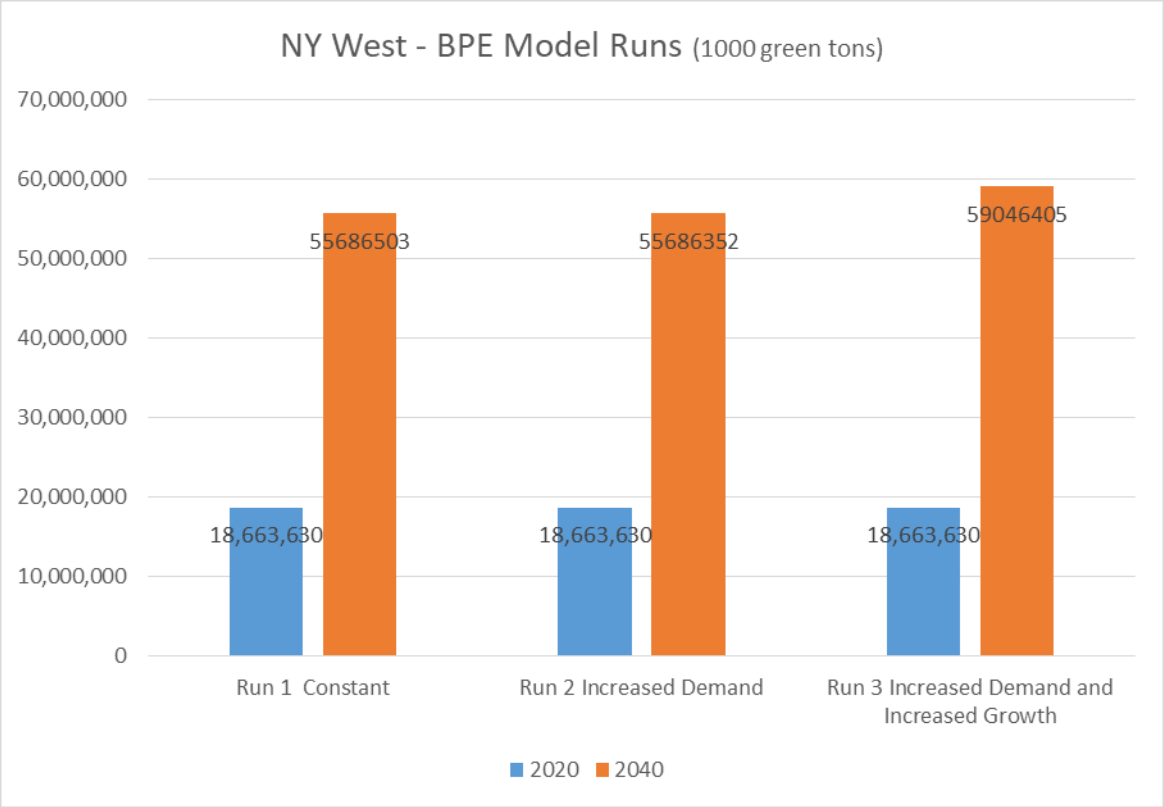
** The volume of annual wood growth that occurred on accessible timberland acres AND was not already captured by existing harvest.

*** Available tops and limbs is the estimated volume of wood in the tops of harvested trees, which was not extracted from the woods.

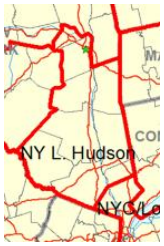
Available timber volume per year (Accessible Growth) in 2020 – 18,663,630 green tons

Available timber volume per year in year 2040 – 59,046,405 green tons

Approximately 64% of ending standing available volume in 2040 is in higher value quality timber.


NY West - BPE Model Runs (1000 green tons)
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
55686503
55686352
59046405
18,663,630
18,663,630
18,663,630
Run 1 Constant
Run 2 Increased Demand
Run 3 Increased Demand and Increased Growth
2020
2040

8. Sub-Region NY – Lower Hudson



Overview - The smallest of the New York sub-regions, the 9-county Lower Hudson Valley, encompasses most of the NY City Watershed and Hudson River Estuary. The Catskill Mountains are also located here. Due to the presence of the NYC Watershed and its mission to conserve forests through forestry programs, there are unique opportunities for the forestry sector in the sub-region.

The major forest species in this sub region are Eastern White Pine, Red Oak, Red Maple, and Ash. Other important species include White Oak and Eastern Hemlock. White Oak in this region has been receiving some attention from barrel makers in recent years.

The population of this sub-region increased between 2000 and 2010 from 1,521,119 million people to 1,601,299 million people, a 5.3% increase. Other than the greater NYC and Long Island Metropolitan Areas of the state, this sub-region has seen the greatest increase in population. This is also the areas where the greater development pressure on the forest resource occurs.

Timber data major findings for the NY – Lower Hudson Sub-region - The Lower NY sub-region FIA data shows timber standing inventory increasing year after year overall on both public and private land. The overall net growth to removals ratio is 4.1:1, meaning that for every unit of timber harvested, 4.1 units are grown. On private land, the volume increase is seen across all of the species groups and the net growth to removals ratio is 4.2:1. On public lands, the ratio is 3.9 for all species and that is also true of all major species groups.

Overall stocking per acre – a measurement of the density of trees in the forest and a very important indicator of future potential in addition to growth to removals ratio – is over 30.1 cords per acre for both public and private land. This indicates substantial standing timber in the sub-region, lending itself to increased harvesting across virtually all species groups. The growth to harvest ratio for the Ash, Beech, Birch, Maples, Hickory, Red Oak, Eastern Hemlock and Eastern White Pine is over 2:1 for both public and private lands. It is over 4:1 Maples, Hickory, Red Oaks Eastern Hemlock and Eastern White Pine.

Lastly, the natural mortality in the forest of this sub-region at 40,891,270 cubic feet per year, is over 225% of the annual removals at 18,134,856 cubic feet. This further indicates an opportunity for additional harvesting to capture some of the mortality for economic purposes.

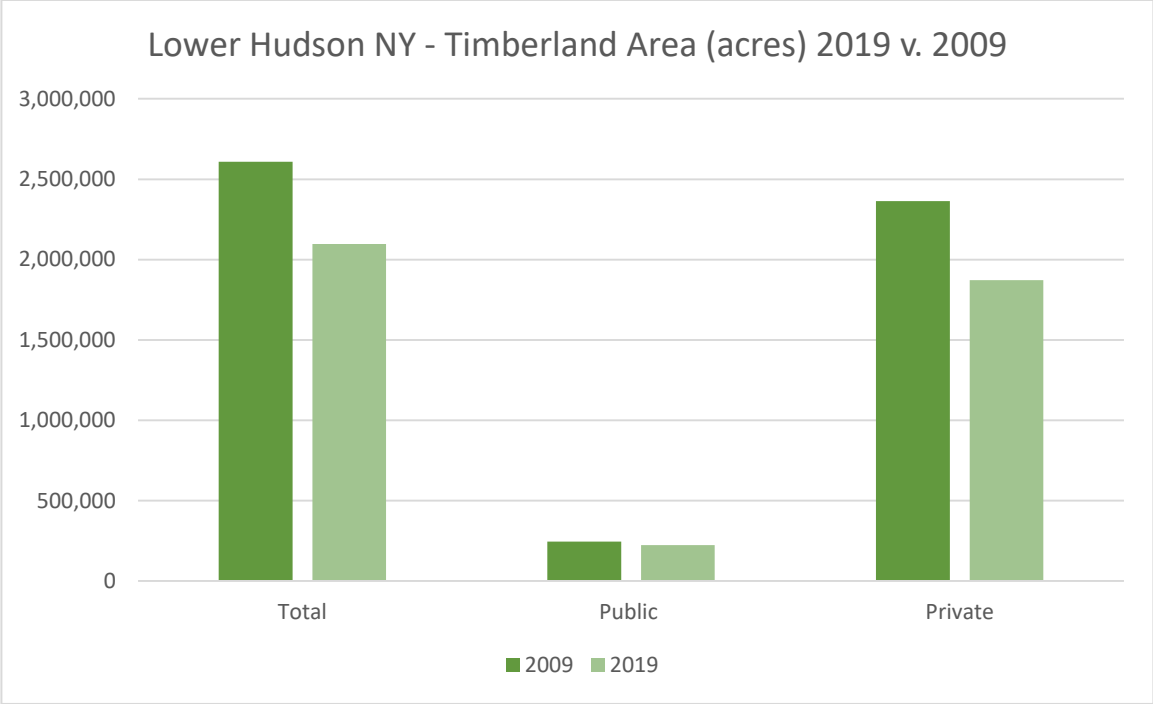
The Lower Hudson NY sub-region is little more than half forested and well stocked with standing timber in the forested areas. Forests are growing timber at rates much higher than is being removed annually. From a timber supply perspective, this sub-region is attractive for establishing additional wood-using industries or expanding existing timber users.

Timberland Area

This region includes Albany, Columbia, Dutchess, Greene, Orange, Putnam, Schenectady, Sullivan and Ulster Counties in New York and represents approximately 2,097,377 acres of timberland. As a percentage of land and water area in the sub-region, the area is 54% forested. The sub-region has almost over eight times the timberland acreage in private land as it does in

public land (1,872,752 acres private vs. 224,625 acres public) – see Figure 79. Comparing the area using 2009 and 2019 data, the sub-region lost 512,313 acres of timberland over the 10-year period (approximately 2 % of the forests in the sub-region). The area lost 20,332 acres[10] of public land during that period and lost 491,981 acres of private timberland (from the public land gained plus additional acreage that changed to developed or agricultural uses). Much of this loss was to non-forest uses. The loss of timberland results from a combination of forest converted to non-forest use and converted to non-timberland forests (such as Wilderness on national forests or State land in the Adirondack Park area).

Figure 78 Lower Hudson - Timberland Area



Source: USDA Forest Service, Forest Inventory and Analysis

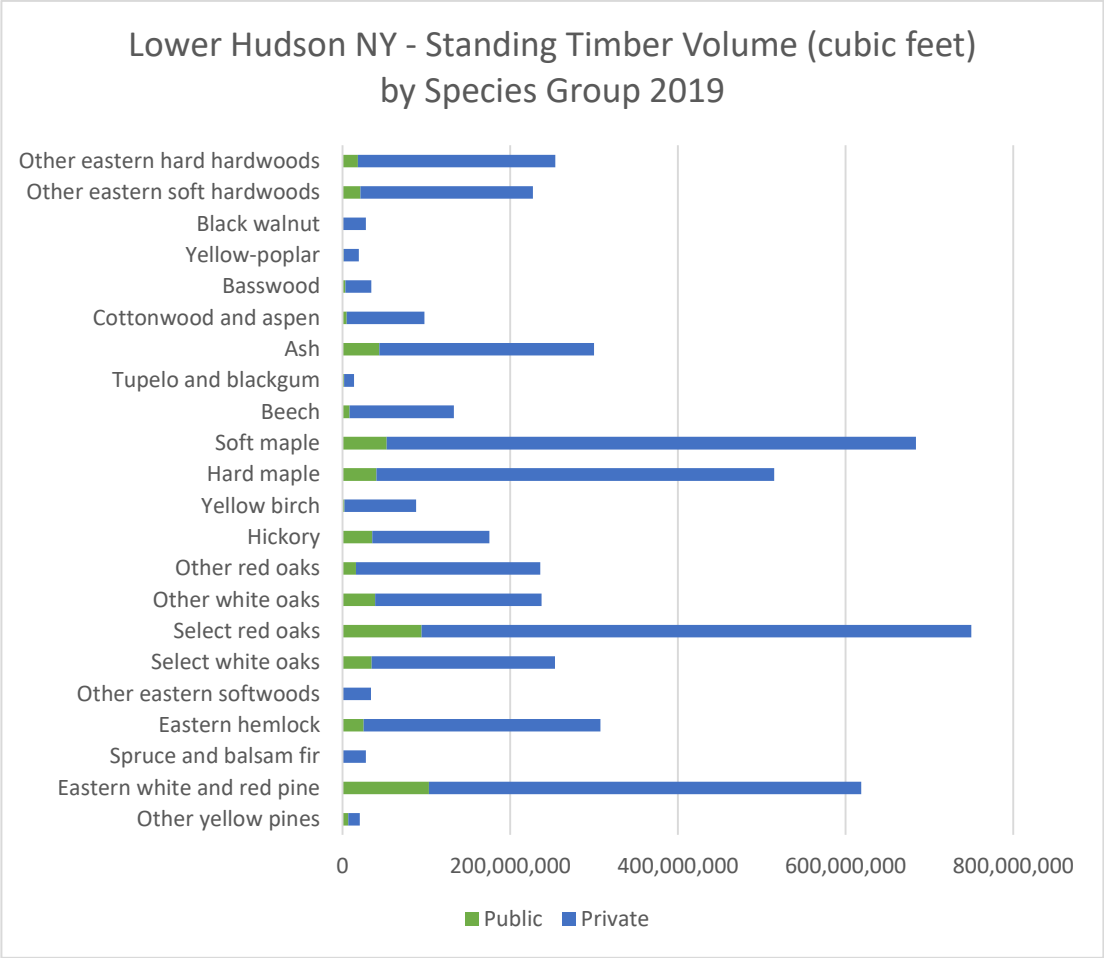
Timber Volume and Changes 2009-2019

Overall, on all timberlands in the sixteen-county region, standing timber volume in 2019 for all species was 5,052,364,014 cubic feet. This represents 2,408.9 cubic feet/acre or 30.1 cords per acre – 30.0 cords/ac private land and 30.7 cords/ac on public land. This represents standing volumes of timber considered good density stocking. Timber stocking guides, created for different species groups, are typically used to determine if a stand of trees is overstocked or understocked. An overstocked forest is not growing as much timber on an acre in a year compared to a forest that is stocked just right (fully stocked) or one that is understocked. Although stocking guides use basal area as a measurement of forest density which is directly related to standing volume, in northeastern forests, anything over 20 cords of standing live trees per acre is generally considered good density stocking.

