Catchment Area Analysis of Forest Management and Market Trends:

Enviva Pellets Ahoskie
Enviva Pellets Northampton
Enviva Pellets Southampton

Prepared for:

Drax Group plc

By:

Hood Consulting
3100 Old Canton Road, Suite 200
Jackson, MS 39216

1-601-540-8602
hbhood@hoodconsultingllc.com

Report date: April 25, 2020

Table of Contents

Table of Tables

Table of Figures

Executive Summary

The fiber catchment area in North Carolina and Virginia that supports Enviva Pellets Ahoskie, Enviva Pellets Northampton, and Enviva Pellets Southampton was examined in accordance with Drax's initiative to monitor forest management and timber market trends across its supply chain. Details regarding these three mills include:

- Enviva Pellets Ahoskie is located in Ahoskie, North Carolina, and commenced pellet production in November of 2011. The Ahoskie pellet mill was built on the site of a former Georgia-Pacific sawmill with new infrastructure purpose-built for wood pellet production. Enviva Pellets Ahoskie has a production capacity of approximately 370,000 metric tons of pellets per year.
- Enviva Pellets Northampton is located in Northampton County, North Carolina, near the towns of Gaston, Roanoke Rapids and Garysburg, and commenced pellet production in April of 2013. The facility has a production capacity of 510,000 metric tons of pellets per year.
- Enviva Pellets Southampton is located in Southampton County, Virginia, just outside the towns of Courtland and Franklin, and commenced pellet production in October of 2013. The facility was developed by its sponsor, Enviva Holdings LP, under a joint venture with affiliates of John Hancock Life Insurance Company and later acquired by Enviva Partners in 2015. Enviva Pellets Southampton has a production capacity of 510,000 metric tons of pellets per year.

The following catchment area analysis examines and identifies trends with timber inventory, growth, removals, wood demand, raw material prices, and harvest activities and practices in the Enviva Chesapeake catchment area since 2000. It also includes an assessment of long-term market sustainability and provides a market outlook through 2022.

Key report findings are highlighted and summarized on the following pages.

Is there any evidence that bioenergy demand has caused the following:	Analysis Findings
Deforestation?	**No.** US Forest Service (USFS) data shows the opposite. Total timberland acreage in the Enviva Chesapeake catchment area has increased an estimated 204,648 acres (+1.8%) since Enviva Pellets Ahoskie commenced full production in 2012.
A change in management practices (rotation lengths, thinnings, conversion from hardwood to pine)?	**No / Inconclusive.** Changes in management practices have occurred in the catchment area since 2012, but there is little evidence to suggest that bioenergy demand has caused these changes. Conversion of hardwood and mixed pine-hardwood timberland to planted pine timberland has occurred in the catchment area. Specifically, hardwood and mixed pine-hardwood timberland decreased an estimated 80,710 acres (-1.3%) from 2012-2018, compared to an increase of 81,749 acres (+2.6%) in planted pine timberland. However, it is inconclusive as to whether bioenergy demand caused this change. Conversion from naturally regenerated timber to planted pine is typical in this market. As less productive naturally regenerated timber stands are harvested, these stands are replaced with more productive planted pine (improved genetics that offer better growth, improved form, reduced susceptibility to disease, and improved financial returns). Also, worth noting is that naturally regenerated pine timberland increased an estimated 203,608 acres (+10.7%) over this same period. However, data provided by the US Department of Agriculture (USDA) suggests that this significant increase in naturally regenerated pine timberland is largely attributed to land reclassification. Specifically, land classified by the USDA as woodland (wooded land used for pasture and grazing) decreased an estimated 178,184 acres (-10.9%) from 2012-2018, close to the amount in which naturally regenerated pine timberland increased over this period. Timber management in this area is largely focused on the production of sawtimber grade timber, and rotation lengths of managed forests have remained unchanged (between 25-35 years of age) despite increases in bioenergy demand. Increased bioenergy demand, however, has benefited landowners in this catchment area, providing additional outlets for pulpwood removed from thinnings – a management activity necessary for sawtimber production. Market research also shows that changes in management activities as it relates to harvest activities has changed very little in the catchment area since 2012. Specifically, thinnings have become no more or no less prevalent in the catchment area since Enviva Pellets Ahoskie commenced full production in 2012.
Diversion from other markets?	**No / Inconclusive.** Since 2012, pulpwood demand not attributed to bioenergy has decreased 19%; however, this decrease is largely attributed to decreased demand from the pulp/paper sector. Also, demand for softwood and hardwood sawlogs have increased an estimated 14% and 7%, respectively, since 2012.
An unexpected increase in wood prices?	**No / Inconclusive.** From 2012 through 2014, the first year all three of Enviva's mills together operated at full production, hardwood biomass-related wood demand more than quadrupled. This increase in hardwood biomass demand coincided with price increases of 10-24% for delivered hardwood pulpwood and hardwood chips (the primary raw materials consumed by Enviva's three pellet mills). However, these price increases were also likely linked to a combination of both supply chain issues (shortage of local loggers following pulp/paper mill closures in the region) and elevated prices offered by Enviva to ensure guaranteed wood supply the first several years of operation, as prices for delivered hardwood pulpwood and hardwood chips proceeded to decline 16% and 9%, respectively, from 2014 to

Is there any evidence that bioenergy demand has caused the following:	Analysis Findings
	2017 (despite hardwood biomass demand holding steady at between 2.1 and 2.3 million tons per year during this period). Ultimately, hardwood raw material prices have increased in the Chesapeake catchment area since Enviva entered this market in 2012, and there is sufficient evidence that links changes in these hardwood prices to changes in total hardwood pulpwood demand (from all sources). However, these changes cannot be linked or attributed to increased demand from bioenergy alone. Delivered pine pulpwood and pine chips account for a much smaller percentage of Enviva's total wood purchases, and prices for these products increased between 11-19% from 2012-2014. However, since 2014, prices for these pine products have held flat even though softwood raw material purchases (demand) by Enviva have more than doubled. In this catchment area, changes in pine pulpwood and pine chip prices are largely driven by demand attributed to the pulp/paper sector, and there is little evidence to suggest that increased bioenergy-related wood demand has caused an abnormal or unexpected increase in these pine raw material prices.
A reduction in growing stock timber?	**No.** Total growing stock inventory in the catchment area increased 19% from 2012 through 2018, the latest available. Specifically, over this period, inventories increased as follows for each of the five major timber products: +33% for pine sawtimber, +23% for pine chip-n-saw, +14% for pine pulpwood, +12% for hardwood sawtimber, and +14% for hardwood pulpwood. The increase in timber inventory can be linked to a combination of increased forest area (additional acreage = additional inventory) and annual harvest levels below the sustainable yield capacity of the catchment area forest (i.e. annual growth has continued to exceed annual removals, resulting in increased inventory levels).
A reduction in the sequestration rate of carbon?	**No.** US Forest Service data shows the average annual growth rate of growing stock timber has increased slightly since 2012, and a faster timber growth rate essentially represents an increase in the sequestration rate of carbon. Increased timber growth rates/carbon sequestration rates can be linked to a combination of changes in species composition and silvicultural practices. Softwood (pine) grows at a much quicker rate compared to hardwood species, and in the Enviva Chesapeake catchment area, pine timberland acreage increased from 43.6% of total timberland acreage in 2011 to 46.0% in 2018. Also, improvements in silviculture have continued to enhance growth and overall productivity. Together, these factors help explain how average per acre volume growth increased from 85.1 ft^3 in 2011 to 108.5 ft^3 in 2018. Also, worth noting is that increases in timberland acreage since 2011 have elevated total carbon sequestration levels in the catchment area (i.e. more forest area, more trees, and more carbon sequestered).
An increase in harvesting above the sustainable yield capacity of the forest area?	**No.** Growth-to-removals ratios, which compare annual timber growth to annual harvests, provides a measure of market demand relative to supply as well as a gauge of market sustainability. In 2018, the latest available, growth-to-removals ratio for pine and hardwood pulpwood, the timber products utilized by bioenergy, equaled 2.49 and 2.76, respectively (a value greater than 1.0 indicates sustainable harvest levels). Even with the increased harvesting required to satisfy bioenergy demand, harvest levels remain well below the sustainable yield capacity of the catchment forest area.

Impact of bioenergy demand on:	Analysis Findings
Timber growing stock inventory	**Neutral.** Total wood demand increased an estimated 14% from 2012-2018, and much of that increase can be attributed to increased demand from bioenergy. Intuitively, increased demand means more timber is harvested, which reduces total growing stock inventory. However, in this catchment area, inventories are so substantial that increases in demand from bioenergy, as well as from other sources, have not been great enough to offset annual timber growth, and, as such, total growing stock inventory has continued to increase – an average of 2.9% per year since Enviva first entered this market in 2012.
Timber growth rates	**Neutral.** Timber growth rates have increased for pine sawtimber, pine chip-n-saw, pine pulpwood, and hardwood pulpwood since 2012; hardwood sawtimber growth rates have declined slightly. Evidence suggests these overall increases in growth rates are linked to changes in age class distribution (i.e. a younger forest), not due to changes in bioenergy demand. Increased growth rates are typically indicative of a younger forest, and this, in part, is what USFS data shows. Specifically, USFS data indicates that the average age of softwood growing stock timber decreased from 38.8 years old in 2009 to 38.5 years old in 2018. However, the average age of hardwood growing stock timber increased from 58.1 to 60.9 years old over this period. Increases in softwood growth rates reflect the decrease in softwood growing stock age, so too is the increase in hardwood growing stock age reflected in the decreased hardwood sawtimber growth rates.
Forest area	**Positive / Neutral.** Total forest area (timberland acreage) in the catchment area increased more than 200,000 acres (+1.8%) from 2012 through 2018, the latest available. Our analysis of biomass demand and forest area found a strong positive correlation between these two variables but also a moderately strong correlation between softwood sawlog demand and forest area. However, changes in timberland acreage were not found to be linked to changes in other (non-biomass-related) pulpwood demand or changes in hardwood sawlog demand. These findings suggest that increases in timberland acreage can be attributed, in part, to increases in both biomass demand and softwood sawlog demand.
Wood prices	**Neutral / Negative.** Intuitively, an increase in demand should result in an increase in price, and that's what the data shows in this catchment area as it relates to increased biomass demand from Enviva's three pellet mills and the prices of the various raw materials consumed by these mills. Specifically, the additional wood demand placed on this market by Enviva from 2012-2014 coincided with a 19% increase in delivered pine pulpwood price and a 24% increase in delivered hardwood pulpwood price. Pine and hardwood chip prices also increased 10-11% over this period. However, since 2014, delivered pine and hardwood pulpwood prices, respectively, have not moved in sync with softwood biomass demand and hardwood biomass demand. While softwood raw material purchases (demand) by Enviva have more than doubled since 2014, overall demand for pine pulpwood (from both bioenergy and other sources) has remained nearly unchanged, and so too have delivered pine pulpwood prices. Also, bioenergy-related hardwood pulpwood demand has held relatively constant since 2014 but delivered hardwood pulpwood prices have declined. Ultimately, while delivered pine pulpwood and pine chip prices have increased in the catchment area since Enviva entered this market, results are inconclusive as to the impact bioenergy demand has had on these prices, as changes in these prices appear to be more directly linked to other sources of demand (i.e. pulp/paper). Also, our analysis found evidence that increases in hardwood pulpwood and hardwood chip prices can be linked to increases in total hardwood pulpwood demand. However, given that hardwood bioenergy demand has accounted for over 75% of total hardwood pulpwood

Impact of bioenergy demand on:	Analysis Findings
	demand in the catchment area since 2014, it is reasonable to conclude that hardwood pulpwood demand attributed to bioenergy has had some level of impact on delivered hardwood pulpwood and hardwood chip prices.
Markets for solid wood products	**Positive.** In the Enviva Chesapeake catchment area, demand for softwood and hardwood sawlogs used to produce lumber and other solid wood products increased 15% and 9%, respectively, from 2012-2018. A by-product of the sawmilling process are sawmill residuals – a material utilized by Enviva's three mills to produce wood pellets. With the increased production of both softwood and hardwood lumber, so too has come an increase in sawmill residuals, some of which has been purchased/consumed by Enviva. Not only has Enviva benefited from the greater availability of this by-product, but lumber producers have also benefited, as Enviva's three mills have provided an additional outlet for these producers and their by-products.
Forest landowners	**Positive.** Increased demand attributed to bioenergy has been a positive for forest landowners in the Chesapeake catchment area. Not only has bioenergy provided an additional outlet for pulpwood (particularly hardwood pulpwood), but the increase in pulpwood prices as a result of an overall increase in both softwood and hardwood pulpwood demand has transferred through to landowners (improved compensation). Specifically, since 2013 (the first year all three Enviva pellet mills were operating), hardwood pulpwood stumpage price – the price paid to landowners – has averaged roughly $5.60 per ton in the Chesapeake catchment area. This represents a 47% increase over the approximately $3.80 per ton averaged by hardwood pulpwood stumpage in the catchment area over the 10 years prior (2003-2012). Similarly, pine pulpwood stumpage prices have averaged $12.95 per ton in the catchment area since 2013, up 67% from the 2003-2012 average of $7.75 per ton. Moreover, with increased hardwood pulpwood prices, returns associated with hardwood timber management have also been improved, providing landowners with more flexibility and expanded timber management options.

1. Report Background

Drax Group is a British electrical power generation and supply company that runs Europe's biggest biomass-fueled power station, supplying between 7-8% of the country's electricity needs. Drax is also among the world's largest single-point consumers of wood and is committed to sourcing that wood responsibly.

In accordance with Drax's initiative to monitor forest management and timber market trends across its supply chain, this report focuses specifically on Enviva Pellets Ahoskie, Enviva Pellets Northampton, and Enviva Pellets Southampton and the fiber catchment area in North Carolina and Virginia that supports these three pellet mills.

This catchment area analysis examines and identifies trends with timber inventory, growth, removals, wood demand, raw material prices, and harvest activities and practices in the Enviva Chesapeake catchment area since 2000. It also includes an assessment of long-term market sustainability and provides a market outlook through 2022.

1.1 About Hood Consulting

Hood Consulting provides professional forest industry advisory and consulting services to both private and corporate landowners and investors, forest product companies, manufacturers, natural resource firms, and state and local economic development authorities.

Dr. Harrison Hood is a Forest Economist and Principal of Hood Consulting. His experience also includes the furniture import and export business, real estate development, and land management. Dr. Hood received a B.B.A. in Finance from the University of Mississippi as well as a Masters of Forest Resources in Forest Business and a Ph.D. in Forest Economics from the University of Georgia.

2. Market Profile & Resource Assessment

A mill's catchment area is the area in which a single pellet mill ("nucleus mill") has directly acquired fiber since the mill started operations, including any additional forest areas where future purchase contracts exist. However, given the proximity of Enviva Pellets Ahoskie, Enviva Pellets Southampton, and Enviva Pellets Northampton, these three mills operate under a single, extended catchment area to procure the required fiber to meet cumulative production needs.

According to Enviva Biomass, the combined catchment area for these three mills (denoted 'Chesapeake' catchment area hereafter) extends as far as 300 miles north-south and 180 miles east-west, covering an area nearly 35,000 square miles in size. Specifically, this area includes 39 counties in North Carolina and 33 counties or independent cities in Virginia (Figure 1).

***Figure 1**. Enviva Chesapeake Catchment Area (as defined by Enviva Biomass)*

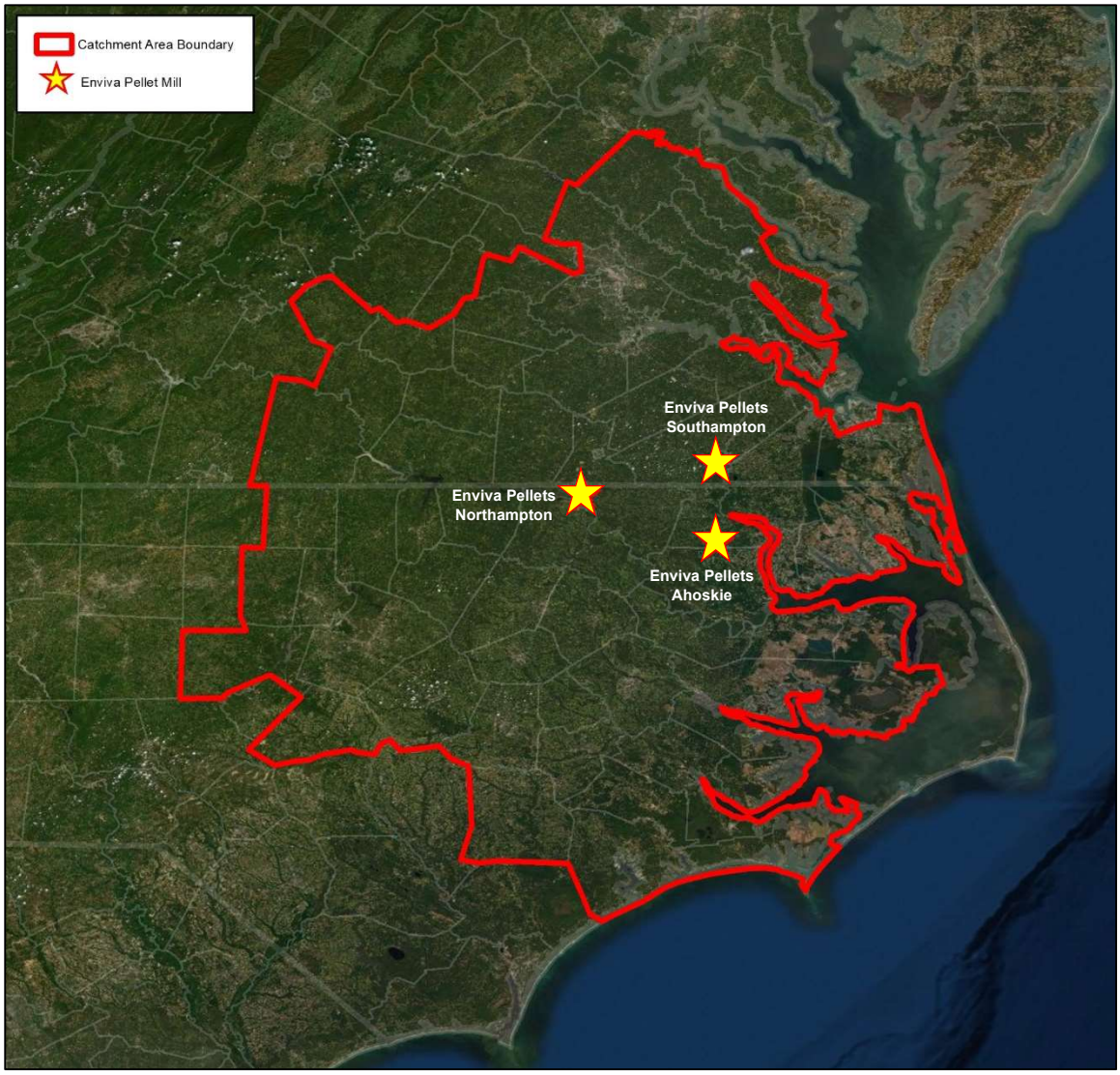


***Table 1**. Enviva Chesapeake Catchment Area – County List*

State	County	State	County
NC	Beaufort	NC	Washington
NC	Bertie	NC	Wayne
NC	Camden	NC	Wilson
NC	Carteret	VA	Amelia
NC	Chatham	VA	Appomattox
NC	Chowan	VA	Brunswick
NC	Craven	VA	Caroline
NC	Currituck	VA	Charles City
NC	Duplin	VA	Charlotte
NC	Durham	VA	Chesapeake City
NC	Edgecombe	VA	Chesterfield
NC	Franklin	VA	Dinwiddie
NC	Gates	VA	Essex
NC	Granville	VA	Gloucester
NC	Greene	VA	Greensville
NC	Halifax	VA	Halifax
NC	Harnett	VA	Hanover
NC	Hertford	VA	Henrico
NC	Hyde	VA	Isle of Wight
NC	Johnston	VA	James City
NC	Jones	VA	King & Queen
NC	Lenoir	VA	King William
NC	Martin	VA	Lunenburg
NC	Nash	VA	Mecklenburg
NC	Northampton	VA	New Kent
NC	Onslow	VA	Newport News City
NC	Orange	VA	Nottoway
NC	Pamlico	VA	Powhatan
NC	Pasquotank	VA	Prince Edward
NC	Perquimans	VA	Prince George
NC	Person	VA	Southampton
NC	Pitt	VA	Suffolk City
NC	Tyrrell	VA	Surry
NC	Vance	VA	Sussex
NC	Wake	VA	Virginia Beach City
NC	Warren	VA	York

2.1 Land Area & Use

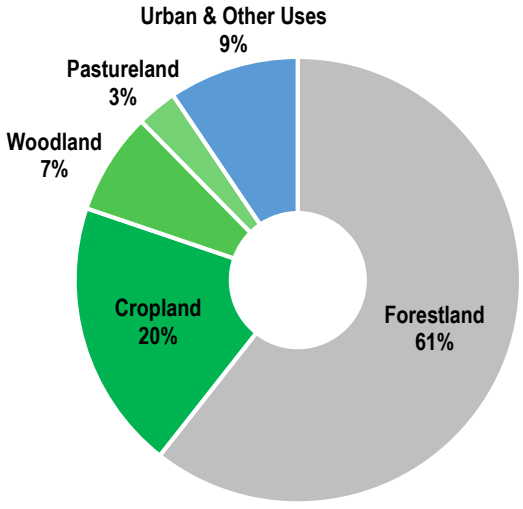
According to the US Department of Agriculture (USDA), Enviva's Chesapeake catchment area totals approximately 19,651,853 acres in size. Approximately 61% (11,911,722 acres) of the total land area is classified as forestland, 30% (5,884,646 acres) is farmland, and 9% (1,855,485 acres) is urban areas or land that is classified as having other uses.

***Table 2**. Enviva Chesapeake Catchment Area - Land Area by Land Classification & Use (2018)*

Land Classification / Use	Acres	% of Total
Forestland	11,911,722	61%
Farmland:		
Cropland	3,851,380	20%
Woodland	1,454,636	7%
Pastureland	578,630	3%
Total Farmland	5,884,646	30%
Urban & Other Uses	1,855,485	9%
Total	**19,651,853**	**100%**

Source: USDA – US Forest Service; USDA Census of Agriculture

***Figure 2**. Enviva Chesapeake Catchment Area - Acreage Distribution by Land Classification & Use (2018)*



2.1.1 *Forestland*

Forestland, defined by the USDA as land at least 10% stock with trees of any kind, totals approximately 11,911,722 acres and constitutes 61% of the catchment area's total land area.

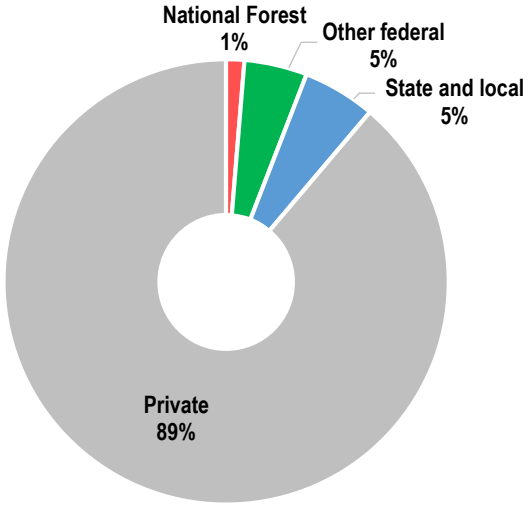
Ownership of forestland in the Enviva Chesapeake catchment area is predominantly privately owned. According to US Forest Service - Forest Inventory and Analysis (FIA) data from 2018, the latest available, privately-owned forestland constitutes 89% of total forestland and totals approximately 10,579,621 acres. Public forestland constitutes 11% of total forestland in the catchment area, with National Forests totaling 156,605 acres (1%), other federal forestland totaling 545,229 acres (5%), and forestland owned by state and local authorities totaling 630,265 acres (5%).

***Table 3**. Enviva Chesapeake Catchment Area - Forestland Acreage by Ownership Group (2018)*

Ownership Group	Acres	% of Total
National Forest	156,605	1%
Other Federal	545,229	5%
State and Local	630,265	5%
Private	10,579,621	89%
Total	**11,911,722**	**100%**

Source: USDA – US Forest Service

***Figure 3**. Enviva Chesapeake Catchment Area - Distribution of Forestland Acreage by Ownership Group (2018)*



2.1.1.1 *Timberland*

Not all forestland is capable of commercial timber production. However, the USDA provides an alternative designation for forestland that can be commercially productive. Timberland is defined by the USDA as forestland that is capable of producing at least 20 ft^3 of industrial wood per year.

In the Enviva Chesapeake catchment area, timberland constitutes nearly 98% of total forestland and totals approximately 11,623,969 acres. *Note that this report will focus specifically on timberland, and all data provided hereafter regarding timber inventory, growth, and removals will be from timberland only.*

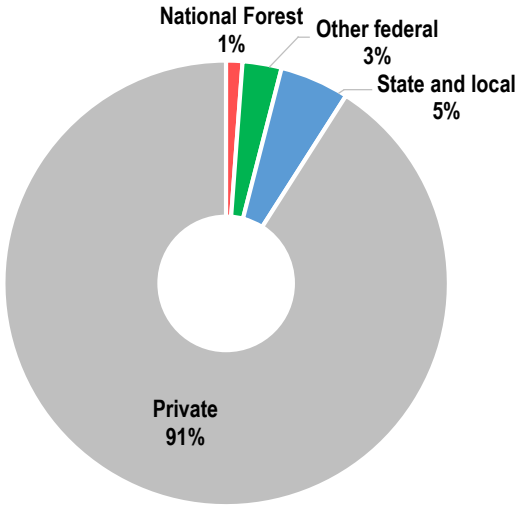
Ownership of timberland in the Enviva Chesapeake catchment area is similar to that of forestland, with 91% (10,572,348 acres) of total timberland privately owned, compared to 1% (138,394 acres) National Forests, 3% (328,188 acres) other federal, and 5% (585,039 acres) owned by state and local authorities.

***Table 4**. Enviva Chesapeake Catchment Area - Timberland Acreage by Ownership Group (2018)*

Ownership Group	Acres	% of Total
National Forest	138,394	1%
Other Federal	328,188	3%
State and Local	585,039	5%
Private	10,572,348	91%
Total	**11,623,969**	**100%**

Source: USDA – US Forest Service

***Figure 4**. Enviva Chesapeake Catchment Area - Distribution of Timberland Acreage by Ownership Group (2018)*



Age Class Distribution

According to US Forest Service data, of the 11,623,969 acres of timberland in the catchment area, approximately 44% (5,170,455 acres) is softwood, 43% (4,962,214 acres) is hardwood, and 13% (1,491,300 acres) is mixed pine-hardwood.

Distribution of timberland acreage by age class varies by forest type. Approximately 83% of softwood timberland is 40 years of age or younger, with 56% less than 26 years of age. Distribution of mixed pine-hardwood timberland closely resembles that of softwood timberland, with approximately 70% of mixed pine-hardwood timberland 45 years of age or younger.

US Forest Service data shows that approximately 11% of hardwood timberland is five years of age or younger. This value presumably includes transitional stands and those with low stocking levels that will likely not reach maturity. However, if we exclude this youngest age class, hardwood timberland acreage has a bimodal distribution – with approximately 29% of the remaining acreage 6-30 years old and 44% of hardwood timberland 51-90 years old.

***Table 5**. Enviva Chesapeake Catchment Area - Distribution of Timberland Acreage by Age Class & Forest Type (2018)*

Age Class (Years)	*Softwood*		*Hardwood*		*Mixed Pine-Hardwood*		*Total*	
	Acres	Distribution	Acres	Distribution	Acres	Distribution	Acres	Distribution
0-5	443,262	9%	543,087	11%	220,925	15%	1,207,273	10%
6-10	498,935	10%	223,191	4%	124,406	8%	846,532	7%
11-15	755,317	15%	284,680	6%	92,210	6%	1,132,207	10%
16-20	567,532	11%	280,811	6%	122,381	8%	970,725	8%
21-25	621,148	12%	248,801	5%	129,115	9%	999,064	9%
26-30	570,814	11%	245,574	5%	85,852	6%	902,240	8%
31-35	504,731	10%	198,702	4%	137,414	9%	840,846	7%
36-40	337,217	7%	167,925	3%	58,249	4%	563,391	5%
41-45	142,788	3%	192,557	4%	69,486	5%	404,831	3%
46-50	135,362	3%	207,359	4%	23,933	2%	366,654	3%
51-55	132,026	3%	238,644	5%	46,129	3%	416,799	4%
56-60	108,565	2%	282,203	6%	85,011	6%	475,779	4%
61-65	86,276	2%	266,032	5%	59,544	4%	411,851	4%
66-70	77,275	1%	266,775	5%	53,479	4%	397,529	3%
71-75	48,156	1%	268,948	5%	47,679	3%	364,783	3%
76-80	42,235	1%	204,955	4%	43,748	3%	290,937	3%
81-85	24,931	0%	201,200	4%	21,993	1%	248,124	2%
86-90	27,183	1%	223,323	5%	20,558	1%	271,063	2%
91-95	22,553	0%	165,843	3%	30,492	2%	218,888	2%
96-100	7,198	0%	76,012	2%	0	0%	83,210	1%
100+	16,952	0%	175,593	4%	18,697	1%	211,242	2%
Total	**5,170,455**	**100%**	**4,962,214**	**100%**	**1,491,300**	**100%**	**11,623,969**	**100%**

Source: USDA - US Forest Service

***Figure 5**. Enviva Chesapeake Catchment Area - Distribution of Timberland Acreage by Age Class (2018)*

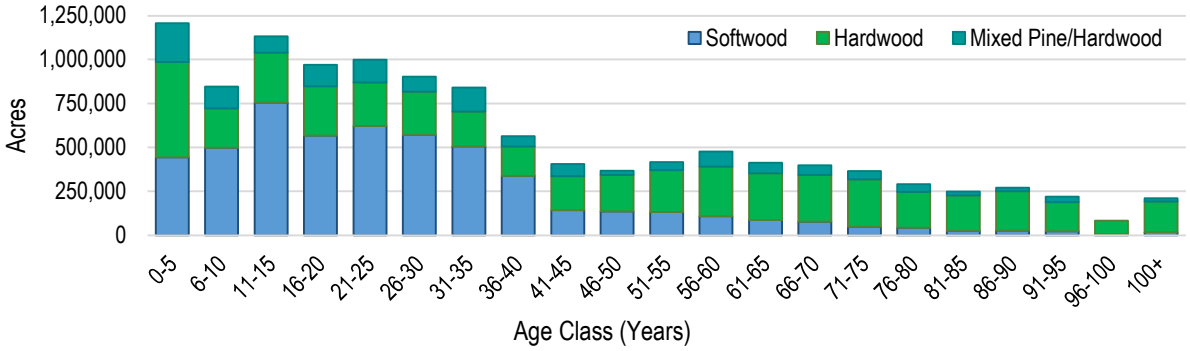
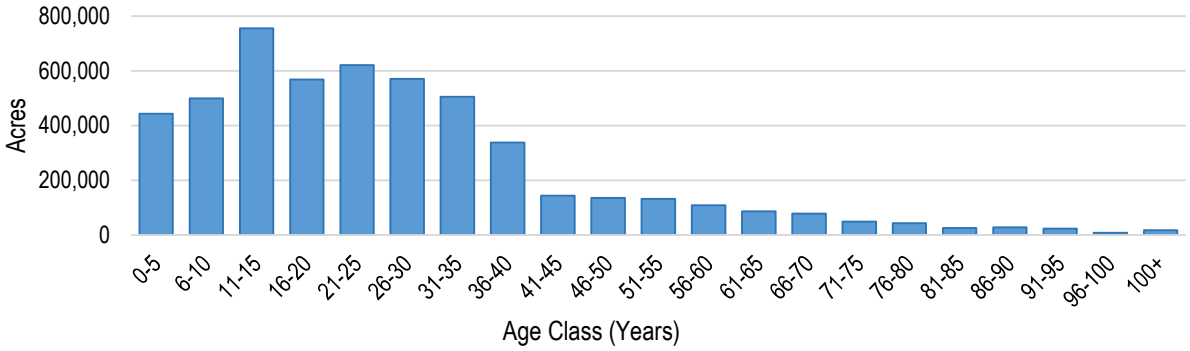
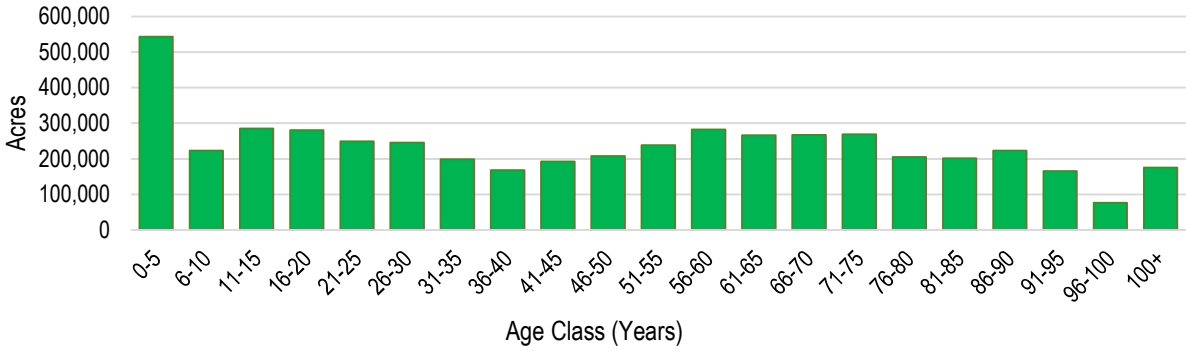


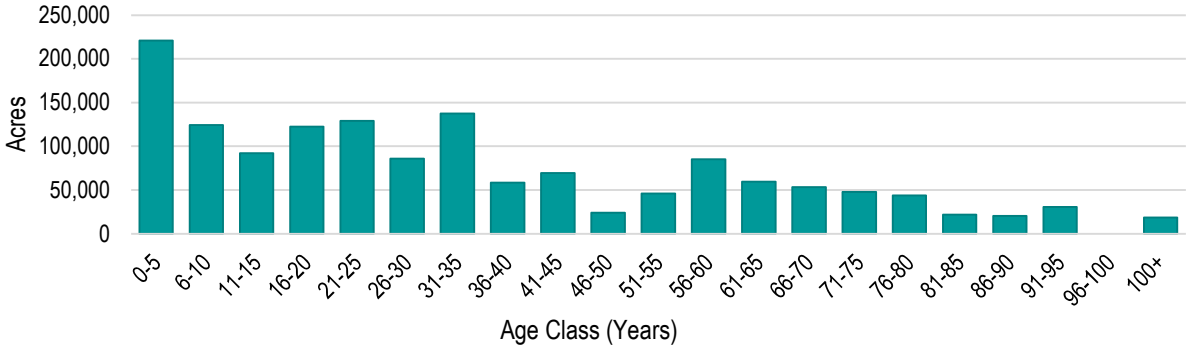
***Figure 6**. Enviva Chesapeake Catchment Area - Distribution of Timberland Acreage by Age Class & Forest Type (2018)*



(a) Softwood Timberland



(b) Hardwood Timberland



(c) Mixed Pine-Hardwood Timberland

Stand Origin

The US Forest Service provides two classifications for stand origin: 1) naturally regenerated and 2) planted. The USFS defines a *naturally regenerated* timber stand as one that has been established naturally. A *planted* timber stand is defined as an artificially regenerated stand established by planting or artificial seedling.

Based on the most current USFS estimates, approximately 69% (8,065,929 acres) of total catchment area timberland acreage is classified as naturally regenerated forests versus 31% (3,558,040 acres) planted forests. However, stand origin acreage distribution varies widely by major forest type.

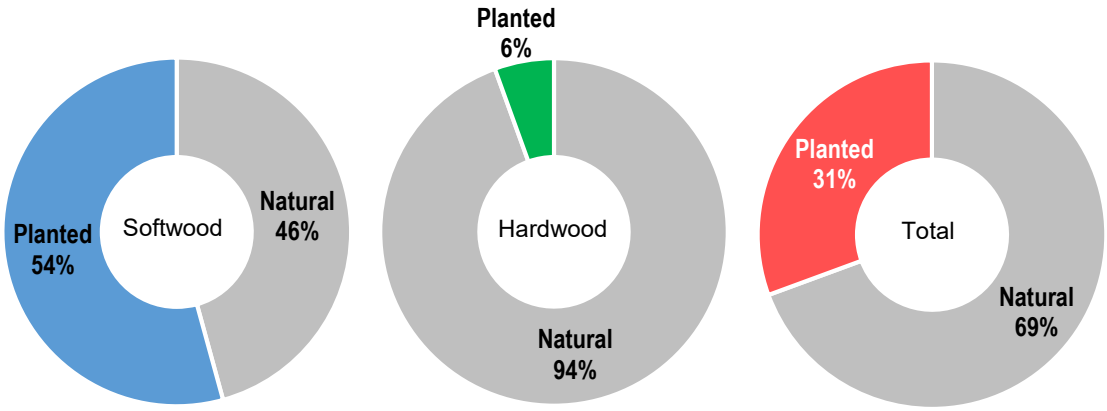
US Forest Service data shows approximately 46% (2,733,562 acres) of softwood timberland acreage is naturally regenerated versus 54% (3,245,027 acres) planted. In contrast, approximately 94% (5,332,367 acres) of hardwood timberland acreage is naturally regenerated, compared to 6% (313,013 acres) planted.

***Table 6**. Enviva Chesapeake Catchment Area - Timberland Acreage by Stand Origin & Major Forest Type (2018)*

	Softwood		Hardwood		Total	
Stand Origin	**Acres**	**Distribution**	**Acres**	**Distribution**	**Acres**	**Distribution**
Naturally Regenerated	2,733,562	46%	5,332,367	94%	8,065,929	69%
Planted	3,245,027	54%	313,013	6%	3,558,040	31%
Total	**5,978,589**	**100%**	**5,645,380**	**100%**	**11,623,969**	**100%**

Source: USDA - US Forest Service

***Figure 7**. Enviva Chesapeake Catchment Area - Distribution of Timberland Acreage by Stand Origin & Major Forest Type (2018)*



2.2 Timber Inventory

Timber inventory data for the Enviva Chesapeake catchment area is provided by the US Forest Service - Forest Inventory & Analysis (FIA) program. FIA data utilizes approximately 50-60 sample plots per county to calculate inventory estimates, with sampling errors of 10-25%.

Note that this section profiles timber inventory, growth, and removal details as of 2018[1], the most current available. Further analysis, including inventory trends since 2000 and projections through 2022, is provided in the *Market Trends, Analysis, & Outlook* section beginning on page 51.

2.2.1 *By Ownership Group*

Growing stock inventory on timberland in the Enviva Chesapeake catchment area totals an estimated 24.5 billion ft^3, of which approximately 86% (21.8 billion ft^3) is privately owned, 6% (1.3 billion ft^3) is owned by state and local authorities, 4% (1.0 billion ft^3) is owned by other federal authorities, and 1% (308 million ft^3) is National Forest.

Note that the distributions of both softwood and hardwood growing stock inventory by ownership group are nearly identical to that of total growing stock inventory. See Table 7 for details.

***Table 7**. Enviva Chesapeake Catchment Area - Growing Stock Volume on Timberland by Ownership Group and Major Species (2018)*

Ownership Group	Softwood Inventory	Hardwood Inventory	Total Inventory
		(Million Cubic Feet)	
National Forest	223	85	308
Other Federal	437	588	1,025
State and Local	640	700	1,340
Private	11,121	10,682	21,803
Total	**12,421**	**12,055**	**24,475**

Source: USDA - US Forest Service

[1] US Forest Service FIA data for those areas located in Virginia were only available through 2017. Estimates for 2018 have been included and are based on historical trends and a local area inventory model.

2.2.2 *By Diameter Class Distribution*

Distribution of total growing stock inventory on timberland by diameter class varies by major species group. Based on the most current US Forest Service data, the distribution of softwood growing stock inventory shows approximately 74% (9.3 billion ft^3) is 7- 17 inches in diameter, with 89% (11.1 billion ft^3) of total softwood inventory 5-19 inches in diameter.

Hardwood growing stock inventory's distribution is a bit more widespread than that of softwood inventory, with 73% (8.8 billion ft^3) of hardwood inventory 5-19 inches in diameter, and 91% (11.0 billion ft^3) less than 25 inches in diameter.