[10] It is rare to lose public land to development or change in use and it is not clear why that appears to be the case for this sub-region.

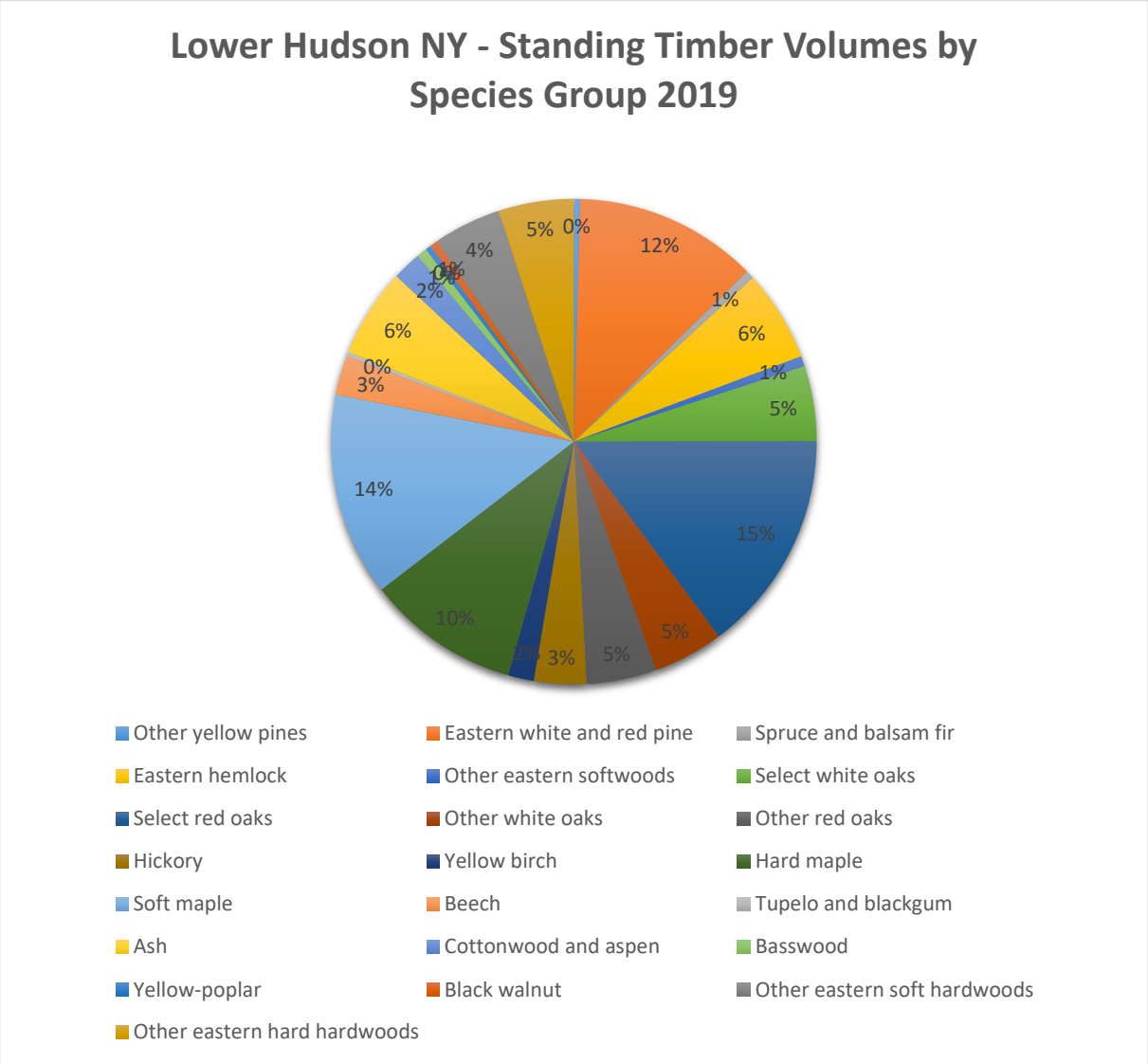
The breakdown of standing volume by species groups for the Lower Hudson NY sub-region can be seen in Figure 79. Ash, the Maples, Red and White Oaks, Eastern Hemlock and Eastern White Pine are the dominant species groups in terms of volume in the sub-region.

Figure 79 Lower Hudson NY Standing Timber Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 80 Lower Hudson NY Timber Volume by Species



Source: USDA Forest Service, Forest Inventory and Analysis

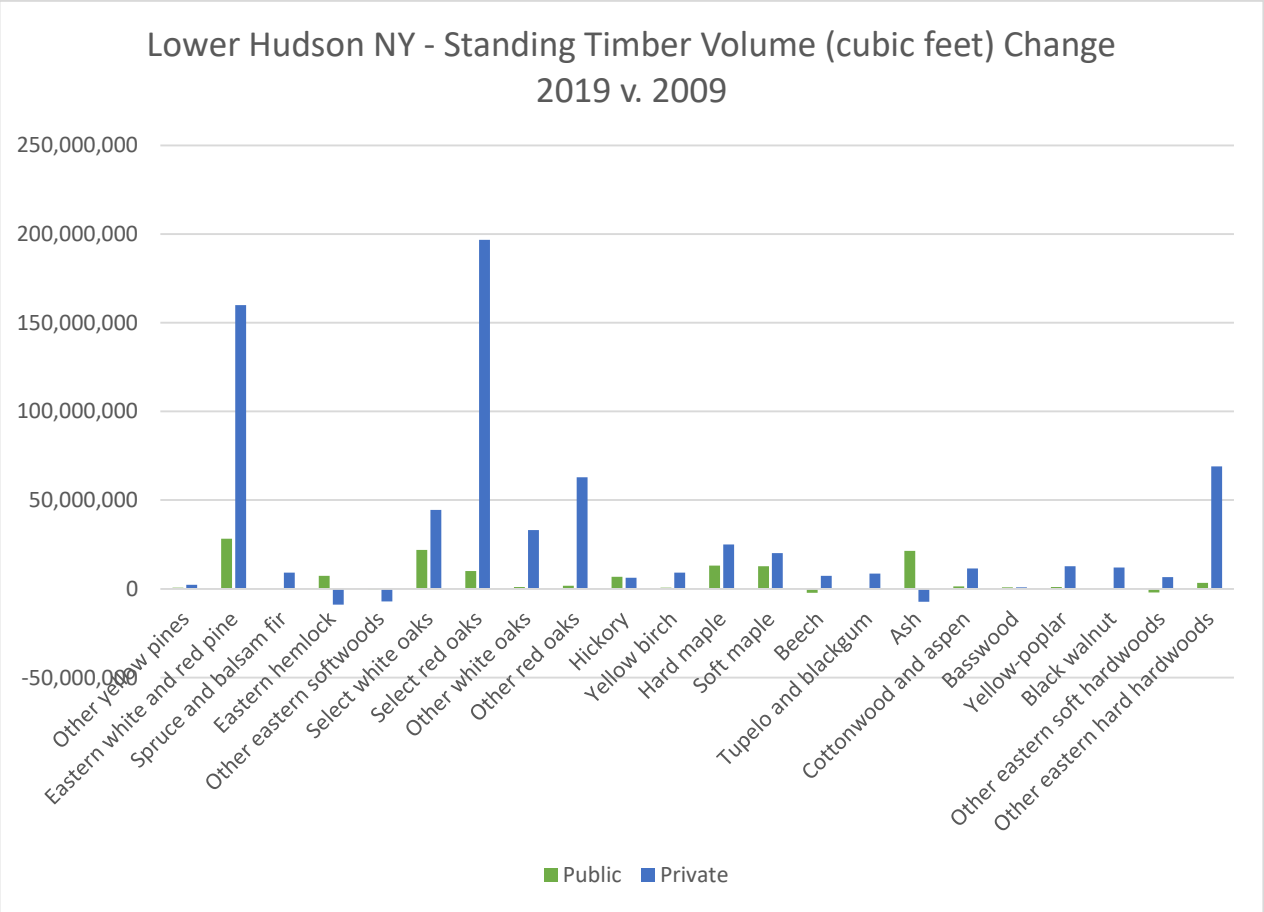
Above in this timber volume section and below in the timber quality section, we use current data on the forest of the sub-region. It represents what the forests look like today, based on the most recent FIA data set that ended in 2019. We have also drawn some limited FIA data from 2009 in order to look at what the timber volume trends are for the sub-region. Overall from 2009 to 2019, the sub-region standing volume of timber increased by 5,052,364,014 cubic feet or 19 % of standing volume – a very large increase. This occurred despite the loss of timberland in the sub-region. Seeing how standing timber volume in a sub-region changes over time – in this case over the recent 10-year period - is an important metric to understand since it looks at changes over time as opposed to static data for a particular year like the current data we use elsewhere in this analysis. This static one-year data is useful also (see the previous figures and those following Figure 71) but it must be understood as a current snapshot in time.

Figure 81 shows the standing tree volume change by species group and by ownership category. As can be expected, the reduction in standing timber in specific species groups

occurred mostly on private land in the sub-region where most of the timber is harvested. Generally speaking, more timber harvesting occurs and more timber volume is removed per acre on average on private lands in the northeast U.S. as compared to public land.

From Figure 81, the notable change is that virtually all species volume from 2009-2019 include large increases – for all ownerships.

Figure 81 Lower Hudson NY Tree Volume Change



Source: USDA Forest Service, Forest Inventory and Analysis

Note on Figure 81 chart – a bar above the "0" line indicates an increase in volume from 2009 to 2019 and a bar below the line indicates a decrease over the period.

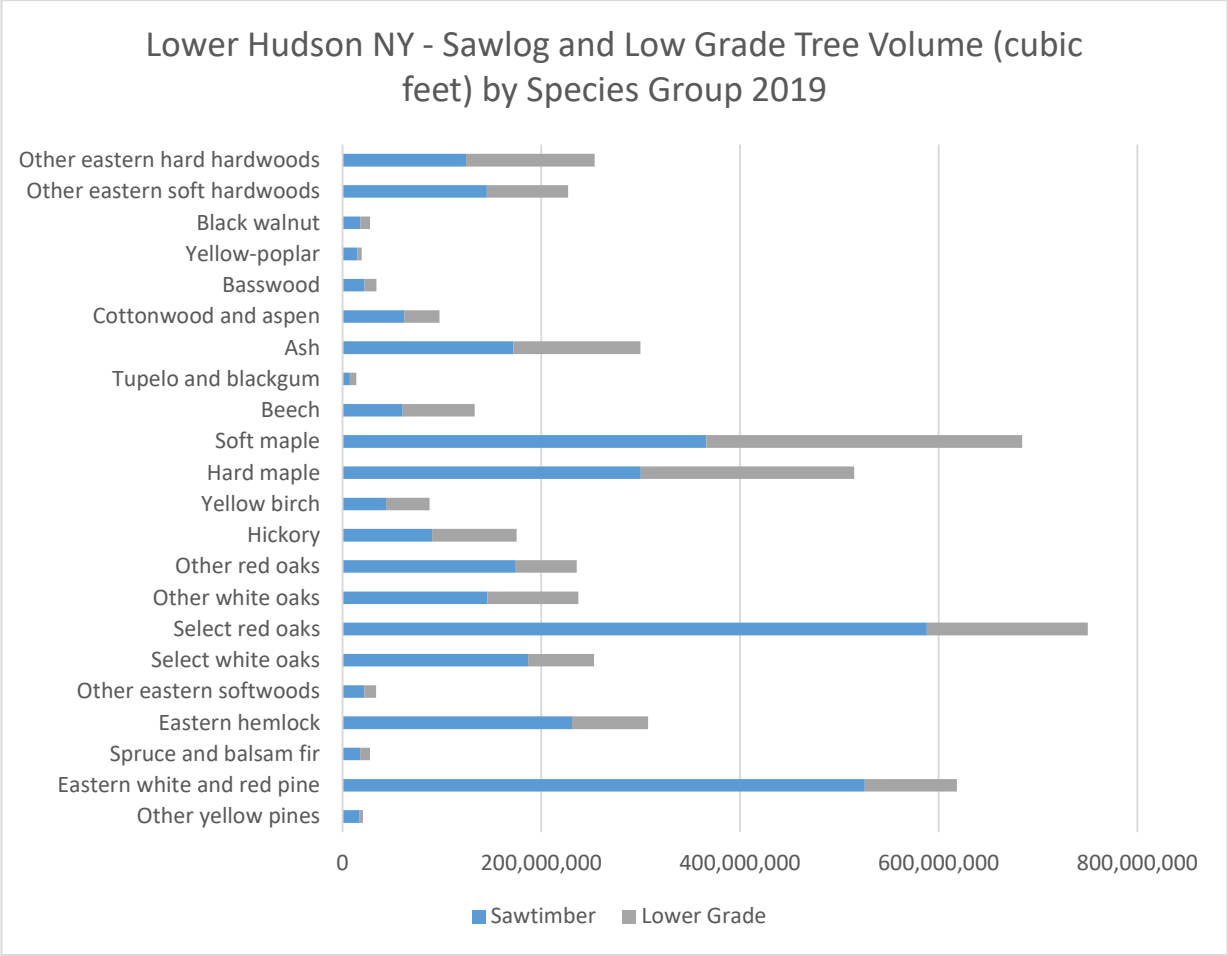
Timber Quality

Standing timber quality can be understood for the sub-region by the data in Figure 82 which shows the total standing timber volume broken down by sawlog and lower quality (non-sawlog) trees.