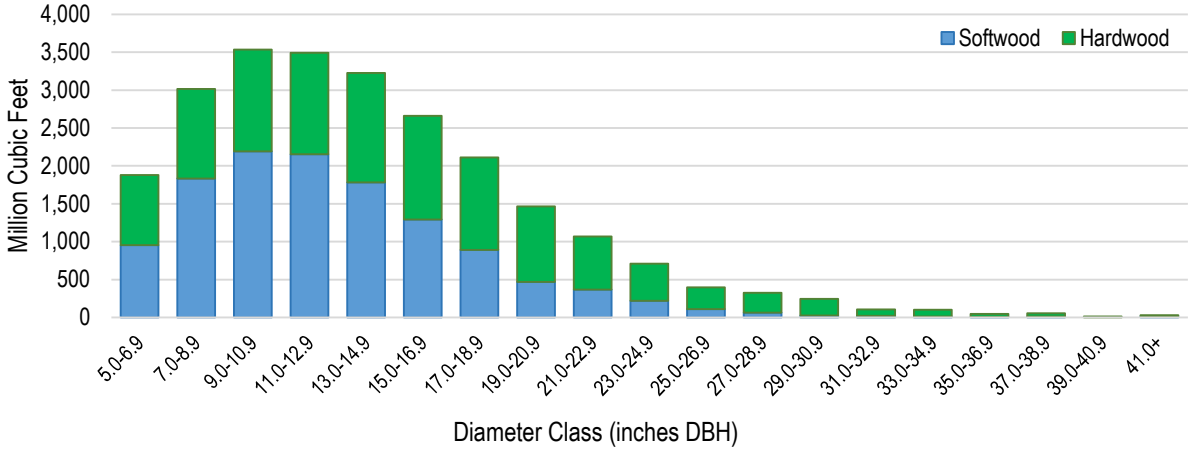
Based on these diameter class distributions, softwood growing stock inventory averages an estimated 12.9 inches in diameter, compared to 15.5 inches for hardwood growing stock.

***Table 8**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Species Group & Diameter Class (2018)*

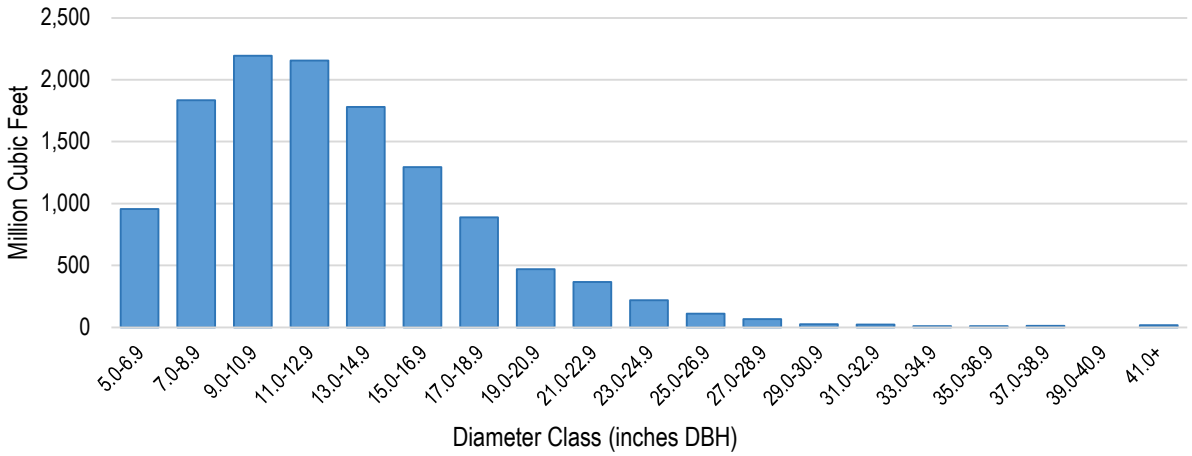
Diameter Class (inches DBH)	*Softwood*		*Hardwood*		*Total*	
	Volume (Million ft3)	Distribution	Volume (Million ft3)	Distribution	Volume (Million ft3)	Distribution
5.0-6.9	955	8%	925	8%	1,880	8%
7.0-8.9	1,834	15%	1,184	10%	3,017	12%
9.0-10.9	2,192	18%	1,341	11%	3,534	14%
11.0-12.9	2,154	17%	1,338	11%	3,492	14%
13.0-14.9	1,781	14%	1,445	12%	3,226	13%
15.0-16.9	1,293	10%	1,368	11%	2,661	11%
17.0-18.9	889	7%	1,221	10%	2,110	9%
19.0-20.9	471	4%	994	8%	1,464	6%
21.0-22.9	366	3%	700	6%	1,066	4%
23.0-24.9	220	2%	490	4%	710	3%
25.0-26.9	110	1%	286	2%	396	2%
27.0-28.9	65	1%	261	2%	327	1%
29.0-30.9	24	0%	220	2%	244	1%
31.0-32.9	21	0%	84	1%	106	0%
33.0-34.9	10	0%	91	1%	102	0%
35.0-36.9	8	0%	38	0%	46	0%
37.0-38.9	11	0%	42	0%	53	0%
39.0-40.9	0	0%	12	0%	12	0%
41.0+	16	0%	13	0%	29	0%
Total	**12,421**	**100%**	**12,055**	**100%**	**24,475**	**100%**

Source: USDA - US Forest Service

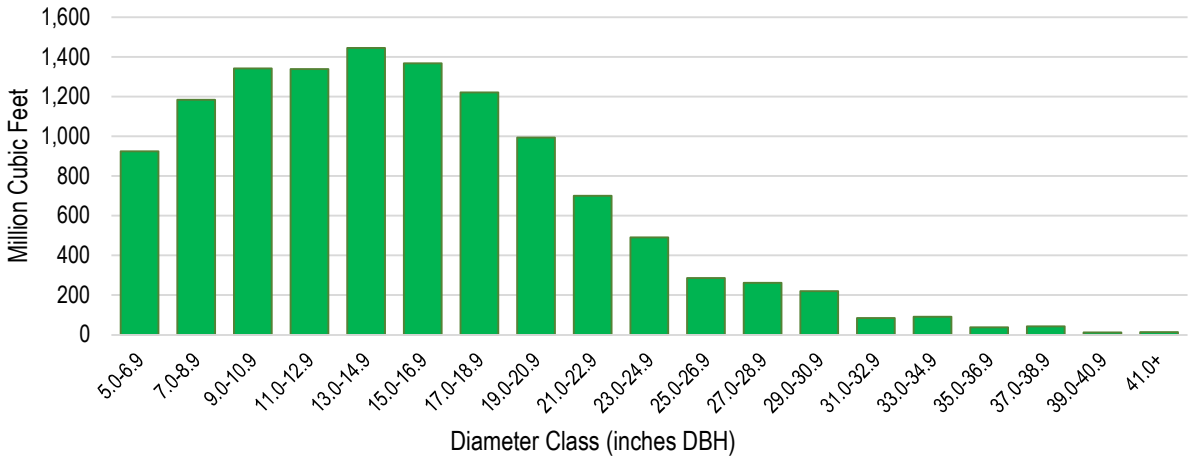
***Figure 8**. Enviva Chesapeake Catchment Area - Distribution of Growing Stock Volume on Timberland by Diameter Class (2018)*



(a) Total Growing Stock



(b) Softwood Growing Stock



(c) Hardwood Growing Stock

In addition, FIA estimates of diameter class distribution by major species group allow us to break down volume estimates according to major timber product. Since pine constitutes 97% of total softwood inventory in the catchment area (according to FIA data), for these calculations, all softwood inventory is considered pine. Individual product specifications are defined as follows:

Major Product	DBH (inches)
Pine Pulpwood	5.0 – 8.9
Pine Chip-n-saw	9.0 – 11.9
Pine Sawtimber	12.0+
Hardwood Pulpwood	5.0 – 9.9
Hardwood Sawtimber	10.0+

Based on these product specifications, approximately 6.4 billion ft^3 of total growing stock inventory is classified as pine sawtimber (26%), compared to 3.3 billion ft^3 of pine chip-n-saw (13%), 2.8 billion ft^3 of pine pulpwood (12%), 9.3 billion ft^3 of hardwood sawtimber (38%), and 2.8 billion ft^3 of hardwood pulpwood (11%).

***Table 9**. Enviva Chesapeake Catchment Area - Distribution of Total Growing Stock Volume by Major Timber Product (2018)*

Product	Volume (Million ft^3)	Distribution
Pine Sawtimber	6,363	26%
Pine Chip-n-saw	3,269	13%
Pine Pulpwood	2,788	12%
Hardwood Sawtimber	9,275	38%
Hardwood Pulpwood	2,779	11%
Total	**24,475**	**100%**

Source: USDA - US Forest Service

2.2.3 *By Age Class Distribution*

Distribution of total growing stock volume on timberland by age class is bimodal, with approximately 51% of total inventory 11-45 years of age and 37% of total inventory 51-95 years of age (see Figure 8). However, this is explained by major species composition and its respective age class distribution.

According to US Forest Service data, the distribution of softwood growing stock volume by age class shows that 64% (8.0 billion ft^3) is 11-40 years of age, with only 17% (2.2 billion ft^3) greater than 60 years of age. In contrast, hardwood inventory's distribution is more widespread, with 54% (6.5 billion ft^3) 56-95 years of age and 87% (10.4 billion ft^3) 21-95 years of age.

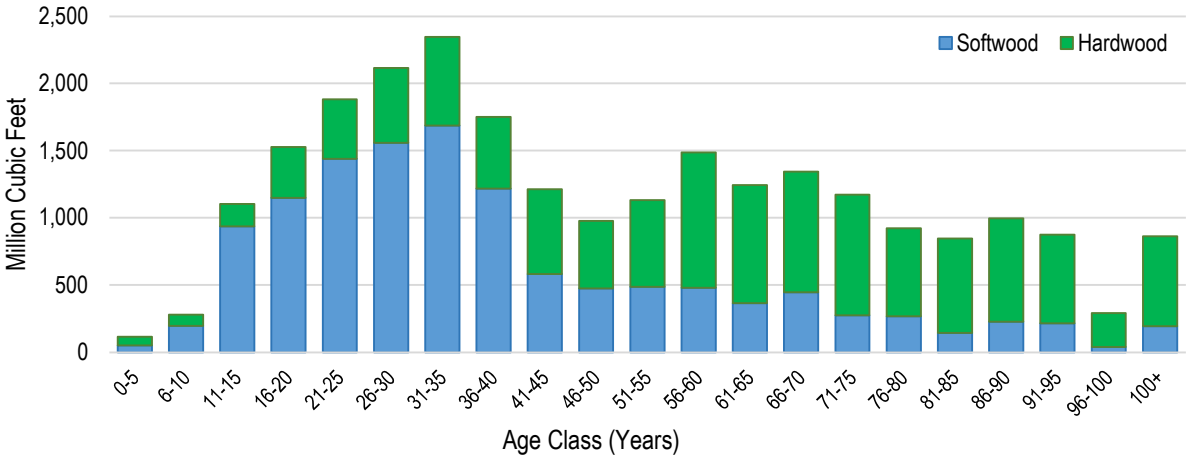
Based on these age class distributions, softwood growing stock inventory averages an estimated 38.6 years old, compared to 60.9 years old for hardwood growing stock.

***Table 10**. Enviva Chesapeake Catchment Area - Distribution of Growing Stock Volume by Age Class & Major Species (2018)*

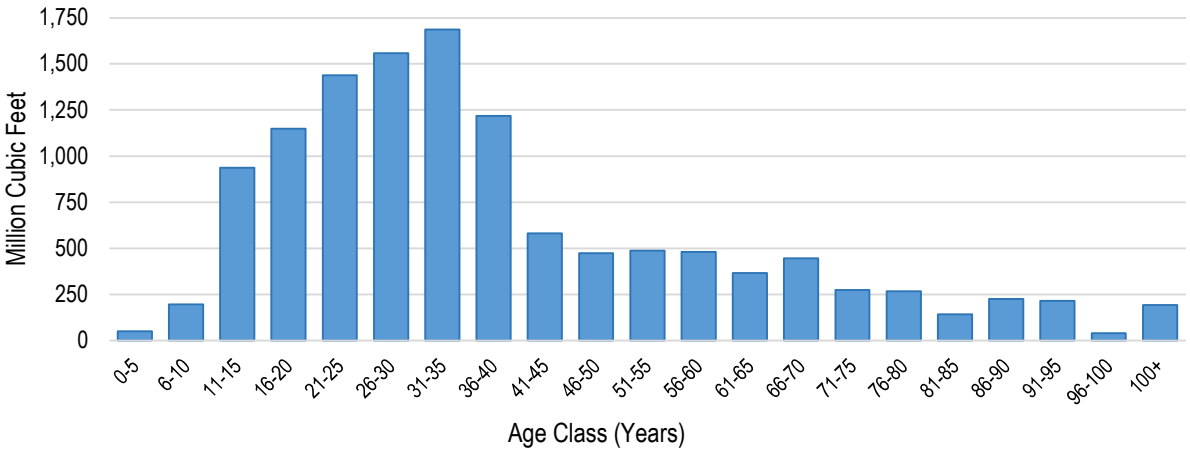
	Softwood		*Hardwood*		*Total*	
Age Class (Years)	**Volume** (Million ft3)	**Distribution**	**Volume** (Million ft3)	**Distribution**	**Volume** (Million ft3)	**Distribution**
0-5	51	0%	64	1%	114	0%
6-10	196	2%	83	1%	278	1%
11-15	936	8%	168	1%	1,101	4%
16-20	1,149	9%	377	3%	1,523	6%
21-25	1,438	12%	443	4%	1,877	8%
26-30	1,557	13%	559	5%	2,112	9%
31-35	1,686	14%	660	5%	2,343	10%
36-40	1,217	10%	535	4%	1,749	7%
41-45	581	5%	632	5%	1,213	5%
46-50	474	4%	503	4%	977	4%
51-55	487	4%	645	5%	1,132	5%
56-60	480	4%	1,006	8%	1,488	6%
61-65	366	3%	879	7%	1,247	5%
66-70	445	4%	899	7%	1,346	5%
71-75	274	2%	898	7%	1,174	5%
76-80	266	2%	655	5%	923	4%
81-85	143	1%	704	6%	849	3%
86-90	226	2%	769	6%	998	4%
91-95	216	2%	658	5%	875	4%
96-100	39	0%	251	2%	291	1%
100+	193	2%	669	6%	864	4%
Total	**12,421**	**100%**	**12,055**	**100%**	**24,475**	**100%**

Source: USDA - US Forest Service

***Figure 9**. Enviva Chesapeake Catchment Area - Distribution of Growing Stock Volume on Timberland by Age Class (2018)*



(a) Total Growing Stock



(b) Softwood Growing Stock

(c) Hardwood Growing Stock

2.2.4 *By Stand Origin*

US Forest Service data includes two classifications for stand origin: 1) naturally regenerated timber stands and 2) planted timber stands. Specifically, *naturally regenerated* timber stands are defined by the USFS as those that have been established naturally. A *planted* timber stand is defined as an artificially regenerated stand established by planting or artificial seedling.

Based on the most current US Forest Service FIA estimates, approximately 73% of total growing stock volume in the catchment area, or 17.8 billion ft^3, is naturally regenerated timber, compared to 27% (6.7 billion ft^3) that was planted. However, stand origin distribution varies widely by major species group.

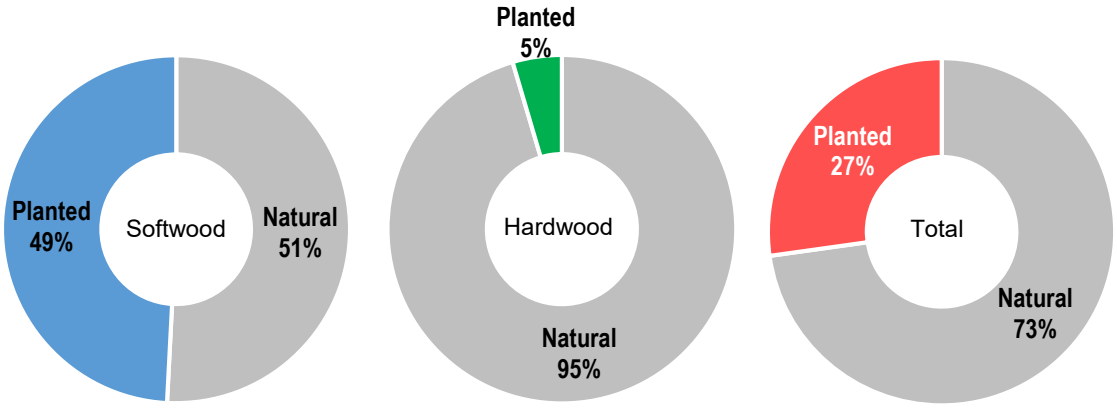
US Forest Service data shows approximately 51% (6.3 billion ft^3) of softwood growing stock is naturally regenerated versus 49% (6.1 billion ft^3) planted. In contrast, approximately 95% (11.5 billion ft^3) of hardwood inventory is naturally regenerated, compared to 5% (548 million ft^3) planted.

***Table 11**. Enviva Chesapeake Catchment Area - Growing Stock Volume on Timberland by Stand Origin & Major Species (2018)*

	Softwood		*Hardwood*		*Total*	
Stand Origin	**Volume** (Million ft3)	**Distribution**	**Volume** (Million ft3)	**Distribution**	**Volume** (Million ft3)	**Distribution**
Naturally Regenerated	6,315	51%	11,503	95%	17,818	73%
Planted	6,110	49%	548	5%	6,658	27%
Total	**12,425**	**100%**	**12,051**	**100%**	**24,475**	**100%**

Source: USDA - US Forest Service

***Figure 10**. Enviva Chesapeake Catchment Area - Distribution of Growing Stock Volume on Timberland by Stand Origin & Major Species (2018)*



2.3 Timber Growth & Removals

2.3.1 *Timber Growth*

According to US Forest Service data, net annual growth of growing stock timber in the Enviva Chesapeake catchment area totaled an estimated 1.261 billion ft^3 in 2018, the latest available. Specifically, 70% (874 million ft^3) of total growth was attributed to softwood species compared to 30% (387 million ft^3) hardwood species.

Annual growth was highest for pine pulpwood, totaling 325 million ft^3 and accounting for 26% of total volume growth, followed by pine sawtimber at 302 million ft^3 (24%), pine chip-n-saw at 247 million ft^3 (20%), hardwood sawtimber at 218 million ft^3 (17%), and hardwood pulpwood at 169 million ft^3 (13%).

***Table 12**. Enviva Chesapeake Catchment Area - Net Growth of Growing Stock Timber by Major Timber Product (2018)*

Product	Volume Growth (Million ft^3)	% of Total Growth
Pine Sawtimber	302	24%
Pine Chip-n-saw	247	20%
Pine Pulpwood	325	26%
Hardwood Sawtimber	218	17%
Hardwood Pulpwood	169	13%
Total	**1,261**	**100%**

Source: USDA - US Forest Service

2.3.2 *Timber Removals*

According to the USFS, timber removals in the catchment area totaled 698 million ft^3 in 2018, of which approximately 73% (507 million ft^3) was softwood timber and 27% (191 million ft^3) was hardwood timber.

Of the five major timber products, removals were highest for pine sawtimber, totaling 233 million ft^3 and accounting for 33% of total removals, followed by pine chip-n-saw at 144 million ft^3 (20%), pine pulpwood at 130 million ft^3 (19%), hardwood sawtimber at 130 million ft^3 (19%), and hardwood pulpwood at 61 million ft^3 (9%).

***Table 13**. Enviva Chesapeake Catchment Area - Timber Removals by Major Timber Product (2018)*

Product	Removals (Million ft^3)	% of Total Removals
Pine Sawtimber	233	33%
Pine Chip-n-saw	144	20%
Pine Pulpwood	130	19%
Hardwood Sawtimber	130	19%
Hardwood Pulpwood	61	9%
Total	**698**	**100%**

Source: USDA - US Forest Service

2.3.3 *Growth-to-Removals Ratios*

Growth-to-removals analysis compares annual timber growth to annual harvests and provides a measure of market demand relative to supply. A growth-to-removals ratio of 1.0 indicates a balanced market where growth equals removals. A value of >1 indicates growth exceeds removals, signifying sustainable harvest levels (as well as oversupply). A value of <1 indicates removals (or harvest levels) exceed growth, signifying more highly competitive market conditions and harvest levels that are unsustainable over the long term.

According to US Forest Service data from 2018, the latest available, overall inventory growth totaled 1,261 million ft^3, compared to total removals of 698 million ft^3, or a growth-to-removals ratio of 1.81. The growth-to-removal ratio for softwood species was 1.71 compared to 2.03 for hardwood species.

Growth-to-removals ratios by species and individual timber product are as follows: pine sawtimber=1.30, pine chip-n-saw=1.72, pine pulpwood=2.49, hardwood sawtimber=1.68, and hardwood pulpwood=2.76. Note that growth-to-removal ratios for all five major timber products are well above 1.0, indicating sustainable market conditions as well as oversupply.

***Table 14**. Enviva Chesapeake Catchment Area - Annual Growth, Removals, & Growth-to-Removal Ratios by Major Timber Product (2018)*

Softwood (Pine)	Growth (million ft^3)	Removals (million ft^3)	G:R Ratio
Pine Sawtimber	302	233	1.30
Pine Chip-n-saw	247	144	1.72
Pine Pulpwood	325	130	2.49
Softwood (Pine) Total	**874**	**507**	**1.71**

Hardwood	Growth (million ft^3)	Removals (million ft^3)	G:R Ratio
Hardwood Sawtimber	218	130	1.68
Hardwood Pulpwood	169	61	2.76
Hardwood Total	**387**	**191**	**2.03**

Product	Growth (million ft^3)	Removals (million ft^3)	G:R Ratio
Sawtimber	767	506	1.51
Pulpwood	494	191	2.58
Total	**1,261**	**698**	**1.81**

Source: USDA - US Forest Service

3. Wood Demand & Raw Material Cost Assessment

3.1 Mill Capacity & Wood Demand

According to TimberMart-South's mill database, as of the end 2019, there were 146 wood-consuming mills operating in and around the Enviva Chesapeake catchment area (within 175 miles of Enviva Pellets Ahoskie, Northampton, or Southampton). This includes 106 lumber mills (54 softwood mills and 52 hardwood mills), 12 pulp/paper mills, 13 panel (plywood/OSB) mills, 8 chip mills, and 7 pellet mills (including the three Enviva mills).

Total production capacity associated with these 146 mills translates to nearly 51 million tons of roundwood per year. However, not all wood consumed by these mills are procured from within the Enviva Chesapeake catchment area. Based on the relative location of these mills to Enviva's three mills and the catchment area, we estimate the total allocated capacity of these mills to the Enviva Chesapeake catchment area at approximately 27,101,861 tons.

***Table 15**. Number of Mills, Total Mill Capacity, & Catchment Area Allocated Mill Capacity (2019)*

Mill Type	No. Mills	Total Capacity (Tons*)	Catchment Area Allocation (Tons*)
Lumber	106	17,788,480	10,909,204
Pulp / Paper	12	23,448,230	10,011,163
Plywood / OSB	13	4,161,694	1,986,100
Chip	8	2,257,500	1,133,475
Pellet	7	3,296,000	3,061,920
Total	**146**	**50,951,904**	**27,101,861**

*Roundwood equivalent volume

Source: TimberMart-South; Hood Consulting

***Table 16**. Enviva Chesapeake Catchment Area - Mill List (2019)*

Mill Name / Company	City	County	State	Capacity	Units	Demand
		Softwood Sawmill				
Barnes Manufacturing Co	Kenbridge	Lunenburg	VA	12	MM Bf	76,440
Dimension Milling Co	Denton	Davidson	NC	12	MM Bf	94,440
Gregory Lumber Co.	Java	Pittsylvania	VA	12	MM Bf	94,440
King Lumber Co	Seagrove	Randolph	NC	12	MM Bf	94,440
Pembleton Forest Products	Blackstone	Nottoway	VA	12	MM Bf	76,440
Pruitt Lumber Co	Louisburg	Franklin	NC	12	MM Bf	94,440
Amelia Lumber Co	Amelia	Amelia	VA	14	MM Bf	110,180
Isle of Wight Forest Products	Wakefield	Sussex	VA	14	MM Bf	110,180
Edward Wood Products	Liberty	Randolph	NC	16	MM Bf	125,920
Shenandoah Wood Preservers	Scotland Neck	Halifax	NC	17	MM Bf	133,790
Tidewater Lumber Corp	Tappahannock	Essex	VA	17	MM Bf	133,790
Carolina Wood Enterprises	Siler City	Chatham	NC	19	MM Bf	149,530
Clary Lumber Co	Gaston	Northampton	NC	20	MM Bf	157,400
Potomac Supply, LLC	Kinsale	Westmoreland	VA	20	MM Bf	157,400
Toney Lumber Co	Louisburg	Franklin	NC	20	MM Bf	157,400
Ball Lumber Co	Millers Tavern	Essex	VA	23	MM Bf	137,540
J.W. Jones Lumber Co	Elizabeth City	Pasquotank	NC	25	MM Bf	196,750
Morgan Lumber Co	Red Oak	Charlotte	VA	26	MM Bf	204,620
Bill Hanks Lumber Co	Danbury	Stokes	NC	30	MM Bf	236,100
Ashton Lewis Lumber Co	Gatesville	Gates	NC	32	MM Bf	251,840
Jerry G. Williams & Sons	Smithfield	Johnston	NC	36	MM Bf	229,320
R.A. Yancey Lumber Corp	Crozet	Albemarle	VA	39	MM Bf	306,930
Flippo Lumber Corp	Doswell	Hanover	VA	40	MM Bf	314,800
Chips Inc	Troy	Fluvanna	VA	43	MM Bf	338,410
Pine Prod Inc	Martinsville	Henry	VA	50	MM Bf	230,500
Lampe & Malphrus Lumber	Smithfield	Johnston	NC	55	MM Bf	253,550
Franklin Lumber, LLC	Franklin	Southampton	VA	60	MM Bf	276,600
Potomac Supply, LLC	Kinsale	Westmoreland	VA	75	MM Bf	345,750
Georgia-Pacific	Ahoskie	Hertford	NC	78	MM Bf	359,580
Georgia-Pacific	Dudley	Wayne	NC	84	MM Bf	387,240
Canfor	Graham	Alamance	NC	90	MM Bf	414,900
ArborTech Forest Products	Blackstone	Nottoway	VA	98	MM Bf	451,780
Troy Lumber Co	Troy	Montgomery	NC	99	MM Bf	456,390
Weyerhaeuser	New Bern	Craven	NC	120	MM Bf	517,200
West Fraser	Seaboard	Northampton	NC	140	MM Bf	603,400
West Fraser	Riegelwood	Columbus	NC	174	MM Bf	749,940
Jordan Lumber & Supply	Mount Gilead	Montgomery	NC	185	MM Bf	797,350
Weyerhaeuser	Greenville	Pitt	NC	260	MM Bf	1,120,600
Weyerhaeuser	Plymouth	Washington	NC	260	MM Bf	1,120,600
Klausner Group	Enfield	Halifax	NC	350	MM Bf	1,508,500
		Hardwood Sawmill				
American Hardwood Industries	Amissville	Culpeper	VA	10	MM Bf	71,700
Josey Lumber Co. Inc	Scotland Neck	Halifax	NC	10	MM Bf	71,700
Pallet One	Chase City	Mecklenburg	VA	10	MM Bf	71,700
American Hardwood Industries	North Garden	Albemarle	VA	12	MM Bf	86,040
Ontario Hardwood Co. Inc	Keysville	Charlotte	VA	12	MM Bf	86,040
Turn Bull Lumber Co.	Elizabethtown	Bladen	NC	12	MM Bf	86,040
American Hardwood Industries	Staunton	Augusta	VA	14	MM Bf	100,380
American Hardwood Industries	West Point	King William	VA	14	MM Bf	110,180
Griffith Lumber Co	Woolwine	Patrick	VA	15	MM Bf	101,700
Meherrin River Forest Products	Weldon	Halifax	NC	19	MM Bf	136,230
Carolina Lumber Co.	Siler City	Chatham	NC	20	MM Bf	143,400
Mackeys Ferry Sawmill Inc	Roper	Washington	NC	20	MM Bf	143,400
Tram Lumber Co.	Asheboro	Randolph	NC	20	MM Bf	143,400
Virginia-Carolina Forest Products	Lawrenceville	Brunswick	VA	22	MM Bf	149,160
Corbett Packaging Inc.	Wilmington	New Hanover	NC	30	MM Bf	215,100
Edwards Wood Products	Liberty	Alamance	NC	75	MM Bf	537,750

Mill Name / Company	City	County	State	Capacity	Units	Demand
		Plywood/Panel Mill				
Blue Ridge Fiberboard	Danville	Pittsylvania	VA	-	MM SqFt	-
Columbia Forest Products	Chatham	Pittsylvania	VA	-	MM SqFt	-
Southern Veneer Co.	Thomasville	Davidson	NC	-	MM SqFt	-
Franklin Veneer	Franklinton	Franklin	NC	6	MM SqFt	12,188
International Veneer Co.	South Hill	Mecklenburg	VA	25	MM SqFt	48,750
West Point Veneer	West Point	King William	VA	25	MM SqFt	48,750
Boise Cascade	Moncure	Chatham	NC	59	MM SqFt	114,563
Georgia-Pacific	Emporia	Greensville	VA	150	MM SqFt	292,500
Arauco	Moncure	Chatham	NC	373	MM SqFt	-
Georgia-Pacific	Dudley	Wayne	NC	437	MM SqFt	851,906
Georgia-Pacific	Gladys	Campbell	VA	478	MM SqFt	873,825
Louisiana-Pacific	Roxboro	Person	NC	500	MM SqFt	915,000
Huber	Crystal Hill	Halifax	VA	549	MM SqFt	1,004,213
		Pulp/Paper Mill				
Greif	Riverville	Amherst	VA	333	M tons	1,195,470
Georgia-Pacific	Big Island	Bedford	VA	590	M tons	-
WestRock	West Point	King William	VA	891	M tons	3,198,690
WestRock	Covington	Alleghany	VA	942	M tons	3,381,780
International Paper	Franklin	Southampton	VA	300	M tons	1,077,000
International Paper	New Bern	Craven	NC	320	M tons	1,148,800
Cascades Inc.	Doswell	Hanover	VA	320	M tons	1,148,800
Domtar	Plymouth	Washington	NC	380	M tons	1,593,960
Kapstone Kraft	Roanoke Rapids	Halifax	NC	460	M tons	483,000
WestRock	Hopewell	Prince George	VA	527	M tons	1,891,930
WestRock	West Point	King William	VA	920	M tons	3,302,800
International Paper	Riegelwood	Columbus	NC	1,400	M tons	5,026,000
		Chip Mill				
Georgia-Pacific	Brookneal	Campbell	VA	-	M tons	-
Cotton Creek Chip Co.	Star	Moore	NC	-	M tons	-
J.W. Jones Chip Mill	Elizabeth City	Pasquotank	NC	-	M tons	-
International Paper	Snow Hill	Greene	NC	200	M tons	210,000
International Paper	Norlina	Warren	NC	200	M tons	210,000
Rentech, Inc.	Gold Hill	Buckingham	VA	250	M tons	262,500
Rentech, Inc.	Cascade	Pittsylvania	VA	300	M tons	315,000
WestRock	West Point	King William	VA	1,200	M tons	1,260,000
		Pellet Mill				
O'Malley Timber Products	Tappahannock	Essex	VA	35	M tons	-
Big Heat Wood Pellets	Chester	Chesterfield	VA	80	M tons	-
Lignetics	Kenbridge	Lunenburg	VA	90	M tons	-
Trea Fuels	Bumpass	Louisa	VA	200	M tons	400,000
Enviva - Ahoskie	Ahoskie	Hertford	NC	386	M tons	772,000
Enviva - Northampton	Garysburg	Northampton	NC	500	M tons	1,000,000
Enviva - Southampton	Franklin	Southampton	VA	562	M tons	1,124,000

Note: Table includes all major mills located within or that procure wood from within the Enviva Chesapeake catchment area. Also, only sawmills with annual production capacity of 10 million board feet or greater were included in this list.

***Figure 11**. Enviva Chesapeake Catchment Area - Mill Map (2019)*

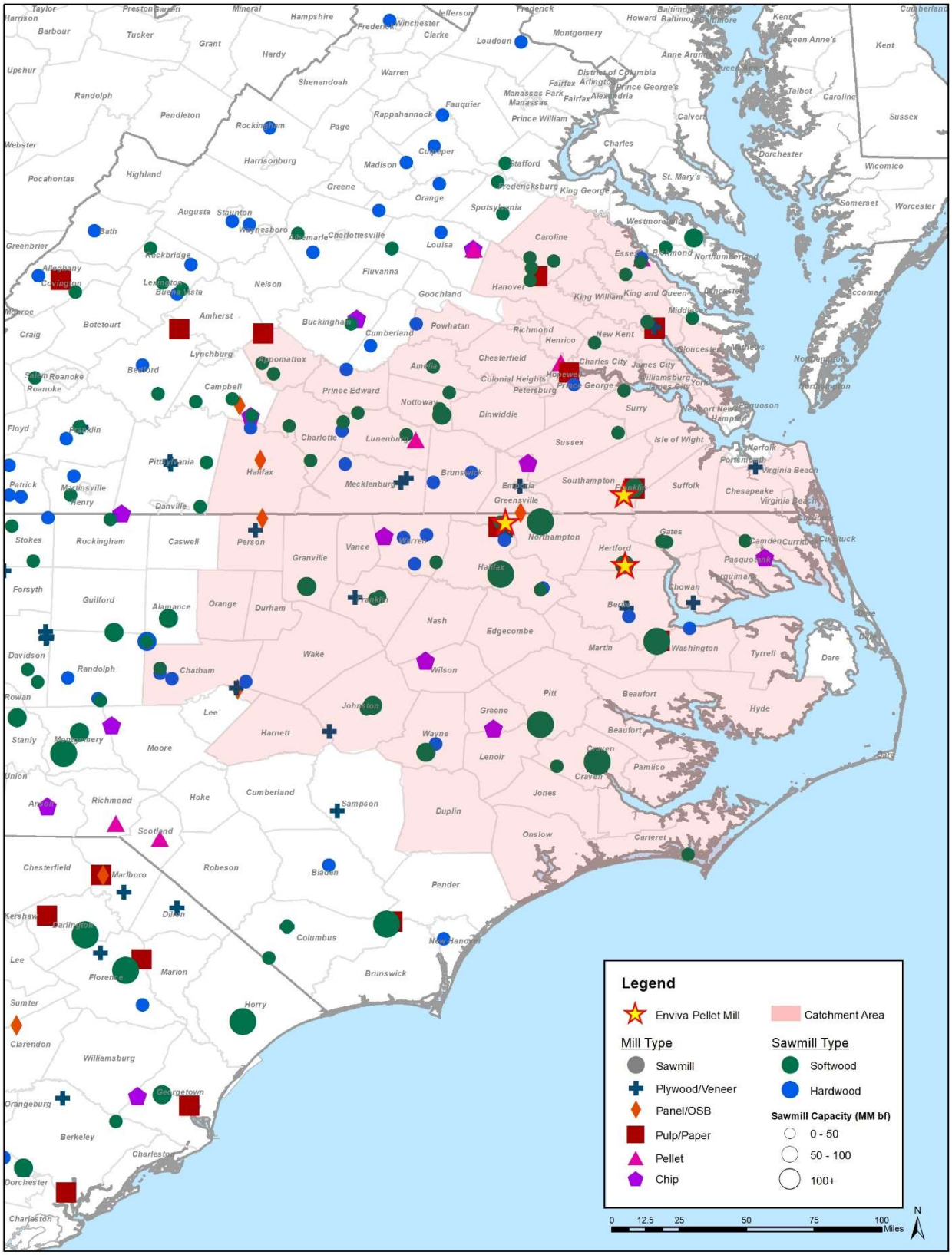


***Figure 12**. Enviva Chesapeake Catchment Area - Lumber, Plywood, & Veneer Mills (2019)*

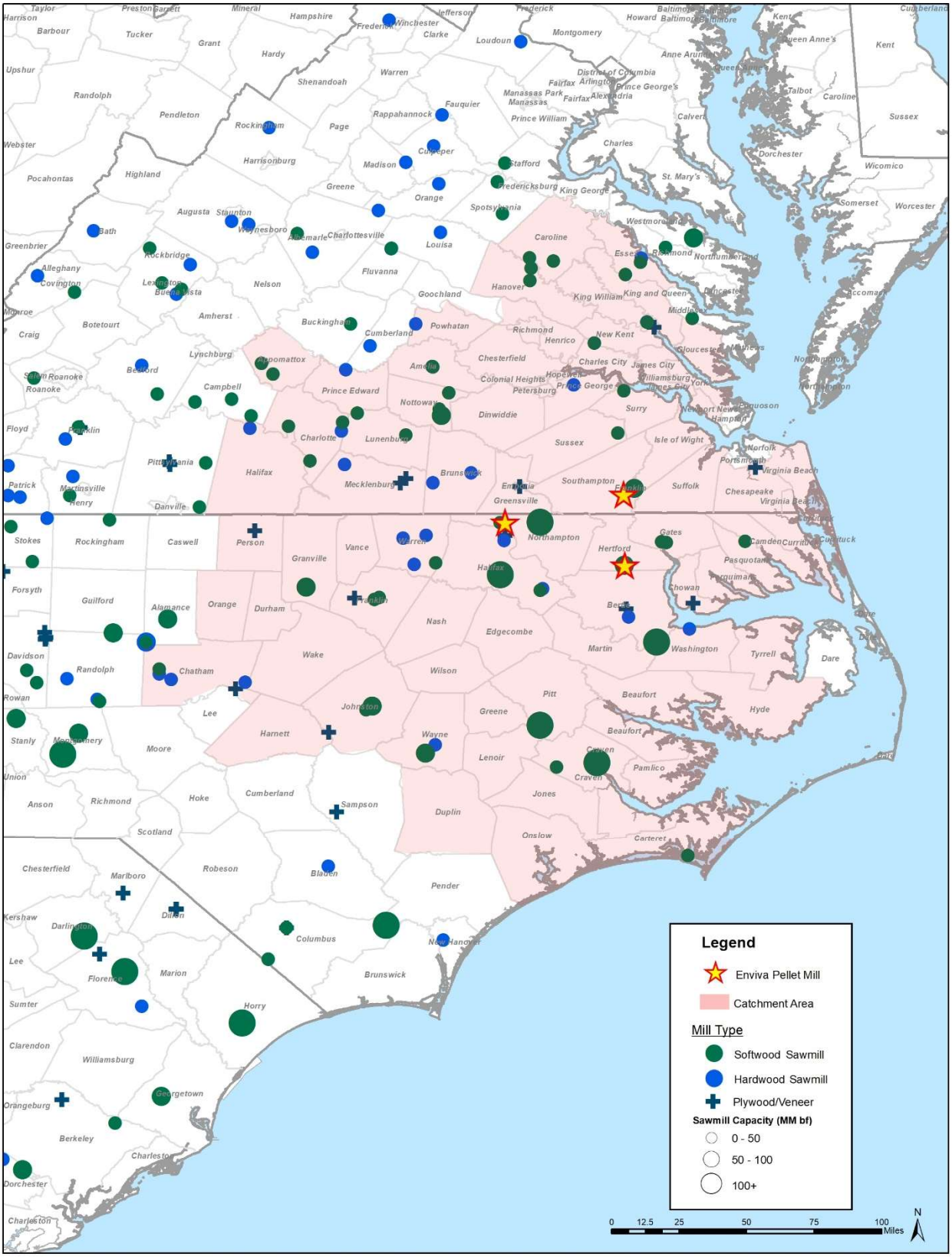
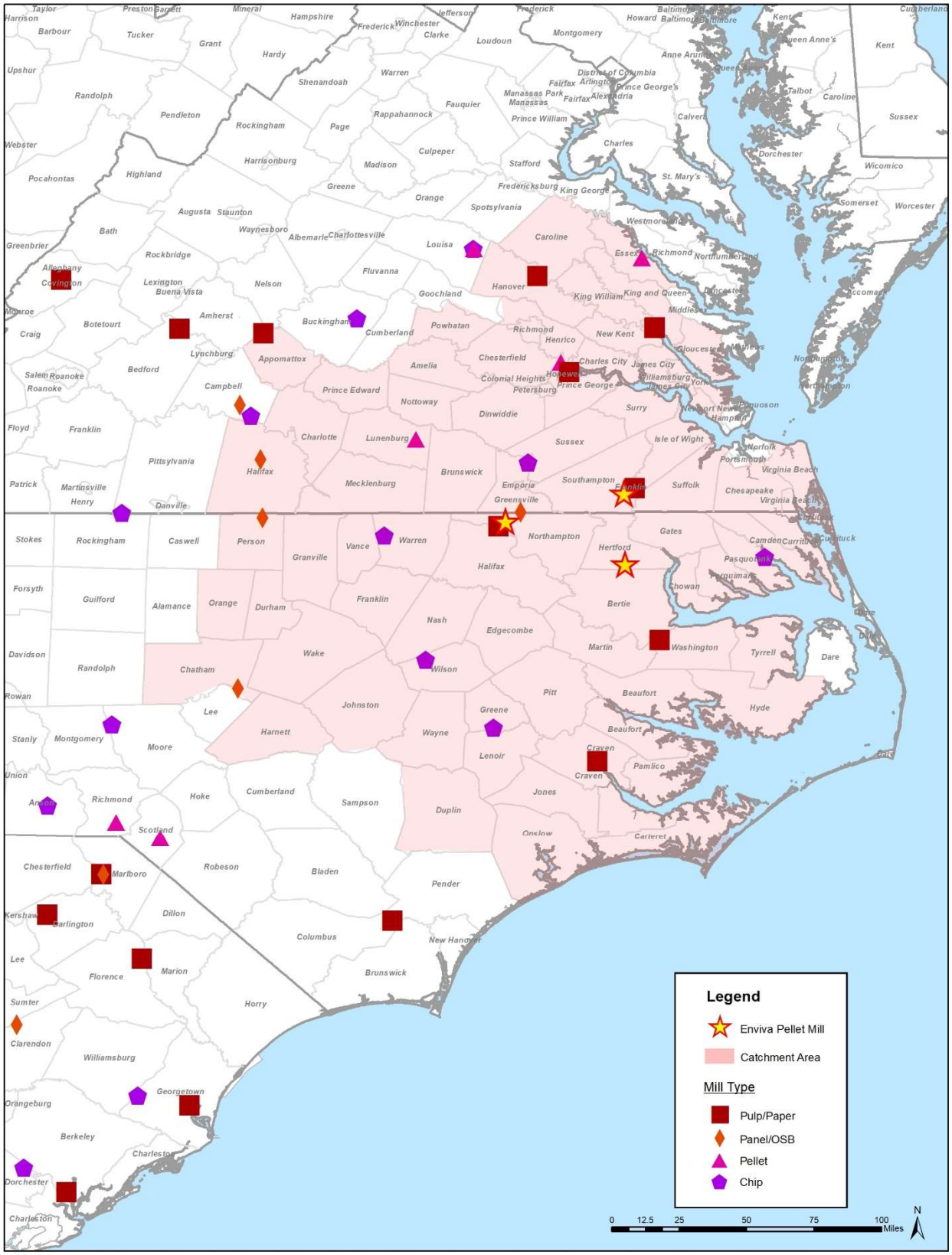


***Figure 13**. Enviva Chesapeake Catchment Area - Pulp/Paper, Pellet, Chip, & Panel Mills (2019)*



3.1.1 *Catchment Area Wood Demand*

Note that total capacity is not the same as actual demand, but rather the maximum potential demand associated with mills running at full production capacity. While total capacity is estimated at approximately 27.1 million tons, actual wood demand[2] in the Enviva Chesapeake catchment area in 2018, the latest available, was estimated at 26.0 million tons.