Important species groups such as Ash, the Maples, Hickory, Red Oak, Eastern Hemlock and Eastern White Pine all show sawlog volumes at or over half of standing volumes. Some, such as

Red Oak, Eastern Hemlock and Eastern White Pine are over 2/3 sawlog. These are positive findings from a high-quality timber perspective for this sub-region.

Figure 82 Lower Hudson NY Sawlog v. Low-Grade Volume



Source: USDA Forest Service, Forest Inventory and Analysis

Timber Net Growth and Removals

Another important set of data to help describe the timber resource in a region is growth and removals. We have chosen to look at the *net growth* – the gross growth per year less the mortality of trees – and also the *annual removals* of timber which includes both the harvest of timber but also the reduction of timberland acreage to non-timberland use or not available for harvest as a result of public policy such as land in a national forest going into Wilderness status. Nearly all of the annual removals volume in this sub-region comes from timber harvest as opposed to land management policy changes. The Removals from Harvest number in Figure 83 below confirms that.

A summary table of net growth vs. removals for the dataset ending in 2019 can be seen in Figure 83. Net growth for the year was 74.8 million cubic feet and removals 18.1 million cubic feet. The important result (growth less removals) is a net increase of 72.8 million cubic feet (707.756 cords) of standing timber volume per year in the sub-region.

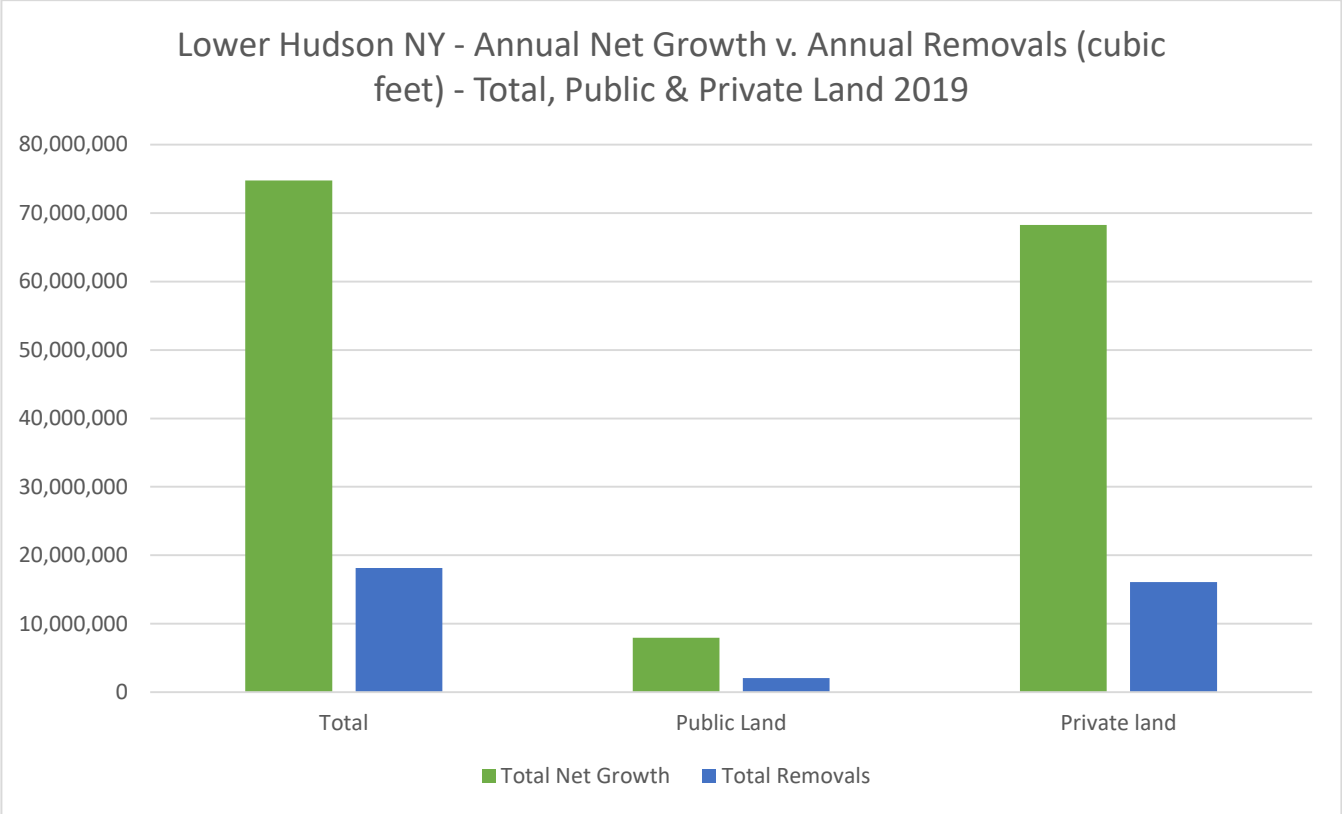
Figure 83 Lower Hudson NY Summary Table - Net Growth v. Removals

SUMMARY TABLE ANNUAL NET GROWTH V. REMOVALS - Lower Hudson NY			
2019	***Net Growth***	cubic feet	
	all	74,755,318	
	public	7,936,766	
	private	68,268,035	
	Removals		**Removals from Harvest**
	all	18,134,856	15,748,757
	public	122,532	
	private	14,141,267	
	Growth less Removals		
	all	56,620,462	
	public	7,814,234	
	private	54,126,768	

Source: USDA Forest Service, Forest Inventory and Analysis

A break-down of this same net growth and removals data by public and private land can be found in Figure 84. On both public and private land more timber volume is growing every year than is being removed through harvests and land entering non-timber uses. This is a positive metric for the sub-region.

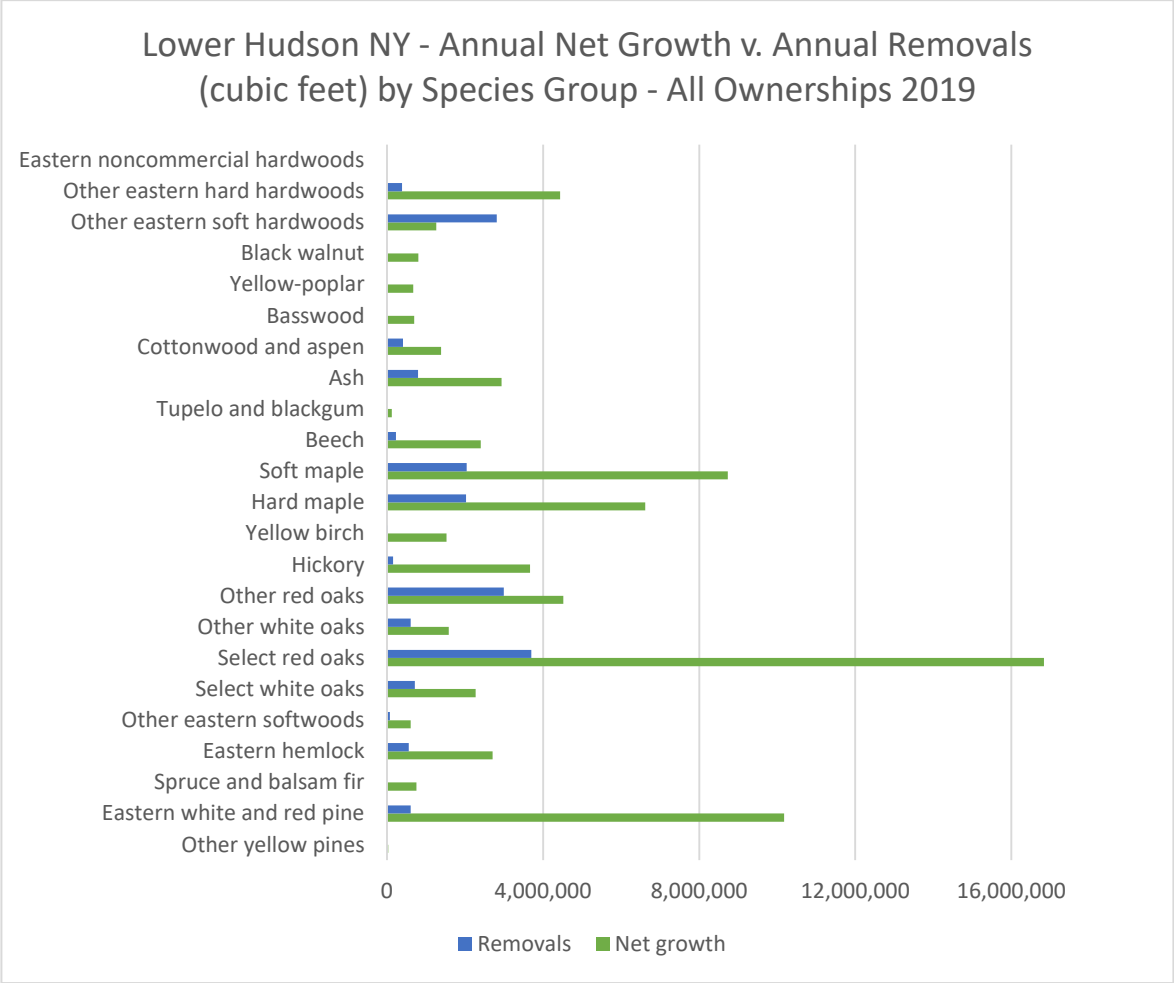
Figure 84 Lower Hudson NY Net Growth v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

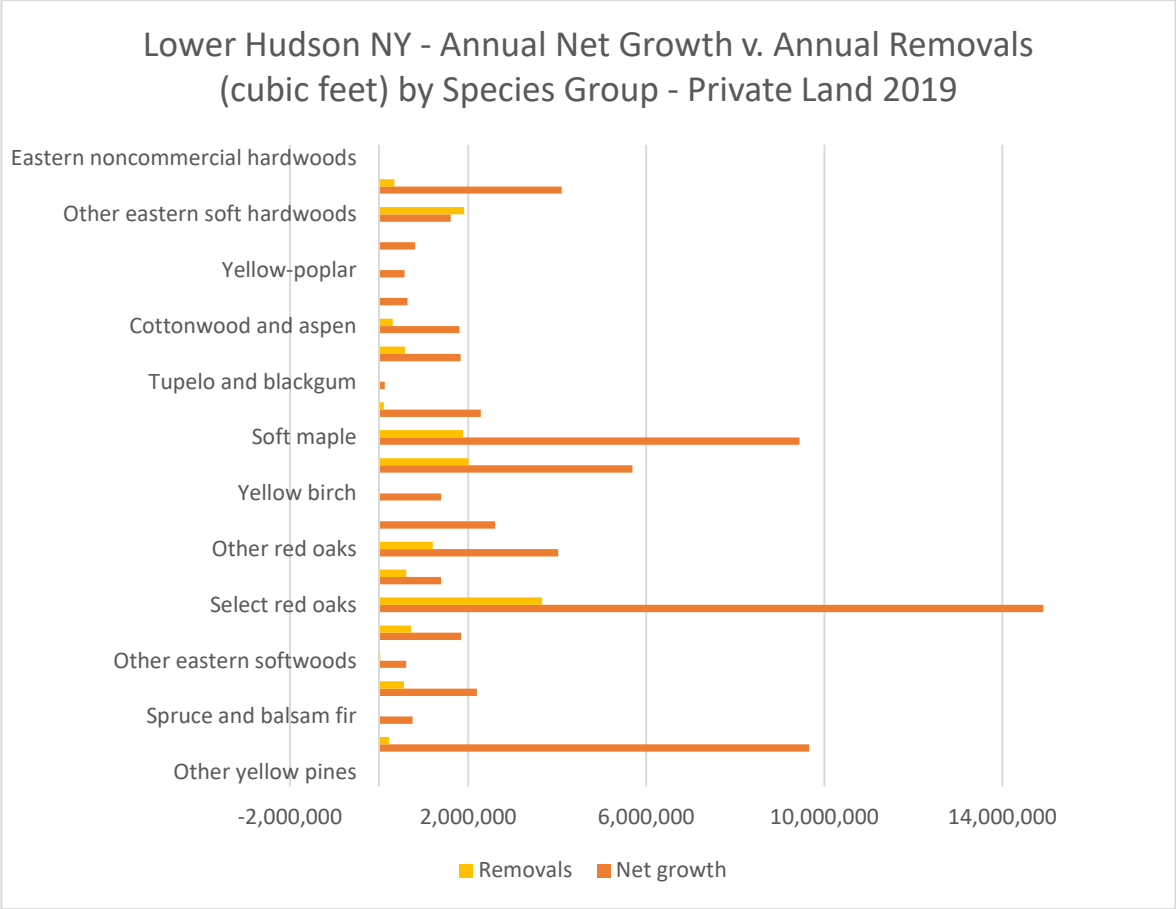
Figures 85 through 87 break down this net growth vs. removals data in finer detail by both ownership and species group. For the major species groups, all show a positive net growth to removals ratio. This means that all are increasing in volume over time – a good sign. A particular bright spot is that Ash, Maples, Hickory, Red Oak, Eastern Hemlock and Eastern White Pine are showing a wide ratio of net growth to removals.

Figure 85 Lower Hudson NY Net Growth v. Removals by Species Group



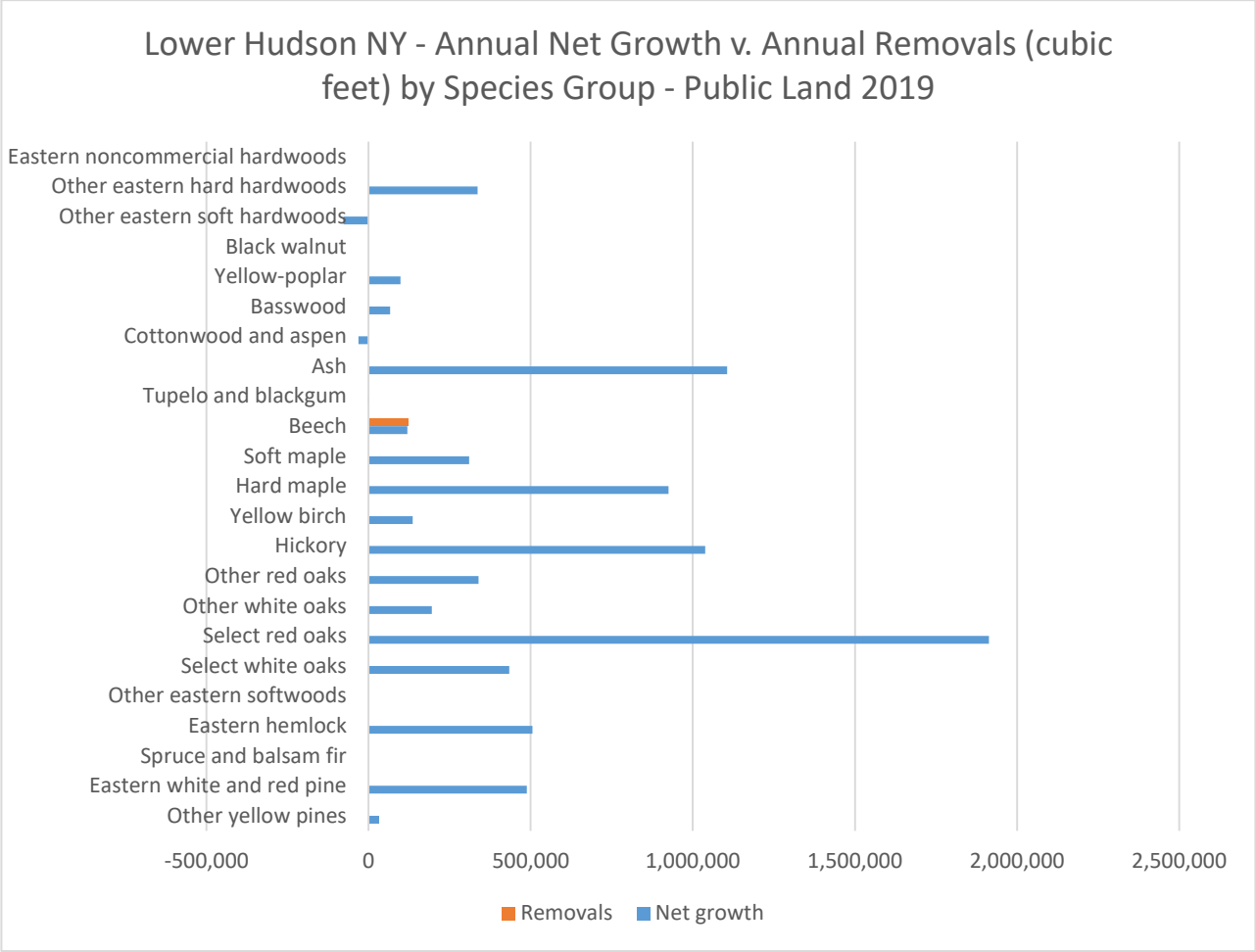
Source: USDA Forest Service, Forest Inventory and Analysis

Figure 86 Lower Hudson NY Net Growth v. Removals Private Land



Source: USDA Forest Service, Forest Inventory and Analysis

Figure 87 Lower Hudson NY Net Growth v. Removals Public Land



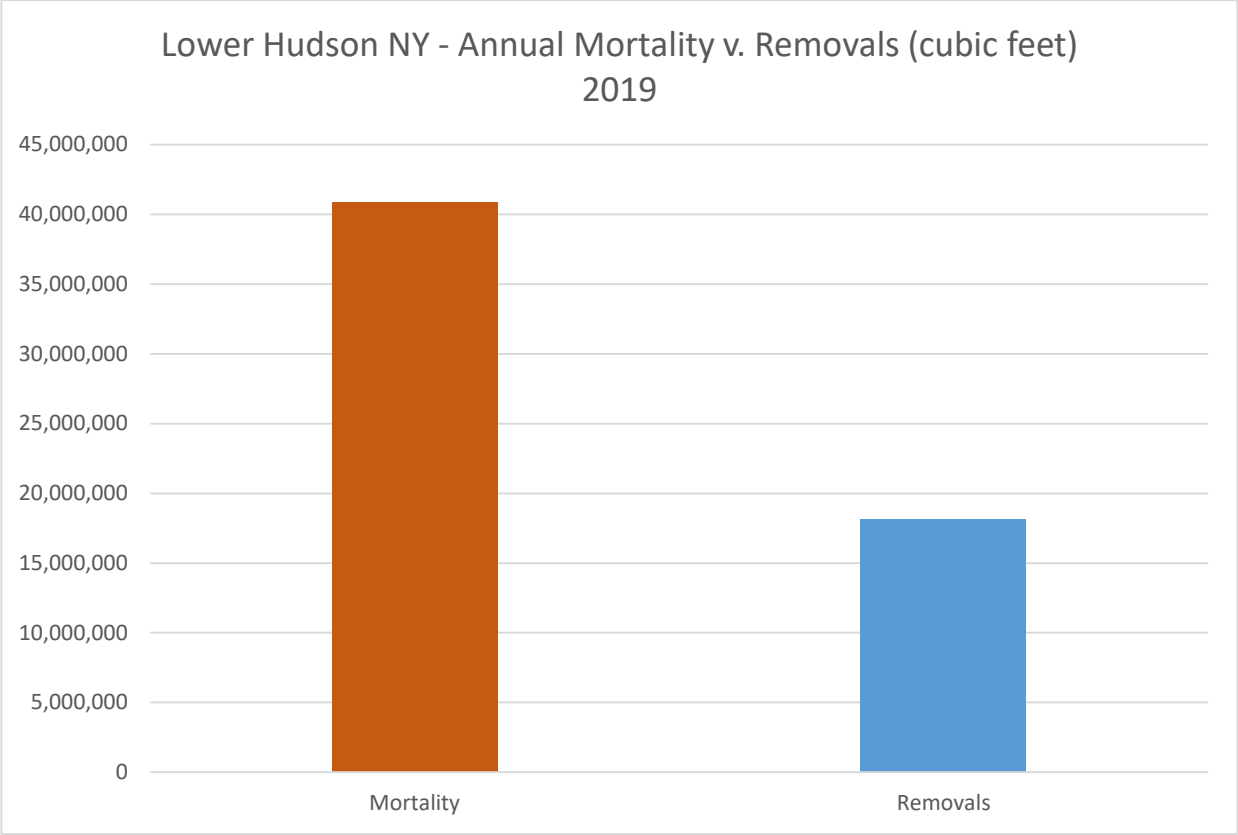
Source: USDA Forest Service, Forest Inventory and Analysis

Mortality

Trees naturally grow and die over long periods of time. Short-lived trees like aspen might span 60-80 years and long-lived trees like sugar maple or hemlock several hundred years. As forests grow and age, their rate of annual mortality grows with it. As more grown trees die, they lose their value as timber and also start the natural degradation process that releases CO2 and methane into the atmosphere as they break down. Dead trees also have wildlife value as standing snags and as downed logs or stems. If more trees can be captured in harvest, some of the negative consequences of tree death can be negated.

Figure 88 below shows the annual mortality in volume for the West NY trees vs. the amount removed (mostly through harvest). With 2019 data, annual mortality is 225% of annual removals.

Figure 88 Lower Hudson Timber Mortality v. Removals



Source: USDA Forest Service, Forest Inventory and Analysis

Note on the New York City and Long Island Counties – The heavily urban counties that make up New York City and Long Island are intentionally omitted from this study. These counties have little timberland compared to the other NY sub-regions and are less likely to be locations for forest products manufacturing than the rest of NY highlighted in this report.

Future Timber Projections

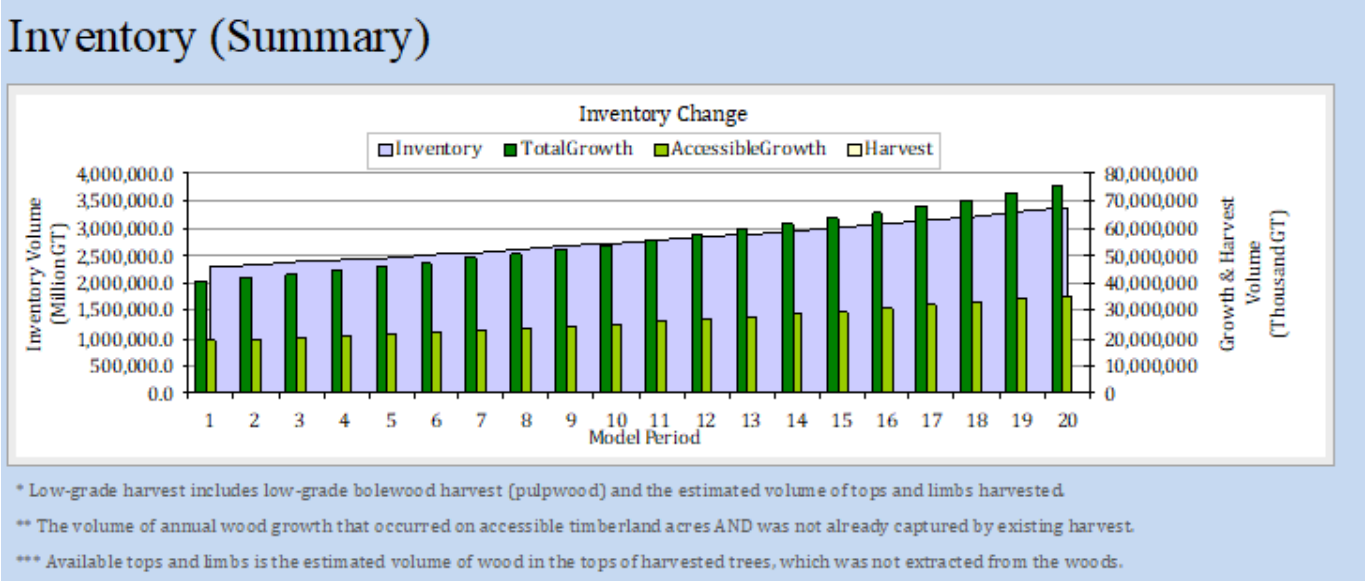
Note: See the beginning of the NH North section for an explanation of the future timber projections using the BPE model.

The BPE model runs for the NY Lower Hudson sub-region are:

In BPE Figures below, the results of model runs are shown graphically followed by available timber volume summaries and then a graphic summary for all model runs at the end of this section for this sub-region.

Run 1: Constant or business as usual – In this model run, it is assumed that timberland acreage stays the same as today, that harvest levels are the same as provided by FIA

data in the tiles ending in 2019 and that forest growth stays the same as today. This run represents the "business as usual" run where the projections are based on the current situation in the sub-region.

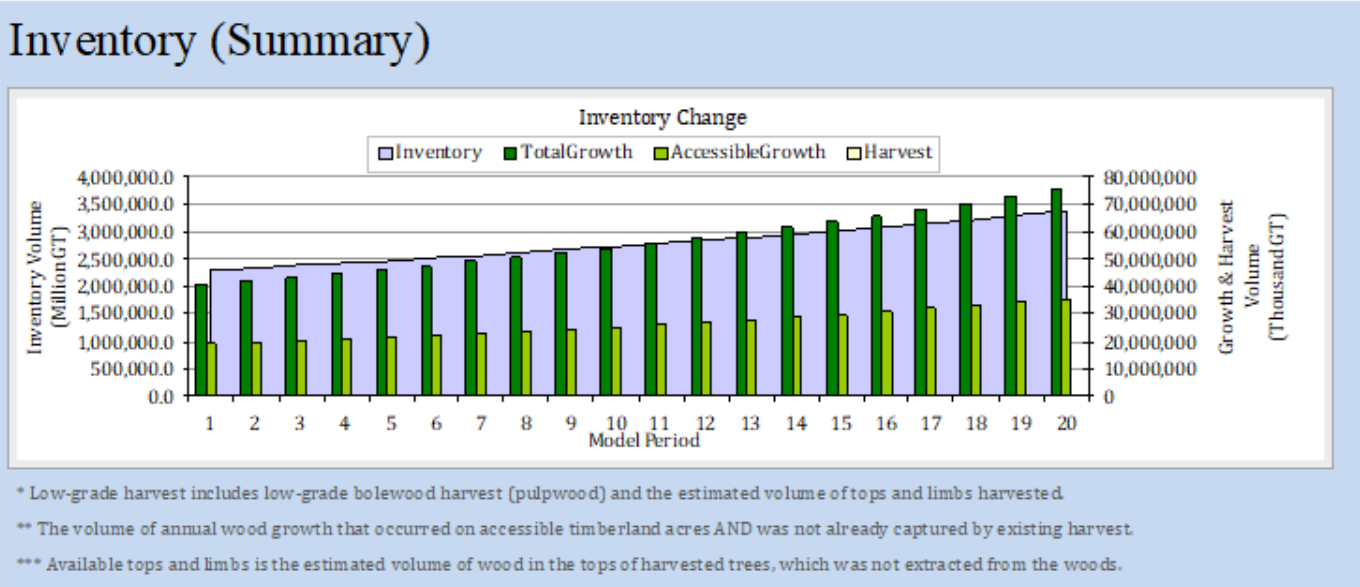


Available timber volume per year (Accessible Growth) in 2020 – 15,181,841 green tons

Available timber volume per year in year 2040 – 28,537,935 green tons

Approximately 66% of ending standing available volume in 2040 is in higher value quality timber.