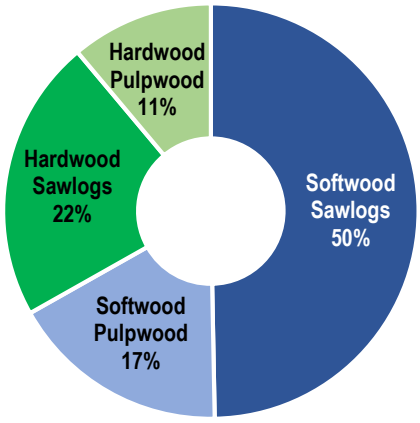
Distribution of total wood demand by major species in 2018 included 67% (17.4 million tons) softwood and 33% (8.6 million tons) hardwood. Specifically, 74% of total softwood demand was attributed to softwood sawlogs, compared to 26% softwood pulpwood. Of total hardwood demand, an estimated 67% was attributed to hardwood sawlogs versus 33% hardwood pulpwood.

***Table 17**. Enviva Chesapeake Catchment Area - Wood Demand (2018)*

Major Species / Product	Demand (Tons)	% of Total
Softwood:		
Sawlogs	12,919,107	50%
Pulpwood	4,508,636	17%
Softwood Total	*17,427,743*	*67%*
Hardwood:		
Sawlogs	5,833,628	22%
Pulpwood	2,758,924	11%
Hardwood Total	*8,592,552*	*33%*
Total	**26,020,296**	**100%**

Source: USDA US Forest Service-TPO; TimberMart-South

***Figure 14**. Enviva Chesapeake Catchment Area - Distribution of Wood Demand by Major Species & Product (2018)*



[2] Wood demand estimates for the Enviva Chesapeake catchment area are based on USDA Forest Service data as well as TimberMart-South wood demand data.

3.1.1.1 *Biomass Demand*

Biomass demand, defined in this analysis as softwood and hardwood pulpwood (roundwood) consumed by pellet or other bioenergy facilities, totaled an estimated 2.6 million tons in 2018, the latest available, accounting for approximately 36% of total pulpwood demand. Non-bioenergy related pulpwood demand, predominately for pulp/paper production, accounted for approximately 64% of total pulpwood demand in the catchment area.

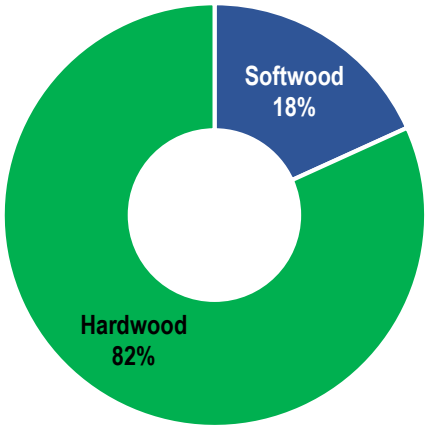
Note that not all wood consumed by a pellet mill or other bioenergy facility is encompassed in biomass demand. Wood consumption (demand) at pellet and other bioenergy facilities generally includes a combination of wood chips and sawmill residuals. However, sawmill residuals are a by-product of the sawmilling process – from the processing of sawlogs, not pulpwood. As such, sawmill residuals consumed by biomass facilities are not included in our calculation of biomass demand.

***Table 18**. Enviva Chesapeake Catchment Area - Biomass & Total Pulpwood Demand (2018)*

Product	Demand (Tons)	% of Total
Softwood Pulpwood:		
Biomass	475,332	7%
Other Pulpwood	4,033,304	55%
Softwood Pulpwood Total	*4,508,636*	*62%*
Hardwood Pulpwood:		
Biomass	2,131,743	29%
Other Pulpwood	627,181	9%
Hardwood Pulpwood Total	*2,758,924*	*38%*
Total Pulpwood	**7,267,561**	**100%**

Source: USDA US Forest Service–TPO; TimberMart-South; Enviva

***Figure 15**. Enviva Chesapeake Catchment Area - Distribution of Biomass Demand by Major Species (2018)*



3.2 Raw Material Costs

Current and historic prices for both stumpage and delivered timber as well as pulp quality chips have been provided by TimberMart-South (TMS). Note that these prices are specific to the Enviva Chesapeake catchment area and are average market prices calculated from actual timber sales reported to TMS.

3.2.1 *Stumpage (Standing Timber) Prices*

Stumpage price is the value of timber as it stands uncut on the stump and is what landowners are paid by loggers and other wood buyers for their standing timber.

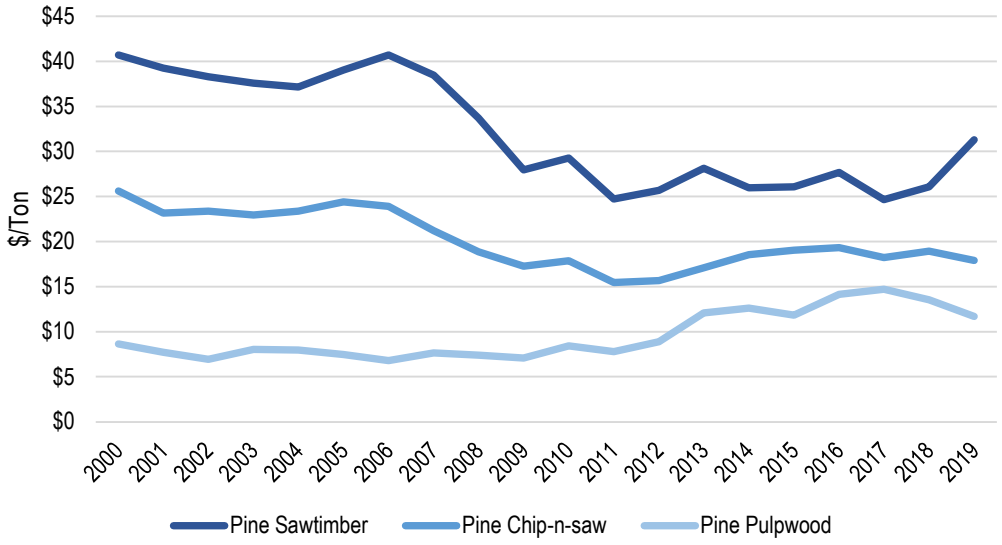
Table 19 below provides annual average stumpage prices in the Enviva Chesapeake catchment area for each of the five major timber products since 2000. For a detailed assessment of these prices and historic trends, see the *Market Trends, Analysis, & Outlook* section beginning on page 51.

***Table 19**. Enviva Chesapeake Catchment Area – Annual Stumpage Prices ($/Ton)*

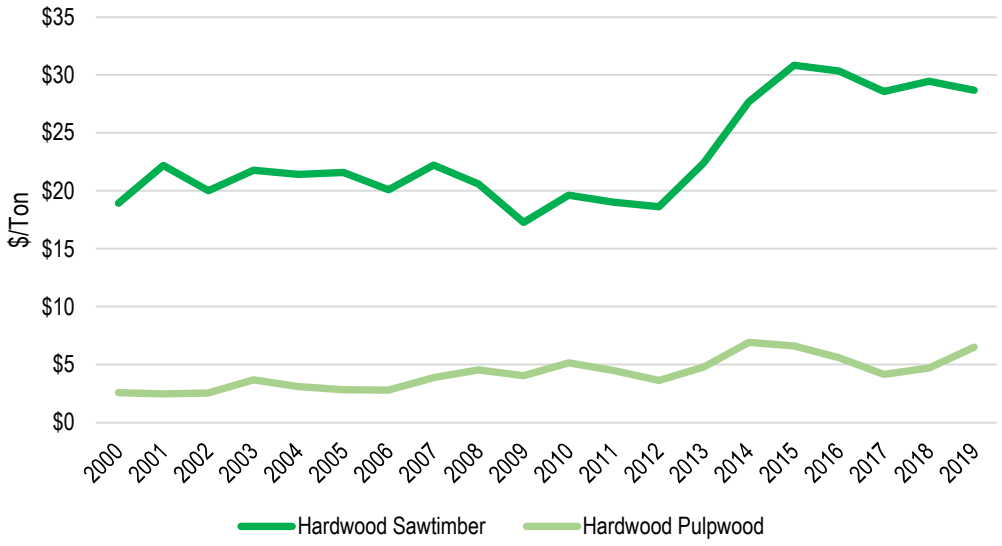
Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood
			($/Ton)		
2000	$40.73	$25.61	$8.64	$18.95	$2.59
2001	$39.23	$23.15	$7.72	$22.20	$2.48
2002	$38.29	$23.39	$6.93	$20.01	$2.56
2003	$37.58	$22.95	$8.04	$21.76	$3.67
2004	$37.16	$23.38	$7.97	$21.41	$3.10
2005	$39.05	$24.39	$7.47	$21.58	$2.83
2006	$40.70	$23.91	$6.82	$20.09	$2.82
2007	$38.47	$21.21	$7.65	$22.21	$3.89
2008	$33.71	$18.86	$7.40	$20.59	$4.55
2009	$27.97	$17.28	$7.08	$17.30	$4.06
2010	$29.26	$17.87	$8.44	$19.63	$5.15
2011	$24.74	$15.47	$7.78	$19.02	$4.49
2012	$25.69	$15.67	$8.88	$18.62	$3.62
2013	$28.12	$17.08	$12.08	$22.41	$4.80
2014	$25.97	$18.56	$12.61	$27.70	$6.94
2015	$26.07	$19.05	$11.82	$30.84	$6.62
2016	$27.66	$19.32	$14.16	$30.33	$5.60
2017	$24.66	$18.22	$14.71	$28.58	$4.15
2018	$26.07	$18.93	$13.55	$29.45	$4.71
2019	$31.31	$17.92	$11.68	$28.67	$6.51

Source: TimberMart-South

***Figure 16**. Enviva Chesapeake Catchment Area – Annual Stumpage Prices (2000-2019)*



(a) Pine Stumpage Prices



(b) Hardwood Stumpage Prices

3.2.2 *Delivered Timber Prices*

Delivered prices are those paid for timber delivered to the mill. These prices include stumpage (standing timber) price plus any costs associated with cutting, loading, and hauling timber to the mill.

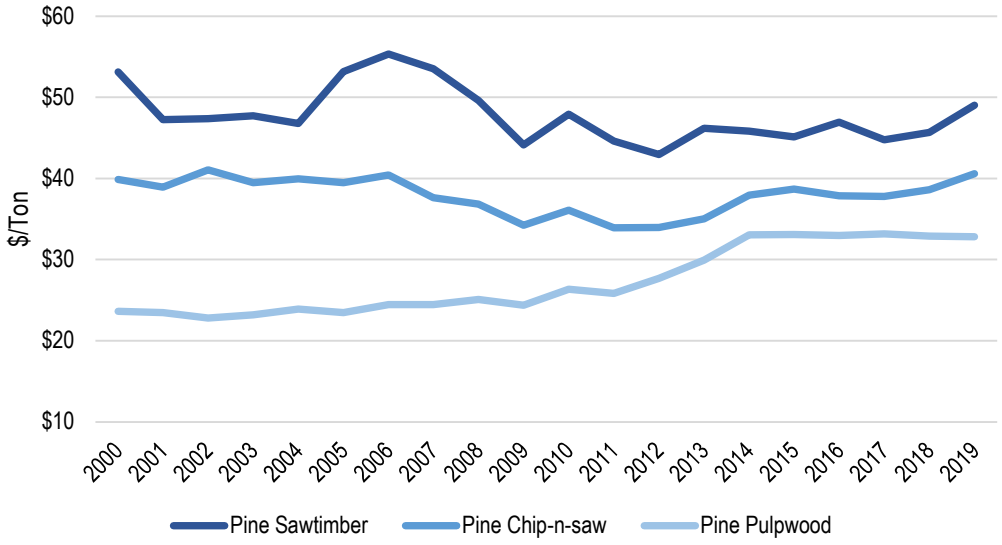
Table 20 below provides annual average delivered timber prices in the Enviva Chesapeake catchment area for each of the five major timber products since 2000. For a detailed assessment of these prices and historic trends, see the *Market Trends, Analysis, & Outlook* section beginning on page 51.

***Table 20**. Enviva Chesapeake Catchment Area – Annual Delivered Timber Prices ($/Ton)*

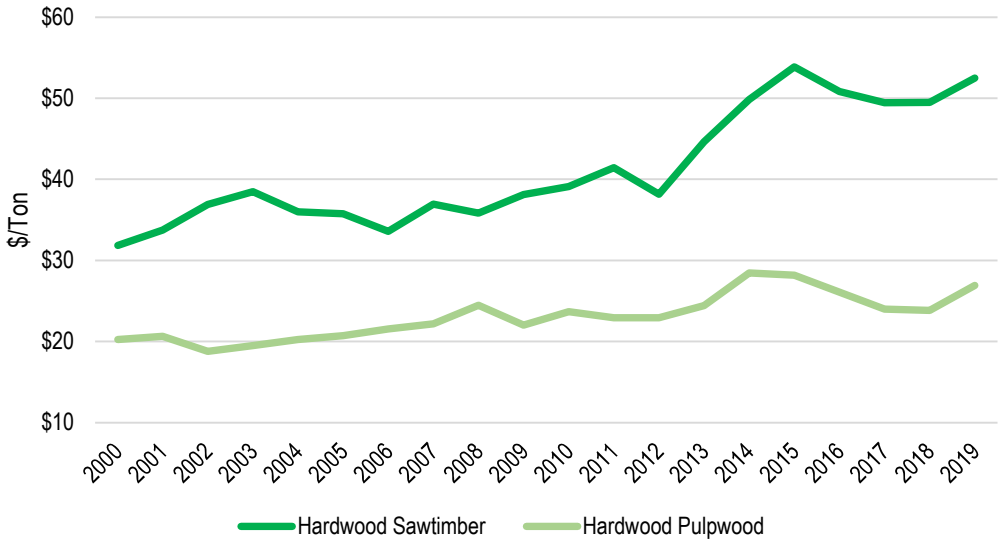
Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood
			($/Ton)		
2000	$53.15	$39.88	$23.62	$31.84	$20.23
2001	$47.25	$38.92	$23.46	$33.74	$20.62
2002	$47.36	$41.10	$22.79	$36.89	$18.81
2003	$47.73	$39.47	$23.17	$38.48	$19.47
2004	$46.79	$39.97	$23.92	$36.00	$20.25
2005	$53.17	$39.47	$23.48	$35.75	$20.73
2006	$55.36	$40.44	$24.44	$33.58	$21.55
2007	$53.53	$37.62	$24.45	$36.95	$22.16
2008	$49.63	$36.83	$25.07	$35.81	$24.47
2009	$44.16	$34.24	$24.36	$38.10	$22.01
2010	$47.91	$36.09	$26.36	$39.12	$23.69
2011	$44.62	$33.94	$25.83	$41.43	$22.93
2012	$42.96	$33.97	$27.69	$38.17	$22.93
2013	$46.19	$35.02	$29.95	$44.64	$24.40
2014	$45.85	$37.96	$33.06	$49.82	$28.47
2015	$45.13	$38.70	$33.07	$53.86	$28.16
2016	$46.95	$37.88	$32.98	$50.81	$26.08
2017	$44.76	$37.79	$33.17	$49.42	$23.99
2018	$45.69	$38.62	$32.90	$49.47	$23.83
2019	$49.02	$40.58	$32.82	$52.48	$26.91

Source: TimberMart-South

***Figure 17**. Enviva Chesapeake Catchment Area – Annual Delivered Timber Prices (2000-2019)*



(a) Delivered Pine Prices



(b) Delivered Hardwood Prices

3.2.3 *Pulp Quality Chip Prices*

Pulpwood quality chips (FOB point of production) include both pine and hardwood sawmill chips (sawmill residuals) and pine and hardwood chip mill chips.

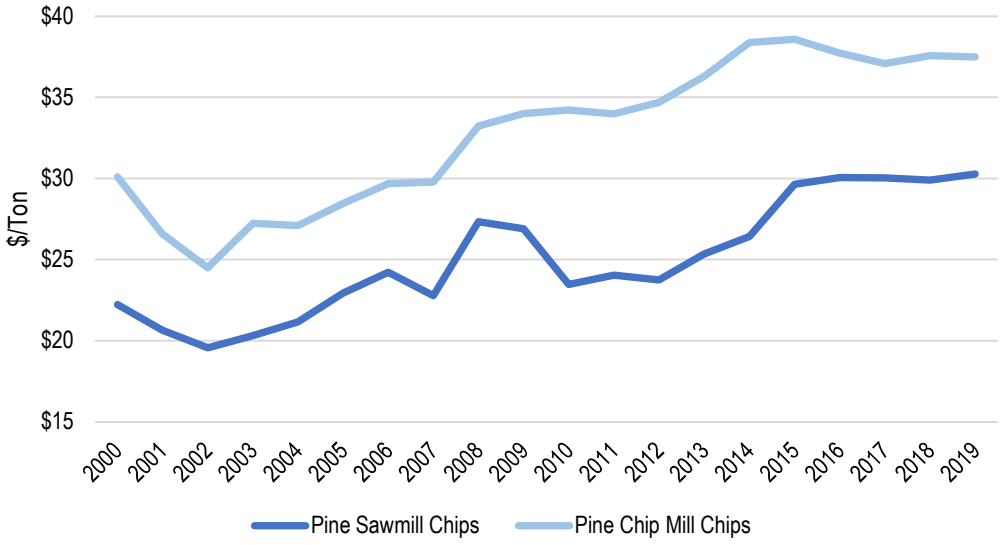
Table 21 below provides annual average pulp quality chip prices in the Enviva Chesapeake catchment area since 2000. For a detailed assessment of these prices and historic trends, see the *Market Trends, Analysis, & Outlook* section beginning on page 51.

***Table 21**. Enviva Chesapeake Catchment Area – Annual Pulp Quality Chip Prices ($/Ton)*

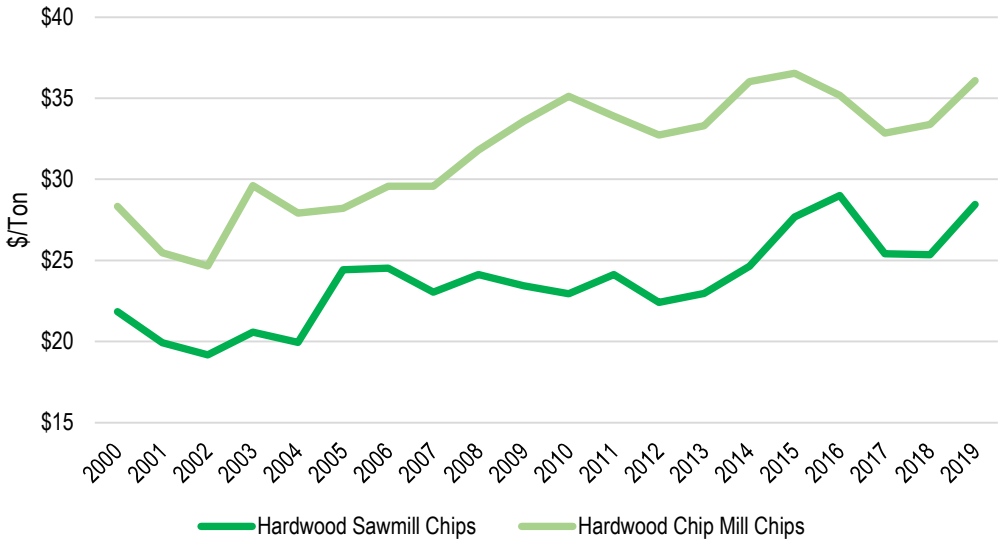
Year	Pine Sawmill Chips	Hardwood Sawmill Chips	Pine Chip Mill Chips	Hardwood Chip Mill Chips
		($/Ton – FOB point of production)		
2000	$22.22	$21.84	$30.09	$28.33
2001	$20.64	$19.92	$26.59	$25.47
2002	$19.58	$19.17	$24.50	$24.67
2003	$20.31	$20.58	$27.24	$29.61
2004	$21.15	$19.94	$27.09	$27.92
2005	$22.94	$24.41	$28.46	$28.20
2006	$24.22	$24.52	$29.69	$29.58
2007	$22.77	$23.04	$29.78	$29.56
2008	$27.33	$24.12	$33.23	$31.79
2009	$26.91	$23.44	$34.00	$33.57
2010	$23.47	$22.94	$34.22	$35.12
2011	$24.04	$24.13	$33.98	$33.88
2012	$23.74	$22.40	$34.69	$32.73
2013	$25.34	$22.96	$36.30	$33.30
2014	$26.43	$24.64	$38.38	$36.02
2015	$29.65	$27.67	$38.59	$36.55
2016	$30.05	$29.01	$37.73	$35.18
2017	$30.03	$25.41	$37.09	$32.85
2018	$29.91	$25.34	$37.57	$33.38
2019	$30.28	$28.44	$37.49	$36.09

Source: TimberMart-South

***Figure 18**. Enviva Chesapeake Catchment Area – Annual Pulp Quality Chip Prices (2000-2019)*



(a) Pine Chip Prices

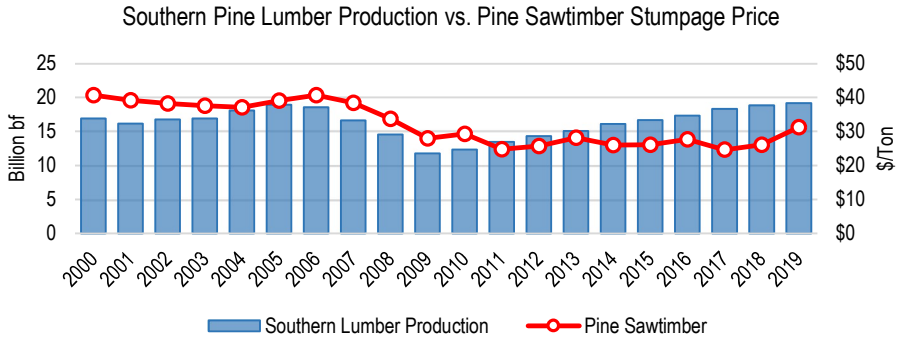


(b) Hardwood Chip Prices

3.2.4 *Timber Price Drivers*

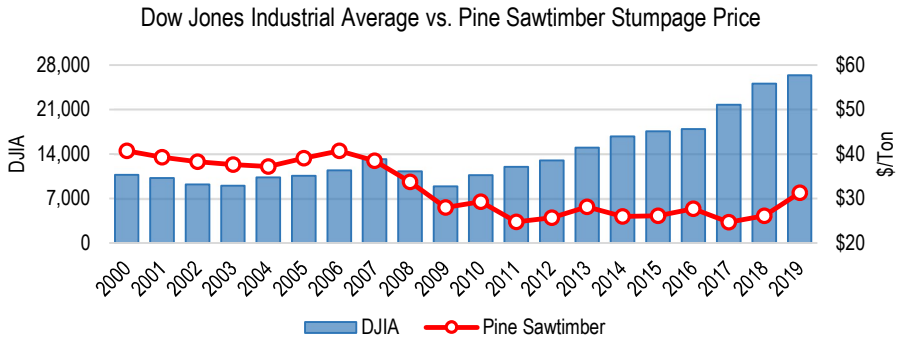
A detailed assessment of raw material prices and price trends is provided in the *Market Trends, Analysis, & Outlook* section beginning on page 51. However, we would like to point out and highlight some of the major price drivers and indicators.

- Production. Production levels for forest products are representative of wood demand and have historically been a strong indicator of timber price. The figure below shows annual Southern pine lumber production and annual average pine sawtimber stumpage prices in the Enviva Chesapeake catchment area from 2000-2019. Looking at this figure, pine sawtimber price closely tracked lumber production through around 2010. However, the relationship has been much weaker since. Specifically, according to the Southern Forest Products Association, southern pine lumber production increased 55% from 2010-2019, whereas pine sawtimber stumpage price increased only 7% over this period. This divergence in production and price is largely due to increases in wood supply, which is documented in detail in subsequent sections of this report.



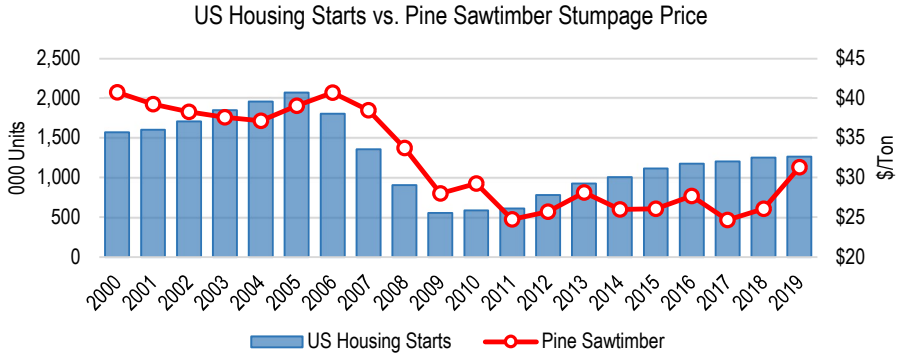
Source: Southern Forest Products Association, TimberMart-South

- Domestic Economy. The state of the domestic economy also drives changes in timber prices both locally and across the Southern region. Financial markets generally reflect economic conditions and have historically been a strong indicator of price. For instance, the figure below shows pine sawtimber stumpage prices in the catchment area closely followed the Dow Jones Industrial Average (DJIA) from 2000-2010. However, persistent wood oversupply since that time has caused these two to diverge and financial markets to weaken as an indicator of sawtimber price.



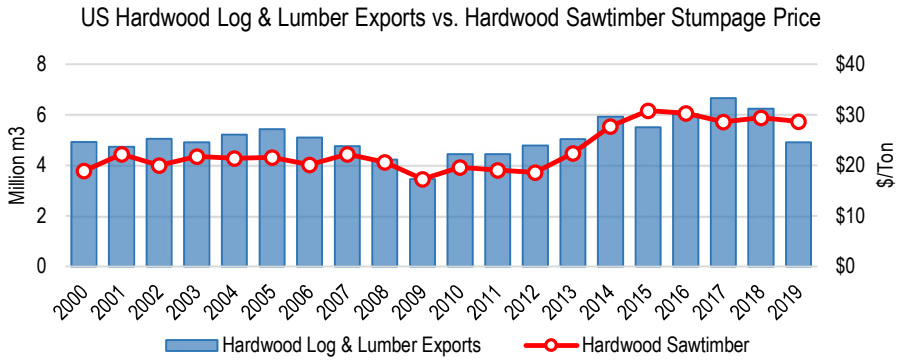
Source: US Federal Reserve Bank, TimberMart-South

- Housing Starts. US residential building construction is a principal driver of the wood products industry, and domestic housing starts have historically been a major indicator of sawtimber price. However, the relationship between these two has been much weaker through the 2010s due in large part to wood oversupply. Specifically, according to the US Census Bureau, US housing starts have increased 61% since 2012, compared to an increase of 22% for pine sawtimber stumpage prices in the Enviva Chesapeake catchment area. See figure below.



Source: US Census Bureau, TimberMart-South

- International Trade. International trade and foreign trade policy also drive changes in timber prices, particularly those of hardwood sawtimber. Specifically, hardwood log and lumber exports, which constitute around 65-75% of total US log and lumber exports, averaged approximately 4.7 million m^3 per year from 2000-2012. However, exports increased 24% from 2012 to 2014 and since have averaged 5.9 million m^3 per year. Hardwood sawtimber stumpage prices in the Enviva Chesapeake catchment area closely tracked exports (see figure below), increasing more than 40% from 2012-2014. However, trade policies enacted by the current US President over the last several years have slowed growth in US exports and, consequently, hardwood sawtimber prices have held relatively flat since.



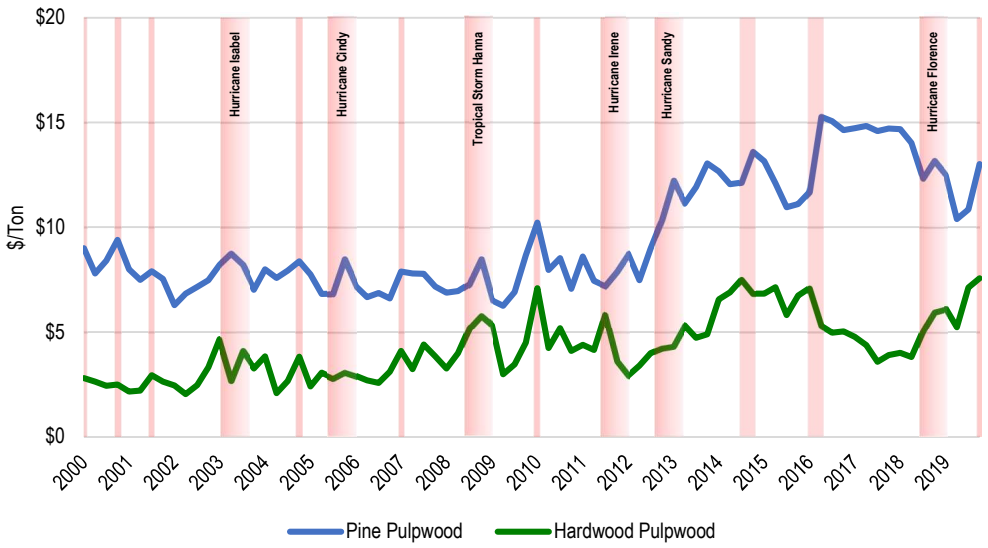
Source: US Department of Agriculture, TimberMart-South

- Weather. Weather trends also impact timber prices; however, these trends are much more seasonal in nature and affect short-term price movements. In this region, wet conditions typically persist throughout the winter (in the 1st and 4th quarters of the year), creating wood accessibility issues and constraining supply. And, as a result, timber prices increase over the short term. However, wet winters are followed by hot summers, which alleviate supply constraints and provide greater access to wood. In turn, with supply no longer an issue, timber prices decline in the short term (typically during the 2nd or 3rd quarter of the year).

  However, the Chesapeake market is also impacted periodically by hurricanes and tropical storms, with hurricane season typically occurring between July and October (3rd and 4th quarters of the year). These storms can bring heavy rainfall that constrain wood supply, driving prices upward in the short term. However, tropical storms with extremely high winds can also cause extensive forest damage, resulting in short-term oversupply from wood salvage and driving prices downward.

  The figure below shows quarterly average pine pulpwood and hardwood pulpwood stumpage prices in the Enviva Chesapeake catchment from 2000 through 2019, identifying seasonal weather-related price spikes as well as major hurricanes and tropical storms that impacted this market. Note that of the 15 seasonal spikes identified below, 14 (93%) occurred in either the 1st or 4th quarter of the year or within two quarters of a major hurricane or tropical storm.

Enviva Chesapeake Catchment Area – Pine Pulpwood & Hardwood Pulpwood Stumpage Prices



Source: TimberMart-South

4. Forest Management Practices Assessment

Historic timber sales reported to TimberMart-South were examined to help assess how forest management practices in the Enviva Chesapeake catchment area and surrounding markets have changed since 2000. Specifically, we examined trends related to total sale volume, acreage, and harvest type to identify how this area responds to various market conditions. Study details and key findings are detailed below and on the following pages.

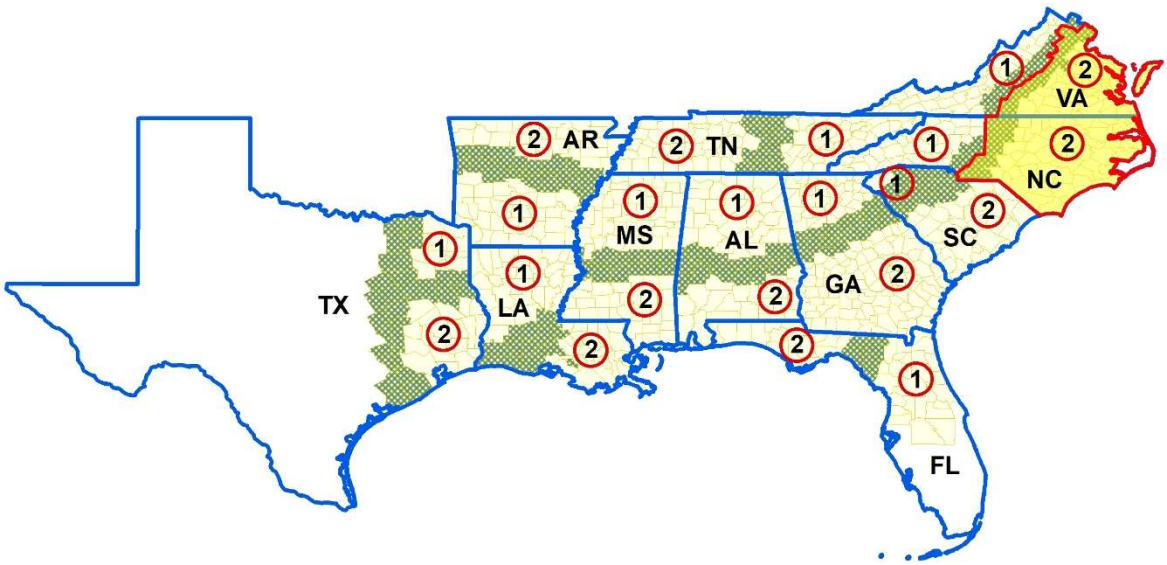
4.1 TimberMart-South Harvest Trends

The TimberMart-South (TMS) sales database includes over 105,000 unique timber sales that have occurred throughout the TMS 11-state region since 2000. In addition to providing details regarding timber prices (by product), these reported sales include information regarding date of sale, location, sale volume, sale size (acres), sale type (final harvest/clearcut vs. thinning), and other unique sale characteristics. The data provided in the following section contains some of these stumpage characteristic details, particularly those related to trends in sale type and harvesting activities.

The Enviva Chesapeake catchment area is located in two different TMS regions: North Carolina Region 2 and Virginia Region 2 (see highlighted portion Figure 19). Data and trends for this 2-region area (denoted 'Chesapeake market' hereafter) have been provided and are intended to be representative of the catchment area.

Note that TMS database sales utilized for this portion of the assessment only includes those reported sales with total sale volumes between 500 and 50,000 tons. Sales that fell outside these parameters were excluded to ensure consistency and to mitigate potential bias from major outliers.

***Figure 19**. TimberMart-South Region Map*



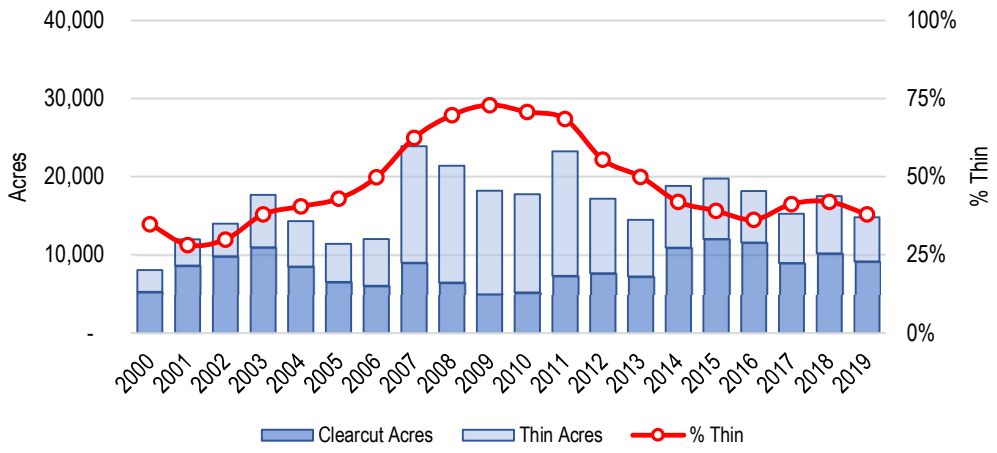
4.1.1 *Total Sale Acreage*

In the Chesapeake market, total reported sale acreage has remained fairly consistent since 2000. However, the data shows a noticeable shift occurred in the distribution of reported sale acreage by harvest type (clearcut vs. thinning) from 2007-2012.

Clearcuts and thinnings are the two major types of harvests that occur in the region, both of which are long-standing, widely used methods of harvesting timber. Specifically, in the Chesapeake market, thinned acres as a percentage of total reported sale acreage remained between roughly 30-45% from 2000-2005 before increasing and peaking at 73% in 2009. This percentage proceeded to decline through the early to mid-2010s, but since 2014 has held relatively steady and average approximately 40%.

This data shows thinnings increased (and clearcuts decreased) when market conditions tighten with the bursting of the US housing bubble in 2006 and Great Recession that followed. Specifically, thinnings increased and accounted for 65% of the total sale acreage from 2006-2012. In contrast, if we consider 2000-2005 and 2013-2019, over these periods, thinnings accounted for less than 40% of total sale acreage.

***Figure 20**. Total Reported Sale Acreage by Harvest Type (2000 - 2019)*



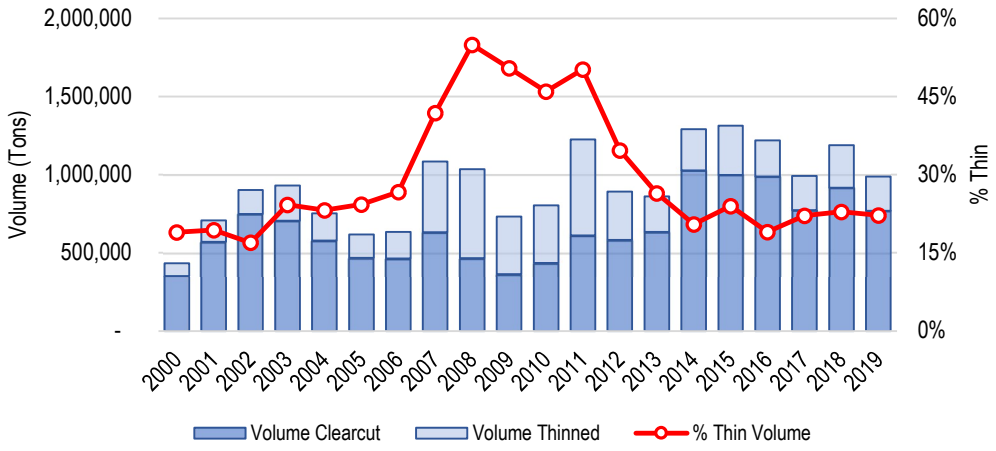
4.1.2 *Total Sale Volume*

In the Chesapeake market, total reported sale volume has fluctuated to a certain extent but overall held relatively steady and averaged approximately 1.05 million tons per year since 2007. Prior to this (2000-2006), total reported sale volume averaged roughly 710,000 tons per year.

However, as with total sale acreage, the distribution of total sale volume by harvest type shows that the proportion of total volume attributed to thinnings increased substantially between 2007 and 2012, with thinnings accounting for 46% of total reported sale volume over this period. In contrast, from 2000-2006 and from 2013-2019, thinnings accounted for an average of 22% of total reported sale volume.

Note that the increase in thinning volume (as a percentage of total sale volume) from 2007-2012 suggests landowners altered their management approach in response to poor market conditions. More specifically, this data suggests that many landowners in this market opted to thin when markets weakened, presumably waiting until timber prices improved before proceeding with the clearcut of mature timber stands. However, the data suggests that as markets conditions settled and stabilized in the early 2010s, many landowners in this market reverted to more standard management practices, deciding to clearcut, not thin, mature timber stands.