Run 2: Increased demand run – This is a run that assumes an annual harvest level or wood use increase of .5 % (compounded) in the sub-region while keeping growth and mortality at current levels. The land acreage available for timber harvesting with this run is the same as BPE Run 1 above.

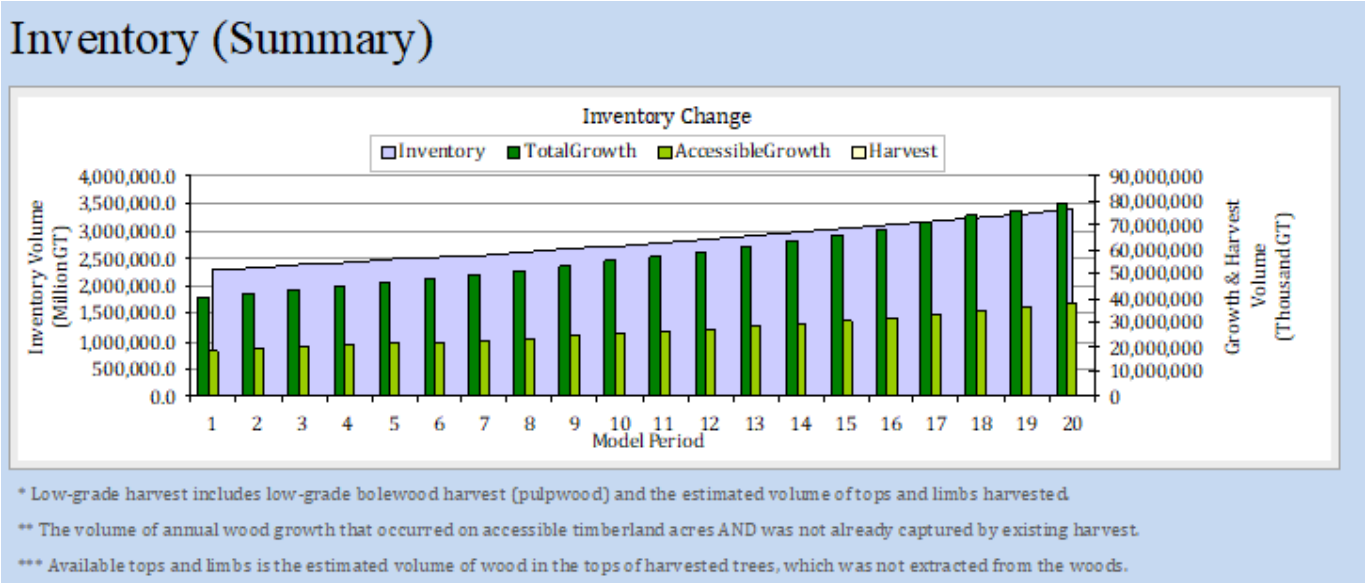


Available timber volume per year (Accessible Growth) in 2020 – 15,181,841 green tons

Available timber volume per year in year 2040 – 28,537,872 green tons

Approximately 66% of ending standing available volume in 2040 is in higher value quality timber.

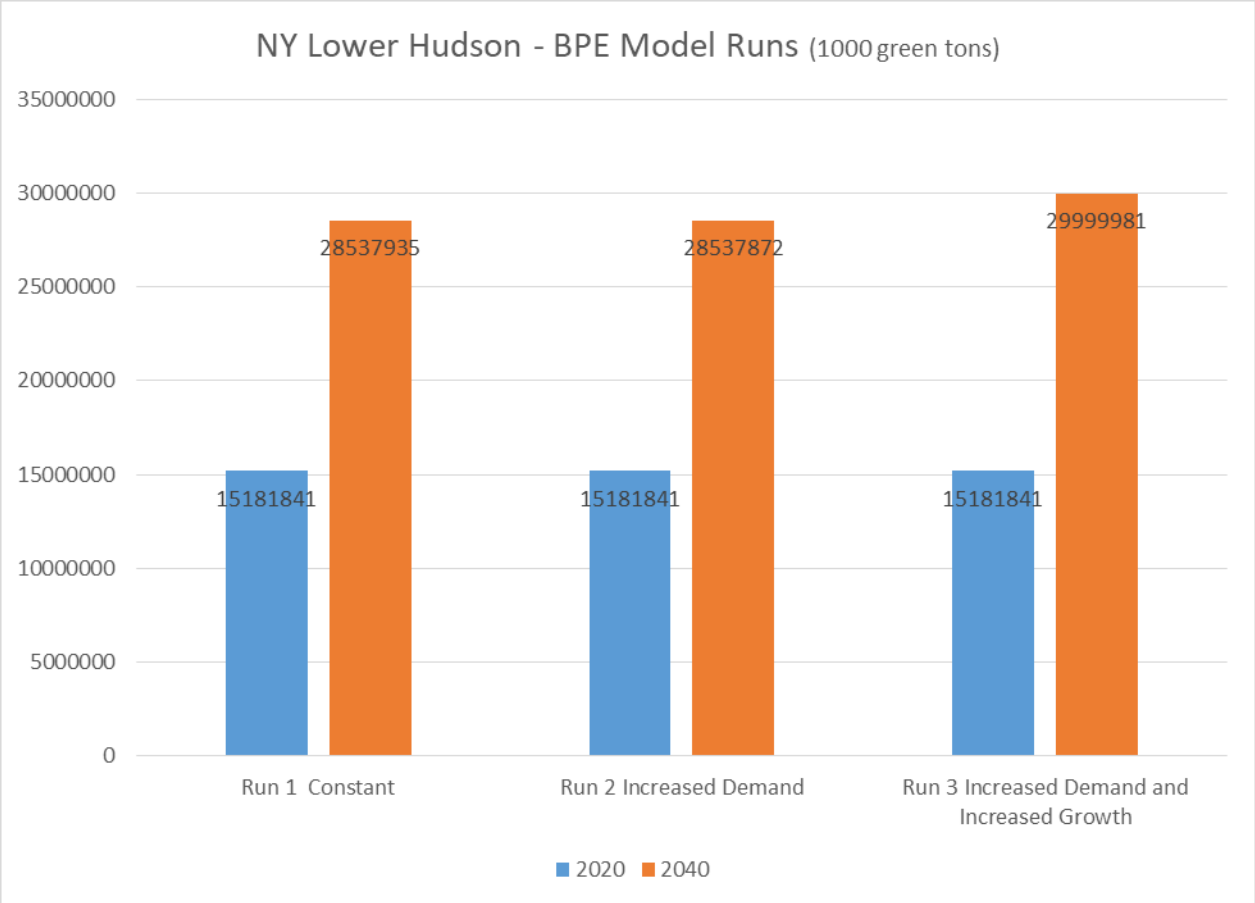
Run 3: Increased forest growth and increased demand run – This combines the assumptions in Run 2 with increased forest growth. It assumes an annual forest growth increase of .2 % (compounded) in the Region while increasing harvesting .5% per year (compounded). The land acreage available for timber harvesting with this run is the same as BPE Run 1 & 2 above. This run might be considered the "preferred" run of the 3 chosen.



Available timber volume per year (Accessible Growth) in 2020 – 15,181,841 green tons

Available timber volume per year in year 2040 – 29,999,981 green tons

Approximately 66% of ending standing available volume in 2040 is in higher value quality timber.



II. Forest Products Industry Supply Chain for New Hampshire, New York and Vermont

The forest products industry supply chain for the New Hampshire, New York and Vermont region is robust. Recent data from the U.S. Department of Commerce shows that the annual value of the industry in these states is over $16 billion annually. The sector employs as many as 55,000 people although this may be changed after the COVID-19 pandemic is over.

Table ___**Annual Economic Value of Forest Products Industry – NH, NY & VT**[11]

	New Hampshire	New York	Vermont	TOTAL
Direct Jobs	7,000	42,000	6,500	55,500
Direct Payroll	$ 363,000,000	$ 3,270,000,000	$ 280,000,000	$ 3,913,000,000
Direct Economic Output	$ 1,600,000,000	$ 13,480,000,000	$ 1,350,000,000	$ 16,430,000,000

The supply chain businesses in the three-state region include[12]:

- Foresters
- Loggers/Truckers
- Sawmills
- Pulp & Paper mills
- Biomass Power Plants
- Wood Pellet mills
- Concentration yards[13]

Research has been conducted for this project to catalogue most of the businesses in these sectors in the three state region. Data was located from public and private sources.

Foresters – Though not always present on a logging operation, foresters are land managers and generally work for the landowner both private and public sector. Foresters develop and work to implement forest management plans to achieve specific outcomes desired by the landowner.

Loggers/Truckers – Loggers harvest timber from private and public lands, often at the direction of the landowner or landowner forester. Truckers, often employed by loggers, bring harvested timber (in the form of logs, pulpwood, firewood and wood chips) from the forest harvest site to the wood-using industry.

Sawmills – Sawmills take higher quality logs cut and delivered by loggers and their truckers and saw them into many forms of squared solid wood product including (depending on the species) boards, two-by-fours and other two inch thick material, and various timbers from round-edge cabin logs to squared timbers. Not included here because the sector uses the highest quality

[11] From a series of state reports developed in 2019 by Public Sector Consultants of Michigan for the Michigan Dept. of Natural Resources with funding from the USDA Forest Service.
[12] Note: The economic data displayed also include the secondary forest products manufacturing sector such as wooden furniture makers and paper mills not connected to pulp mills. This project does not include those secondary businesses and is focused on the primary processing timber using sector.
[13] Concentration yards are businesses that purchase harvested timber and wood chips from loggers and sawmills. These businesses then re-sell the products to various primary processor facilities.

logs like those used by sawmills, veneer mills slice or peel logs into thin sheets of solid wood used to make plywood. There are few veneer mills in this region.

Pulp & Paper mills – Pulp and Paper mills use a slightly lower quality log than sawmills – pulpwood – to make paper and paper-like products. There are currently only two operating pulp mills in the 3-state region – both in New York.

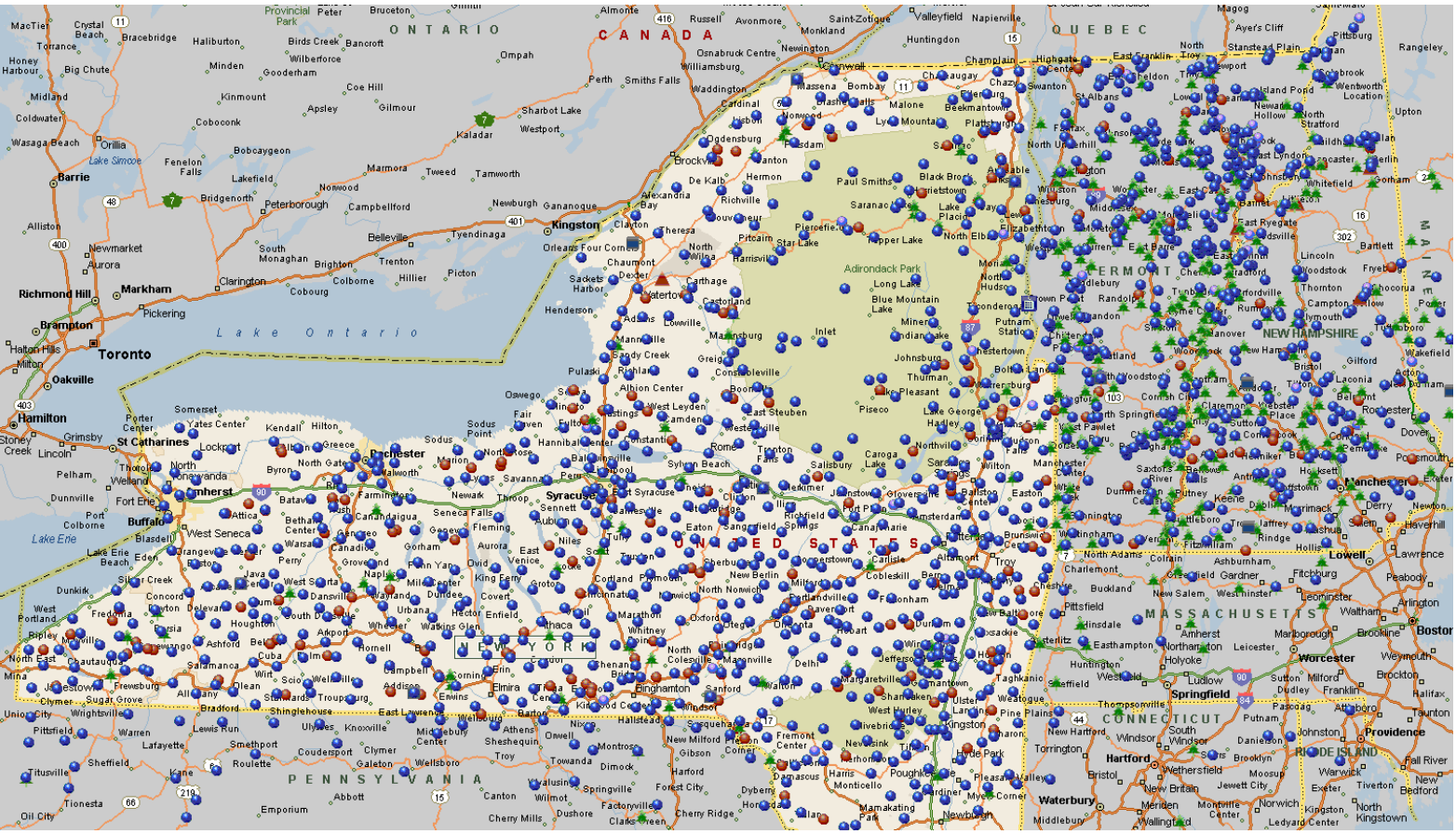
Biomass Power Plants – Biomass Power Plants burn wood chips in a large boiler attached to a generator turbine that delivers electricity to the power grid.

Wood Pellet mills - Wood Pellet mills in these states make wood pellets for building heating and use low grade roundwood and wood chips as wood feedstock for their operations.

Concentration yards - Concentration yards are businesses that purchase harvested timber and wood chips from loggers and sawmills. These businesses then re-sell the products to various primary processor facilities.

The following map shows the various supply chain businesses in these States, differentiated by the categories above.

Figure 89 Forest Products Industry Supply Chain Business Locations for NH, NY & VT



Legend:

Loggers/Truckers

Foresters

Sawmills

Pulp and Paper Mills

Biomass Plants

Wood Pellet Mills

Concentration Yards

The number of businesses in the mapped categories is displayed in the following table.

Figure 90 Forest Products Supply Chain Businesses in NH, NY & VT - the numbers

Industry Category	New Hampshire	New York	Vermont	TOTAL
Foresters	177	80	292	549
Logger/Truckers	305	635	309	1249
Sawmills	61	154	50	265
Pulp & Paper mills	0	2	0	2
Biomass Power Plants	4	1	2	7
Concentration Yards	17	15	20	52

The supply chain for this sector in this three-state region is robust. There are critical concentrations of industry infrastructure in nearly all counties in the region. A listings of all the business that make up this supply chain can be found in the Appendix of this report.

APPENDIX

A. FIA

The USDA Forest Inventory and Analysis dataset is extremely robust and provides for dozens of options for accessing forest and timber data about a state, multiple counties from a state, or other varied geographies. For this analysis we had to choose data options that would be most useful in understanding the timber resource of a sub-region from the perspective of a prospective wood-using industry. We chose:

Timberland Area – To understand the acreage of timberland in the sub-region, which is forestland that is biologically and legally able to produce timber accessible to purchase for forest products manufacturing. This is the basis for understanding the timber resource in a geography. The data also differentiates between public and private land.

Timber Volume and changes over time – Standing timber volume by species group is the core of the timber volume data we used from FIA. The actual amount of timber volume standing in a sub-region by species group is critical to understand whether a particular kind of forest products manufacturing facility or timber user can realistically expect to be able to procure adequate timber feedstocks for their proposed operation. This information needs to be coupled with timber price data to completely understand the opportunity to supply a mill with timber. We have not covered pricing here (and FIA does not include pricing data).

Standing timber volumes today are important as is the density of timber per acre (which we also provide). Also helpful is an understanding of standing timber volume trends. We chose to look at standing volume from two time slots: 2009 and 2019. Making those comparisons, by species group, adds to the understanding of what is transpiring with standing timber volumes over time.

Timber Quality – The FIA data allows for some limited insights into the quality of standing timber in a sub-region. Depending on the timber using industrial user, timber quality may be of paramount interest. For instance, a user of solid logs like a primary processor sawmill, needs to understand if the species they desire as the focus of their operation is standing and likely available for purchase. We drew FIA data on sawtimber standing volume which we report along with lower non-sawtimber volumes.

Timber Net Growth and Removals – In addition to the timber volume change data over 2009-2019 referenced above, it is extremely important to understand the annual growth-to-drain ratio. This is a metric that shows whether existing timber users are using, annually, more or less than is growing. A ratio over one (1) indicates a standing timber resource (the principal of the bank account balance as an analogy) that is growing over time. This is preferred over one that is less than one, although limited periods of growth-to-drain ratios below one are acceptable if the standing timber stocking (density) is high.

Mortality – Timberland areas that have high mortality rates in the northeast tend to be those areas where the growth-to-drain ratio is much higher than one. In other words, when the standing timber resource is too dense and/or too old, trees naturally die at higher rates than a forest that is vigorously managed and where harvests are closer to net growth (gross growth less mortality). This metric, combined with timber volumes and quality data to round out a picture that describes whether there is adequate timber resource to consider a new or expanded wood using manufacturing operation.

FIA Data Options – As described above there are dozens of data options from which to draw in the FIA dataset. One helpful list, from which we focused on only a few of the output options for these analyses, is:

Area

Area Change Total

Annual Area Change

Tree Volume

Tree dry weight

Tree green weight

Tree carbon

Tree number

Tree basal area

Down woody material volume

Down woody material dry weight

Down woody material carbon

Down woody material number

Carbon

Annual net growth volume

Annual net growth dry weight

Annual removals volume

Annual removals dry weight

Annual removals number

Annual harvest removals volume

Annual harvest removals dry weight

Annual harvest removals number

Annual other removals volume

Annual other removals dry weight

Annual other removals number

Annual mortality volume

Annual mortality volume

Annual mortality dry weight

Annual mortality number

Annual gross growth volume

Annual gross growth dry weight

Annual net change volume

Annual net change dry weight

Finer detail of the FIA data set and system is found below.

USDA Forest Service, Forest Inventory and Analysis (from the FIA website)

What is FIA?

The Forest Inventory and Analysis (FIA) program of the USDA Forest Service has been in continuous operation since 1930 with a mission to:

"make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements for the renewable resources of the forest and rangelands of the US."

The FIA Program collects, analyzes, and reports information on the status and trends of America's forests: how much forest exists, where it exists, who owns it, and how it is changing, as well as how the trees and other forest vegetation are growing and how much has died or has been removed in recent years. This information can be used in many ways, such as in evaluating wildlife habitat conditions, assessing the sustainability of ecosystem management practices, and supporting planning and decisionmaking activities undertaken by public and private enterprises.

The Forest Service has significantly enhanced the FIA program by changing from a periodic survey to an annual survey, by increasing our capacity to analyze and publish data, and by expanding the scope of our data collection to include an additional suite of attributes on a subsample of our plots such as soils, understory vegetation, tree crown conditions, down woody material, and invasive species. The FIA program has also expanded to include the sampling of urban trees on all land use types in select cities.

FIA is managed by the Research and Development organization within the USDA Forest Service in cooperation with State and Private Forestry and National Forest Systems. FIA traces its origin back to the McSweeney - McNary Forest Research Act of 1928 (P.L. 70-466). This law initiated the first inventories starting in 1930.

To learn more about what types of data that FIA collects and the processes we use, please review the FIA Data Collection Fact Sheets found in the FIA Library.

National Band System

The objective of the FIA Band System is to develop a nationally consistent, efficient, and complete FIA CORE program. The Bands work together to administer a Change Management process, which is a systematic approach to dealing with all proposed additions, deletions, or modifications to any component of the National FIA Program. There are four Bands that comprise the FIA Band System:

Analysis Band: Focuses on developing statistically defensible approaches to summarizing core FIA data, including identification of new variables (either field measured or computed) needed by FIA customers. More information on the Analysis Band can be found in the Analysis Band Charter or by contacting the Analysis Band Lead, Tom Brandeis.

Information Management Band: Focuses on maintaining data management systems for core FIA data, including systems for data editing and validation, internal and external databases, and web applications for allowing outside users to access and analyze FIA data. More

information on the Information Management Band can be found in the Information Management Band Charter or by contacting the Information Management Band Lead, Chuck Barnett.

Techniques Research Band: Focuses on improving the efficiency, timeliness, and quality of the FIA program by addressing appropriate problem areas as outlined in the FIA strategic plan or identified by the Program Managers and National FIA leadership. More information on the Techniques Research Band can be found in the Techniques Research Band Charter or by contacting the Techniques Research Band Lead, Karen Schleeweis.

Data Acquisition Band: Focuses on developing, testing, and documenting standard approaches to collecting core FIA data collected in the field. This includes developing documentation, training programs, and quality assurance approaches, as well as identifying problems for analysts or indicator advisors to address. More information on the Data Acquisition Band can be found in the Data Acquisition Band Charter or by contacting the Data Acquisition Band Lead, Mark Majewsky.

Research Questions & Data Requests

Data & Tools: FIA has a number of tools available for users to download and/or analyze our data and create custom reports.

Spatial Data Services: In the event that FIA's self-help tools do not provide what the user needs, a data request can be made to FIA staff for additional information.

Customer Service: For general questions and information regarding FIA, FIA's research areas, and FIA data and reporting, please contact the customer support staff for the region of interest.

FIA Data Sets

Program Elements. The FIA program is actually a collection of related surveys designed to focus on different aspects of America's forested ecosystems. These surveys may be considered in the following hierarchy:

1.Forest Monitoring – a three phase sample used to track status and trends in forest extent, cover, growth, mortality, removals, and overall health;

2.Ownership Study – a questionnaire-based survey of landowner plans, desires, values, and intentions.

3.Timber Product Output – A questionnaire-based survey of wood processing facilities used to track the commercial production of wood products.

4.Utilization Studies – studies conducted on logging sites to record how much wood is actually removed during harvest.

Each of these kinds of studies is further described below. Forest Monitoring. The forest monitoring component is the best-known component of the FIA program. This component consists of a three stage systematic sample of sites across all forested lands of the US. Phase 1 consists of remote sensing for stratification, to identify where the forested land is. Phase 2 consists of one field sample site for every 6,000 acres of forest, where field crews collect data on forest type, site attributes, tree species, tree size, and overall tree condition. Phase 3 consists of

a subset of Phase 2 sample plots which are measured for a broader suite of forest health attributes including tree crown conditions, lichen community composition, understory vegetation, down woody debris, and soil attributes. Soil samples are sent to a laboratory for chemical analysis. Finally, an associated sample scheme exists to detect cases of ozone damage occurring to adjacent forest vegetation.

Collectively, the forest monitoring component of FIA provides a nationwide systematic sample of a wide array of measurements on forested ecosystems, which are used by a diverse set of customers for many purposes. For example, FIA data have been used to map habitat for endangered animal species, to identify areas of forest decline, and to track the effect of global change reflected in changing species distributions. In additional to producing a variety of reports and analyses at the state and regional level, information from the FIA forest monitoring program are publicly available through our online database at fia.fs.fed.us.

Ownership Studies. Approximately half of America's forests are privately owned, either by individuals or by corporations. Private owners therefore have a huge impact on the state of America's forests. The FIA program conducts periodic surveys of private forest owners to assess their ownership objectives, expected benefits, harvest intentions, and management plans. These surveys are completed through voluntary questionnaires sent to private forestland owners. Responses are kept confidential to protect landowner privacy. Information is summarized at the state and regional level to provide information on status and trend in forest land ownership.

Timber Product Outputs. The FIA program tracks and reports on the fate of wood, which is harvested from America's forests. Wood may be harvested for industrial purposes, such as the production of lumber or paper; or it may be removed for nonindustrial purposes such as firewood. In either case, monitoring the removal and processing of wood provides information about a significant component of the US economy. Timber Product Output studies are typically done through questionnaires sent to the processors, which may be a timber mill or an individual harvesting fuelwood. Like ownership information, information reported by wood processors is kept confidential and only analyzed and published in aggregate form so as to protect confidentiality. The aggregate Timber Products Output data is also available through the online database.

Utilization Studies. Utilization studies provide the factors needed to link the input (trees standing in the forest) with the output (wood products produced by a mill). These studies take place at active logging operations. Crews measure felled trees as if the tree were still standing on an FIA plot, then the collect more detailed measurements on the portion of the tree which is actually removed from the site. This process yields information about what is left in the woods versus what is removed, and ultimately helps the FIA program to relate timber removals with wood production. Quality Assurance. Quality Assurance includes documentation of methods, training for data collectors, checks of data quality, peer review of analysis products, and continuous feedback to ensure that the system improves over time. QA data and

2/3/05 analyses will be included in publications and made available. All of the studies included in the FIA program are subject to various forms of Quality Assurance. For more information regarding the FIA Program: •See our "FIA Contacts" Fact Sheet •Visit our national FIA website:

Regional Offices & Contacts

FIA is organizationally located within the Research and Development Deputy Area of the U.S. Forest Service. FIA has three levels of internal management: an executive level involving senior executives from the Forest Service and State Forestry Agencies, who provide broad policy guidance; a management level consisting of field program managers from the Forest Service and States responsible for implementing the program on a day-to-day basis; and a technical level consisting of groups of technical specialists drawn from the Forest Service and States, who develop, document, and review program procedures.

Across the country, program work is coordinated out of four regional units. Each region maintains their own internal set of regional customers and partners who collaborate in program implementation.