***Figure 21**. Total Reported Sale Volume by Harvest Type (2000 - 2019)*



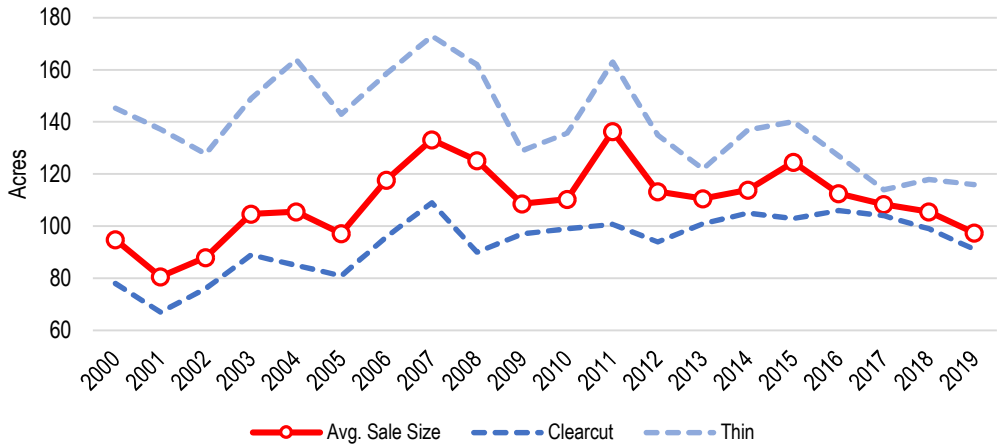
4.1.3 *Average Sale Size*

Average sale size in the Chesapeake market averaged approximately 109 acres in size from 2000-2019. However, reported sale data shows that thinnings have averaged 49% (+46 acres) larger than clearcuts since 2000, with thinnings averaging 140 acres in size compared to 94 acres for clearcuts.

Also, worth noting is that the average size of clearcuts in this market have increased since 2000 while the average size of thinnings have decreased. Specifically, clearcuts averaged 82 acres in size from 2000-2006, increasing to an average of 100 acres from 2012-2019. In contrast, over these same two periods, thinnings decreased from an average of 146 to 126 acres in size. In comparison, thinnings averaged 79% (+65 acres) larger than clearcuts from 2000-2006 but 26% (+26 acres) larger than clearcuts from 2012-2019.

In general, clearcuts tend to be smaller than thinnings in size due to capital requirements (for the logger/wood buyer), as clearcuts typically remove more timber volume per acre and are more costly than thinnings. For example, given the same amount of capital, a wood buyer/logger can purchase a 100-acre tract to be clearcut or a 150-acre tract to be thinned. Also, loggers/wood buyers typically prefer larger tracts for thinning because it allows them to take advantage of economies of scale.

***Figure 22**. Average Reported Sale Size by Harvest Type (2000 - 2019)*



5. Market Trends, Analysis, & Outlook

The following section provides an examination and assessment of market trends in the Enviva Chesapeake catchment area since 2000, including changes in land use, forest area, timber inventory, growth, removals, wood demand, and raw material costs. In addition, a market outlook through 2022 is also provided in this section. This outlook details anticipated changes in wood demand and how these changes are likely to impact this market over the next several years.

5.1 Market Trends & Analysis

A key aspect of this analysis includes assessing and identifying any links or relationships between biomass-related wood demand and other market changes (i.e. forest area, inventory, raw material prices, etc.) in the catchment area, particularly since Enviva commenced pellet production at its Ahoskie mill in late 2011. As such, this section will begin with an assessment of annual wood demand.

5.1.1 *Wood Demand*

Annual wood demand[3] in the Enviva Chesapeake catchment area increased at a steady rate of 1.4% per year from 28.5 million tons in 2000 to 30.5 million tons in 2005. However, demand started to decline in 2006 and by 2011 had fallen to an estimated 22.2 million tons, or a 27% decrease in just a 6-year period. Total annual wood demand held steady through 2012 but proceeded to increase at an average rate of 2.2% per year over the six years that followed, to an estimated 26.0 million tons in 2018.

***Table 22**. Enviva Chesapeake Catchment Area - Annual Wood Demand (Tons): 2000-2018*

Year	Softwood Sawlogs	Softwood Pulpwood	Hardwood Sawlogs	Hardwood Pulpwood	Total Wood Demand
			(Tons)		
2000	13,199,186	3,412,750	9,077,204	2,814,168	28,503,308
2001	13,209,387	3,131,855	9,345,583	2,597,840	28,284,666
2002	13,444,905	3,572,974	9,112,331	2,687,533	28,817,742
2003	13,680,423	4,014,092	8,879,078	2,777,225	29,350,819
2004	13,759,118	3,944,481	9,002,579	3,239,852	29,946,030
2005	13,735,291	3,977,391	9,440,144	3,388,416	30,541,241
2006	13,614,091	3,982,693	9,040,371	3,371,216	30,008,370
2007	12,751,334	3,597,221	8,591,239	3,248,050	28,187,845
2008	12,052,470	3,731,924	7,014,211	3,401,738	26,200,343
2009	11,081,502	3,756,979	5,454,385	3,336,162	23,629,028
2010	11,104,984	3,493,086	5,456,452	2,751,720	22,806,242
2011	10,738,553	3,543,809	5,768,027	2,131,655	22,182,045
2012	11,194,434	4,024,214	5,355,619	2,204,355	22,778,621
2013	11,696,322	4,365,415	4,698,914	2,978,458	23,739,109
2014	11,642,134	4,484,703	5,275,876	3,834,902	25,237,616
2015	11,503,533	4,276,695	5,734,261	3,406,370	24,920,859
2016	11,861,909	4,511,228	5,795,295	2,837,947	25,006,379
2017	12,949,565	4,435,959	5,834,900	2,743,955	25,964,378
2018	12,919,107	4,508,636	5,833,628	2,758,924	26,020,296

Source: USDA US Forest Service-TPO; TimberMart-South

[3] Wood demand estimates for the Enviva Chesapeake catchment area are based on USDA Forest Service FIA & Timber Products Output (TPO) data as well as TimberMart-South wood demand data.

***Figure 23**. Enviva Chesapeake Catchment Area – Total Annual Wood Demand (2000-2018)*

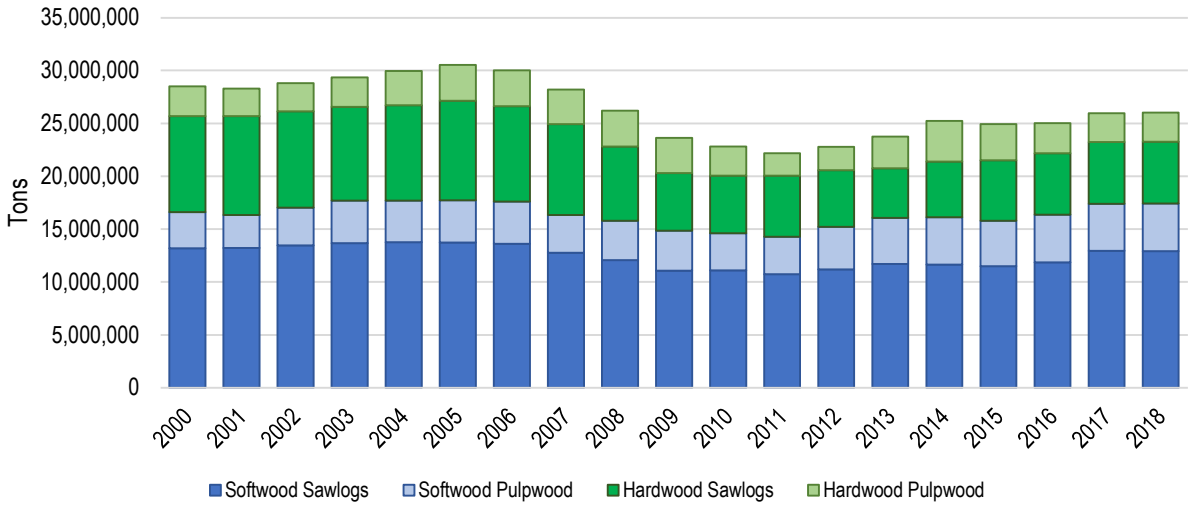
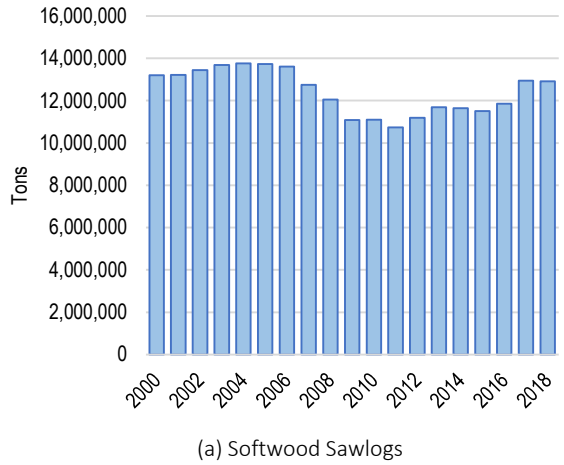
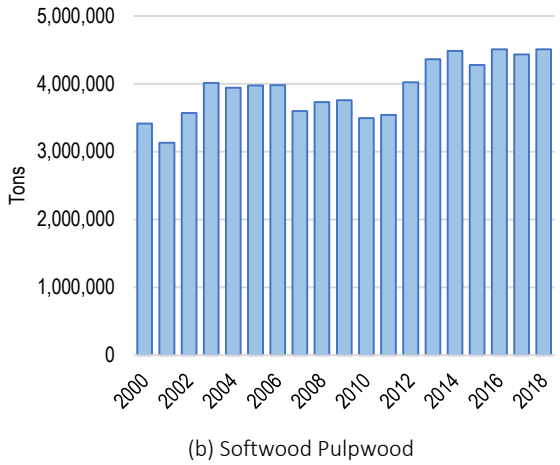


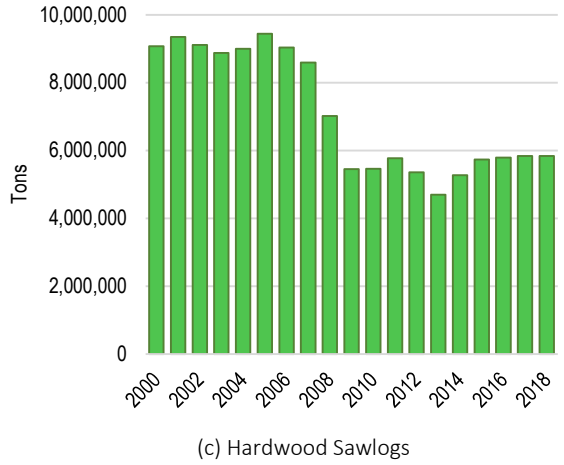
***Figure 24**. Enviva Chesapeake Catchment Area – Annual Wood Demand by Major Species & Product (2000-2018)*



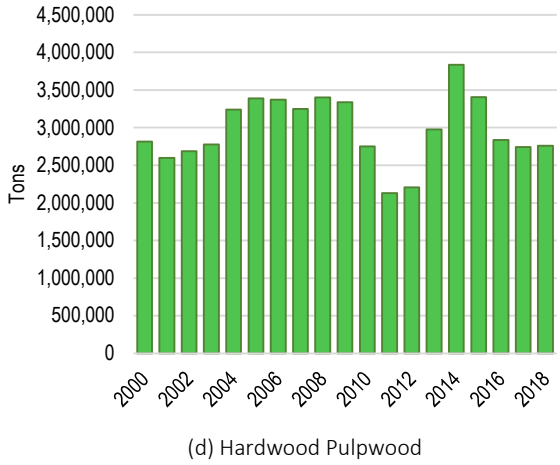
(a) Softwood Sawlogs



(b) Softwood Pulpwood



(c) Hardwood Sawlogs



(d) Hardwood Pulpwood

5.1.1.1 Biomass Demand

Biomass demand is defined as softwood and hardwood pulpwood (roundwood) consumed by pellet or other bioenergy facilities.

Prior to 2008, there was no wood demand attributed to pellet or other bioenergy facilities. However, with the startup of Biomass Energy LLC in Bumpass, Virginia, biomass demand totaled an estimated 16,790 tons in 2008, and steadily increased to approximately 26,520 tons in 2011. Biomass demand increased to an estimated 555,321 tons in 2012 following the startup of Enviva Pellets Ahoskie (in late 2011) and continued to increase over the next several years with the startup of Enviva Pellets Northampton in early 2014 and Enviva Pellets Southampton in late 2015, with bioenergy-related wood demand increasing to over 2.65 million tons in 2016. Biomass demand has decreased slightly since that time, averaging 2.58 million tons per year from 2017 through 2019.

Also note biomass demand's changing contribution towards total pulpwood demand in the catchment area. Specifically, biomass demand as a percentage of total pulpwood demand increased from <1% from 2008-2011, to 9% in 2012, to 28% in 2014, and to an average of 36% from 2016-2019.

***Table 23**. Enviva Chesapeake Catchment Area - Biomass Demand & Total Pulpwood Demand (2000-2018)*

	Biomass Demand			Other Pulpwood Demand			Total Pulpwood Demand		
Year	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total
					(Tons)				
2000	-	-	-	3,412,750	2,814,168	6,226,918	3,412,750	2,814,168	6,226,918
2001	-	-	-	3,131,855	2,597,840	5,729,696	3,131,855	2,597,840	5,729,696
2002	-	-	-	3,572,974	2,687,533	6,260,507	3,572,974	2,687,533	6,260,507
2003	-	-	-	4,014,092	2,777,225	6,791,317	4,014,092	2,777,225	6,791,317
2004	-	-	-	3,944,481	3,239,852	7,184,333	3,944,481	3,239,852	7,184,333
2005	-	-	-	3,977,391	3,388,416	7,365,807	3,977,391	3,388,416	7,365,807
2006	-	-	-	3,982,693	3,371,216	7,353,908	3,982,693	3,371,216	7,353,908
2007	-	-	-	3,597,221	3,248,050	6,845,272	3,597,221	3,248,050	6,845,272
2008	7,642	9,148	16,790	3,724,282	3,392,590	7,116,872	3,731,924	3,401,738	7,133,662
2009	12,331	15,165	27,495	3,744,648	3,320,997	7,065,646	3,756,979	3,336,162	7,093,141
2010	11,925	15,083	27,008	3,481,162	2,736,637	6,217,798	3,493,086	2,751,720	6,244,806
2011	11,518	15,002	26,520	3,532,291	2,116,653	5,648,944	3,543,809	2,131,655	5,675,465
2012	45,835	509,486	555,321	3,978,379	1,694,869	5,673,247	4,024,214	2,204,355	6,228,569
2013	123,107	1,265,036	1,388,143	4,242,308	1,713,423	5,955,730	4,365,415	2,978,458	7,343,873
2014	230,443	2,138,455	2,368,899	4,254,260	1,696,446	5,950,706	4,484,703	3,834,902	8,319,605
2015	279,214	2,285,010	2,564,225	3,997,481	1,121,360	5,118,841	4,276,695	3,406,370	7,683,065
2016	383,230	2,270,820	2,654,050	4,127,998	567,127	4,695,126	4,511,228	2,837,947	7,349,175
2017	427,064	2,196,575	2,623,639	4,008,895	547,380	4,556,274	4,435,959	2,743,955	7,179,914
2018	475,332	2,131,743	2,607,075	4,033,304	627,181	4,660,486	4,508,636	2,758,924	7,267,561
2019	452,101	2,044,118	2,496,219	4,056,706	654,308	4,711,014	4,508,807	2,698,426	7,207,233

Source: USDA-US Forest Service; TimberMart-South; Enviva
**Projected*

Figure 25. Enviva Chesapeake Catchment Area – Softwood Pulpwood Demand (2000-2019)

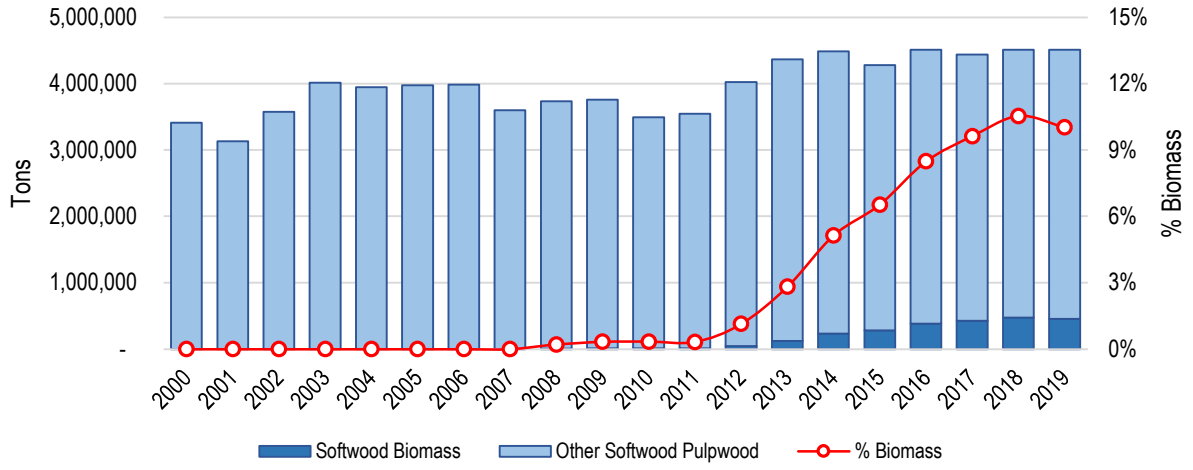


Figure 26. Enviva Chesapeake Catchment Area – Hardwood Pulpwood Demand (2000-2019)

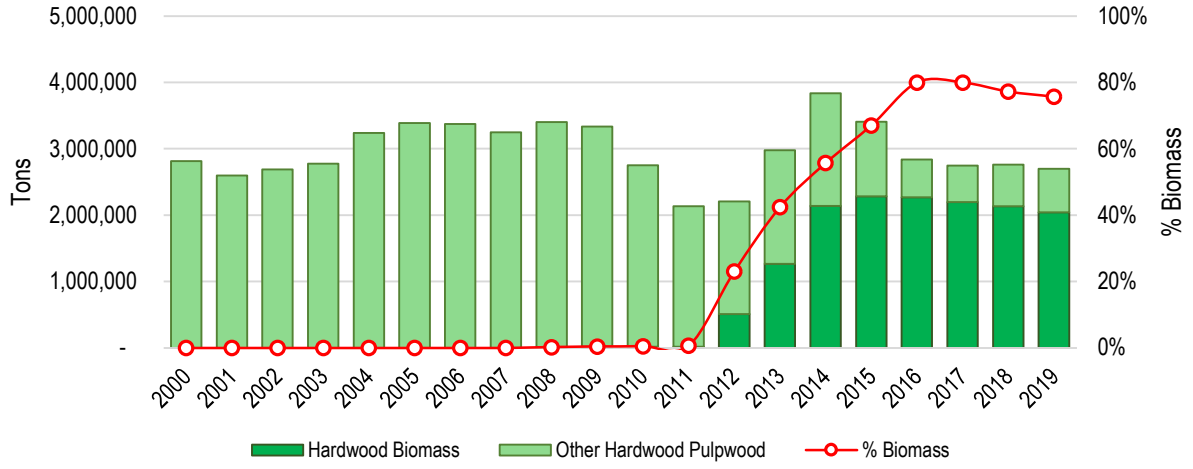
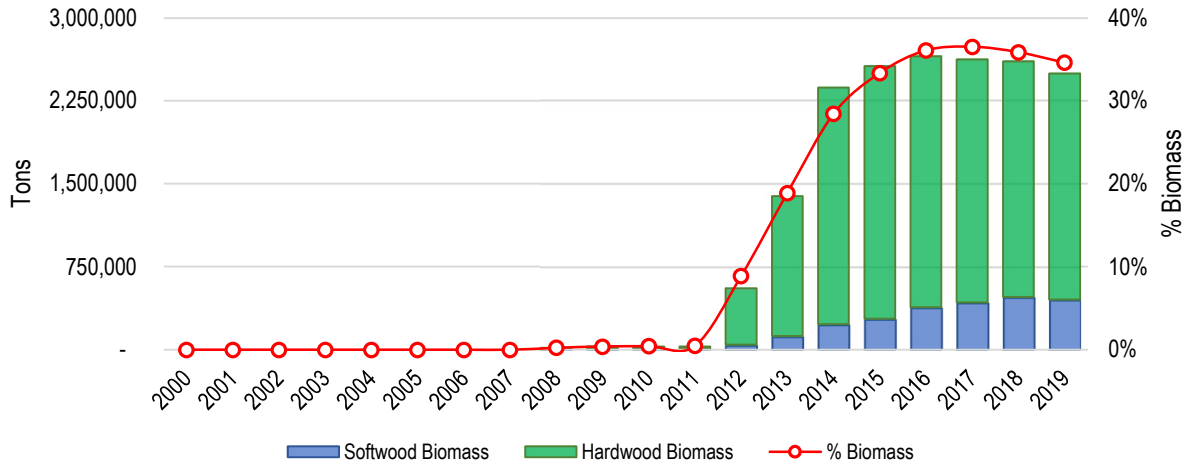


Figure 27. Enviva Chesapeake Catchment Area – Total Biomass Demand (2000-2019)



5.1.2 *Changes in Land Area & Use*

Notable changes in land area have occurred in the catchment area since 2000, including a 0.8% increase in forestland and a 16% decrease in land in farms (i.e. cropland, woodland, and pastureland). Also, urban areas or land classified as having other uses more than doubled from 2000 to 2018.

According to the USDA, total forestland increased from 11,821,711 acres in 2000 to 11,911,722 acres in 2018, or a net increase of 90,011 acres (+0.8%) over this 18-year period. Over this same period, land in farms decreased a total of 1,094,229 acres, with cropland decreasing 298,762 acres (-7%), woodland decreasing 449,127 acres (-24%), and pastureland decreasing 346,339 acres (-37%).

Urban areas and land classified as having other uses increased an estimated 1,004,218 acres from 851,267 acres in 2000 to 1,855,485 acres in 2018. However, note that urban and other lands have held steady at an average of 1,880,120 acres since 2009. See Table 24 for details.

***Table 24**. Enviva Chesapeake Catchment Area – Land Area by Land Classification & Use (2000-2018)*

	Forestland			*Land in Farms*				Urban & Other Land Uses	Total Land Area
Year	Timberland	Other Forestland	Total	Cropland	Woodland	Pastureland	Total		
					(Acres)				
2000	11,546,872	274,839	11,821,711	4,150,142	1,903,764	924,969	6,978,875	851,267	19,651,853
2001	11,552,686	272,817	11,825,503	4,128,042	1,872,445	918,461	6,918,947	907,403	19,651,853
2002	11,566,817	259,109	11,825,926	4,109,438	1,846,026	913,748	6,869,212	956,715	19,651,853
2003	11,573,243	285,195	11,858,438	4,026,994	1,792,799	886,161	6,705,954	1,087,461	19,651,853
2004	11,557,112	298,544	11,855,656	3,949,163	1,744,356	864,630	6,558,149	1,238,048	19,651,853
2005	11,533,414	300,614	11,834,028	3,875,707	1,700,391	847,281	6,423,380	1,394,445	19,651,853
2006	11,478,667	304,182	11,782,849	3,806,406	1,660,644	833,257	6,300,308	1,568,696	19,651,853
2007	11,441,681	323,350	11,765,031	3,741,056	1,624,894	822,267	6,188,217	1,698,605	19,651,853
2008	11,468,352	314,064	11,782,416	3,727,124	1,619,587	786,850	6,133,561	1,735,877	19,651,853
2009	11,429,666	302,162	11,731,828	3,715,115	1,617,818	755,508	6,088,441	1,831,584	19,651,853
2010	11,404,303	311,481	11,715,784	3,705,004	1,619,464	727,733	6,052,201	1,883,868	19,651,853
2011	11,411,813	287,927	11,699,740	3,696,766	1,624,466	703,119	6,024,351	1,927,762	19,651,853
2012	11,419,322	310,299	11,729,620	3,690,381	1,632,820	681,343	6,004,544	1,917,689	19,651,853
2013	11,447,042	312,464	11,759,506	3,713,938	1,587,873	658,682	5,960,492	1,931,855	19,651,853
2014	11,564,139	261,241	11,825,380	3,739,940	1,549,061	638,253	5,927,254	1,899,218	19,651,853
2015	11,597,203	294,057	11,891,260	3,768,420	1,515,879	619,737	5,904,036	1,856,557	19,651,853
2016	11,630,277	283,702	11,913,979	3,799,413	1,487,919	602,915	5,890,247	1,847,627	19,651,853
2017	11,626,964	289,880	11,916,844	3,832,964	1,464,861	587,634	5,885,458	1,849,551	19,651,853
2018	11,623,969	287,753	11,911,722	3,851,380	1,454,636	578,630	5,884,646	1,855,485	19,651,853

Source: USDA – US Forest Service; USDA Census of Agriculture

Figures 28 and 29 provide a side-by-side comparison of biomass demand versus forestland and land in farms in the catchment area from 2000-2018. Looking at these figures, particularly since 2011, we see that forestland has closely tracked biomass demand while land in farms has continued its downward trend, despite changes in biomass demand. Correlation analysis confirmed these relationships, identifying a moderately strong positive correlation between biomass demand and forestland (correlation coefficient=0.64) and a moderately strong negative correlation between biomass demand and land in farms (correlation coefficient=-0.64).

Further analysis also identified moderately strong negative relationships between forestland and other (non-biomass) pulpwood demand and a weak positive relationship between forestland and total sawlog demand in the catchment area over this period, suggesting that increases in biomass demand and (to a lesser degree) sawlog demand have caused increases in forestland (conversion from farmland).

Ultimately, it does seem completely plausible and very likely that the emergence and growth of bioenergy markets in this region have had some positive influence on forestland, but there is not enough evidence to conclude that bioenergy markets alone have caused these changes.

***Figure 28**. Enviva Chesapeake Catchment Area – Biomass Demand vs. Forestland (2000-2018)*

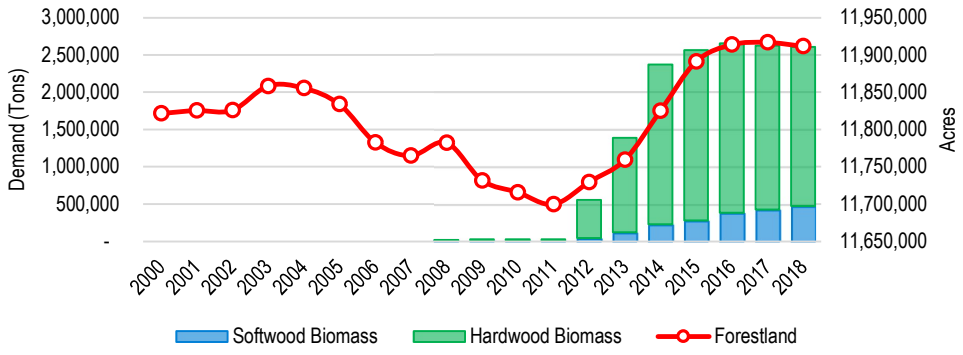
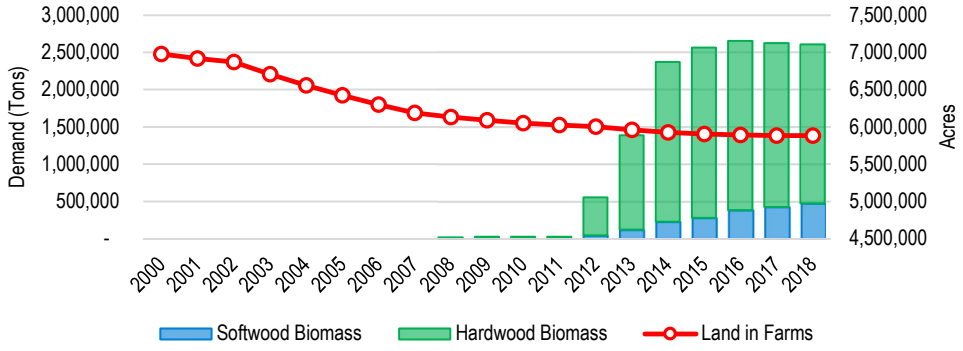


***Figure 29**. Enviva Chesapeake Catchment Area – Biomass Demand vs. Land in Farms (2000-2018)*



5.1.3 *Changes in Forest Area (Timberland)*

According to US Forest Service data, timberland acreage in the Enviva Chesapeake catchment area experienced a net increase of 77,097 acres (+0.7%) from 2000-2018, the latest available, increasing from 11,546,872 to 11,623,969 acres over this 18-year period. However, note that timberland acreage declined in the mid to late-2000s, but from 2010-2018, timberland acreage increased an estimated 219,667 acres, or a 1.9% increase compared to 2010 levels.

The composition of timberland in the catchment area also underwent changes between 2000 and 2018. Specifically, planted pine timberland increased 837,922 acres (+35%) and natural pine increased 31,996 acres (+2%) over this period. Planted and naturally regenerated hardwood timberland decreased 167,709 acres (-35%) and 608,825 acres (-11%), respectively, from 2000-2018. Natural mixed pine-hardwood timberland decreased 16,187 acres (-1%).

Note that the significant increase in planted pine timberland since 2000 has coincided with a simultaneous decrease in farmland acreage in the catchment area. Specifically, the 837,922-acre increase in planted pine acreage accounts for nearly 80% of the 1.1 million-acre decrease in farmland since 2000.

***Table 25**. Enviva Chesapeake Catchment Area - Timberland Acreage by Stand Origin (2000-2018)*

	Planted		*Naturally Regenerated*			
Year	Pine	Hardwood	Pine	Hardwood	Mixed Pine-Hardwood	Total
			(Acres)			
2000	2,407,206	480,721	2,073,233	5,312,859	1,272,853	11,546,872
2001	2,463,087	474,295	2,056,853	5,284,908	1,273,542	11,552,686
2002	2,544,604	491,403	2,017,504	5,229,411	1,283,895	11,566,817
2003	2,657,656	460,961	1,937,301	5,194,253	1,323,071	11,573,243
2004	2,711,508	490,056	1,918,884	5,176,144	1,260,520	11,557,112
2005	2,807,564	479,008	1,865,545	5,137,173	1,244,125	11,533,414
2006	2,922,737	450,316	1,792,017	5,056,653	1,256,943	11,478,667
2007	3,003,307	426,529	1,825,017	4,926,385	1,260,443	11,441,681
2008	3,001,550	426,763	1,838,955	4,943,984	1,257,099	11,468,352
2009	3,084,918	408,040	1,799,152	4,915,763	1,221,793	11,429,666
2010	3,053,163	397,238	1,816,308	4,848,566	1,289,027	11,404,303
2011	3,114,271	401,044	1,856,641	4,778,975	1,260,882	11,411,813
2012	3,163,278	374,304	1,901,621	4,690,308	1,289,811	11,419,322
2013	3,192,185	376,261	1,916,234	4,701,164	1,261,198	11,447,042
2014	3,226,013	354,172	1,952,028	4,714,057	1,317,869	11,564,139
2015	3,229,702	358,318	1,954,383	4,685,773	1,369,027	11,597,203
2016	3,301,104	329,893	1,989,984	4,681,779	1,327,516	11,630,277
2017	3,258,420	330,490	2,051,883	4,688,405	1,297,767	11,626,964
2018	3,245,027	313,013	2,105,229	4,704,034	1,256,666	11,623,969

Source: USDA-US Forest Service

***Figure 30**. Enviva Chesapeake Catchment Area - Timberland Acreage by Year (2000 – 2018)*

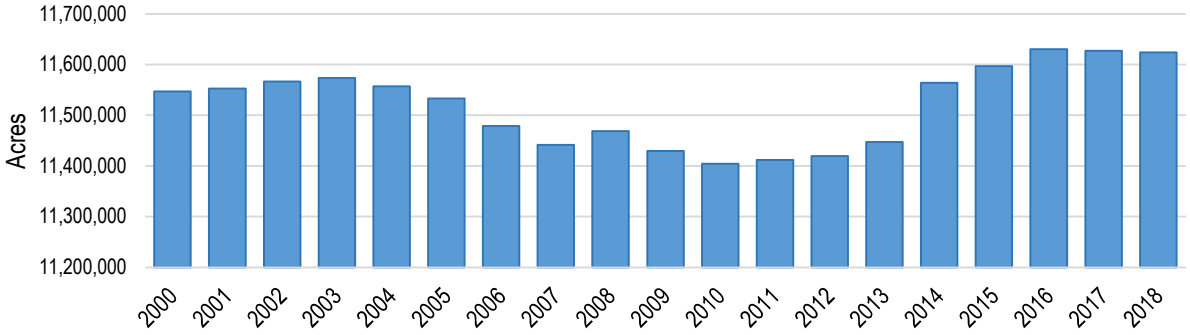
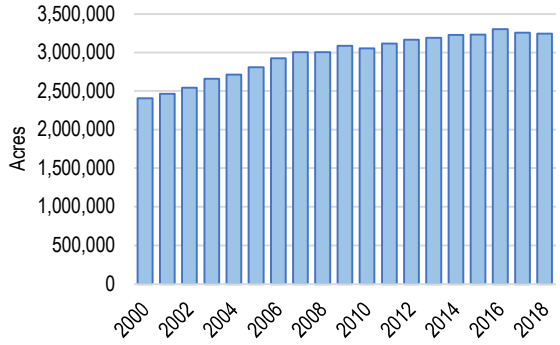
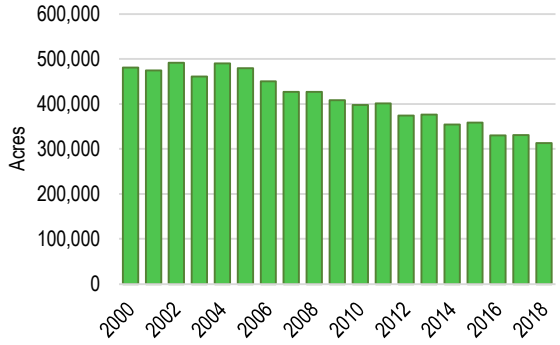


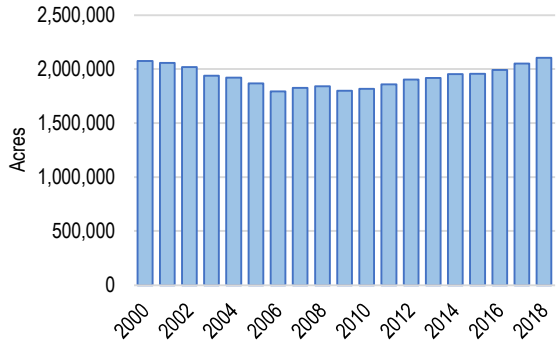
***Figure 31**. Enviva Chesapeake Catchment Area – Timberland Acreage by Stand Origin (2000-2018)*



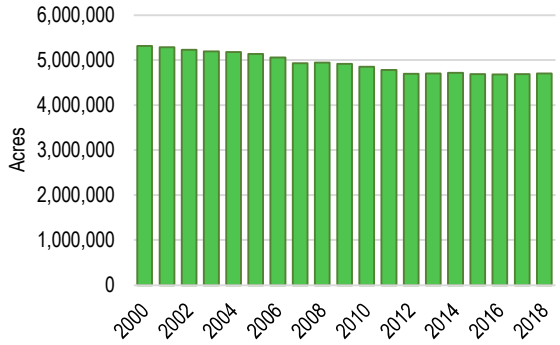
(a) Planted Pine



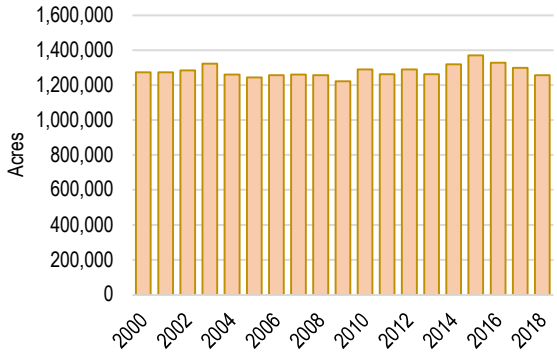
(b) Planted Hardwood



(c) Naturally Regenerated Pine



(d) Naturally Regenerated Hardwood



(e) Naturally Regenerated Mixed Pine-Hardwood

5.1.3.1 *By Forest Type & Physiographic Class*

According to the US Forest Service, timberland classified as uplands and flatwoods[4] increased from an estimated 9,645,102 acres in 2000 to 9,762,629 acres in 2005, or a net increase of 117,527 acres (+1.2%) over this 5-year period. Uplands and flatwoods timberland acreage held steady over the next several years and was down and up through the late 2000s and early-to-mid-2010s. However, this classification of timberland has held steady and averaged approximately 9,757,000 acres since 2014.

Bottomland and other hydric[5] timberland declined from an estimated 1,901,770 acres in 2000 to 1,681,130 acres in 2007, or a net decrease of 220,639 acres (-12%) over this period. However, since 2007, bottomland and other hydric timberland has increased an estimated 188,325 acres (+11%), to 1,869,455 acres in 2018.

We'd like to note that since 2011, only upland/flatwood hardwood and mixed pine-hardwood timberland acreage has declined in the catchment area. Specifically, from 2011-2018, upland/flatwood hardwood timberland decreased an estimated 223,650 acres (-6%) and upland/flatwood mixed pine-hardwood timberland decreased 20,090 acres (-1%). Over this same period, bottomland softwood, hardwood, and mixed pine-hardwood timberland all increased – a combined 145,728 acres (+8%).

***Table 26**. Enviva Chesapeake Catchment Area - Timberland Acreage by Forest Type & Physiographic Class (2000-2018)*

	Uplands & Flatwoods				*Bottomland & Other Hydric*				
Year	Softwood	Hardwood	Mixed Pine / Hdwd	Total	Softwood	Hardwood	Mixed Pine / Hdwd	Total	Total Acres
					(Acres)				
2000	4,039,096	4,133,780	1,472,226	9,645,102	236,711	1,511,486	153,573	1,901,770	11,546,872
2001	4,049,216	4,124,309	1,467,191	9,640,717	242,606	1,512,247	157,117	1,911,970	11,552,686
2002	4,069,974	4,118,573	1,469,311	9,657,857	240,709	1,514,231	154,020	1,908,960	11,566,817
2003	4,136,680	4,110,698	1,460,218	9,707,596	221,032	1,497,283	147,331	1,865,647	11,573,243
2004	4,195,269	4,094,820	1,448,288	9,738,377	200,942	1,477,432	140,362	1,818,735	11,557,112
2005	4,250,890	4,076,296	1,435,443	9,762,629	180,787	1,456,674	133,323	1,770,785	11,533,414
2006	4,339,833	3,964,794	1,449,224	9,753,852	161,753	1,436,135	126,927	1,724,816	11,478,667
2007	4,436,610	3,858,482	1,465,459	9,760,551	142,783	1,417,678	120,669	1,681,130	11,441,681
2008	4,530,981	3,824,585	1,425,254	9,780,819	131,661	1,436,163	119,708	1,687,532	11,468,352
2009	4,598,872	3,769,228	1,377,268	9,745,368	119,879	1,446,344	118,074	1,684,298	11,429,666
2010	4,626,608	3,687,280	1,388,839	9,702,726	134,167	1,437,386	130,024	1,701,576	11,404,303
2011	4,667,621	3,616,076	1,404,390	9,688,086	148,818	1,432,579	142,329	1,723,727	11,411,813
2012	4,708,683	3,544,774	1,419,960	9,673,417	163,489	1,427,765	154,651	1,745,905	11,419,322
2013	4,736,719	3,496,678	1,439,140	9,672,537	159,579	1,457,629	157,297	1,774,505	11,447,042
2014	4,801,948	3,475,167	1,469,755	9,746,870	156,860	1,499,208	161,201	1,817,269	11,564,139
2015	4,832,501	3,427,659	1,489,897	9,750,056	152,945	1,530,240	163,963	1,847,147	11,597,203
2016	4,900,039	3,420,143	1,450,448	9,770,630	165,009	1,538,846	155,792	1,859,647	11,630,277
2017	4,952,261	3,401,923	1,406,450	9,760,634	176,561	1,542,638	147,131	1,866,330	11,626,964
2018	4,977,788	3,392,426	1,384,300	9,754,514	182,313	1,544,356	142,786	1,869,455	11,623,969

Source: USDA-US Forest Service

[4] Uplands and flatwoods include the following USDA physiographic classes: *dry tops and slopes, deep sands, other xeric, flatwoods, rolling uplands, and moist slopes and coves*.

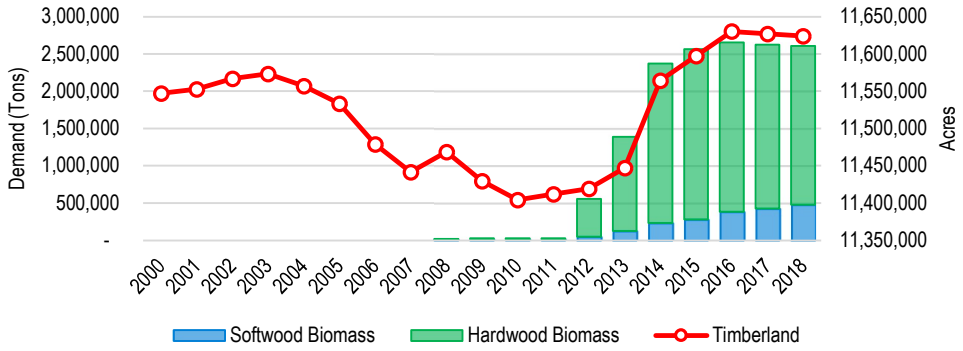
[5] Bottomland and other hydric includes the following USDA physiographic classes: *narrow and flood plains/bottomlands, small drains, swamps/bogs, bays and wet pocosins, beaver and cypress ponds, other mesic, and other hydric*.