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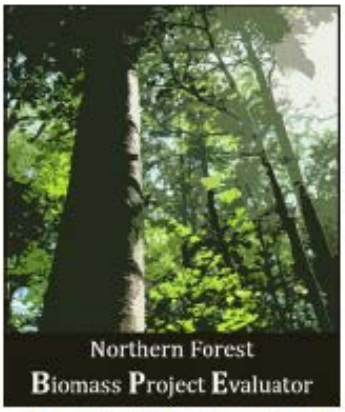
B. Northern Forest Biomass Project Evaluator



Overview of Northern Forest Biomass Project Evaluator (BPE) Features & Processing Steps

The BPE tool is organized into a serious of tabs, which the user moves through in order to set-up and design a model run. Data derived from the most recent US Forest Service Forest Inventory and Analysis (FIA) dataset are used to populate biomass volume, harvest (removals), and timberland acreage estimates within the model. Data for the following states are available: Maine, Massachusetts, New Hampshire, New York, Pennsylvania, and Vermont. The model is intended to focus on residual biomass volume, defined as the portion of annual low-grade growth on accessible timberland acres that is not already captured by existing or projected harvest demand. It is, in part, based on the design of a model produced by the Biomass Energy Resource Center (BERC) in 2010 (www.biomasscenter.org/images/stories/VTWFSSUpdate2010_.pdf).

I. Data Setup

On the **Data Setup** tab (Figure 1), users have the option to define their focal study area in one of two ways: by choosing individual counties or by using a circular area based on a specified center point and radius greater than or equal to 30 miles. Once satisfied with their selection, users click the corresponding "select" button to extract the chosen data from several "master" (hidden) data tables into the model input data tables.

Other features on the Data Setup tab include:

- "Model Reset" button that will clear any data from previous model runs
- Button that opens a report with US Census Bureau maps of each state with county boundaries for reference
- Option to view the selected plots in Google Earth (to run this feature users must have Google Earth installed on their computer)
- Button that opens a report with general descriptive information about growth, species-type composition, and timber quality within the selected study area (very helpful for selecting certain key assumptions)

II. Key Assumptions

The key assumptions are at the heart of the BPE tool and are used to define a series of important model parameters, which the model applies to the entire selected study area. Under the first key assumptions tab (Figure 2), users set several general assumptions related to the timber inventory and the proportion of private timberland in different ownership categories.

Clicking on the "View Timberland Acres with Current Proportions" button opens a table that displays the number of timberland acres in the selected area, broken down by ownership category and organized by county. With the table open, users can make changes to the private land ownership proportions and see the effect these changes have on the corresponding acreages.

On the second key assumptions tab (Figure 3), users set assumptions related to the accessibility and availability of timberland acres for harvest; first, by setting the percentage of acres in different ownership types that are likely to be harvested and second, by setting the percentage of land that will not be harvested due to reasons of physical inaccessibility.

Clicking on the "View Acres with Current Key Assumptions" button opens a table that displays total versus accessible acres, based on the current assumptions. With the table open, users can make changes to these assumptions and see the effect on available timberland.

If the user made any changes to the default assumption values, they will see this reflected in the optional "save key assumptions" box. Here the current modeling 'scenario' can be named, saved, and called again for later use. Users may also click on the help buttons for additional explanation and guidance when choosing key assumption values.

III. Model Setup

On the Model Setup tab (Figure 4), the user sets the number of projection years they would like the model to run. "Save" adds this number of periods to the harvest, acreage, and growth tables. Next, the user must open data input forms for high-value (sawtimber) harvest, low-grade harvest, timberland acres, and forest growth in order to populate data for each of the model projection years they have specified. Within these forms the user can makes changes to the harvest or timberland acres data by typing directly in the form or by utilizing the "calculate" button (Figure 5). Users may also copy and paste from the data forms directly into Excel, in order to keep a record of the harvest or timberland data used in the model run.

The "calculate" button can be used to simulate harvest levels or forest growth rates that will either remain constant, increase, or decrease by a certain percentage over time. Using the dropdown "projection year" box, users can filter the model year they are viewing. If the user selects *All* in this dropdown and then uses the "calculate" button, the tool will perform the calculation for all years after year zero, based on the values in year zero.

However, users can also select a different projection year in the dropdown box and use the "calculate" button to calculate change from the selected year on. For example, if you want to simulate the increase in low-grade harvest demand that will occur when a new biomass plant becomes operational in year 3 of your model projection, you would select "3" in the projection year dropdown, enter the expected increase in demand across the counties affected, and finally use the "calculate" button to calculate some static, increasing, or decreasing demand that will begin in that year and continue for the remainder of the model projection.

In all cases, Period 0 data represent the baseline that will be projected. **Important: the FIA data for harvesting and land ownership are provided as starting points for these critical estimates. They should not be considered definitive simply because they come from recent FIA inventories!** The user should spend the most attention on reviewing these estimates with his or her experience and other more reliable sources.

The harvest data are the most "crude" of the estimates. Total FIA removals are based on estimates derived from stump counts on harvested FIA measurement plots. These removals include removals for all products, in cubic foot volume of the merchantable section. A separate item estimates removals of sawtimber. We seed the high-quality harvest table with sawtimber removals, converted to green tons, and then discounted based on the user-defined key assumption "% of total sawtimber harvest that is high-value (sawlog quality)." The low-quality table is simply total removals less sawtimber removals, plus the portion of sawtimber-sized removals that were down-graded to low-quality based on the "% of total sawtimber harvest that is high-value (sawlog quality)" assumption. Topwood removals are not included in these estimates.

After working through the aforementioned steps, the user clicks the "Run Model" button to perform the model calculations for the specified number of projection years.

IV. Output

The Output tab (Figure 6) has several options for users to view the results of their model run in chart or tabular form, in both reports and pivot charts. A more detailed explanation of model results, calculations, and the use of pivot charts can be found by clicking the "Model Help" button. In addition, while viewing a table (only), the user can use the "Export to Excel" option on the top ribbon menu to move the chosen table and all model run results directly into an Excel spreadsheet.

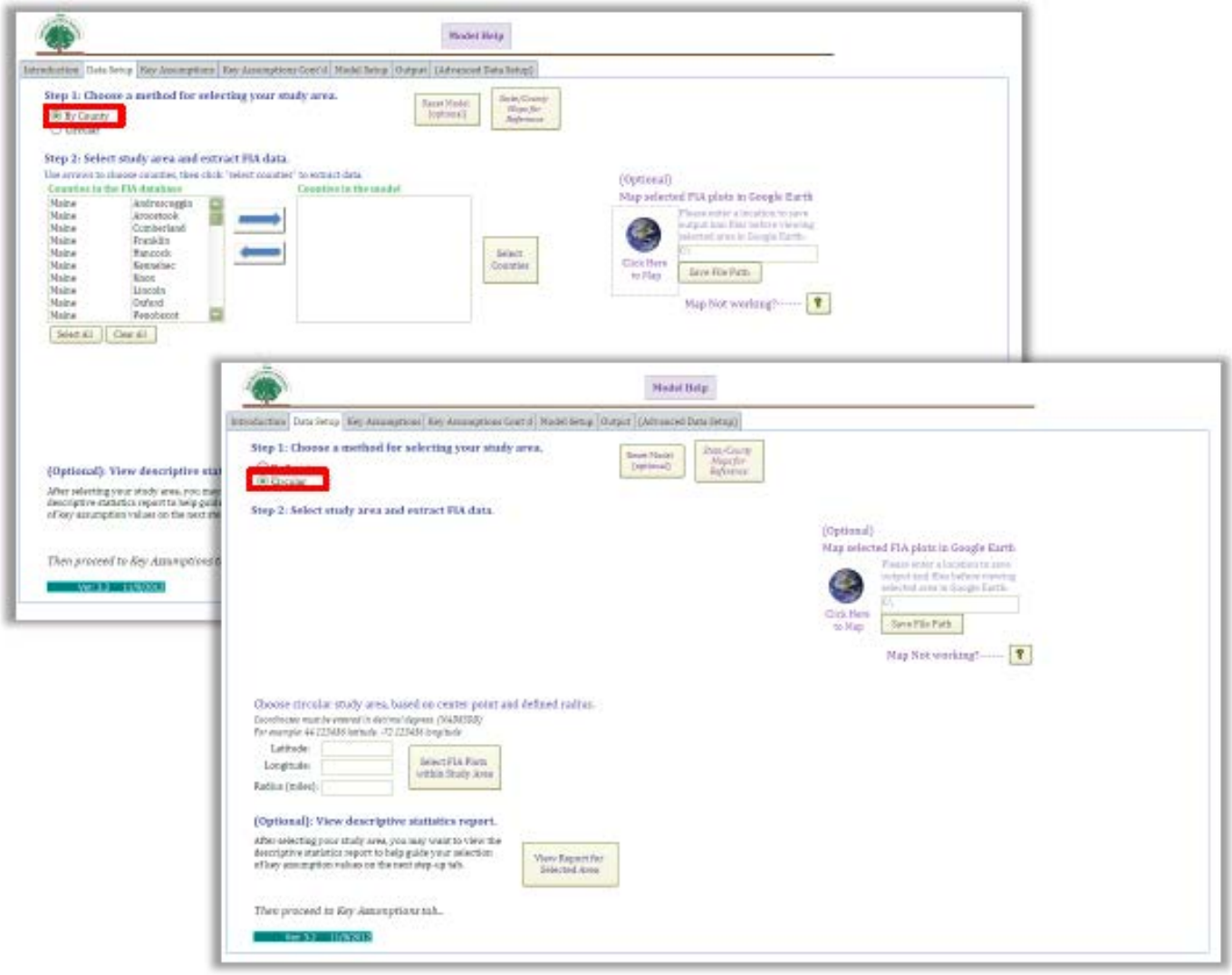


Figure 1: Data Setup tab, with By County or Circular selection.

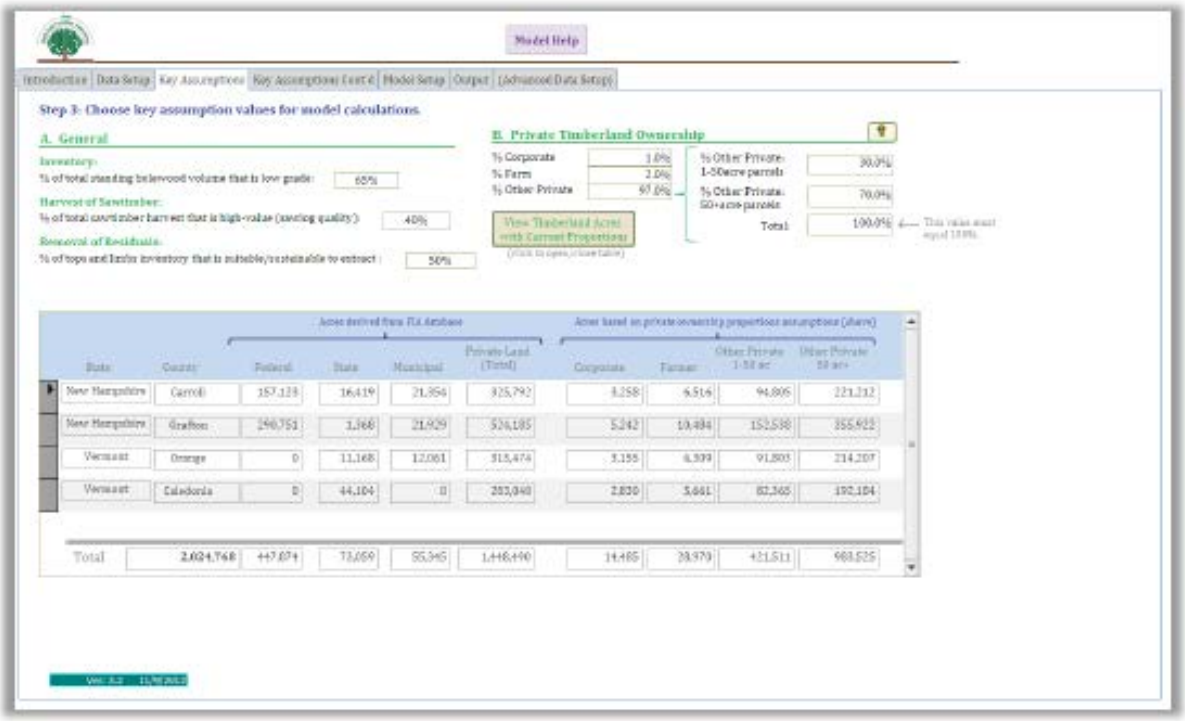


Figure 2: First Key Assumptions tab.

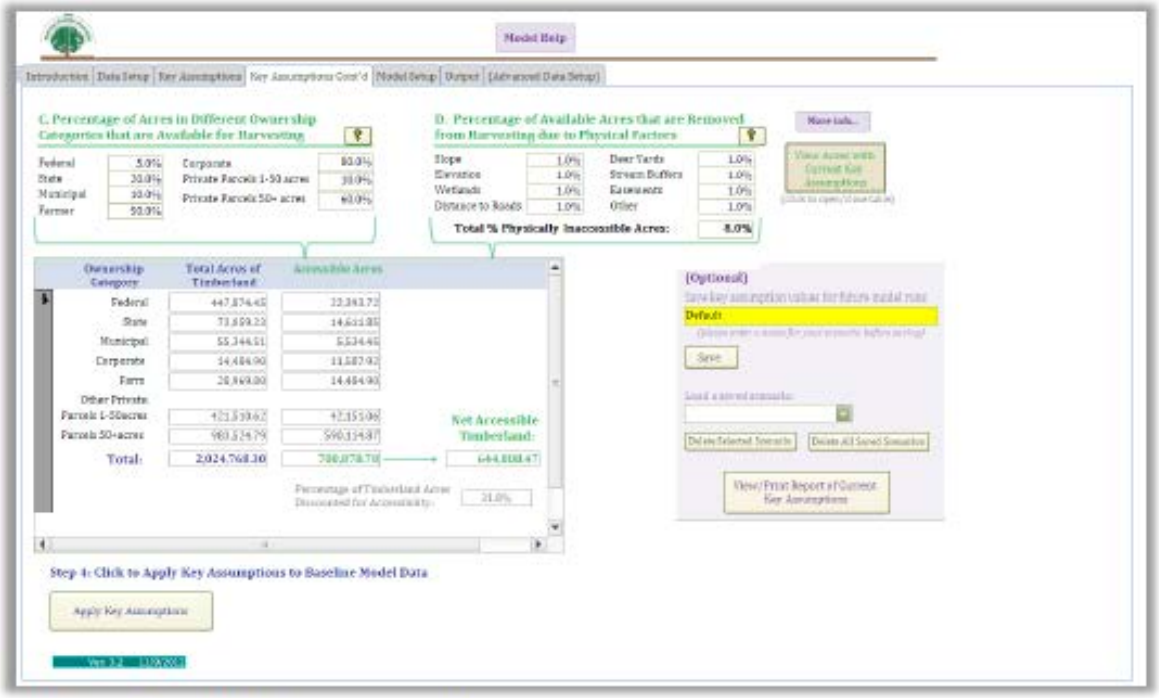


Figure 3: Second Key Assumptions tab.