Correlation Analysis: *Biomass Demand vs. Timberland*

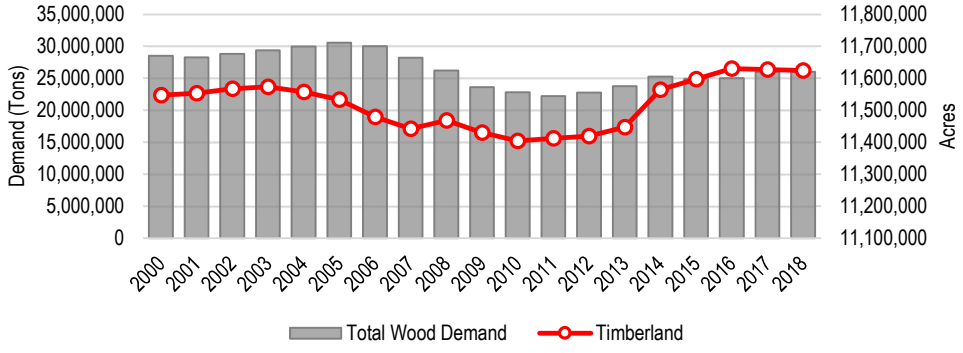
Figures 32 provides a side-by-side comparison of both biomass demand and total wood demand versus timberland acres in the catchment area from 2000-2018. In comparing changes in biomass demand to changes in timberland acres, what we see is that biomass demand and timberland acres have closely tracked one another since around 2012, and to a lesser degree from 2008-2011. Prior to 2008, there was no biomass-related wood demand in the catchment area. However, overall, correlation analysis identified a moderately strong positive correlation (correlation coefficient=0.61) between biomass demand and timberland acres from 2000-2018.

Figure 32(b), which compares total wood demand to timberland acres in the catchment area since 2000, provides a bit more insight and shows that total wood demand loosely tracked timberland acres from 2000-2007; however, the two have more closely followed one another since 2008. Correlation analysis ultimately identified a weak positive correlation between total demand and timberland (correlation coefficient=0.41) from 2000-2018. However, note that a strong correlation (correlation coefficient=0.79) was found between total wood demand and timberland acres from 2008-2018.

***Figure 32**. Enviva Chesapeake Catchment Area – Biomass Demand & Total Wood Demand vs. Timberland Acres (2000-2018)*



(a) Biomass Demand vs. Timberland



(b) Total Wood Demand vs. Timberland

***Table 27**. Correlation Analysis –Biomass Demand, Pulpwood Demand & Timberland Acreage (2000-2018)*

	Softwood Biomass Demand	*Other Softwood Pulpwood Demand*	*Total Softwood Pulpwood Demand*	*Pine Timberland*	*Total Timberland*
Softwood Biomass Demand	1				
Other Softwood Pulpwood Demand	0.57	1			
Total Softwood Pulpwood Demand	0.79	0.94	1		
Pine Timberland	0.86	0.61	0.79	1	
Total Timberland	0.65	0.30	0.48	0.23	1

	Hardwood Biomass Demand	*Other Hardwood Pulpwood Demand*	*Total Hardwood Pulpwood Demand*	*Hardwood Timberland*	*Total Timberland*
Hardwood Biomass Demand	1				
Other Hardwood Pulpwood Demand	-0.90	1			
Total Hardwood Pulpwood Demand	0.15	0.29	1		
Hardwood Timberland	-0.74	0.62	0.03	1	
Total Timberland	0.60	-0.52	0.14	0.04	1

	Softwood Biomass Demand	*Hardwood Biomass Demand*	*Total Biomass Demand*	*Total Timberland*
Softwood Biomass Demand	1			
Hardwood Biomass Demand	0.95	1		
Total Biomass Demand	0.96	0.99	1	
Total Timberland	0.65	0.60	0.61	1

5.1.4 *Changes in Timber Inventory*

Timber inventory data for the Enviva Chesapeake catchment area is provided by the US Forest Service - Forest Inventory & Analysis (FIA) program from 2000 through 2018[6], the most current available.

According to US Forest Service data, total growing stock inventory on timberland in the Enviva Chesapeake catchment area increased from 18.5 billion ft^3 in 2000 to 24.5 billion ft^3 in 2018, or a net increase of over 6.0 billion ft^3 (+32%) over this period. Note, however, that much of this growth in inventory has occurred since 2011. Specifically, total growing stock inventory increased 11% (+0.9% per year) from 2000-2011 but 19% (+2.9% per year) from 2011-2018.

See Table 28 below for timber inventory estimates, including a breakdown by major timber product, in the catchment area from 2000 through 2018, the latest available.

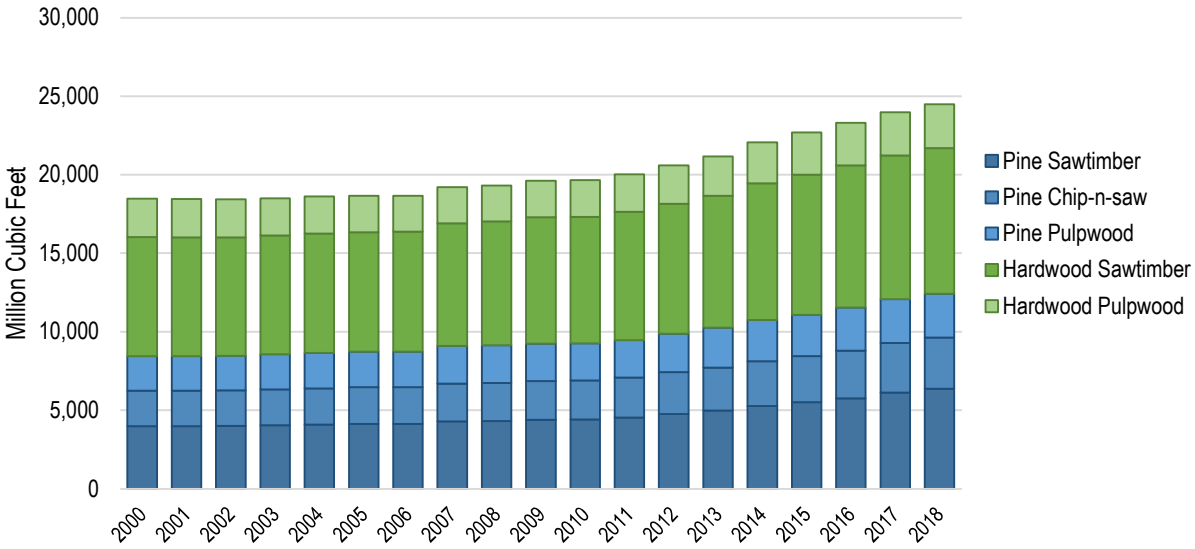
***Table 28**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Timber Product (2000-2018)*

	Softwood			Hardwood		
Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	Total
			(Million Cubic Feet)			
2000	3,990	2,261	2,189	7,584	2,455	18,479
2001	3,994	2,262	2,192	7,568	2,442	18,459
2002	4,003	2,263	2,199	7,547	2,420	18,432
2003	4,043	2,286	2,246	7,546	2,375	18,496
2004	4,088	2,297	2,275	7,597	2,351	18,608
2005	4,130	2,335	2,259	7,615	2,315	18,654
2006	4,126	2,352	2,248	7,642	2,293	18,661
2007	4,298	2,405	2,395	7,814	2,294	19,206
2008	4,314	2,427	2,402	7,873	2,301	19,317
2009	4,392	2,477	2,381	8,037	2,335	19,622
2010	4,409	2,499	2,364	8,047	2,331	19,650
2011	4,528	2,552	2,381	8,166	2,382	20,011
2012	4,767	2,662	2,445	8,271	2,437	20,582
2013	4,982	2,729	2,554	8,385	2,512	21,161
2014	5,274	2,841	2,626	8,707	2,611	22,059
2015	5,517	2,929	2,636	8,912	2,700	22,693
2016	5,759	3,034	2,751	9,052	2,710	23,307
2017	6,121	3,173	2,775	9,156	2,756	23,981
2018	6,363	3,269	2,788	9,275	2,779	24,475

Source: USDA - US Forest Service

[6] US Forest Service FIA data for those areas located in Virginia were only available through 2017. Estimates for 2018 have been included and are based on historical trends and a local area inventory model.

***Figure 33**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Timber Product (2000-2018)*

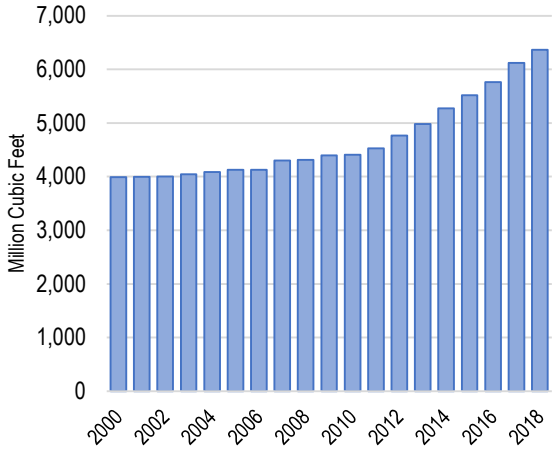


Note that inventories of all five major timber products increased from 2000-2018. Pine sawtimber inventory increased the largest amount over this period, increasing 2.4 billion ft^3 (+59%) from 2000-2018, followed by inventories of hardwood sawtimber (+1.7 billion ft^3; +22%), pine chip-n-saw (+1.0 billion ft^3; +45%), pine pulpwood (+600 million ft^3; +27%), and hardwood pulpwood (+324 million ft^3; +13%).

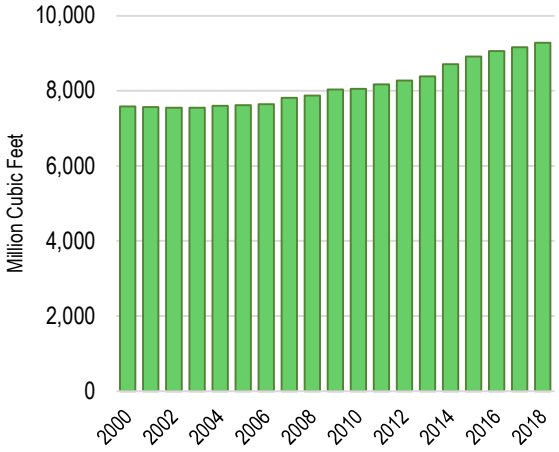
However, also note the rate at which inventory levels increased went up substantially from 2011-2018. Reduced harvest levels in the late 2000s and early 2010s allowed inventory levels to grow so large that annual timber growth far outpaced removals, resulting in an inventory compounding affect. Specifically, comparing the average annual rate of inventory growth for each of the five major products from 2000-2011 versus 2011-2018:

	Average Annual Δ	
Major Product	2000-2011	2011-2018
Pine Sawtimber	+1.2% / year	+5.0% / year
Pine Chip-n-saw	+1.1% / year	+3.6% / year
Pine Pulpwood	+0.9% / year	+2.2% / year
Hardwood Sawtimber	+0.7% / year	+1.8% / year
Hardwood Pulpwood	-0.1% / year	+2.2% / year

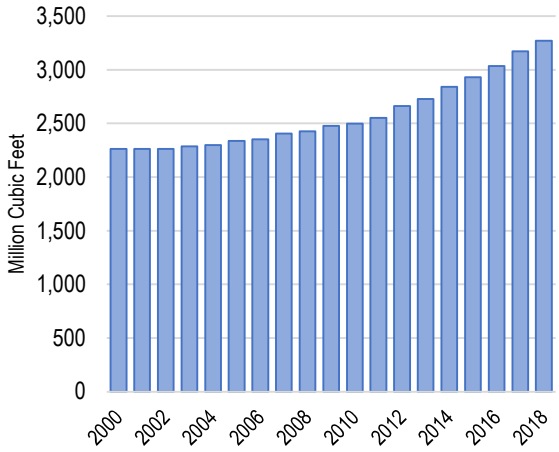
***Figure 34**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Timber Product (2000-2018)*



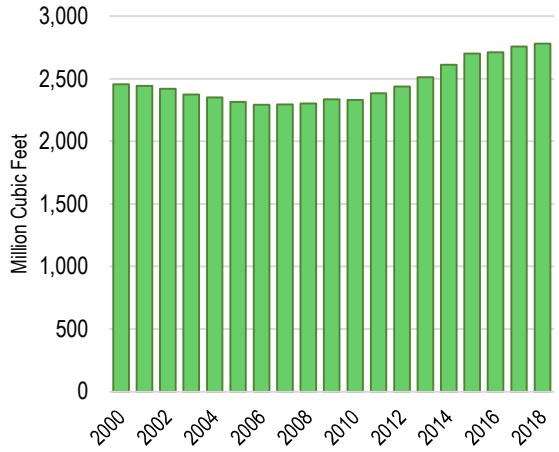
(a) Pine Sawtimber



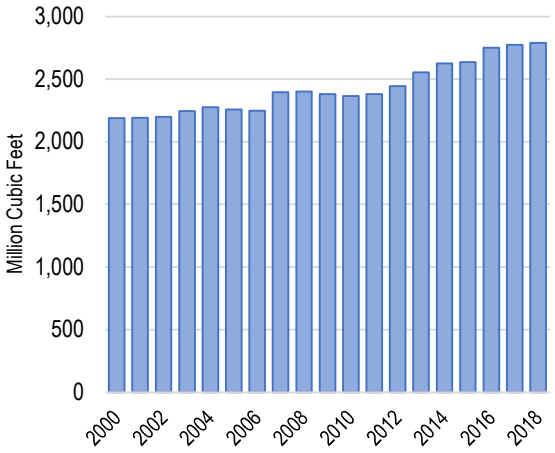
(d) Hardwood Sawtimber



(b) Pine Chip-n-saw



(e) Hardwood Pulpwood



(c) Pine Pulpwood

5.1.4.1 *Diameter Class Distribution*

Total growing stock inventory on timberland increased from 18.5 billion ft^3 in 2000 to 24.5 billion ft^3 in 2018, or a net increase of 6.0 billion ft^3 (+32% total; +1.6% per year average). However, the actual distribution of growing stock inventory by diameter class in the catchment area has remained nearly unchanged for softwood inventory since 2000 (and changed only slightly for hardwood inventory).

Table 29 below provides a comparison of growing stock inventory estimates in the catchment area by major species group and diameter class in 2000, 2009, and 2018. Specifically, USFS data shows that in 2000, 2009, and 2018, approximately 94% of softwood growing stock inventory was less than 21 inches in diameter, with approximately 75% of softwood inventory 7-17 inches in diameter in each of these three periods.

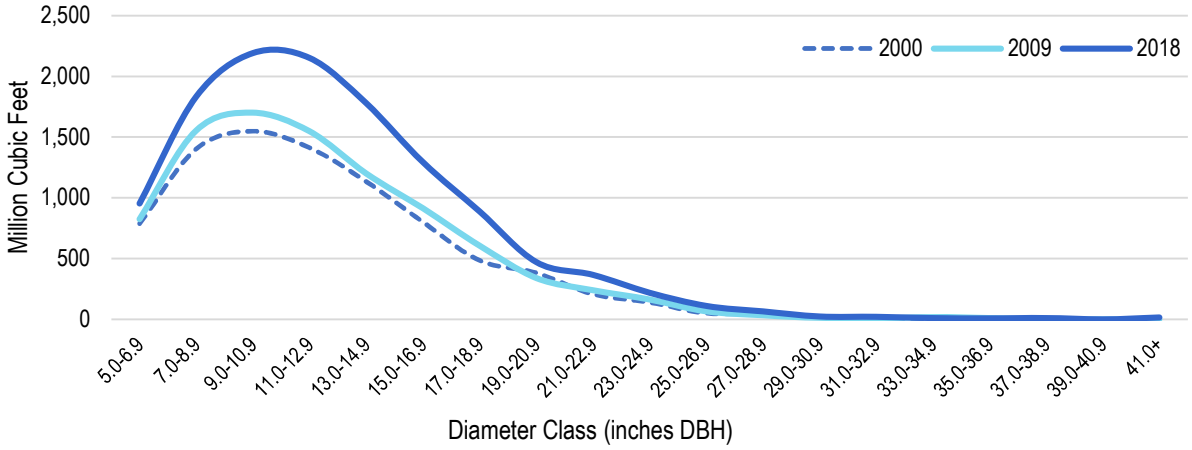
The historic distributions of hardwood growing stock inventory by diameter class show 91-94% of hardwood inventory was less than 25 inches in diameter in 2000, 2009, and 2018. However, in 2000, approximately 79% of hardwood growing stock inventory was less than 19 inches in diameter, compared to 76% in 2009 and 73% in 2018 within these same parameters.

***Table 29**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Species Group & Diameter Class (2000, 2009, & 2018)*

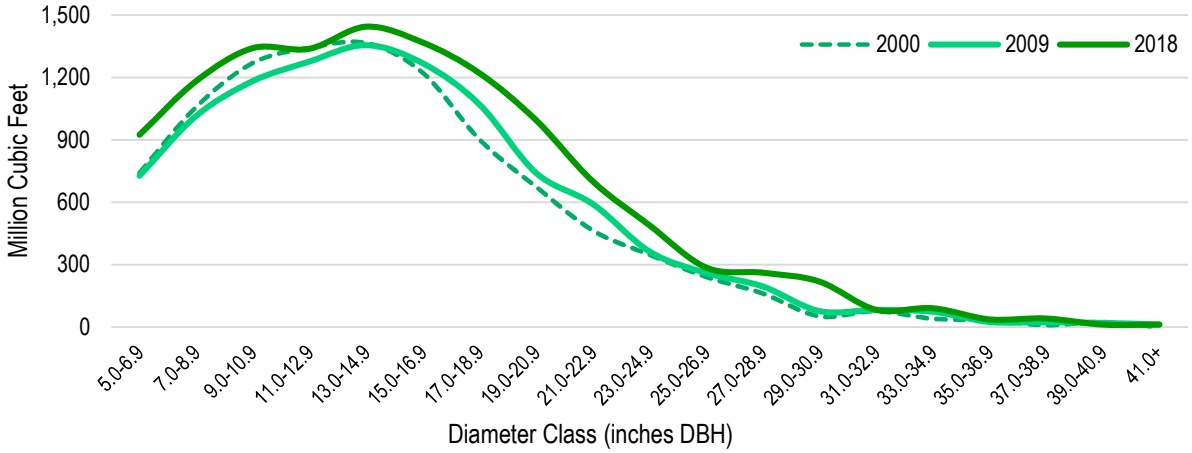
Diameter Class	Softwood			Hardwood			Total		
(inches DBH)	2000	2009	2018	2000	2009	2018	2000	2009	2018
				(Million Cubic Feet)					
5.0-6.9	788	826	955	743	728	925	1,532	1,554	1,880
7.0-8.9	1,404	1,556	1,834	1,059	1,016	1,184	2,466	2,571	3,017
9.0-10.9	1,550	1,702	2,192	1,271	1,183	1,341	2,823	2,885	3,534
11.0-12.9	1,413	1,549	2,154	1,343	1,277	1,338	2,758	2,826	3,492
13.0-14.9	1,135	1,203	1,781	1,366	1,356	1,445	2,500	2,559	3,226
15.0-16.9	802	914	1,293	1,223	1,269	1,368	2,024	2,182	2,661
17.0-18.9	485	607	889	902	1,070	1,221	1,386	1,677	2,110
19.0-20.9	383	341	471	675	741	994	1,057	1,082	1,464
21.0-22.9	208	239	366	465	592	700	672	831	1,066
23.0-24.9	140	165	220	349	364	490	488	529	710
25.0-26.9	51	66	110	242	261	286	292	327	396
27.0-28.9	48	33	65	162	196	261	210	230	327
29.0-30.9	15	12	24	52	78	220	67	90	244
31.0-32.9	8	8	21	78	83	84	85	91	106
33.0-34.9	0	20	10	41	75	91	41	94	102
35.0-36.9	10	11	8	34	26	38	44	36	46
37.0-38.9	0	0	11	10	24	42	10	24	53
39.0-40.9	0	0	0	25	21	12	25	21	12
41.0+	0	0	16	0	13	13	0	13	29
Total	**8,440**	**9,250**	**12,421**	**10,039**	**10,372**	**12,055**	**18,479**	**19,622**	**24,475**

Source: USDA - US Forest Service

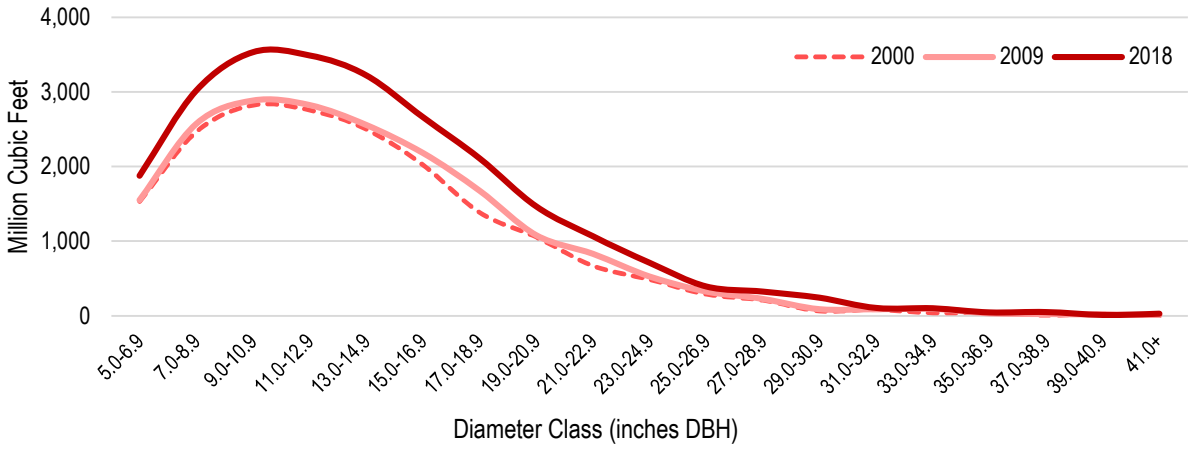
***Figure 35**. Timber Inventory by Major Species Group & Diameter Class (2000, 2009, & 2018)*



(a) Softwood Growing Stock



(b) Hardwood Growing Stock



(c) Total Growing Stock

5.1.4.2 *Age Class Distribution*

Examination of changes in growing stock inventory by age class reveals some interesting trends amongst major species groups. Specifically, USFS data indicates average age of softwood growing stock inventory in the catchment area decreased from 40.2 years old in 2000 to 38.8 years old in 2009 and to 38.5 years old in 2018. However, the average age of hardwood growing stock inventory increased over this same period – from 55.9 to 58.1 and to 60.9 years old in 2000, 2009, and 2018, respectively.

These changes in average age are explained by changes in age class distribution over this period. Specifically, the distribution of softwood growing stock inventory 40 years of age or younger increased from 58% in 2000 to 63% in 2009 and to 65% in 2018. Conversely, the distribution of hardwood growing stock inventory greater than 50 years of age increased from 61% to 64% and to 67% over these same three periods.

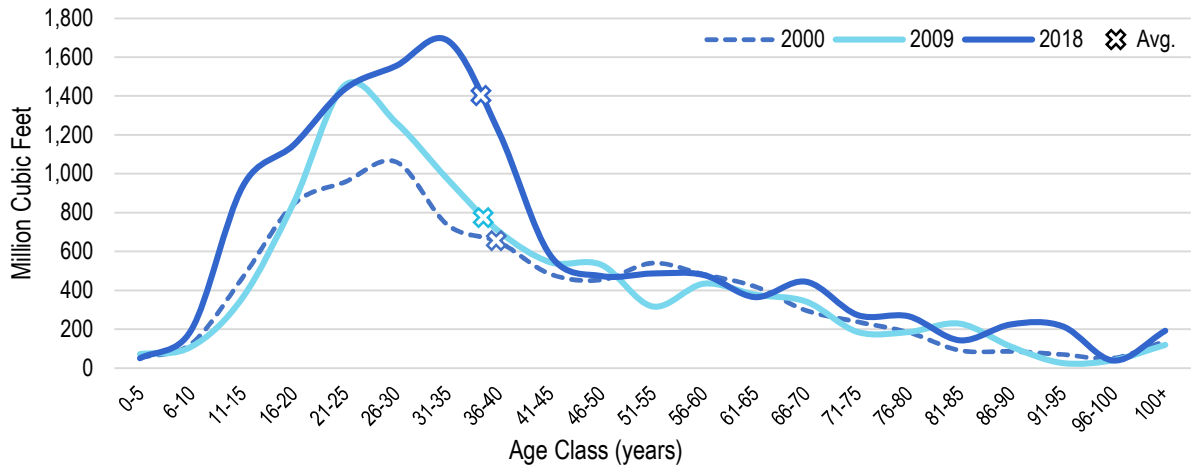
Table 30 below provides US Forest Service estimates of softwood and hardwood growing stock inventory by age class in 2000, 2009, and 2018. Corresponding values are shows graphically in Figure 36.

***Table 30**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Species Group & Age Class (2000, 2009, & 2018)*

Age Class	Softwood			Hardwood			Total		
(years)	2000	2009	2018	2000	2009	2018	2000	2009	2018
					(Million Cubic Feet)				
0-5	53	72	51	157	89	64	210	161	114
6-10	126	110	196	182	130	83	308	241	278
11-15	467	363	936	241	128	168	709	492	1,101
16-20	845	854	1,149	345	289	377	1,192	1,143	1,523
21-25	959	1,457	1,438	343	463	443	1,305	1,920	1,877
26-30	1,061	1,263	1,557	402	533	559	1,466	1,796	2,112
31-35	737	973	1,686	453	517	660	1,192	1,490	2,343
36-40	649	705	1,217	482	425	535	1,132	1,130	1,749
41-45	485	546	581	618	598	632	1,102	1,143	1,213
46-50	454	532	474	741	519	503	1,194	1,051	977
51-55	541	317	487	811	881	645	1,351	1,198	1,132
56-60	482	435	480	767	792	1,006	1,248	1,227	1,488
61-65	420	378	366	759	798	879	1,179	1,176	1,247
66-70	297	343	445	731	726	899	1,026	1,069	1,346
71-75	238	187	274	756	779	898	993	966	1,174
76-80	184	187	266	656	696	655	838	883	923
81-85	91	229	143	513	721	704	603	950	849
86-90	86	110	226	252	396	769	338	506	998
91-95	71	27	216	266	172	658	336	199	875
96-100	52	42	39	185	237	251	237	279	291
100+	140	120	193	380	483	669	519	603	864
Total	**8,440**	**9,250**	**12,421**	**10,039**	**10,372**	**12,055**	**18,479**	**19,622**	**24,475**

Source: USDA - US Forest Service

***Figure 36**. Enviva Chesapeake Catchment Area - Timber Inventory by Major Species Group & Age Class (2000, 2009, & 2018)*



(a) Softwood Growing Stock

(b) Hardwood Growing Stock

(c) Total Growing Stock

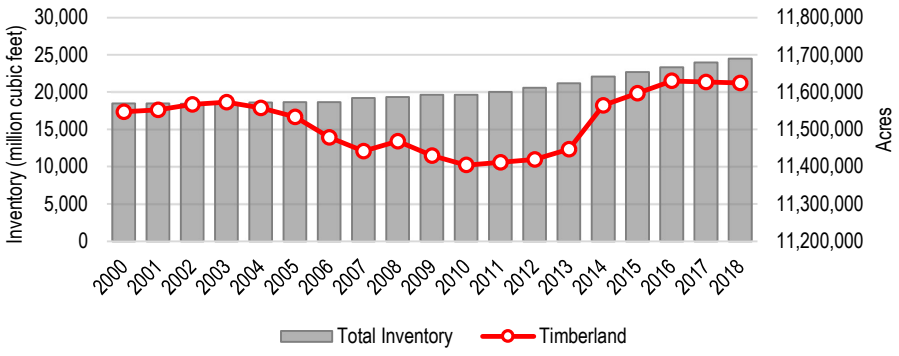
Correlation Analysis: *Biomass Demand vs. Timber Inventory*

US Forest Service data shows that, since 2000, timber inventory has continued to increase in the catchment area, and at a more rapid pace since around 2010-2011. Intuitively, timber inventories can increase one of two ways: 1) through additional timberland gains or 2) through an environment in which annual growth outpaces annual removals.

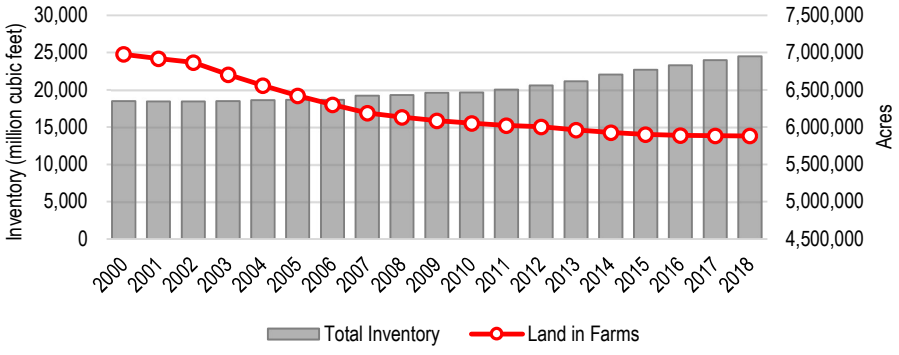
In the Enviva Chesapeake catchment area, both have occurred. Specifically, total timberland in the catchment area increased by over 77,000 acres from 2000-2018, largely from the conversion of agricultural land. In addition, the extended period of reduced wood demand from 2007-2011 (caused by the bursting of the US housing bubble in 2006 and Great Recession that followed) allowed timber inventory in the catchment area to grow to such substantial levels that annual timber growth has continued to outpace annual removals (demand), leading to persistent oversupply and increased inventory levels.

Correlation analysis confirms the direct relationship between timberland and timber inventory as well as the inverse relationship between agricultural land (land in farms) and timber inventory. Specifically, timber inventory was found to have a moderately strong positive correlation (correlation coefficient=0.46) with timberland and a strong negative correlation (correlation coefficient=-0.76) with land in farms in the catchment area from 2000-2018.

***Figure 37**. Enviva Chesapeake Catchment Area – Timber Inventory vs. Timberland Acres & Land in Farms (2000-2018)*



(a) Timber Inventory vs. Timberland Acres



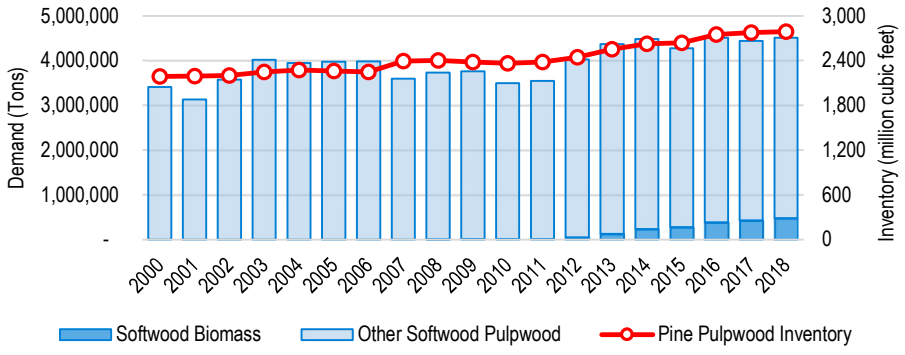
(b) Timber Inventory vs. Land in Farms

Like total timber inventory, inventories of both pine and hardwood pulpwood have also increased in the catchment area since 2000, and there is some evidence that links these increases to changes in wood demand. Specifically, Figures 38 provides a side-by-side comparison of pulpwood demand (which includes both biomass-related and other pulpwood demand) versus pulpwood inventory in the catchment area from 2000-2018.

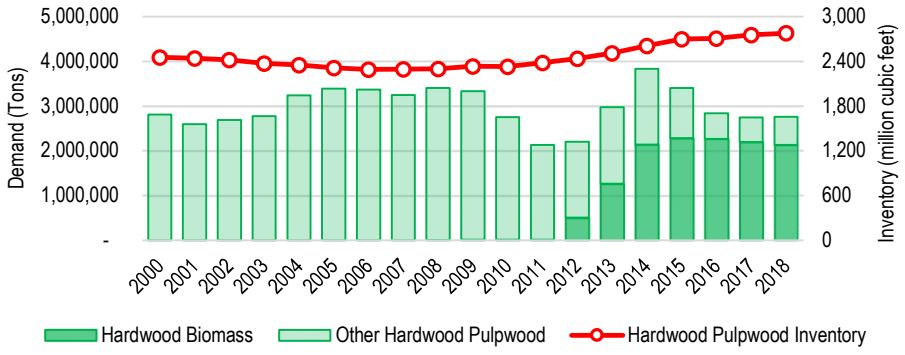
Figure 38(a), which provides a comparison of softwood pulpwood demand and pine pulpwood inventory, shows these two sets of variables have tracked one another fairly closely since 2000. Correlation analysis confirmed this relationship, identifying a strong positive correlation (correlation coefficient=0.81) between softwood pulpwood demand and pine pulpwood inventory from 2000-2018.

On the other hand, Figure 38(b), which provides a comparison of hardwood pulpwood demand and hardwood pulpwood inventory, shows no clearly identifiable relationship between these two sets of variables. Hardwood pulpwood inventory appears to move inversely to hardwood pulpwood demand from 2000-2010; however, after this, these two variables more closely track one another. Correlation analysis confirms the lack of an identifiable relationship, identifying no correlation (correlation coefficient=-0.08) between hardwood pulpwood demand and hardwood pulpwood inventory from 2000-2018.

***Figure 38**. Enviva Chesapeake Catchment Area – Biomass Demand & Pulpwood Demand vs. Pulpwood Inventory (2000-2018)*



(a) Softwood Pulpwood Wood Demand vs. Pine Pulpwood Inventory



(b) Hardwood Pulpwood Wood Demand vs. Hardwood Pulpwood Inventory

Note, however, that statistical analysis identified a strong positive correlation (correlation coefficient=0.96) between hardwood biomass demand, which has accounted for over 75% of total hardwood pulpwood demand since 2015, and hardwood pulpwood inventory.

The strong positive correlations found between pulpwood/biomass demand and pulpwood inventories are largely coincidental in nature, not indicative of a causal relationship. In other words, increases in softwood or hardwood biomass demand have not caused softwood/hardwood pulpwood inventory levels to increase in the catchment area. As we will detail in subsequent sections, annual growth has continued to outpace annual removals every year since 2005 (despite increases in biomass demand), and as a result inventory levels have continued to increase.

***Table 31**. Correlation Analysis –Biomass Demand, Pulpwood Demand & Timber Inventory (2000-2018)*

	Softwood Biomass Demand	*Other Softwood Pulpwood Demand*	*Total Softwood Pulpwood Demand*	*Pine Pulpwood Inventory*	*Total Pine Inventory*
Softwood Biomass Demand	1				
Other Softwood Pulpwood Demand	0.53	1			
Total Softwood Pulpwood Demand	0.79	0.94	1		
Pine Pulpwood Inventory	0.93	0.61	0.81	1	
Total Pine Inventory	0.97	0.57	0.80	0.98	1

	Hardwood Biomass Demand	*Other Hardwood Pulpwood Demand*	*Total Hardwood Pulpwood Demand*	*Hardwood Pulpwood Inventory*	*Total Hardwood Inventory*
Hardwood Biomass Demand	1				
Other Hardwood Pulpwood Demand	-0.90	1			
Total Hardwood Pulpwood Demand	0.15	0.29	1		
Hardwood Pulpwood Inventory	0.94	-0.95	-0.08	1	
Total Hardwood Inventory	0.96	-0.94	-0.03	0.93	1

	Softwood Biomass Demand	*Hardwood Biomass Demand*	*Total Biomass Demand*	*Total Pulpwood Inventory*	*Total Inventory*
Softwood Biomass Demand	1				
Hardwood Biomass Demand	0.95	1			
Total Biomass Demand	0.96	0.99	1		
Total Pulpwood Inventory	0.98	0.97	0.98	1	
Total Inventory	0.97	0.95	0.96	0.99	1

5.1.5 *Changes in Annual Timber Growth*

Timber growth data for the Enviva Chesapeake catchment area is provided by the US Forest Service - Forest Inventory & Analysis (FIA) program. However, note that FIA growth data for this catchment area is only available since 2005. As such, this section provides an examination of historical timber growth from 2005 through 2018, the latest available.

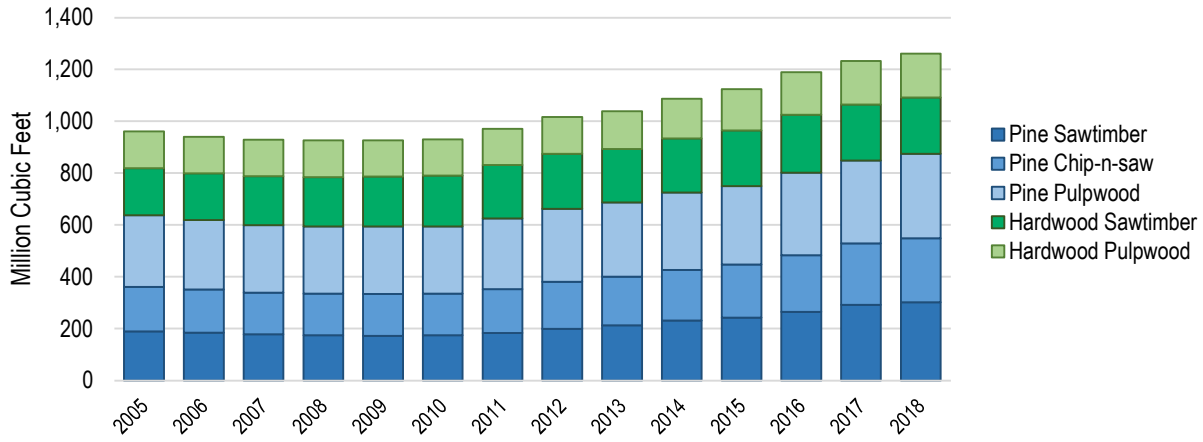
According to US Forest Service data, net growth in timber volume totaled 960 million ft^3 in 2005, decreasing to 930 million ft^3 in 2010. However, since that time, total annual growth has increased an average of 3.9% per year (+36% total), to 1.261 billion ft^3 in 2018. See Table 32.

***Table 32**. Enviva Chesapeake Catchment Area - Annual Growth by Major Timber Product (2005-2018)*

Year	Softwood			Hardwood		Total
	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	
	(Million Cubic Feet)					
2005	189	172	276	183	141	960
2006	184	167	268	181	140	940
2007	179	160	261	189	140	929
2008	174	160	260	191	141	926
2009	172	163	260	192	140	927
2010	174	160	259	196	140	930
2011	183	170	273	205	140	971
2012	199	181	281	213	142	1,016
2013	213	187	287	206	146	1,039
2014	231	196	298	209	152	1,086
2015	243	204	303	214	160	1,124
2016	264	218	319	224	165	1,190
2017	292	236	320	215	169	1,233
2018	302	247	325	218	169	1,261

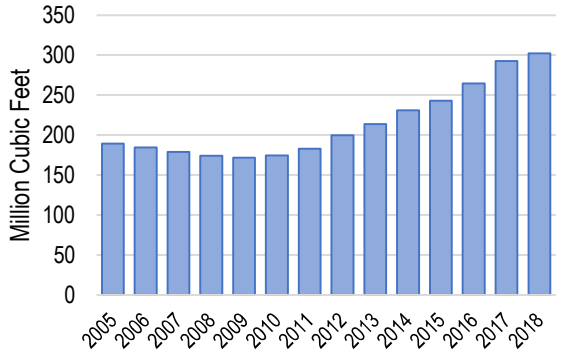
Source: USDA-US Forest Service

***Figure 39**. Enviva Chesapeake Catchment Area - Net Growth of Growing Stock Timber on Timberland (2005-2018)*

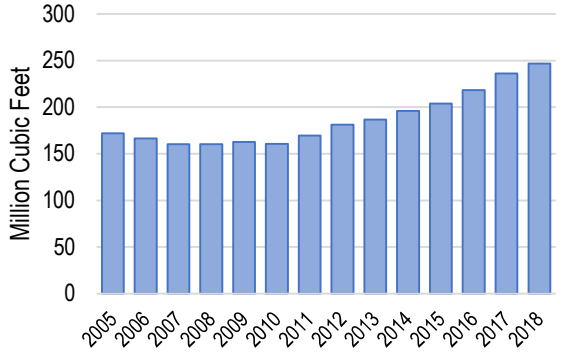


Note that annual growth has increased for all five major timber products since Enviva Pellets Ahoskie first commenced production 2011. Specifically, annual growth has increased an average of 7.4% per year for pine sawtimber, 5.5% per year for pine-chip-n-saw, 2.5% per year for pine pulpwood, 0.9% per year for hardwood sawtimber, and 2.7% per year for hardwood pulpwood since 2011.

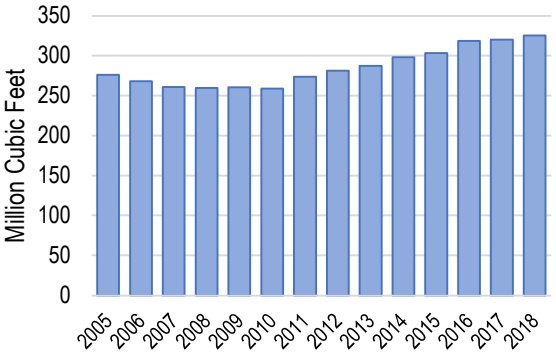
***Figure 40**. Enviva Chesapeake Catchment Area - Net Annual Growth by Major Timber Product (2005-2018)*



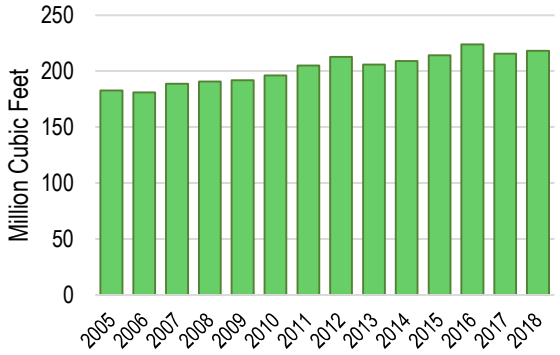
(a) Pine Sawtimber



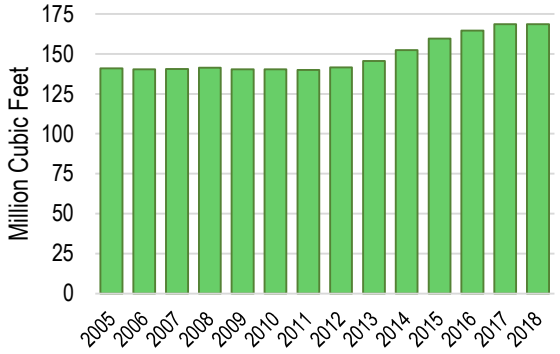
(b) Pine Chip-n-saw



(c) Pine Pulpwood



(d) Hardwood Sawtimber



(e) Hardwood Pulpwood

5.1.5.1 *Growth Rates & Per-Acre Growth*

According to USFS data, average annual growth rates in the catchment area declined slightly from 2005-2009. However, over the last nine years, the annual timber growth rates have steadily risen, increasing from 4.7% in 2010 to 5.2% in 2018. Specifically, since 2010, growth rates have increased for all three major pine products but more-or-less held constant for both hardwood sawtimber and hardwood pulpwood. See Table 33.

Examination of changes in average per-acre volume growth provides a bit more insight and evidence of a more productive forest. Specifically, US Forest Service data indicates the average per-acre growth increased from 82 ft^3 in 2010 to 109 ft^3 in 2018, with average per-acre growth increasing for all five major timber products over this period (see Table 34).

Evidence of a more productive forest aligns with what we've observed with changes in land use and timber management trends. Specifically, nearly 170,000 acres of farmland (i.e. cropland, woodland, and pastureland) was converted to timberland from 2010-2018. In addition, FIA data indicates that roughly 3% of naturally regenerated hardwood timberland was converted to more productive pine timberland over this period.

***Table 33**. Enviva Chesapeake Catchment Area - Average Annual Growth Rate by Major Timber Product (2005-2018)*

	Softwood			Hardwood		
Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	Total
	Annual Growth Rate (%)					
2005	4.6%	7.4%	12.2%	2.4%	6.1%	5.1%
2006	4.5%	7.1%	11.9%	2.4%	6.1%	5.0%
2007	4.2%	6.7%	10.9%	2.4%	6.1%	4.8%
2008	4.0%	6.6%	10.8%	2.4%	6.1%	4.8%
2009	3.9%	6.6%	10.9%	2.4%	6.0%	4.7%
2010	4.0%	6.4%	11.0%	2.4%	6.0%	4.7%
2011	4.0%	6.6%	11.5%	2.5%	5.9%	4.9%
2012	4.2%	6.8%	11.5%	2.6%	5.8%	4.9%
2013	4.3%	6.8%	11.3%	2.5%	5.8%	4.9%
2014	4.4%	6.9%	11.4%	2.4%	5.8%	4.9%
2015	4.4%	7.0%	11.5%	2.4%	5.9%	5.0%
2016	4.6%	7.2%	11.6%	2.5%	6.1%	5.1%
2017	4.8%	7.4%	11.5%	2.4%	6.1%	5.1%
2018	4.7%	7.6%	11.7%	2.4%	6.1%	5.2%

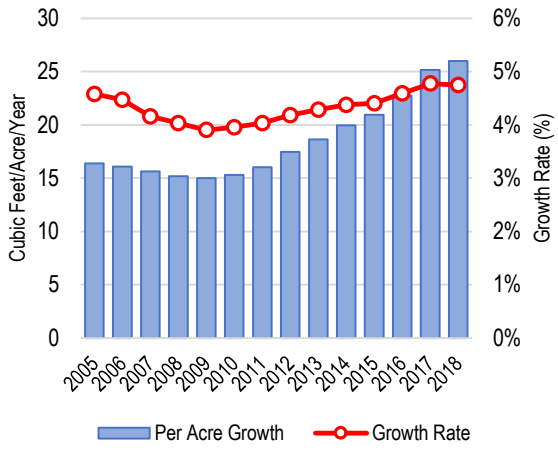
Source: USDA - US Forest Service

***Table 34**. Enviva Chesapeake Catchment Area - Average Per Acre Volume Growth by Major Timber Product (2005-2018)*

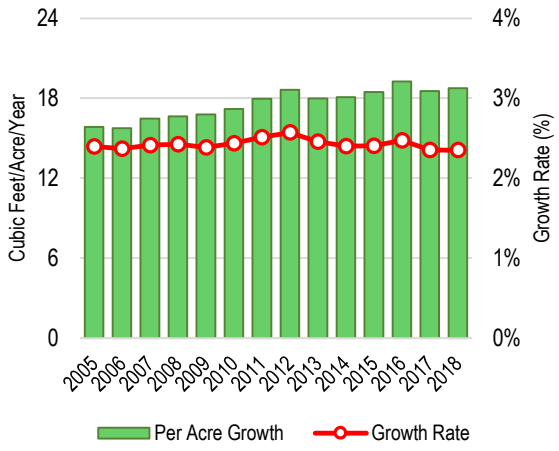
Year	Softwood			Hardwood		Total
	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	
	(Cubic Feet/Acre/Year)					
2005	16.4	14.9	23.9	15.8	12.2	83.3
2006	16.1	14.5	23.3	15.8	12.2	81.9
2007	15.6	14.0	22.8	16.5	12.3	81.2
2008	15.2	14.0	22.6	16.6	12.3	80.8
2009	15.0	14.2	22.8	16.8	12.3	81.1
2010	15.3	14.1	22.7	17.2	12.3	81.6
2011	16.0	14.9	24.0	18.0	12.3	85.1
2012	17.5	15.9	24.6	18.6	12.4	89.0
2013	18.6	16.3	25.1	18.0	12.7	90.8
2014	20.0	16.9	25.8	18.1	13.2	93.9
2015	21.0	17.6	26.1	18.5	13.8	96.9
2016	22.7	18.8	27.4	19.3	14.1	102.3
2017	25.2	20.3	27.5	18.5	14.5	106.0
2018	26.0	21.2	28.0	18.8	14.5	108.5

Source: USDA - US Forest Service

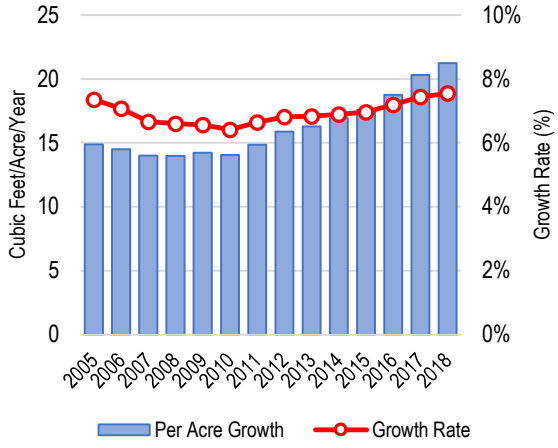
***Figure 41**. Enviva Chesapeake Catchment Area - Annual Growth Rates & Per-Acre Growth by Major Timber Product (2005-2018)*



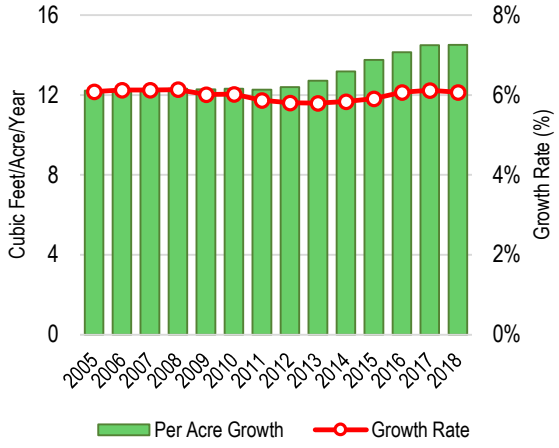
(a) Pine Sawtimber



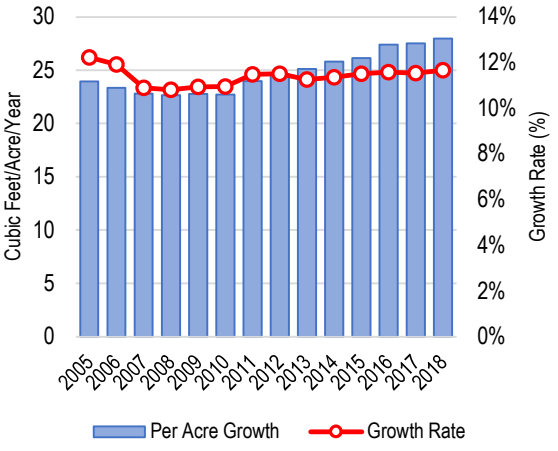
(d) Hardwood Sawtimber



(b) Pine Chip-n-saw



(e) Hardwood Pulpwood



(c) Pine Pulpwood

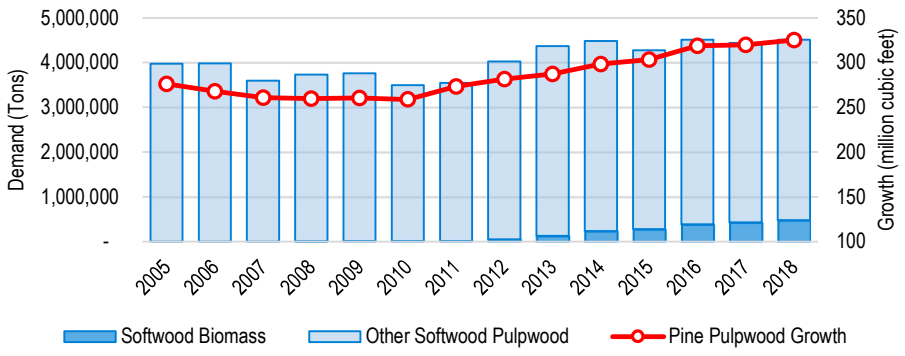
Correlation Analysis: *Biomass Demand vs. Timber Growth*

Figure 42(a) provides a side-by-side comparison of softwood pulpwood demand (including softwood biomass demand) and annual pine pulpwood growth in the catchment area from 2005-2018. This data shows softwood pulpwood demand and pine pulpwood growth have closely tracked one another since 2005. Correlation analysis confirmed this relationship, identifying a strong positive correlation (correlation coefficient=0.90) between these two from 2005-2018.

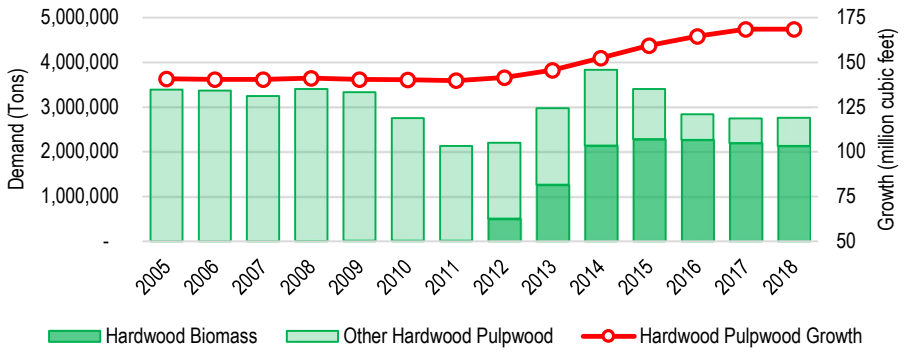
In Figure 42(b), no clear relationship stands out between hardwood pulpwood demand and hardwood pulpwood growth in the catchment area, and this lack of an identifiable relationship is confirmed by correlation analysis, which found no correlation (correlation coefficient=-0.05) between total hardwood pulpwood demand and hardwood pulpwood growth from 2005-2018. However, a direct relationship does appear present between hardwood biomass demand, specifically, and annual hardwood pulpwood growth. Correlation analysis confirmed this relationship, identifying a strong positive correlation (correlation coefficient=0.92) between these two sets of variables from 2005-2018.

We'd like to note that these results do not indicate that increases in pulpwood/biomass demand have caused increases in annual growth of pulpwood in the catchment area. These strong positive correlations appear to be more coincidental, not evidence of a causal relationship.

***Figure 42**. Enviva Chesapeake Catchment Area – Pulpwood Demand vs. Annual Pulpwood Growth (2005-2018)*



(a) Softwood Pulpwood Demand vs. Pine Pulpwood Growth



(b) Hardwood Pulpwood Demand vs. Hardwood Pulpwood Growth

US Forest Service data shows that annual growth of both pine and hardwood pulpwood held relatively steady from 2005-2010, after which annual growth started to increase at a much more rapid pace. Specifically, from 2010-2018, annual growth of pine pulpwood increased 26%, compared to a 20% increase for hardwood pulpwood.

Evidence suggests that these increases in annual timber growth are more directly linked to increased inventory levels – from increased timberland acreage as well as from persistent oversupply (growth in excess of removals). Specifically, annual growth of both pine and hardwood pulpwood were found to have a strong positive correlation to pine pulpwood inventory (correlation coefficient=0.92) and hardwood pulpwood inventory (correlation coefficient=0.96), respectively, from 2005-2018.

***Table 35**. Correlation Analysis –Biomass Demand, Pulpwood Demand & Annual Timber Growth (2005-2018)*

	Softwood Biomass Demand	*Other Softwood Pulpwood Demand*	*Total Softwood Pulpwood Demand*	*Pine Pulpwood Growth*	*Total Pine Growth*
Softwood Biomass Demand	1				
Other Softwood Pulpwood Demand	0.56	1			
Total Softwood Pulpwood Demand	0.84	0.92	1		
Pine Pulpwood Growth	0.97	0.67	0.90	1	
Total Pine Growth	0.98	0.62	0.87	0.99	1

	Hardwood Biomass Demand	*Other Hardwood Pulpwood Demand*	*Total Hardwood Pulpwood Demand*	*Hardwood Pulpwood Growth*	*Total Hardwood Growth*
Hardwood Biomass Demand	1				
Other Hardwood Pulpwood Demand	-0.90	1			
Total Hardwood Pulpwood Demand	0.07	0.37	1		
Hardwood Pulpwood Growth	0.92	-0.88	-0.05	1	
Total Hardwood Growth	0.93	-0.98	-0.27	0.93	1

	Softwood Biomass Demand	*Hardwood Biomass Demand*	*Total Biomass Demand*	*Total Pulpwood Growth*	*Total Growth*
Softwood Biomass Demand	1				
Hardwood Biomass Demand	0.94	1			
Total Biomass Demand	0.95	0.99	1		
Total Pulpwood Growth	0.99	0.94	0.95	1	
Total Growth	0.99	0.93	0.94	0.99	1

5.1.6 *Changes in Annual Removals*

According to the US Forest Service, timber removals totaled 857 million ft^3 in 2000, steadily increasing over the next five years and peaking at approximately 917 million ft^3 in 2005. Total removals proceeded to decline 30% over the nine years that followed, bottoming out at 639 million ft^3 in 2014. However, total removals increased 9% over the four years that followed, to an estimated 698 million ft^3 in 2018.

In terms of historical context, total annual removals averaged an estimated 867 million ft^3 per year through the 2000s. In comparison, total annual removals have averaged 679 million ft^3 per year in the 2010s (2010-2018), which was down approximately 22% compared to the average level of removals in the 2000s.

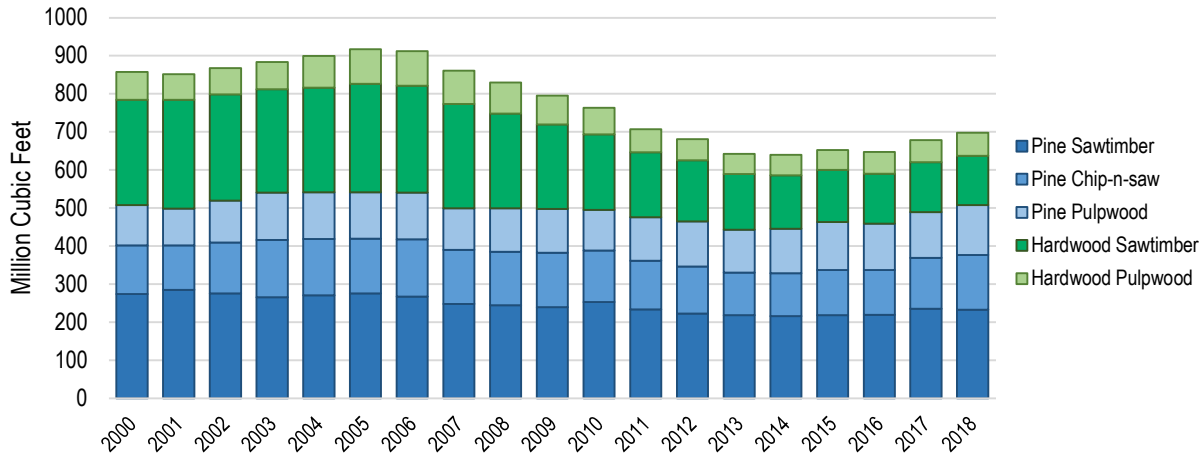
See Table 36 below for a breakdown of annual removal estimates by major timber product in the Enviva Chesapeake catchment area from 2000 through 2018.

***Table 36**. Enviva Chesapeake Catchment Area - Annual Removals by Major Timber Product (2000-2018)*

	Softwood			Hardwood		
Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	Total
			(Million Cubic Feet)			
2000	274	128	106	277	73	857
2001	285	117	97	285	67	851
2002	275	134	111	278	69	867
2003	266	150	125	271	72	884
2004	271	148	122	275	84	900
2005	276	144	122	285	90	917
2006	267	150	123	281	91	912
2007	248	142	110	274	87	861
2008	244	141	114	249	82	830
2009	239	143	115	222	76	795
2010	253	135	107	198	70	763
2011	233	128	114	171	60	707
2012	223	123	119	160	56	681
2013	219	112	112	147	52	642
2014	216	112	117	141	53	639
2015	219	119	125	138	52	653
2016	219	118	121	132	57	647
2017	235	133	120	131	58	678
2018	233	144	130	130	61	698

Source: USDA - US Forest Service

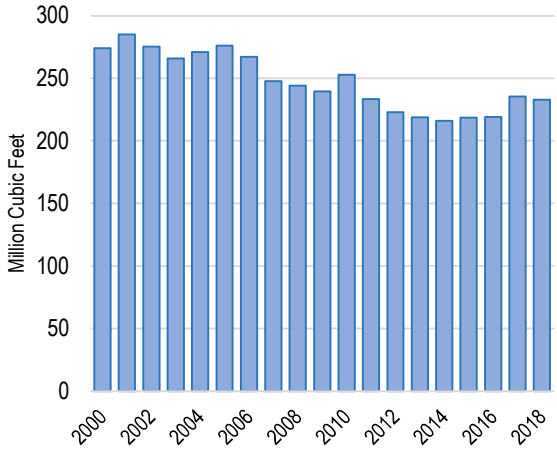
***Figure 43**. Enviva Chesapeake Catchment Area - Annual Removals by Year (2000-2018)*



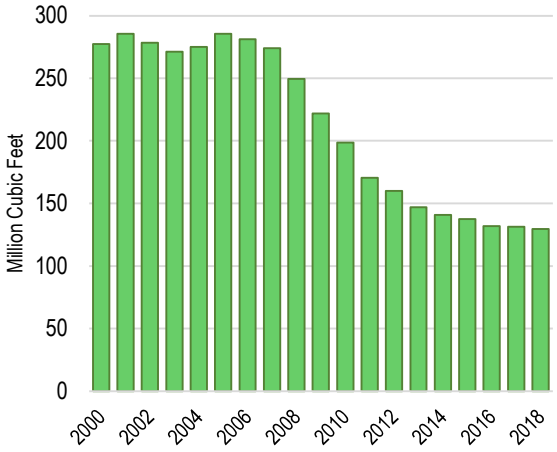
Annual removals of pine sawtimber and pine chip-n-saw (i.e. softwood sawlogs) fell a combined 22% from 420 million ft^3 in 2005 to 328 million ft^3 in 2014. However, removals of softwood sawlogs have steadily increased since that time and in 2018 totaled a combined 377 million ft^3, up 15% compared to 2014 levels. On the other hand, hardwood sawtimber removals declined 48% from a peak of 285 million ft^3 in 2005 to 147 million ft^3 in 2013. Removals of hardwood sawtimber have held relatively steady since, declining only slightly and averaging 136 million ft^3 per year since 2013.

Annual removals of pine pulpwood held relatively steady and averaged 116 million ft^3 per year from 2002-2010. However, since 2010, pine pulpwood removals have steadily increased at an average rate of 2.5% per year, to 130 million ft^3 in 2018. Removals of hardwood pulpwood, the other major bioenergy feedstock, peaked in 2006 at an estimated 91 million ft^3 before falling 42% over the seven years that followed, to 52 million ft^3 in 2013. Note that this decrease can be linked to both mill closures and weakening pulp/paper markets over this period. However, since 2013, hardwood pulpwood removals have increased 17%, to an estimated 61 million ft^3 in 2018.

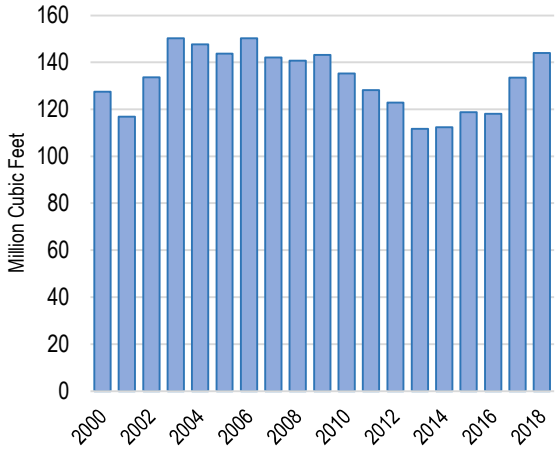
***Figure 44**. Enviva Chesapeake Catchment Area - Annual Removals by Major Timber Product (2000-2018)*



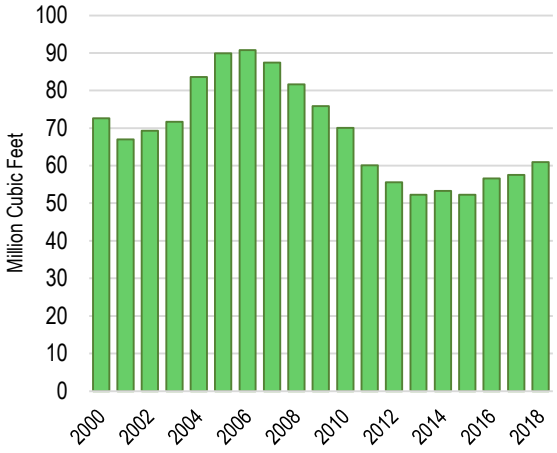
(a) Pine Sawtimber



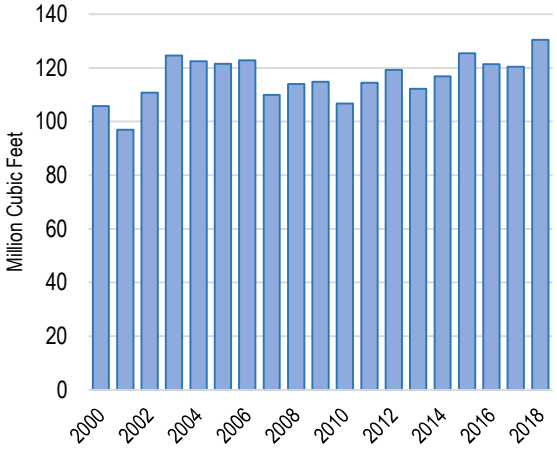
(d) Hardwood Sawtimber



(b) Pine Chip-n-saw



(e) Hardwood Pulpwood



(c) Pine Pulpwood

5.1.6.1 *Growth-to-Removals Ratios*

Recall that growth-to-removals analysis compares annual timber growth to annual harvests and provides a measure of market demand relative to supply. A growth-to-removals ratio of 1.0 indicates a balanced market where growth equals removals. A value of >1 indicates growth exceeds removals, signifying sustainable harvest levels (as well as oversupply). A value of <1 indicates removals (or harvest levels) exceed growth, signifying more highly competitive market conditions and harvest levels that are unsustainable over the long term.

According to US Forest Service data, growth-to-removals ratios for pine and hardwood pulpwood, the two primary bioenergy feedstocks, have both remained well above 1.0 in the catchment area since 2005, indicating that harvest levels have remained well below the sustainable yield capacity of the forest area. Growth-to-removals ratios have also remained above 1.0 for pine chip-n-saw since 2005.

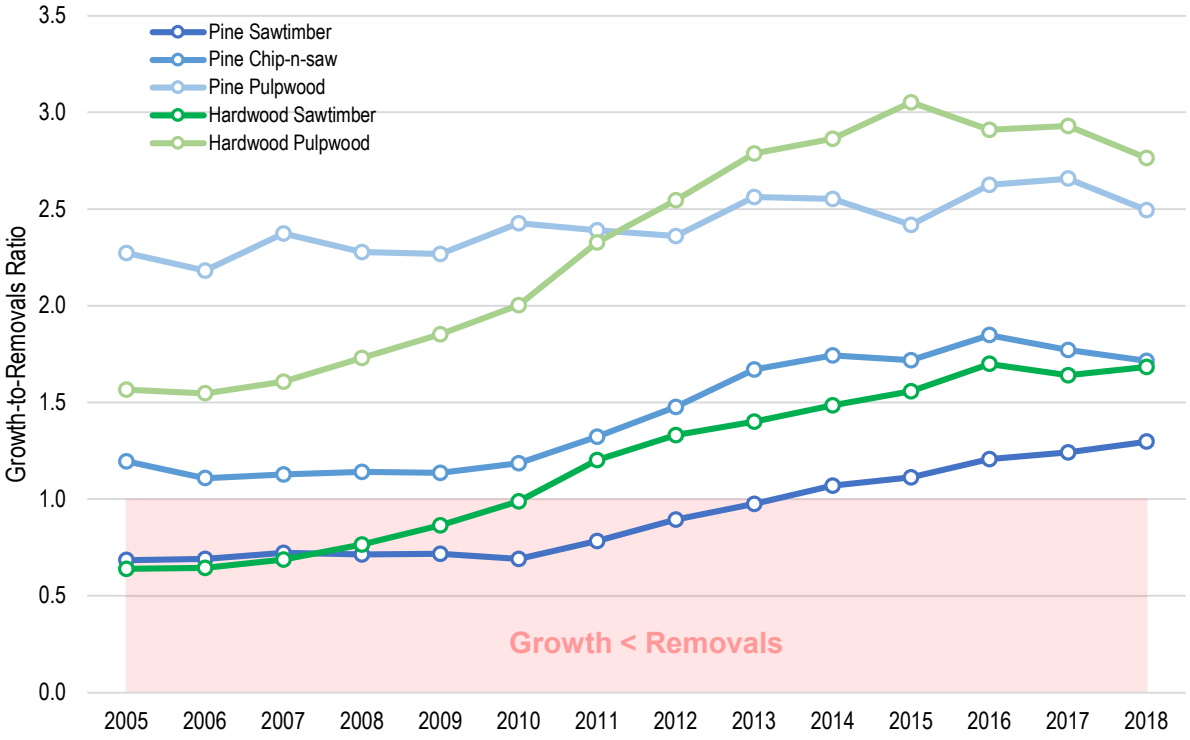
Unsustainable harvest levels had persisted in the catchment area for both pine and hardwood sawtimber, as growth-to-removals ratios fell below 1.0 from 2005-2013 for pine sawtimber and from 2005-2010 for hardwood sawtimber. However, reduced harvest levels through much of the 2010s allowed inventories to replenish, and since 2014, harvest levels have remained below the sustainable yield capacity of the forest area.

***Table 37**. Enviva Chesapeake Catchment Area – Growth-to-Removals Ratios (2005-2018)*

	Softwood			Hardwood		
Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	Total
			(Growth-to-Removals Ratio)			
2005	0.69	1.19	2.27	0.64	1.57	1.05
2006	0.69	1.11	2.18	0.64	1.55	1.03
2007	0.72	1.13	2.37	0.69	1.61	1.08
2008	0.71	1.14	2.28	0.76	1.73	1.12
2009	0.72	1.14	2.27	0.86	1.85	1.17
2010	0.69	1.19	2.43	0.99	2.00	1.22
2011	0.78	1.32	2.39	1.20	2.33	1.37
2012	0.89	1.48	2.36	1.33	2.55	1.49
2013	0.98	1.67	2.56	1.40	2.79	1.62
2014	1.07	1.74	2.55	1.49	2.86	1.70
2015	1.11	1.72	2.42	1.56	3.05	1.72
2016	1.21	1.85	2.63	1.70	2.91	1.84
2017	1.24	1.77	2.66	1.64	2.93	1.82
2018	1.30	1.72	2.49	1.68	2.76	1.81

Source: USDA - US Forest Service

***Figure 45**. Enviva Chesapeake Catchment Area – Growth-to-Removals Ratios by Major Timber Product (2005-2018)*

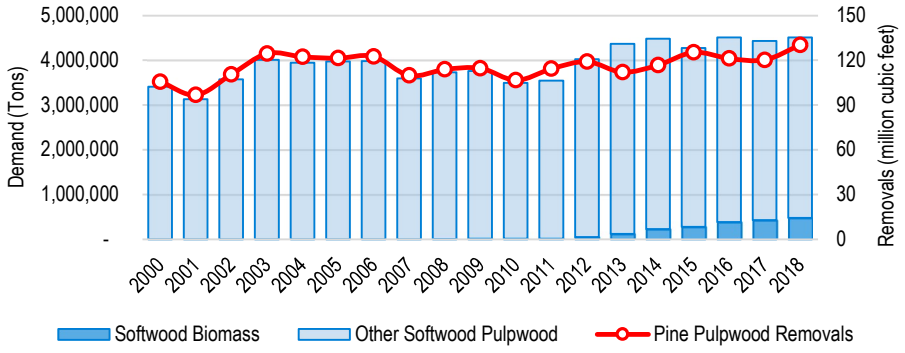


Correlation Analysis: *Biomass Demand vs. Timber Removals*

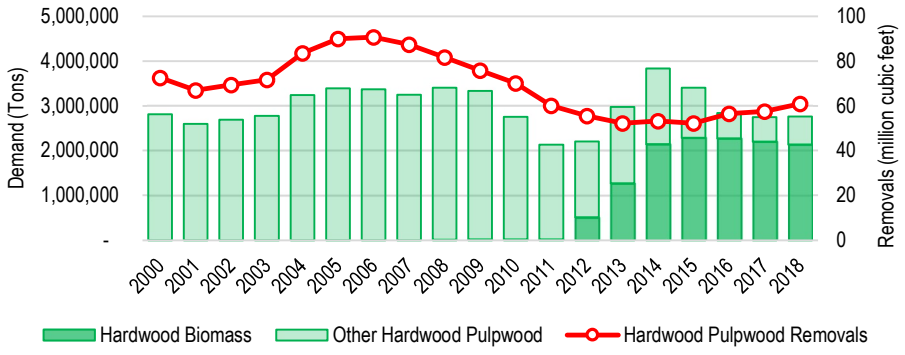
Figure 46 provides a side-by-side comparison of biomass demand and total pulpwood demand versus pulpwood removals in the catchment area from 2000-2018. Since pulpwood removals should be representative of pulpwood demand, we'd expected these two to be very strongly (positively) correlated, and that's exactly what this figure shows. Statistical analysis confirms this relationship, identifying a strong positive correlation (correlation coefficient=0.77) between softwood pulpwood demand and pine pulpwood removals in the catchment area over this period.

Note, however, that statistical analysis identified only a weak positive relationship between hardwood pulpwood demand and hardwood pulpwood removals (correlation coefficient=0.35). This is primarily due to the assumed hardwood pulpwood product specifications (5.0-10.0 inches DBH), as hardwood logs larger than this in diameter may be consumed and utilized as hardwood pulpwood. A more accurate comparison is total hardwood demand versus total hardwood removals, which statistical analysis found to be highly positively correlated (correlation coefficient=0.90).

***Figure 46**. Enviva Chesapeake Catchment Area – Pulpwood Demand vs. Annual Pulpwood Removals (2000-2018)*



(a) Softwood Pulpwood Demand vs. Pine Pulpwood Removals



(b) Hardwood Pulpwood Demand vs. Hardwood Pulpwood Removals

***Table 38**. Correlation Analysis –Biomass Demand, Pulpwood Demand & Annual Timber Removals (2000-2018)*

	Softwood Biomass Demand	*Other Softwood Pulpwood Demand*	*Total Softwood Pulpwood Demand*	*Pine Pulpwood Removals*	*Total Pine Removals*
Softwood Biomass Demand	1				
Other Softwood Pulpwood Demand	0.53	1			
Total Softwood Pulpwood Demand	0.79	0.94	1		
Pine Pulpwood Removals	0.51	0.78	0.77	1	
Total Pine Removals	-0.44	-0.26	-0.36	0.14	1

	Hardwood Biomass Demand	*Other Hardwood Pulpwood Demand*	*Total Hardwood Pulpwood Demand*	*Hardwood Pulpwood Removals*	*Total Hardwood Removals*
Hardwood Biomass Demand	1				
Other Hardwood Pulpwood Demand	-0.90	1			
Total Hardwood Pulpwood Demand	0.15	0.29	1		
Hardwood Pulpwood Removals	-0.72	0.85	0.35	1	
Total Hardwood Removals	-0.85	0.90	0.18	0.89	1

	Softwood Biomass Demand	*Hardwood Biomass Demand*	*Total Biomass Demand*	*Total Pulpwood Removals*	*Total Removals*
Softwood Biomass Demand	1				
Hardwood Biomass Demand	0.95	1			
Total Biomass Demand	0.96	0.99	1		
Total Pulpwood Removals	-0.26	-0.38	-0.37	1	
Total Removals	-0.71	-0.81	-0.80	0.69	1

***Table 39**. Enviva Chesapeake Catchment Area - Timber Inventory, Growth, Removals, & Mortality (2005-2018)*

Volume Category	Year	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood	Total
				Million Cubic Feet			
Inventory	2018	6,363	3,269	2,788	9,275	2,779	24,475
	2017	6,121	3,173	2,775	9,156	2,756	23,981
	2016	5,759	3,034	2,751	9,052	2,710	23,307
	2015	5,517	2,929	2,636	8,912	2,700	22,693
	2014	5,274	2,841	2,626	8,707	2,611	22,059
	2013	4,982	2,729	2,554	8,385	2,512	21,161
	2012	4,767	2,662	2,445	8,271	2,437	20,582
	2011	4,528	2,552	2,381	8,166	2,382	20,011
	2010	4,409	2,499	2,364	8,047	2,331	19,650
	2009	4,392	2,477	2,381	8,037	2,335	19,622
	2008	4,314	2,427	2,402	7,873	2,301	19,317
	2007	4,298	2,405	2,395	7,814	2,294	19,206
	2006	4,126	2,352	2,248	7,642	2,293	18,661
	2005	4,130	2,335	2,259	7,615	2,315	18,654
Growth	2018	302	247	325	218	169	1,261
	2017	292	236	320	215	169	1,233
	2016	264	218	319	224	165	1,190
	2015	243	204	303	214	160	1,124
	2014	231	196	298	209	152	1,086
	2013	213	187	287	206	146	1,039
	2012	199	181	281	213	142	1,016
	2011	183	170	273	205	140	971
	2010	174	160	259	196	140	930
	2009	172	163	260	192	140	927
	2008	174	160	260	191	141	926
	2007	179	160	261	189	140	929
	2006	184	167	268	181	140	940
	2005	189	172	276	183	141	960
Removals	2018	233	144	130	130	61	698
	2017	235	133	120	131	58	678
	2016	219	118	121	132	57	647
	2015	219	119	125	138	52	653
	2014	216	112	117	141	53	639
	2013	219	112	112	147	52	642
	2012	223	123	119	160	56	681
	2011	233	128	114	171	60	707
	2010	253	135	107	198	70	763
	2009	239	143	115	222	76	795
	2008	244	141	114	249	82	830
	2007	248	142	110	274	87	861
	2006	267	150	123	281	91	912
	2005	276	144	122	285	90	917
Mortality	2018	26	22	36	78	26	188
	2017	24	20	37	77	26	184
	2016	24	22	34	69	25	174
	2015	29	21	32	65	24	170
	2014	31	23	31	64	25	174
	2013	34	23	30	62	25	173
	2012	37	25	32	63	25	182
	2011	39	28	36	64	25	192
	2010	44	29	38	72	25	209
	2009	50	31	41	78	25	225
	2008	49	31	41	76	25	221
	2007	49	31	41	75	25	221
	2006	47	30	38	74	25	213
	2005	47	30	38	74	25	214

Source: USDA - US Forest Service

5.1.7 *Changes in Raw Material Costs*

Historically, raw material purchases at Enviva Pellets Ahoskie, Enviva Pellets Northampton, and Enviva Pellets Southampton have included a combination of pulpwood (roundwood), pulp quality chips, and sawmill residuals. However, in this section, pine and hardwood sawtimber prices are also examined to assess how these prices have changed and trended in the catchment area since 2000.

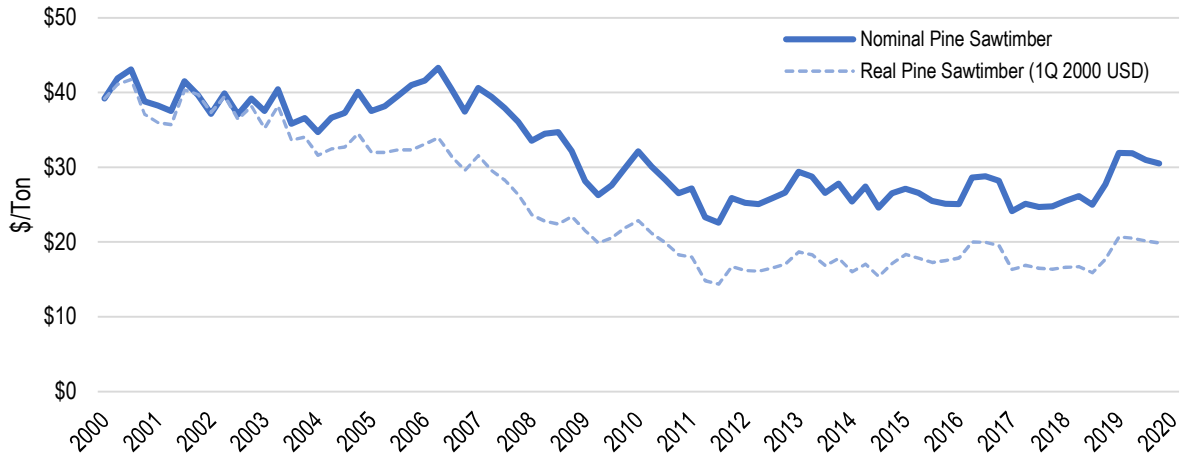
Note that all prices have been provided by TimberMart-South and, unless otherwise stated, are specific to the Enviva Chesapeake catchment area. Also, historic quarterly raw material prices are provided in tabular form in Appendix A.