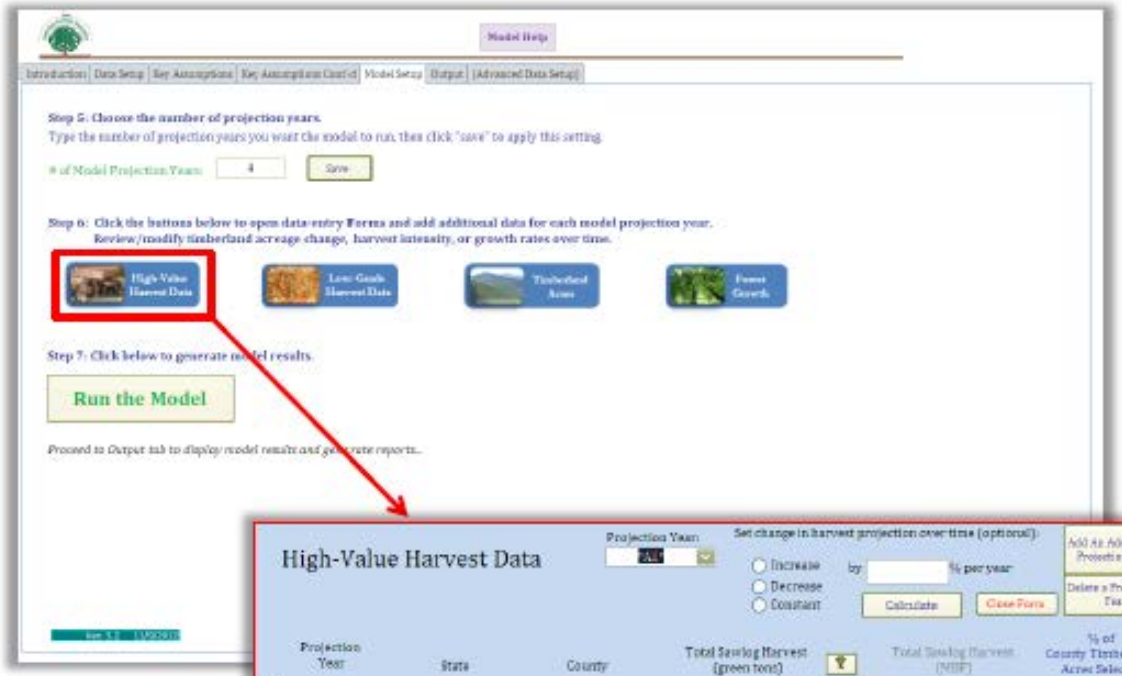


Figure 4:
Model Setup tab.

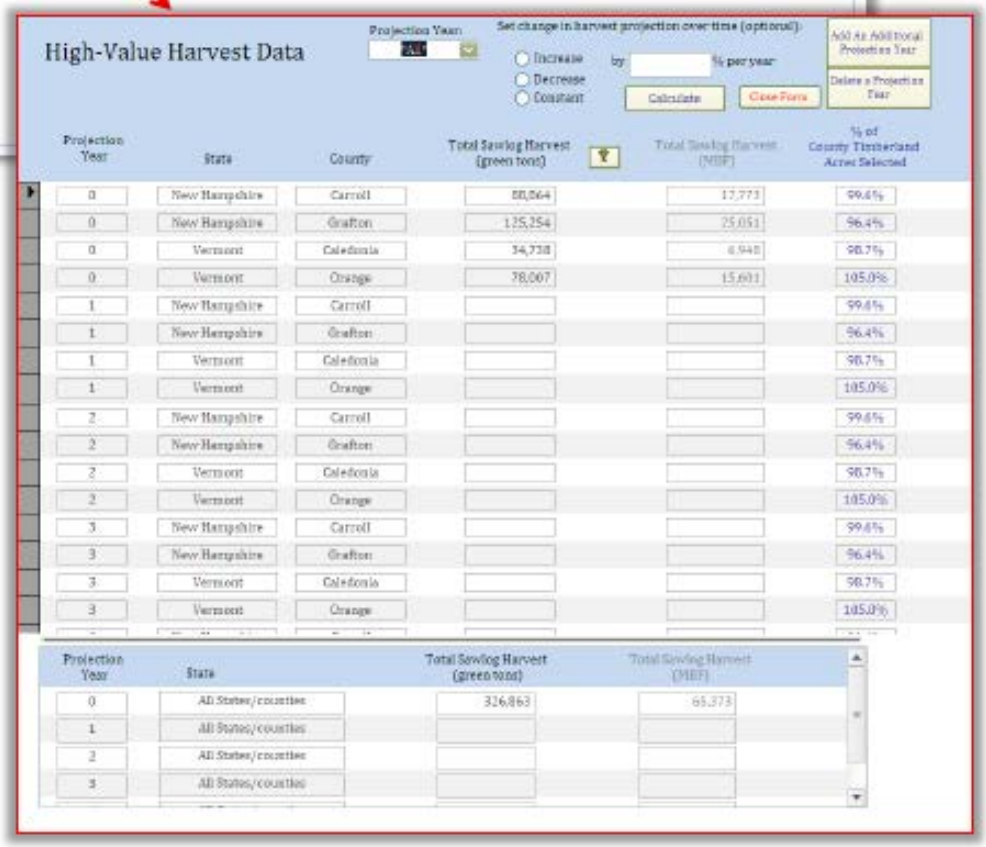


Figure 5: Example data input form.

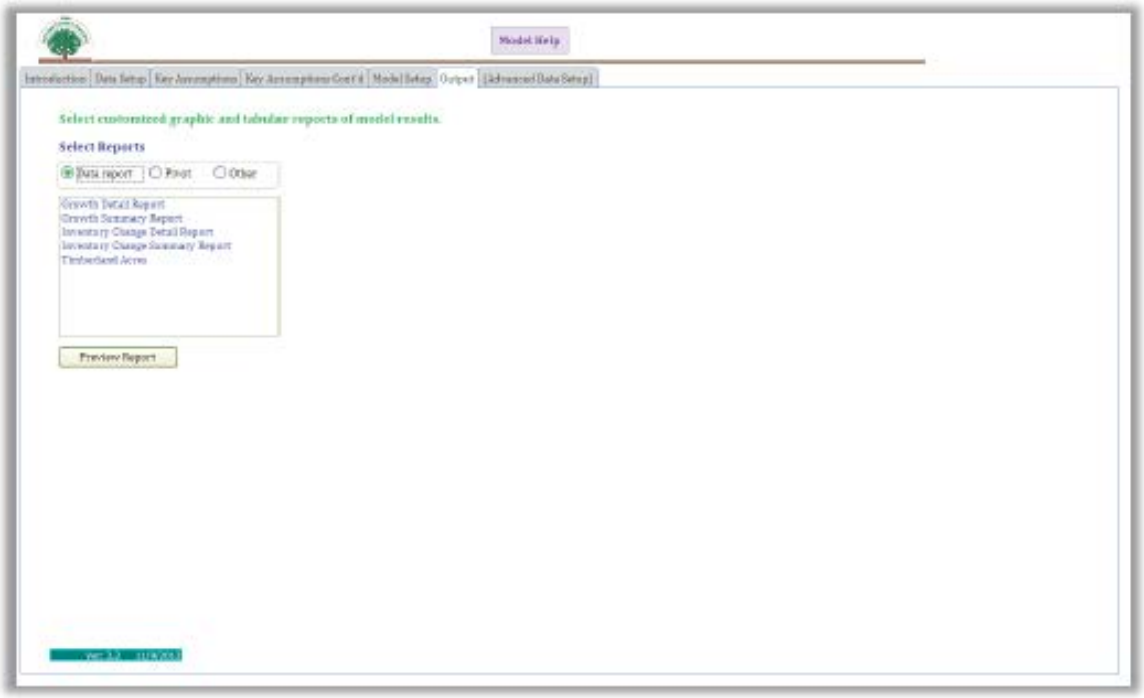


Figure 6: Output tab.

C. Timber Stocking Guides

Determining the optimal density of trees per area to get the maximum annual growth on a site is important for timber managers. The best density for even-aged stands is reflected in stocking guides (also called stocking charts). These guides help the timber manager determine if the forest is stocked too heavily with trees (overstocked), too lightly (understocked), or adequately (fully stocked).

Traditional timber stocking guides provide at least two reference lines, an A-line and a B-line and also sometimes a C-line. In general, the A-line shows the upper density limit of a naturally developing uncut forest stand, although some stands do become more dense. The B-line estimates the best density for sawtimber growth in the stand. If the stand's density is higher than the B-line, the stand is too crowded and diameter growth will likely be slower than possible on the site. If density is lower than the B-line the stand is understocked, meaning that there is too much space between trees to fully occupy the site. This results in lower timber growth per acre than is possible and potentially excessive branchiness, resulting in more knots in the timber than a stand that is fully stocked where the lower branches naturally prune because the sun does not reach them.

When density has increased to halfway between the A-line and the B-line, foresters generally want to reduce the stand's density toward the B-line level. This typically permits a commercial harvest and increases diameter growth on the remaining trees. The trees removed are often the poorest quality, so the growth is concentrated on the best quality trees (crop trees). Crop trees may be chosen on the basis of commercial value, aesthetic quality, or their contribution to desired wildlife habitat. Since crop trees are the most capable of achieving the desired goals, use extra consideration when deciding the spacing around these trees and how much light they receive.

An example of two timber stocking guides for northern hardwood forest type:

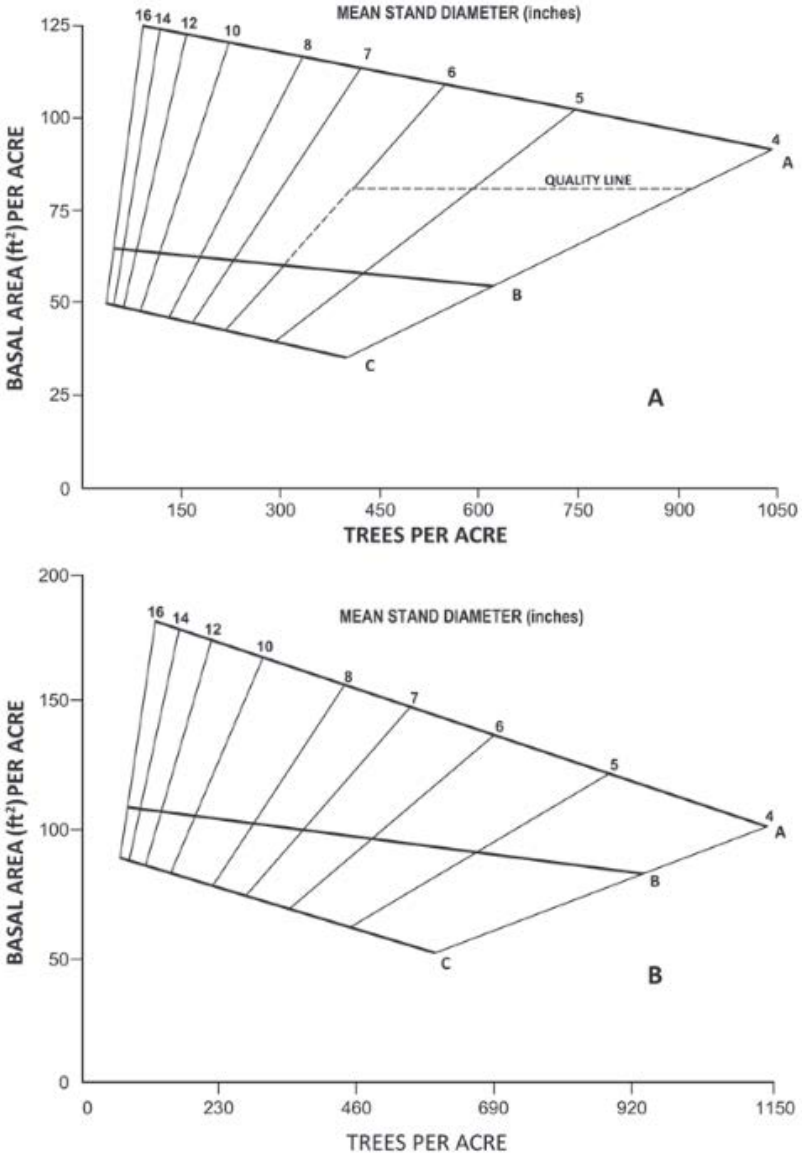


Figure 2.—Northern hardwood (A) and mixed-wood (B) stocking guides.

Source: Silvicultural Guide for Northern Hardwoods in the Northeast, Leak, Yamasaki & Holleran 2014