5.1.7.1 *Stumpage Prices*

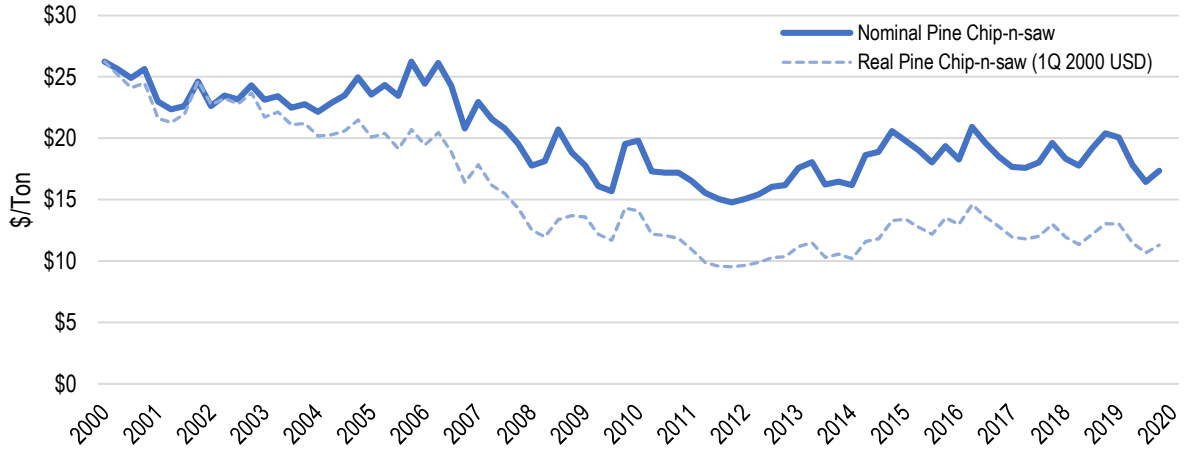
Trends/changes with nominal stumpage prices in the catchment area since 2000 are as follows:

- Pine Sawtimber Stumpage. Pine sawtimber stumpage prices held relatively steady and averaged nearly $39 per ton from 1Q 2000-2Q 2006. However, after peaking at $43.31 per ton in 2Q 2006, pine sawtimber prices proceeded to decline nearly 50% over the five years that followed, bottoming out at $22.60 per ton in 3Q 2011. Prices rebounded modestly over the next two years but since 2013 have held more-or-less flat and averaged just over $27 per ton.
- Pine Chip-n-saw Stumpage. Pine chip-n-saw stumpage prices have followed a trend very similar to that of pine sawtimber stumpage, holding steady from 2000-2006 ($23.92 per ton average) before declining 43% over the five years that followed – and bottoming out $14.78 per ton in 4Q 2011. Pine chip-n-saw prices have improved modestly over the two years that followed but since 2013 have held relatively steady and averaged $18.44 per ton.
- Pine Pulpwood Stumpage. Pine pulpwood stumpage prices held steady through the 2000s and early 2010s, averaging $7.70 per ton from 1Q 2000 through 3Q 2012. However, prices proceeded to increase 70% over the next four years, peaking at $15.28 per ton in 2Q 2016. Pine pulpwood stumpage prices have come down slightly since but have averaged $13.31 per ton since 1Q 2017.
- Hardwood Sawtimber Stumpage. Hardwood sawtimber stumpage prices held steady and averaged $20.24 per ton from 1Q 2000 through 2Q 2012. However, prices increased more than 80% over the 11 quarters that followed, peaking at $33.16 per ton in 2Q 2015. Hardwood sawtimber prices have come down slightly but have held relatively steady and averaged greater than $29 per ton since.
- Hardwood Pulpwood Stumpage. Hardwood pulpwood stumpage prices steadily increased through the 2000s and early 2010s, increasing at an average rate of 4.1% per year from $2.79 per ton in 1Q 2000 to $4.88 per ton in 4Q 2013. Prices increased 34% the following quarter and from 1Q 2015 through 1Q 2016 averaged $6.81 per ton. However, hardwood pulpwood prices fell to $5.30 per ton in 2Q 2016 and proceeded to hold steady and average roughly $4.40 per ton through 2Q 2018. Prices started to rebound in the second half of 2018 and in 2019 averaged $6.50 per ton, up nearly 50% from 2016-2018 levels.

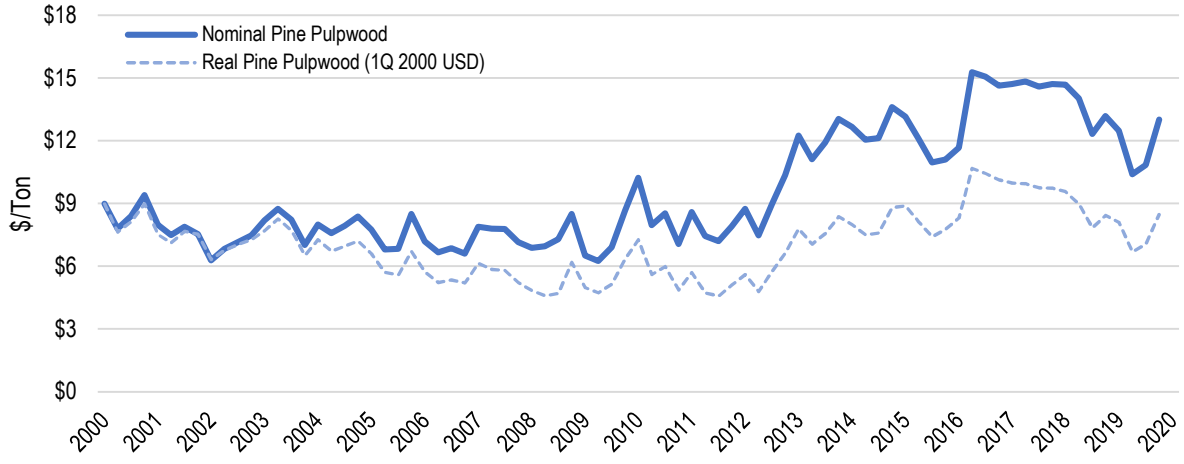
***Figure 47**. Enviva Chesapeake Catchment Area – Nominal & Real Quarterly Pine Stumpage Prices ($/Ton)*



(a) Pine Sawtimber Stumpage

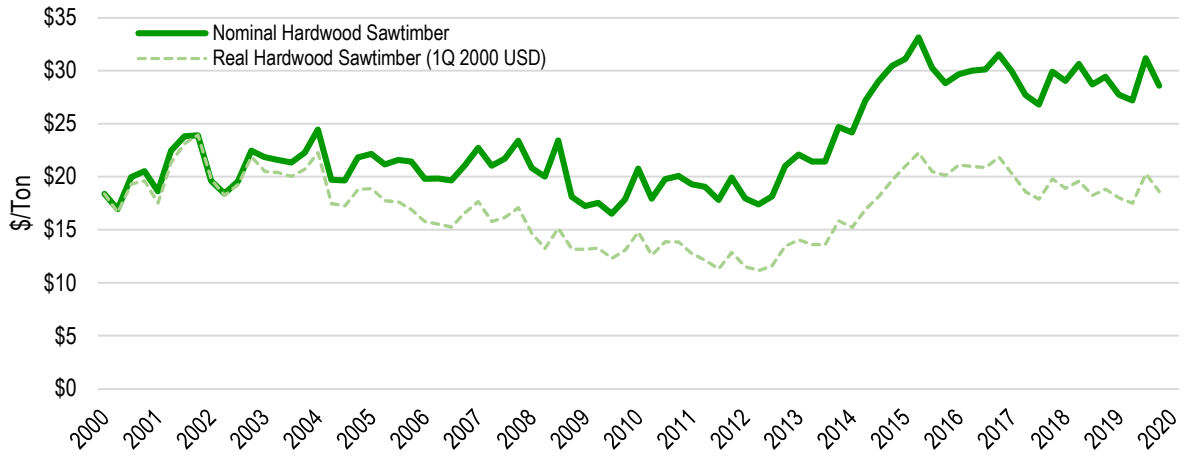


(b) Pine Chip-n-saw Stumpage

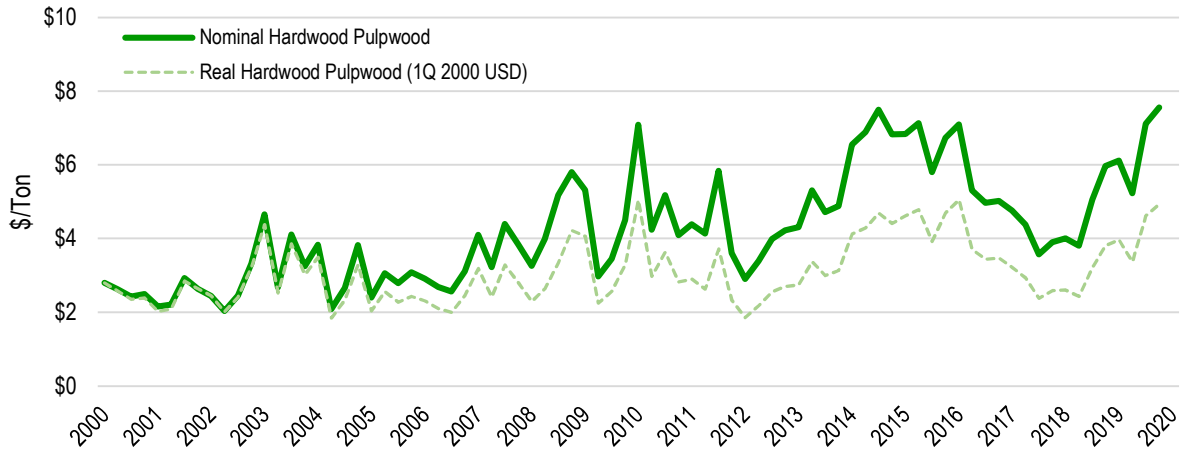


(c) Pine Pulpwood Stumpage

***Figure 48**. Enviva Chesapeake Catchment Area – Nominal & Real Quarterly Hardwood Stumpage Prices ($/Ton)*



(a) Hardwood Sawtimber Stumpage



(b) Hardwood Pulpwood Stumpage

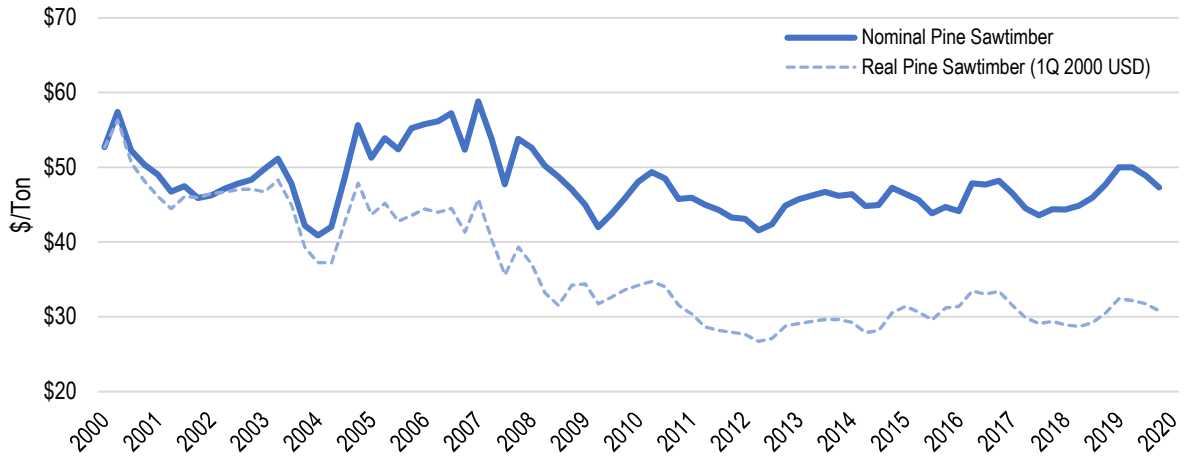
5.1.7.2 *Delivered Sawtimber Prices*

Delivered prices are those paid for timber delivered to the mill. These prices include stumpage (standing timber) price plus any costs associated with cutting, loading, and hauling timber to the mill.

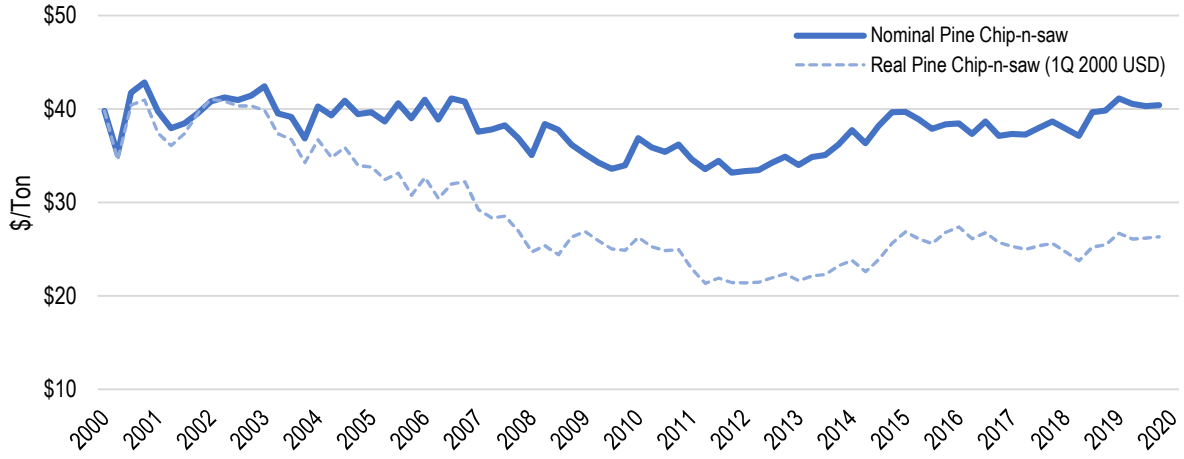
Trends/changes with nominal delivered sawtimber prices in the catchment area since 2000 are as follows:

- Delivered Pine Sawtimber. Delivered pine sawtimber prices experienced a bit of volatility through the early to mid-2000s before ultimately peaking in 1Q 2007 at nearly $59 per ton. However, prices fell 29% over the nine quarters that followed, to below $42 per ton in 2Q 2009. Prices have held relatively steady and trended slightly upwards since that time, increasing at an average annual rate of 1.5% to over $49 per ton in 2019.
- Delivered Pine Chip-n-saw. Delivered pine chip-n-saw prices also experienced some volatility in the early to mid-2000s but ultimately averaged nearly $40 per ton from 2000-2006. Prices proceeded to fall 18% over the five years that followed, bottoming out at just over $33 per ton in 4Q 2011. However, delivered pine chip-n-saw prices rebounded over the next three years and have averaged nearly $39 per ton since 4Q 2014 (and averaging more than $40 per ton in 2019).
- Delivered Hardwood Sawtimber. Delivered hardwood sawtimber prices steadily increased from $31.45 per ton in 1Q 2000 to $36.50 per ton in 2Q 2012, increasing at an average rate of 1.2% per year over this more than 12-year period. However, prices proceeded to increase 54% over the three years that followed, peaking at more than $56 per ton in 2Q 2015. Delivered hardwood sawtimber prices have come down slightly since, stabilizing and averaging nearly $51 per ton since 1Q 2016.

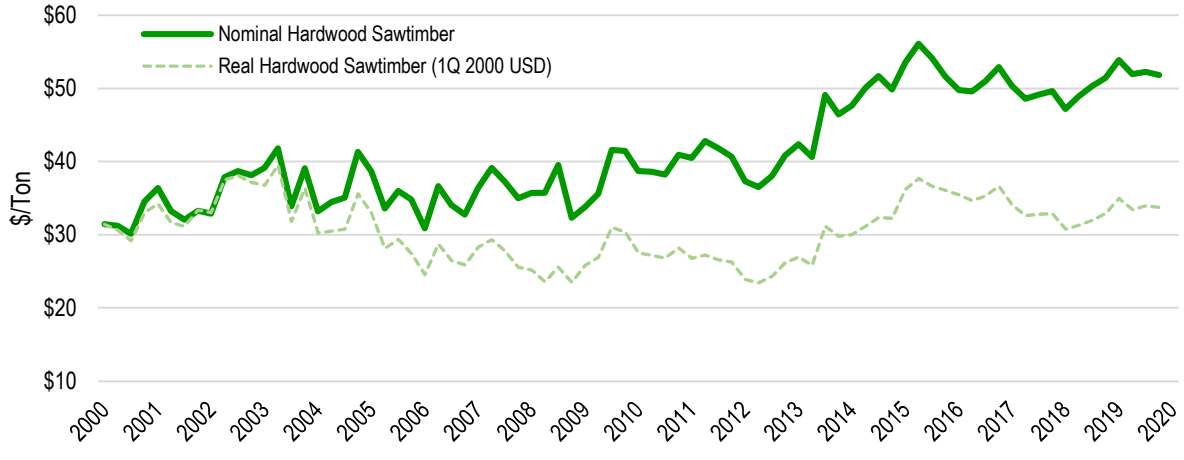
***Figure 49**. Enviva Chesapeake Catchment Area - Nominal & Real Quarterly Delivered Sawtimber Prices ($/Ton)*



(a) Delivered Pine Sawtimber



(b) Delivered Pine Chip-n-saw



(c) Delivered Hardwood Sawtimber

5.1.7.3 *Delivered Pulpwood Prices*

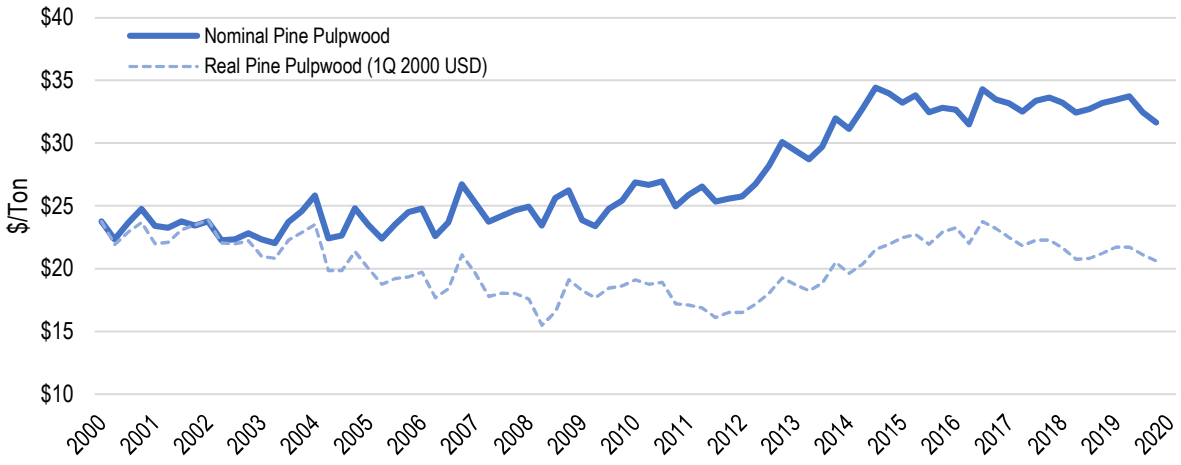
Prices for delivered pine and hardwood pulpwood closely tracked one another from 2000-2015, with pine pulpwood averaging a 15% premium over hardwood pulpwood over this period. However, beginning in 2016, prices started to diverge, as delivered pine pulpwood prices held steady while delivered hardwood pulpwood prices started to fall. Delivered hardwood pulpwood prices rebounded in late 2018 and since that time have more closely tracked those of delivered pine pulpwood, albeit at a lower level.

Trends/changes with nominal delivered pulpwood prices since 2000 are as follows:

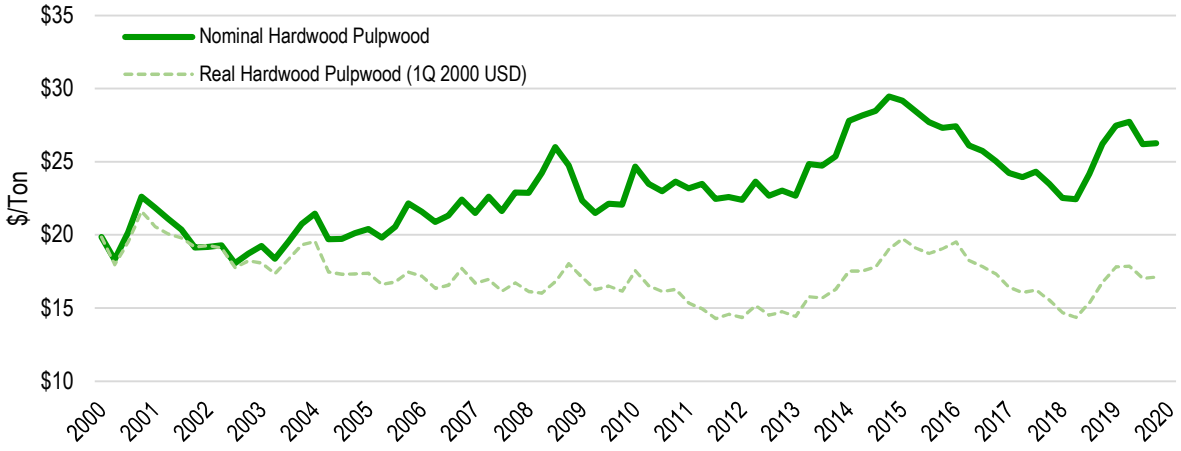
- Delivered Pine Pulpwood. Delivered pine pulpwood prices steadily increased at an average rate of 0.7% per year from $23.75 per ton in 1Q 2000 to $25.76 per ton in 1Q 2012. However, prices proceeded to increase 34% over the 10 quarters that followed, to $34.43 per ton in 3Q 2014. Delivered pine pulpwood prices have held steady since, averaging just over $33 per ton for the last five-plus years.
- Delivered Hardwood Pulpwood. Like with pine pulpwood, delivered hardwood pulpwood prices steadily increased through the 2000s and early 2010s, increasing at an average rate of 1.0% per year from $19.86 per ton in 1Q 2000 to $22.67 per ton in 1Q 2013. Prices started to increase rapidly thereafter and by 4Q 2014 had reached $29.46 per ton – a 30% increase in less than two years. However, delivered hardwood pulpwood prices proceeded to fall 24% over the next 14 quarters, bottoming out at $22.43 per ton in 2Q 2018. Prices started to rebound in the second half of 2018 and in 2019 averaged $26.91 per ton, up 20% from 2Q 2018 levels.

Figure 50 on the following page shows historic nominal and real delivered pulpwood prices in the Enviva Chesapeake catchment area since 2000. The corresponding prices are provided in tabular form in Appendix A.

***Figure 50**. Enviva Chesapeake Catchment Area - Nominal & Real Quarterly Delivered Pulpwood Prices ($/Ton)*



(a) Delivered Pine Pulpwood



(b) Delivered Hardwood Pulpwood

5.1.7.4 *Pulp Quality Chip & Sawmill Residual Prices*

Pulpwood quality chips (FOB point of production) include both pine and hardwood sawmill chips (sawmill residuals) and pine and hardwood chip mill chips. Trends/changes with nominal chip and sawmill residual prices since 2000 are as follows:

- Pine Sawmill Chips (Sawmill Residuals). Pine sawmill chip prices declined in the early 2000s and reached as low as $18.76 per ton in 2Q 2002. However, prices proceeded to increase 60% (+7% per year average) over the next seven years, to $29.94 per ton in 1Q 2009. Pine sawmill chip prices fell rapidly through the remainder of 2009 and by 1Q 2010 had fallen to $22.68 per ton, or a 24% decrease is just a 1-year period. Prices then resumed to increase at an average rate of 5.6% per year over the five years that followed, to $30.43 per ton in 2Q 2015. Pine sawmill chip prices have since stabilized and averaged just over $30 per ton over the last 19 quarters.

- Pine Chip Mill Chips. Pine chip mill chip prices steadily increased at an average rate of 4.0% per year from $23.88 per ton in 2Q 2002 to $39.22 per ton in 4Q 2014. Prices have come down slightly since but have held relatively steady and averaged $37.69 per ton over the last five years.

  Note that pine chip mill chip prices have remained above those of pine sawmill chips since 2000. Specifically, pine chip mill chip prices have averaged a roughly 30% premium over pine sawmill chip prices since 2000.

- Hardwood Sawmill Chips (Sawmill Residuals). Prices for hardwood sawmill chips increased at an average rate of 2.1% per year from the 20-year low of $18.25 per ton in 2Q 2002 to $23.27 per ton in 1Q 2014. Prices increased 30% over the seven quarters that followed, to $30.34 per ton in 4Q 2015. However, hardwood sawmill chip prices fell 14% from 3Q 2016 to 4Q 2016 and over the two years that followed averaged $25.38 per ton. Prices have rebounded a bit since and in 2019 averaged $28.44 per ton.

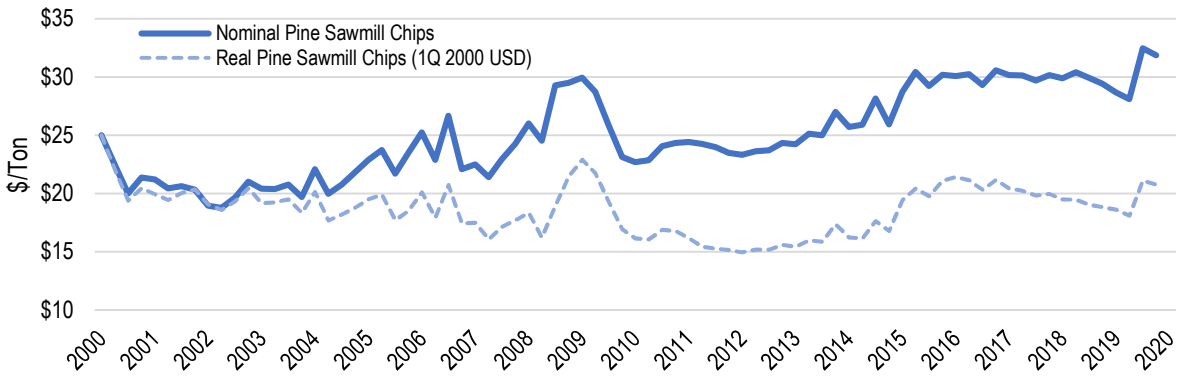
- Hardwood Chip Mill Chips. Prices for hardwood chip mill chips have trended similarly to those of hardwood sawmills chips. Specifically, prices increased at an average rate of 2.8% per year from $25.50 per ton in 1Q 2001 to $37.22 per ton in 4Q 2014. However, hardwood chip mill chip prices started to decline shortly thereafter and by 4Q 2016 had fallen to $33.33 per ton. Prices held steady and averaged approximately $33 per ton over the two years that followed before rebounding and averaging more than $36 per ton in 2019.

  Note that prices of hardwood chip mill chips have historically remained above those of hardwood sawmill chips, with hardwood chip mill chip prices averaging a 34% premium over hardwood sawmill chip prices since 2000.

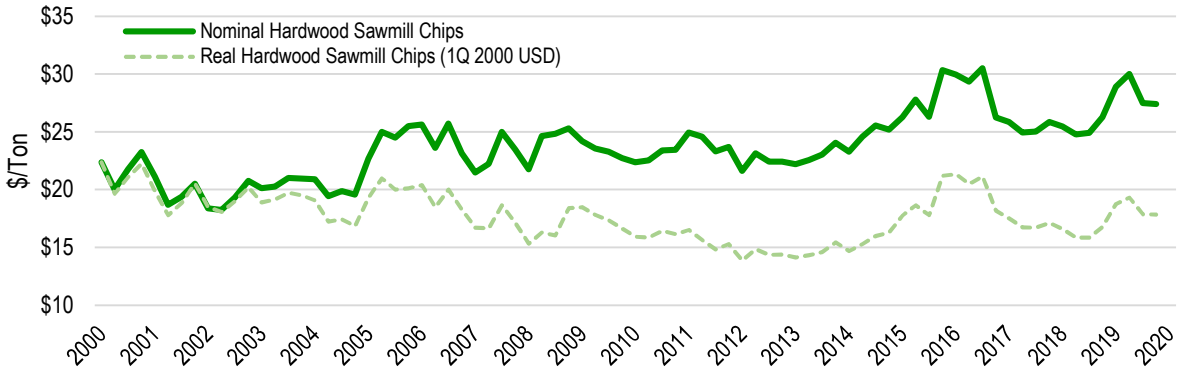
In addition, we'd like to note that pine prices have historically been higher than hardwood prices, with pine sawmill and chip mill chip prices averaging a 6% and 3% premium, respectively, over hardwood sawmill and chip mill chip prices since 2000. However, these premiums have averaged 10% and 8%, respectively, since 2012.

See Figure 51 on the following page for historic pulp quality chip prices in the Enviva Chesapeake catchment area since 2000. The corresponding prices are provided in tabular form in Appendix A.

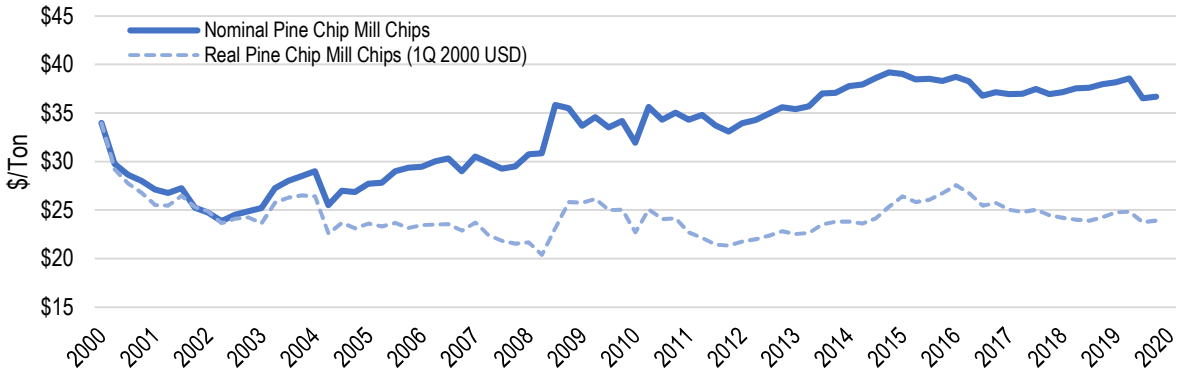
***Figure 51**. Enviva Chesapeake Catchment Area - Nominal & Real Quarterly Pulp Quality Chip Prices ($/Ton)*



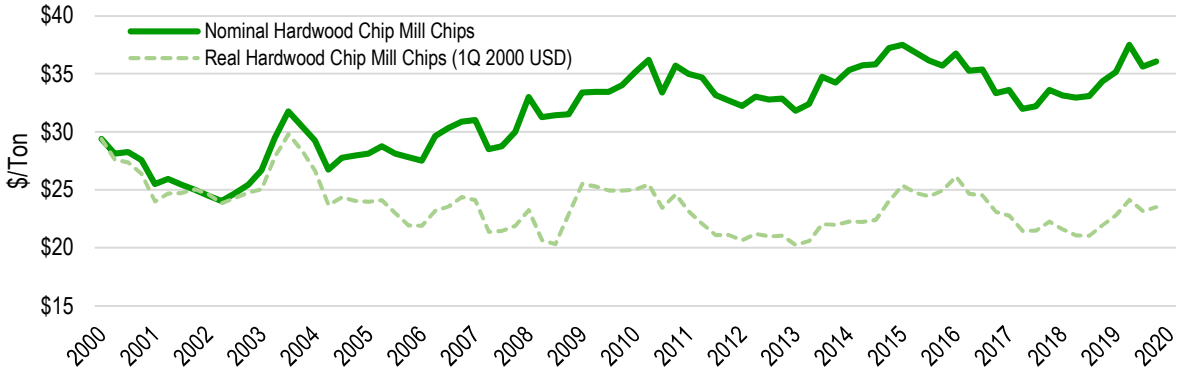
(a) Pine Sawmill Chips



(b) Hardwood Sawmill Chips



(c) Pine Chip Mill Chips



(d) Hardwood Chip Mill Chips

Correlation Analysis: *Biomass Demand vs. Raw Material Costs*

Historically, raw material purchases at Enviva Pellets Ahoskie, Enviva Pellets Northampton, and Enviva Pellets Southampton have included a combination of softwood and hardwood pulpwood (roundwood), pulp quality chips, and sawmill residuals. Specifically, softwood species have constituted 13% of all raw materials consumed by these mills since 2012, compared to 87% hardwood species.

Figure 52 provides a side-by-side comparison of softwood biomass demand and total softwood pulpwood demand versus delivered pine pulpwood, pine sawmill chip, and pine chip mill chip prices in the catchment area from 2000-2019. Intuitively, we'd expect to see prices and demand moving in the same direction, and that's what we see in this figure, particularly since around 2008.

Correlation analysis confirms these direct relationships, identifying strong positive correlations between softwood pulpwood demand and delivered pine pulpwood prices (correlation coefficient=0.83), pine sawmill chip prices (correlation coefficient=0.73), and pine chip mill chip prices (correlation coefficient=0.69). The same strong positive correlations are also found between softwood biomass demand and these raw material prices.

***Figure 52**. Enviva Chesapeake Catchment Area – Softwood Pulpwood Demand vs. Delivered Pine Pulpwood, Pine Sawmill Chip, & Pine Chip Mill Chip Prices (2000-2019)*

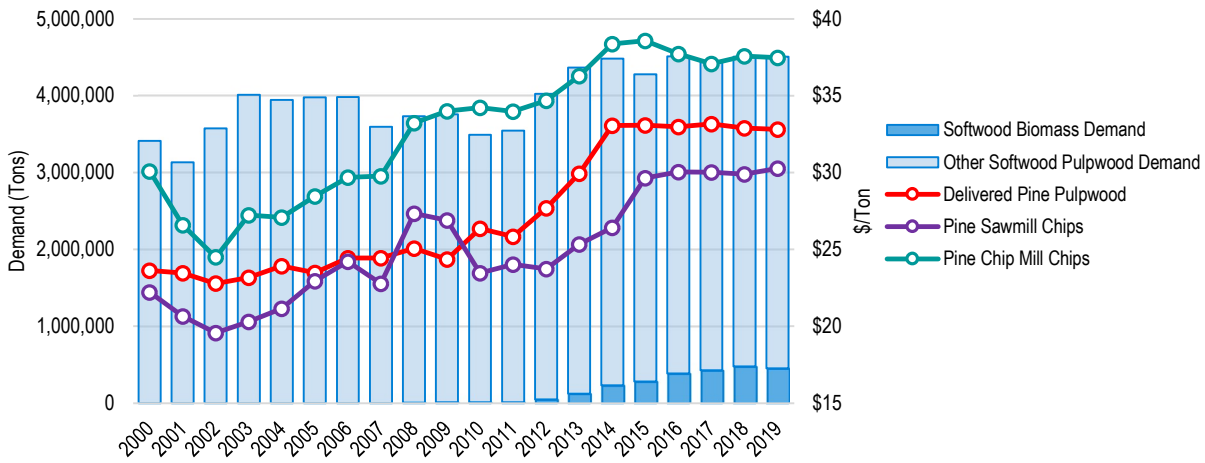


***Table 40**. Correlation Analysis – Softwood Biomass Demand, Delivered Pine Pulpwood Price, Pine Sawmill Chip Price & Pine Chip Mill Chip Price (2000-2019)*

	Softwood Biomass Demand	Other Softwood Pulpwood Demand	Total Softwood Pulpwood Demand	Delivered Pine Pulpwood Price	Pine Sawmill Chip Price	Pine Chip Mill Chip Price
Softwood Biomass Demand	1					
Other Softwood Pulpwood Demand	0.55	1				
Total Softwood Pulpwood Demand	0.81	0.94	1			
Delivered Pine Pulpwood Price	0.92	0.63	0.83	1		
Pine Sawmill Chip Price	0.85	0.53	0.73	0.86	1	
Pine Chip Mill Chip Price	0.75	0.54	0.69	0.90	0.89	1

Hardwood Pulpwood & Hardwood Chip Prices

Figure 53 provides a side-by-side comparison of hardwood pulpwood demand and hardwood raw material costs in the catchment area since 2000. Looking at this figure, raw material costs have tracked demand fairly closely since around 2010. However, prior to that, the relationships appear much weaker. Statistical analysis confirms what we see, identifying only weak positive correlations between hardwood pulpwood demand and hardwood raw material costs from 2000-2019. However, analysis of both of hardwood biomass demand and non-biomass hardwood pulpwood demand versus hardwood raw material costs provides much greater insight.

Specifically, correlation analysis identified strong positive correlations between hardwood biomass demand and delivered hardwood pulpwood prices (correlation coefficient=0.81), hardwood sawmill chip prices (correlation coefficient=0.74), and hardwood chip mill chip prices (correlation coefficient=0.68) from 2000-2019. Conversely, moderately strong negative correlations were found between other hardwood pulpwood demand and delivered hardwood pulpwood prices (correlation coefficient=-0.66), hardwood sawmill chip prices (correlation coefficient=-0.64), and hardwood chip mill chip prices (correlation coefficient=-0.61) over this same period. See Table 41. However, these results are heavily influenced by the lack of hardwood biomass-related wood demand from 2000-2007 (and marginal levels of hardwood biomass demand from 2008-2011).

***Figure 53**. Enviva Chesapeake Catchment Area – Hardwood Pulpwood Demand vs. Delivered Hardwood Pulpwood, Hardwood Sawmill Chip, & Hardwood Chip Mill Chip Prices (2000-2019)*

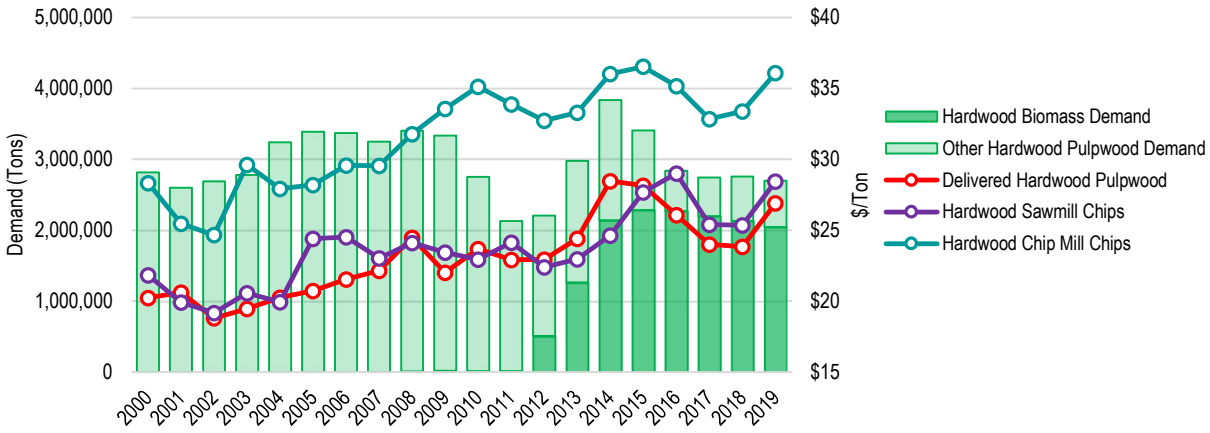


***Table 41**. Correlation Analysis – Hardwood Biomass Demand, Delivered Hardwood Pulpwood Price, Hardwood Sawmill Chip Price & Hardwood Chip Mill Chip Price (2000-2019)*

	Hardwood Biomass Demand	Other Hardwood Pulpwood Demand	Total Hardwood Pulpwood Demand	Delivered Hardwood Pulpwood Price	Hardwood Sawmill Chip Price	Hardwood Chip Mill Chip Price
Hardwood Biomass Demand	1					
Other Hardwood Pulpwood Demand	-0.91	1				
Total Hardwood Pulpwood Demand	0.10	0.32	1			
Delivered Hardwood Pulpwood Price	0.81	-0.66	0.26	1		
Hardwood Sawmill Chip Price	0.74	-0.64	0.17	0.80	1	
Hardwood Chip Mill Chip Price	0.68	-0.61	0.08	0.88	0.77	1

Results of the statistical analysis are quite different when we examine demand and raw material prices from 2013 (the first year all three Enviva pellet mills were operating) through 2019. Specifically, correlation analysis identified only weak positive correlations between delivered hardwood pulpwood price and both hardwood biomass demand (correlation coefficient=0.37) and other hardwood pulpwood demand (correlation coefficient=0.36) from 2013-2019. Similar results were found between hardwood chip mill chip prices and both hardwood biomass and other hardwood pulpwood demand over this same period (see Table 42). However, moderately strong to strong correlations were found between total hardwood pulpwood demand and both delivered hardwood pulpwood price (correlation coefficient=0.75) and hardwood chip mill chip price (correlation coefficient=0.55) from 2013-2019.

Ultimately, the significant increase in hardwood raw material costs from 2012 through 2014 coincided with a substantial increase in hardwood biomass demand (attributed to the startup Enviva's three pellet mills), and the link between the two appears obvious. However, further evidence suggests that changes in hardwood prices since 2012 are linked to changes in total hardwood pulpwood demand, not demand attributed to bioenergy alone. Furthermore, the results of this analysis taken together with our understanding of the laws of supply and demand are suggestive of a causal relationship. That is, increases (decreases) in hardwood pulpwood demand, to some degree, are responsible for increases (decreases) in hardwood raw material costs in the Enviva Chesapeake catchment area.

***Table 42**. Correlation Analysis – Hardwood Biomass Demand, Delivered Hardwood Pulpwood Price, Hardwood Sawmill Chip Price & Hardwood Chip Mill Chip Price (2013-2019)*

	Hardwood Biomass Demand	Other Hardwood Pulpwood Demand	Total Hardwood Pulpwood Demand	Delivered Hardwood Pulpwood Price	Hardwood Sawmill Chip Price	Hardwood Chip Mill Chip Price
Hardwood Biomass Demand	1					
Other Hardwood Pulpwood Demand	-0.59	1				
Total Hardwood Pulpwood Demand	0.11	0.74	1			
Delivered Hardwood Pulpwood Price	0.37	0.36	0.75	1		
Hardwood Sawmill Chip Price	0.67	-0.65	-0.24	0.39	1	
Hardwood Chip Mill Chip Price	0.42	0.16	0.55	0.96	0.59	1

Sawtimber Prices

Pine and hardwood sawtimber prices were also examined to assess the impact biomass demand has had on markets for other solid wood products. Specifically, Figure 54 provides a side-by-side comparison of biomass demand versus delivered pine sawtimber, pine chip-n-saw, and hardwood sawtimber prices in the catchment area from 2000-2019.

Looking at this figure, no discernable relationship is apparent between biomass demand and both delivered pine sawtimber prices and delivered pine chip-n-saw prices. However, delivered hardwood sawtimber prices have closely tracked biomass demand, particularly since 2012. Correlation analysis confirms what we see in Figure 54, identifying no (or a weak negative) correlation between biomass demand and both delivered pine sawtimber prices (correlation coefficient=-0.39) and delivered pine chip-n-saw prices (correlation coefficient=0.07). However, a strong positive correlation was identified between biomass demand and delivered hardwood sawtimber prices (correlation coefficient=0.95).

Note that the strong positive correlation found between biomass demand and delivered hardwood sawtimber prices appears much more coincidental in nature, not indicative of a causal relationship. Increases in hardwood sawtimber prices have occurred across the US South since 2013, and these price increases are largely due to increases in both domestic consumption of hardwood products and foreign demand of US hardwood logs and lumber.

***Figure 54**. Enviva Chesapeake Catchment Area – Biomass Demand vs. Delivered Pine Sawtimber, Pine Chip-n-saw, & Hardwood Sawtimber Prices (2000-2019)*

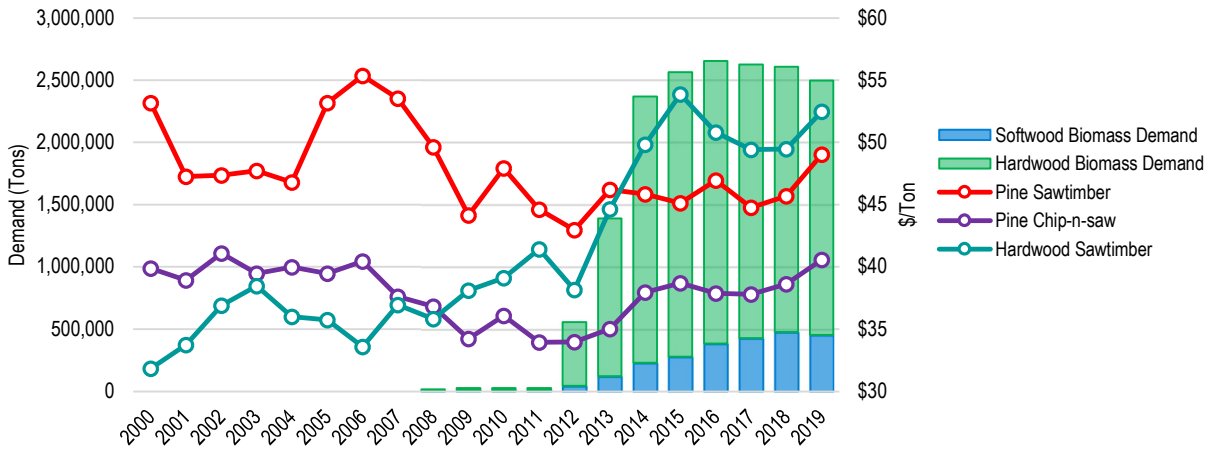


***Table 43**. Correlation Analysis –Biomass Demand & Delivered Sawtimber Prices (2000-2019)*

	Softwood Biomass Demand	Hardwood Biomass Demand	Total Biomass Demand	Delivered Pine Sawtimber	Delivered Pine Chip-n-saw	Delivered Hardwood Sawtimber
Softwood Biomass Demand	1					
Hardwood Biomass Demand	0.94	1				
Total Biomass Demand	0.96	0.99	1			
Delivered Pine Sawtimber	-0.33	-0.40	-0.39	1		
Delivered Pine Chip-n-saw	0.13	0.06	0.07	0.54	1	
Delivered Hardwood Sawtimber	0.90	0.95	0.95	-0.49	-0.05	1

5.2 Market Outlook: 2020-2022

There have been several announcements related to mill openings and closings in the Enviva Chesapeake catchment area that stand to impact this market moving forward. These include:

- Active Energy Group (AEG) announced in the 4th Quarter of 2019 the startup of its softwood lumber mill at its facility in Lumberton NC. The sawmill is a joint venture with Renewable Logistics Systems LLC and will manufacture railroad ties as well as wood chips for other operations. Annual production capacity has not been disclosed.

  The company also nears completion of its CoalSwitch biomass plant, which the company expects to be fully operational in early 2020. This facility will utilize residuals and other wood residues in combination with other feedstock options (e.g. chicken litter and miscanthus grass) for production of its black pellets and other CoalSwitch products.

  The AEG Lumberton facility is located approximately 160 miles southwest of Enviva Pellets Northampton in Robeson County, North Carolina. Given the facility's location, only a marginal amount of additional wood demand is expected to be placed on the Enviva Chesapeake catchment area due to these startups.

- Cascades Inc. announced plans to invest $275 million to convert the Bear Island VA facility it purchased from White Birch Paper in 2018 to recycled linerboard production by the end of 2021. Once the conversion is complete, the facility is expected to have a production capacity of 400,000 tons per year of recycled linerboard.

  The Bear Island facility is located approximately 100 miles north of Enviva Pellets Southampton in Hanover County, Virginia. The mill will primarily utilize recycled containerboard to produce its linerboard. Given this and the facility's location, we anticipate no significant increase in wood demand placed on the Enviva Chesapeake catchment area as a result of the conversion.

- Enviva announced in mid-2019 that the expansion projects at its Northampton NC and Southampton VA pellet facilities were underway and expected to be completed in the first half of 2020. The two expansion projects are expected to increase combined pellet capacity at these two facilities by 400,000 metric tons per year. In addition, the environmental permit received from the Virginia Department of Environmental Quality on November 20th, 2019, allows for the increased consumption of pine (softwood) at the Southampton facility.

  The increased production associated with these expansion projects are expected to add 800,000 tons per year of additional roundwood demand on the Enviva Chesapeake catchment area.

- Teal-Jones announced plans to invest more than $31 million to expand production and dry kiln capacity at its two southern pine sawmills located in Kinsale VA and Martinsville VA. The two mills currently have a combined production capacity of 125 million bf of lumber per year. The company has yet to disclose anticipated production capacity following the investment.

  The Kinsale facility is located approximately 140 miles north of Enviva Pellets Southampton in Westmoreland County, Virginia. The Martinsville facility is located approximately 150 miles west of Enviva Pellets Northampton in Henry County, Virginia. The increased production associated with these expansion projects are expected to add 15,000-25,000 tons per year of additional roundwood demand on the Enviva Chesapeake catchment area.

5.2.1 *Wood Demand Outlook*

Based on the announcements highlighted on the previous page and other expected production changes, we anticipate total wood demand in the Enviva Chesapeake catchment area to increase an estimated 4.1% from 2019 to 2022, due in large part to Enviva's expansion projects at its Northampton NC and Southampton VA pellet mills.

Demand for softwood and hardwood sawlogs is forecasted to increase a combined 1.8% from 2019-2022, compared to an 10% increase in softwood and hardwood pulpwood demand over this same period. Specifically, with Enviva's anticipated production increases, biomass-related wood demand is projected to increase 32% from 2.5 million tons in 2019 to 3.3 million tons in 2022. Softwood and hardwood biomass demand are forecasted to increase 120% and 13%, respectively, over this period.

***Table 44**. Enviva Chesapeake Catchment Area - Projected Wood Demand (2019-2022)*

Product	2019	2020	2021	2022
	Catchment Area – Annual Wood Demand (Tons)			
Sawlogs:				
Softwood	12,964,324	13,048,592	13,172,554	13,238,416
Hardwood	5,874,464	5,909,711	5,933,349	5,945,216
Total Sawlogs	18,838,788	18,958,303	19,105,903	19,183,632
Pulpwood:				
Softwood	4,508,807	4,685,684	4,962,078	5,039,449
Hardwood	2,698,426	2,725,410	2,806,627	2,883,529
Total Pulpwood	7,207,233	7,411,094	7,768,705	7,922,978
Total	**26,046,021**	**26,369,396**	**26,874,608**	**27,106,611**

**projected*

***Table 45**. Enviva Chesapeake Catchment Area – Projected Biomass & Total Pulpwood Demand (2019-2022)*

Product	2019	2020	2021	2022
	Catchment Area – Pulpwood Demand (Tons)			
Biomass Demand:				
Softwood Biomass	452,101	633,034	913,481	994,901
Hardwood Biomass	2,044,118	2,133,418	2,218,253	2,301,302
Total Biomass	**2,496,219**	**2,766,452**	**3,131,734**	**3,296,203**
Other Pulpwood Demand:				
Other Softwood Pulpwood	4,056,706	4,052,649	4,048,597	4,044,548
Other Hardwood Pulpwood	654,308	591,992	588,374	582,227
Total Other Pulpwood	**4,711,014**	**4,644,641**	**4,636,971**	**4,626,775**
Total Pulpwood Demand:				
Total Softwood Pulpwood	4,508,807	4,685,684	4,962,078	5,039,449
Total Hardwood Pulpwood	2,698,426	2,725,410	2,806,627	2,883,529
Total Pulpwood	**7,207,233**	**7,411,094**	**7,768,705**	**7,922,978**

**projected*

***Figure 55**. Enviva Chesapeake Catchment Area - Projected Wood Demand (2019 – 2022)*

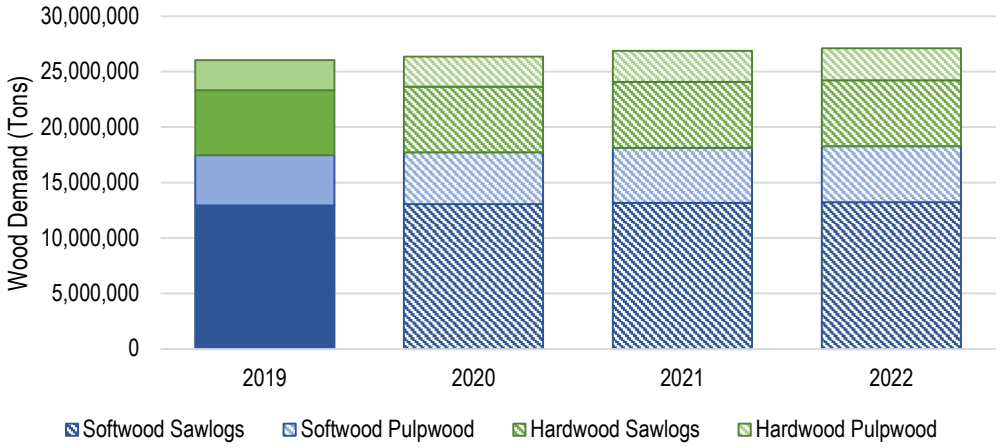
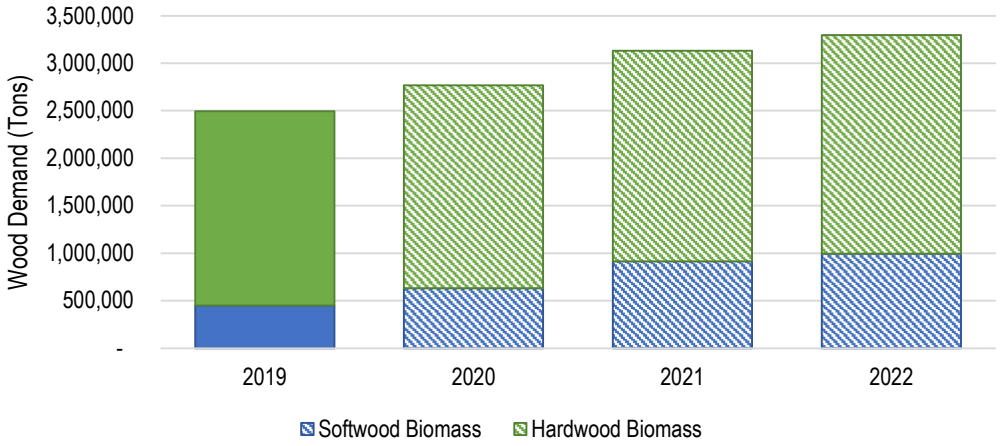


***Figure 56**. Enviva Chesapeake Catchment Area - Projected Biomass Demand (2019 – 2022)*



5.2.2 *Raw Material Price Outlook*

Raw material purchases for Enviva Pellets Ahoskie, Enviva Pellets Northampton, and Enviva Pellets Southampton have historically included a mix of both pine and hardwood pulpwood (roundwood), chips, and sawmill residuals. Specifically, roundwood constituted 36% of the total raw material purchases for these three mills in 2019, compared to 51% chips and 13% other wood residues (e.g. sawdust, shavings, and bark).

In 2019, pine (softwood) constituted only 25% of Enviva's total wood purchases. However, with the expansion projects at Enviva's Northampton and Southampton pellet mills, that species mix is projected to increase to 30% pine versus 70% hardwood by 2022.

Since pine pulpwood (roundwood) and pine chips are expected to account for a majority of the pine purchases for these three mills over the next several years, our pine price forecasts focus specifically on delivered pine pulpwood, pine sawmill chips, and pine chip mill chips. Forecasts include:

- Delivered Pine Pulpwood. Based on our analysis of raw material prices in the catchment area, including anticipated changes in biomass demand and total softwood pulpwood demand moving forward, we forecast a 9% increase in delivered pine pulpwood prices from 2019 through 2022. Overall, delivered pine pulpwood prices are forecasted to average $34.89 per ton from 2020-2022, up 6% (+$2.07 per ton) from the 2019 average of $32.82 per ton.
- Pine Sawmill Chips. Pine sawmill chip prices are forecasted to increase more than 6% from $30.28 per ton in 2019 to $32.25 per ton in 2022. Overall, pine sawmill chip prices are forecasted to average $31.70 per ton from 2020-2022, up 5% (+$1.42 per ton) from the 2019 average.
- Pine Chip Mill Chips. Pine chip mill chip prices are forecasted to increase 7% from $37.49 per ton in 2019 to $40.10 per ton in 2022. Overall, pine chip mill chip prices are forecasted to average $39.38 per ton from 2020-2022, up 5% (+$1.89 per ton) from the 2019 average.

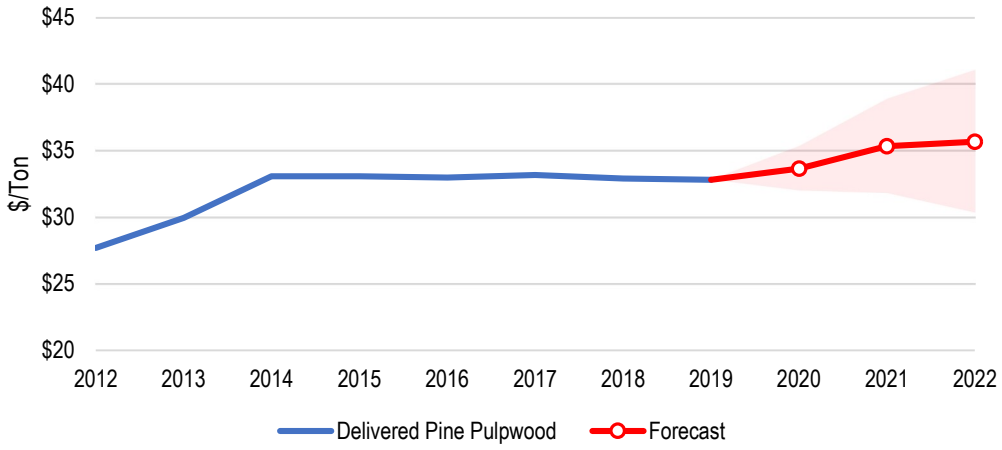
***Table 46**. Forecasted Delivered Pine Pulpwood, Pine Sawmill Chip, & Pine Chip Mill Chip Prices (2020-2022)*

Year	Delivered Pine Pulpwood	Pine Sawmill Chips	Pine Chip Mill Chips
		($/Ton)	
2000	23.62	22.22	30.09
2001	23.46	20.64	26.59
2002	22.79	19.58	24.50
2003	23.17	20.31	27.24
2004	23.92	21.15	27.09
2005	23.48	22.94	28.46
2006	24.44	24.22	29.69
2007	24.45	22.77	29.78
2008	25.07	27.33	33.23
2009	24.36	26.91	34.00
2010	26.36	23.47	34.22
2011	25.83	24.04	33.98
2012	27.69	23.74	34.69
2013	29.95	25.34	36.30
2014	33.06	26.43	38.38
2015	33.07	29.65	38.59
2016	32.98	30.05	37.73
2017	33.17	30.03	37.09
2018	32.90	29.91	37.57
2019	32.82	30.28	37.49
2020	33.66	30.83	38.25
2021	35.33	32.01	39.78
2022	35.68	32.25	40.10

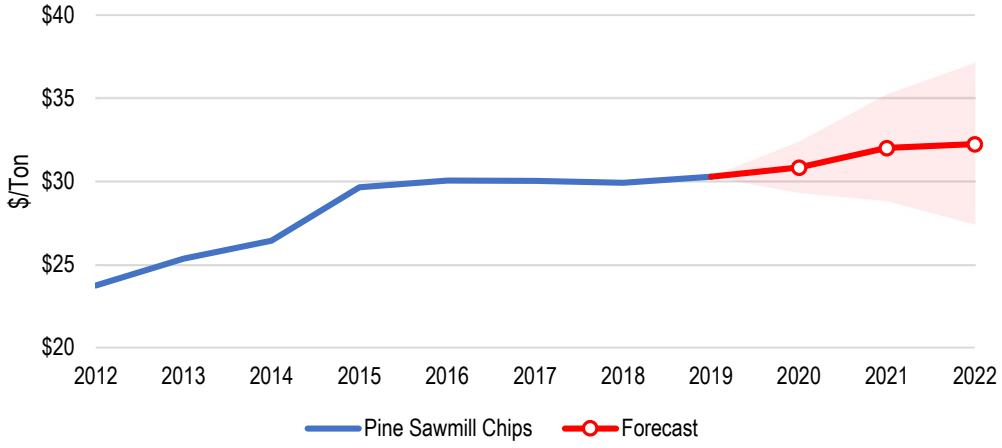
**forecasted*

Note that forecasted values are based on Hood Consulting's assessment of historical prices as well as assumptions regarding future wood demand in the Enviva Chesapeake catchment area.

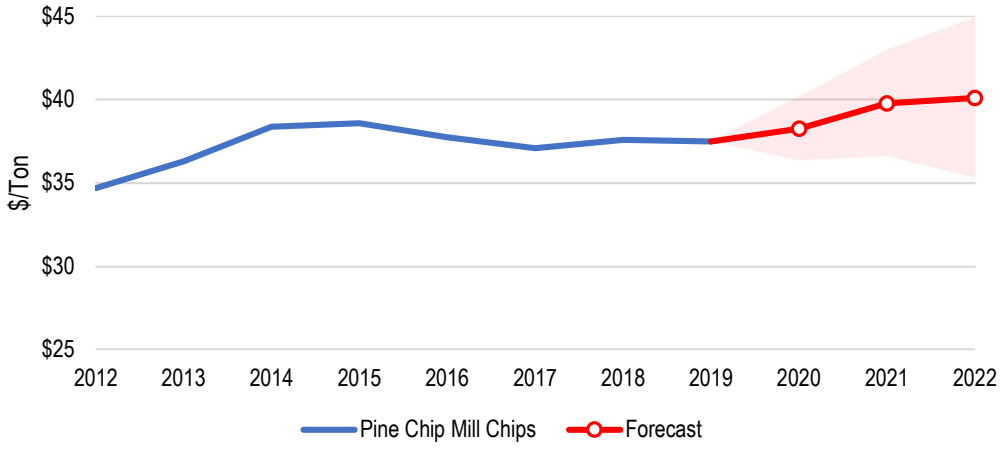
***Figure 57**. Price Forecast: Delivered Pine Pulpwood, Pine Sawmill Chips, & Pine Chip Mill Chips (2020-2022)*



(a) Delivered Pine Pulpwood



(b) Pine Sawmill Chips



(c) Pine Chip Mill Chips

Similarly, hardwood raw material purchases for these three Enviva pellet mills have historically included a combination of hardwood pulpwood (roundwood), chips, and other residuals. Specifically, our hardwood price forecasts focus specifically on hardwood pulpwood and hardwood chips, which are expected to continue to account for a majority of the hardwood purchases for these three mills over the next several years. Forecasts include:

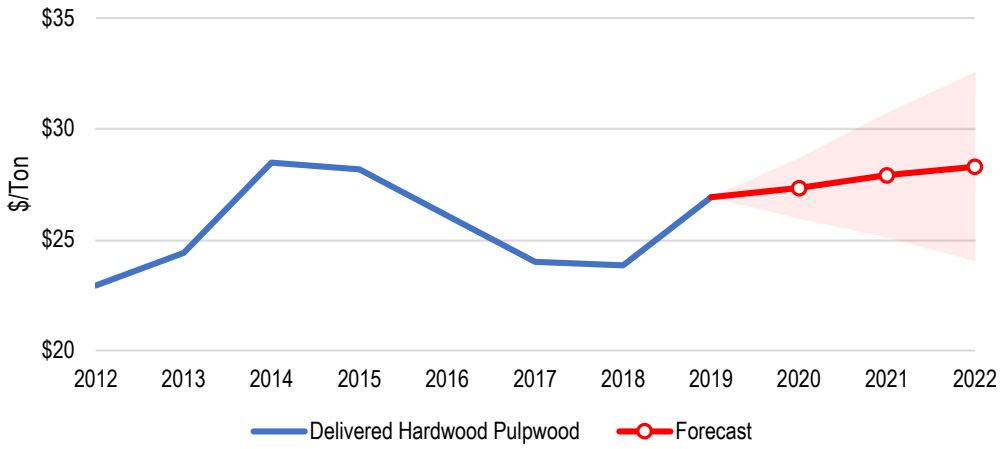
- Delivered Hardwood Pulpwood. Based on our analysis of raw material prices in the catchment area, including anticipated changes in biomass demand and total hardwood pulpwood demand moving forward, we forecast delivered hardwood pulpwood prices to increase 5% from $26.91 per ton in 2019 to $28.30 per ton in 2022. Overall, delivered hardwood pulpwood prices are forecasted to average $27.71 per ton from 2020-2022, up 3% (+$0.93 per ton) from the 2019 average.
- Hardwood Sawmill Chips. Hardwood sawmill chip prices are forecasted to increase more than 5% from $28.44 per ton in 2019 to $29.82 per ton in 2022. Overall, hardwood sawmill chip prices are forecasted to average $29.32 per ton from 2020-2022, up 3% (+$0.88 per ton) from the 2019 average.
- Hardwood Chip Mill Chips. Hardwood chip mill chip prices are forecasted to increase 4% from $36.09 per ton in 2019 to $37.51 per ton in 2022. Overall, hardwood chip mill chip prices are forecasted to average $36.94 per ton from 2020-2022, up 2% (+$0.86 per ton) from the 2019 average.

***Table 47**. Forecasted Delivered Hardwood Pulpwood, Hardwood Sawmill Chip, & Hardwood Chip Mill Chip Prices (2020-2022)*

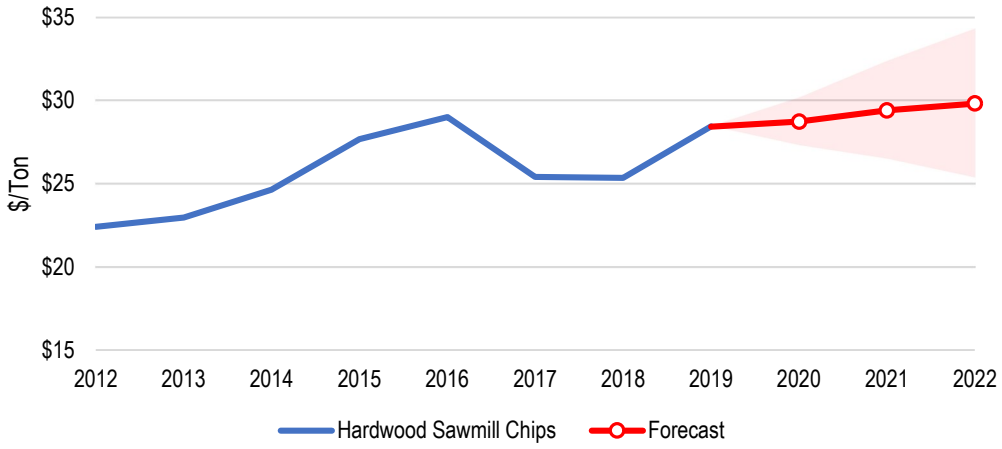
Year	Delivered Hardwood Pulpwood	Hardwood Sawmill Chips	Hardwood Chip Mill Chips
		($/Ton)	
2000	20.23	21.84	28.33
2001	20.62	19.92	25.47
2002	18.81	19.17	24.67
2003	19.47	20.58	29.61
2004	20.25	19.94	27.92
2005	20.73	24.41	28.20
2006	21.55	24.52	29.58
2007	22.16	23.04	29.56
2008	24.47	24.12	31.79
2009	22.01	23.44	33.57
2010	23.69	22.94	35.12
2011	22.93	24.13	33.88
2012	22.93	22.40	32.73
2013	24.40	22.96	33.30
2014	28.47	24.64	36.02
2015	28.16	27.67	36.55
2016	26.08	29.01	35.18
2017	23.99	25.41	32.85
2018	23.83	25.34	33.38
2019	26.91	28.44	36.09
2020	27.33	28.73	36.28
2021	27.91	29.41	37.04
2022	28.30	29.82	37.51

**forecasted*

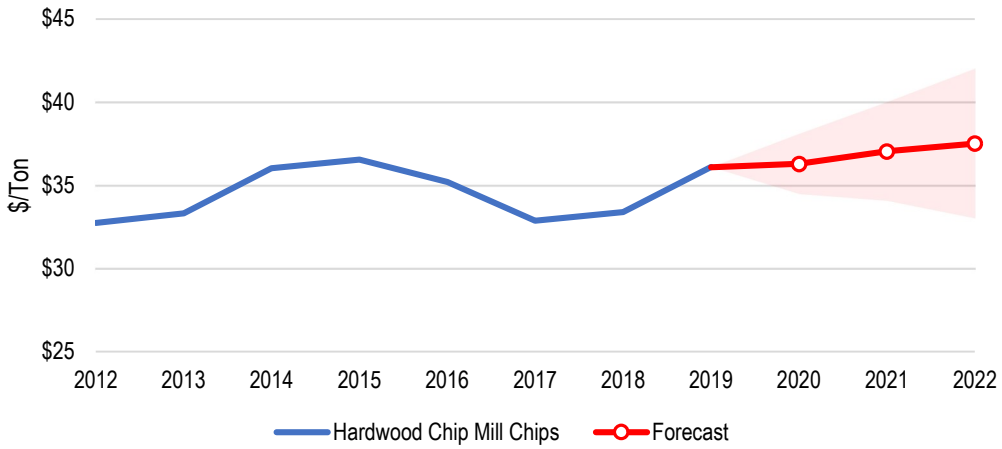
***Figure 58**. Price Forecast: Delivered Hardwood Pulpwood, Hardwood Sawmill Chips, & Hardwood Chip Mill Chips (2020-2022)*



(a) Delivered Hardwood Pulpwood



(b) Hardwood Sawmill Chips



(c) Hardwood Chip Mill Chips

Table 48 provides a cost index (2019=100) that shows Enviva's historic and forecasted per unit raw material costs from 2012 through 2022. These index values are based on Enviva's specific species and product mix, as well as the respective product price, are intended to show how average per unit raw material costs have changed and are projected to change for Enviva over the next several years. Note that these index calculations are not based on actual raw material costs incurred by Enviva, but rather average market prices for the Enviva Chesapeake catchment area.

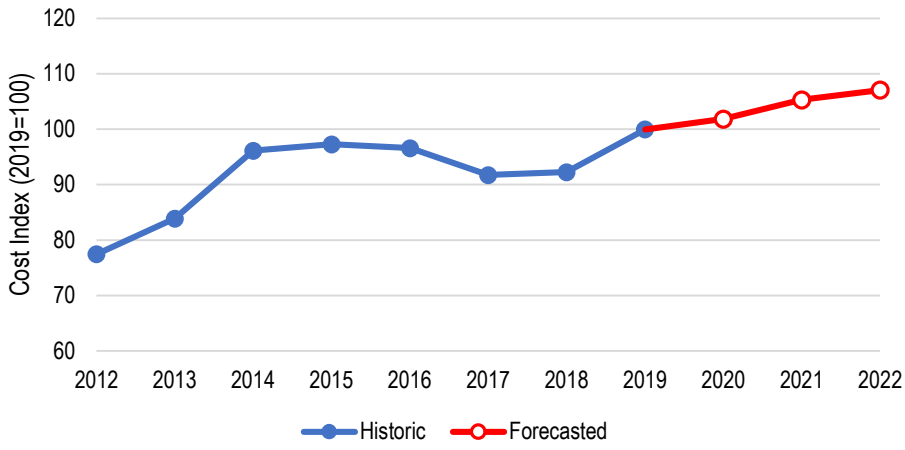
Average per unit costs for Enviva's three pellet mills increased an estimated 29% from 2012-2019, or an average increase of 3.7% per year over this period. However, based on our forecasts and anticipated changes in species and product mix consumption, average per unit raw material costs for Enviva are projected to increase an average of 2.3% per year through 2022, or a total of 7% from 2019-2022.

***Table 48**. Enviva Raw Material Per-Unit Cost Index (2019=100)*

Year	Enviva Raw Material Cost Index (2019 = 100)
2012	77
2013	84
2014	96
2015	97
2016	97
2017	92
2018	92
2019	100
2020	102
2021	105
2022	107

**forecasted*

***Figure 59**. Historic & Projected Raw Material Per Unit Index Cost (2019=100)*



6. Analysis Summary & Findings

Provided below and on the following pages is Hood Consulting's overall analysis summary, including a synopsis of key report elements and analysis findings. Please note that any conclusions drawn by Hood Consulting are based on a thorough assessment of the Enviva Chesapeake catchment area and on our professional expertise and market knowledge.

- Changes in Forest Area

  According to US Forest Service (USFS) data, timberland in the Enviva Chesapeake catchment area increased 77,097 acres (+0.7%) from 2000-2018. However, this increase primarily took place post-2010. Specifically, timberland acreage in the catchment area decreased 142,570 acres from 2000-2010. However, from 2010-2018, timberland acreage increased an estimated 219,667 acres, or a 1.9% increase over this 8-year period.

  The composition of timberland in the catchment area has also undergone changes. Specifically, since Enviva commenced production at its Ahoskie pellet mill in 2012, naturally regenerated and planted pine timberland has increased a combined 285,357 acres (+5.6%); naturally regenerated hardwood timberland, mixed pine-hardwood timberland, and planted hardwood timberland has decreased a combined 80,710 acres (-1.3%).

  The net increase in total timberland acreage – considering pine timberland acreage increased but both hardwood and mixed pine-hardwood timberland acreage decreased – to us indicates three things. First, land not formerly classified as timberland has been converted to timberland. Second, much of the non-pine timberland that has been harvested in this catchment area has been reestablished in pine. And third, harvested pine timberland continues to be replanted in pine.

  A major topic of interest specific to this area has been the loss of bottomland hardwood timberland. According to the USFS, total hardwood timberland decreased an estimated 35,757 acres (-0.7%) from 2012-2018. However, this was due to losses of upland/flatwood hardwood timberland, not losses of bottomland hardwood timberland. Specifically, upland/flatwood hardwood timberland decreased an estimated 152,348 acres (-4.3%) from 2012-2018. Bottomland hardwood timberland increased 116,591 acres (+8.2%) over this period.

  Ultimately, the increases in timberland, particularly pine timberland, in the catchment area provide great indication that adequate supply will be available for the anticipated future increase in softwood (pine) consumption by Enviva. However, given that Enviva's product mix is expected to be around 70-75% hardwoods versus 25-30% softwoods over the next several years, continued supply from hardwood and mixed pine-hardwood timberland will remain important for Enviva. Since 2012, natural hardwood and mixed pine-hardwood timberland acreage has held relatively steady in the catchment area, so adequate supply is expected to remain (at least over the short to mid-term).

Changes in Timber Inventory, Growth, & Removals

Total timber inventory in the catchment area increased 11% (+0.9% per year average) from 2000-2012. However, since 2012, inventory levels have risen at a more accelerated rate, increasing 19% from 2012-2018, or an average of +2.9% per year over this period. Specifically, inventories of pine pulpwood and hardwood pulpwood both increased 14% from 2012-2018, or an average of +2.2% per year over this period.

The increase in timber inventory reflected trends in both growth and removals. Specifically, annual growth of total growing stock timber increased 24% (+3.7% per year) from 2012-2018, compared to an increase of only 3% (+0.4% per year) in annual removals over this period.

Another way to gauge long-term resource availability and market sustainability is to examine growth-to-removal ratios. In this catchment area, total growth-to-removals has remained well above 1.0, increasing rapidly through the mid to late-2010s and peaking at 1.84 in 2016. This ratio has come down only slightly since and equaled 1.81 in 2018. (Recall that a value of >1 indicates growth exceeds removals, signifying oversupply). Growth-to-removals ratios of both pine and hardwood pulpwood have remained between 2.0 and 3.0 since Enviva entered this market in 2012, with pine pulpwood and hardwood pulpwood growth-to-removals equaling 2.49 and 2.76, respectively, in 2018 – indicating that annual growth is 2-3x that of annual removals for both of these timber products.

For Enviva's three pellet mills, this indicates, first, that current harvest levels (demand) are sustainable, and second, that both softwood and hardwood pulpwood demand (including biomass-related wood demand) can increase much further without jeopardizing the long-term sustainability of this market.

Changes in Wood Demand

Total wood demand in the Enviva Chesapeake catchment area increased an estimated 17% from 2011 (the year prior to Enviva's entrance in this market) through 2019, with softwood and hardwood pulpwood demand both increasing an estimated 27% over this period.

Note that the increases in both softwood and hardwood pulpwood demand were largely attributed to Enviva, which accounted for 0% of total pulpwood demand in the catchment area in 2011, compared to an estimated 34% in 2019. And with the expansions of both Enviva Pellets Northampton and Enviva Pellets Southampton, total pulpwood demand attributed to Enviva is projected to increase to over 40% in 2022.

For Enviva, the increased wood demand that will be placed on this catchment area could likely lead to higher raw material costs – as the company may be forced to increase the price they're willing to pay for raw materials to secure adequate wood to meet their production needs. However, given the current imbalance in supply and demand in this market, the impact of increased demand on raw material prices will likely be far smaller than would be expected under balanced conditions.

Changes in Raw Material Prices

Raw material purchases for Enviva Pellets Ahoskie, Enviva Pellets Northampton, and Enviva Pellets Southampton include a combination of pine and hardwood pulpwood (roundwood), chips, sawmill residuals, and other wood residues – with hardwood pulpwood and hardwood chips accounting for approximately 75% of total wood purchases by these three mills from 2012-2019. Pine pulpwood and pine chips accounted for roughly 11% of total wood purchases over this same period. However, with the expansions and increased ability to utilize softwood (pine) beginning in 2020, consumption of pine pulpwood and pine chips is expected to increase significantly over the next several years.

Delivered hardwood pulpwood prices in the catchment area trended upwards from 2000-2014, increasing an average of 2.5% per year over this period. However, since 2014, delivered hardwood pulpwood prices have been a bit more volatile but trended relatively flat to slightly downwards overall. Hardwood sawmill and chip mill chip prices have followed a similar trend. Prices of both raw materials increased an average of approximately 1.8% per year from 2000 through the mid-2010s but trending flat overall the last 3-4 years.

Delivered pine pulpwood prices in the catchment area increased only modestly from 2000-2011, increasing 9% (+0.8% per year average) over this 11-year period. Prices proceeded to increase 28% from 2011-2014; however, since then, delivered pine pulpwood prices have held flat, with annual average prices fluctuating only ±$0.24 per ton the last five years. Similarly, pine sawmill chip prices increased only 7% (+0.6% per year average) from 2000-2012 and then proceeded to increase 25% over the three years that followed. However, since 2015, pine sawmill chip prices have held flat. Pine chip mill chip prices declined 19% from 2000-2002 but proceeded to increase 57% (+3.8% per year average) over the 12 years that followed. However, since 2014, pine chip mill chip prices have held relatively flat, decreasing only slightly over the last five years.

Prices for all these different raw materials are forecasted to increase slightly over the next several years, with delivered hardwood pulpwood and hardwood chip prices forecasted to increase 4-5% and delivered pine pulpwood and pine chips prices forecasted to increase 6-8% from 2019-2022. However, the outlook for Enviva's three mills in terms of raw material costs is positive given the anticipated increases in wood purchases and changes in product mix. With pine expected to represent an increasing percentage of total raw material purchases moving forward, average per unit raw material costs are forecasted to increase an average of only 2.3% per year over the next three years, down from the estimated +3.7% per year average incurred from 2012-2019.

Management/Harvest Trends

As part of this market analysis, Hood Consulting examined management practices to see how harvesting activities have changed since in this market since 2000. Specifically, we wanted to assess how harvest activities change when market conditions weaken versus when market conditions are stable or strong.

TimberMart-South data shows that thinnings increased when poor market conditions persisted in the late 2000s and early 2010s. Specifically, acres thinned as a percentage of total acres harvested (thinned or clearcut) averaged between 35-40% in the early 2000s (when market conditions were strong) and in the latter half of the 2010s (when market conditions were what we would consider stable). However, from 2007-2011, that percentage increased significantly, as thinned acres accounted for 69% of the total acres harvested over this period. Similarly, harvest volume attributed to thinnings as a percentage of total harvest volume held between roughly 20-25% from 2000-2006 and from 2013-2019. However, from 2007-2011, approximately 50% of the total reported harvest volume was from thinnings.

Ultimately, our assessment shows that this market's response to poor market conditions is to decrease clearcuts and increase thinnings. The data suggests that many landowners in this market opted to thin when markets weakened, presumably waiting until timber prices improved before proceeding with the clearcut of mature timber stands. As markets conditions settled and stabilized in the early 2010s, many landowners in this market reverted to more standard management practices, deciding to clearcut, not thin, mature timber stands.

- Impact of Biomass Demand on Raw Material Prices

One of the important components of this analysis was to identify any relationships or linkages between changes in biomass demand and changes in raw material prices. Intuitively, prices and demand should move in the same direction, and that's exactly what the data shows in this catchment area.

Specifically, delivered pine pulpwood and pine chip prices were found to have a strong positive correlation to both softwood biomass demand and other (non-biomass-related) softwood pulpwood demand. However, changes in pine pulpwood and pine chip prices are impacted to a greater degree by other softwood pulpwood demand (i.e. from pulp/paper mills), as other softwood pulpwood demand accounts for approximately 90% of total softwood pulpwood demand in the catchment area.

Delivered hardwood pulpwood price was found to have only a weak positive correlation to both hardwood biomass demand and other (non-biomass-related) hardwood pulpwood demand. However, a strong positive correlation does exist between delivered hardwood pulpwood price and total hardwood pulpwood demand. Ultimately, these findings along with additional analysis provide evidence in support of a causal relationship between total hardwood pulpwood demand and hardwood pulpwood raw material costs. That is, increases (decreases) in total hardwood pulpwood demand, to some degree, are responsible for increases (decreases) in delivered hardwood pulpwood prices. However, changes in hardwood biomass demand alone are not responsible for changes in hardwood pulpwood price.

(Note that while delivered hardwood pulpwood price increased 17% from 2013 to 2014 (coinciding with a nearly 70% increase in hardwood biomass demand), this increase in price was also likely linked to a combination of both supply chain issues – a shortage of local loggers following pulp/paper mill closures in the region – and elevated prices offered by Enviva to ensure guaranteed wood supply the first several years of operation).

Additionally, we examined prices of non-biomass-related timber products (i.e. pine sawtimber, pine chip-n-saw, and hardwood sawtimber) and found no relationships or links between changes in biomass demand and changes in these raw material prices.

Appendix A. Quarterly Stumpage Prices, Delivered Timber Prices, & Pulp Quality Chip Prices (1Q 2000 – 4Q 2019)

Enviva Chesapeake Catchment Area - Quarterly Delivered Timber Prices ($/Ton)

Year	Quarter	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood
2000	1	39.18	26.26	8.99	18.38	2.79
2000	2	41.87	25.65	7.79	16.94	2.62
2000	3	43.08	24.90	8.39	19.94	2.43
2000	4	38.78	25.63	9.39	20.53	2.50
2001	1	38.23	22.99	7.98	18.63	2.15
2001	2	37.53	22.36	7.49	22.46	2.20
2001	3	41.50	22.62	7.89	23.81	2.93
2001	4	39.67	24.62	7.52	23.90	2.63
2002	1	37.11	22.62	6.28	19.62	2.44
2002	2	39.85	23.47	6.83	18.42	2.03
2002	3	37.02	23.16	7.15	19.54	2.45
2002	4	39.17	24.30	7.46	22.45	3.32
2003	1	37.53	23.14	8.19	21.85	4.66
2003	2	40.42	23.42	8.75	21.59	2.68
2003	3	35.82	22.47	8.22	21.34	4.11
2003	4	36.57	22.77	7.01	22.28	3.25
2004	1	34.68	22.15	7.98	24.43	3.83
2004	2	36.61	22.89	7.58	19.72	2.08
2004	3	37.27	23.49	7.93	19.66	2.66
2004	4	40.08	24.97	8.37	21.83	3.82
2005	1	37.53	23.56	7.74	22.16	2.40
2005	2	38.14	24.33	6.80	21.15	3.06
2005	3	39.56	23.44	6.83	21.59	2.79
2005	4	40.98	26.24	8.49	21.43	3.09
2006	1	41.57	24.44	7.18	19.80	2.91
2006	2	43.31	26.14	6.65	19.83	2.68
2006	3	40.46	24.26	6.86	19.65	2.56
2006	4	37.44	20.79	6.59	21.07	3.11
2007	1	40.59	22.96	7.88	22.72	4.10
2007	2	39.38	21.57	7.79	21.04	3.23
2007	3	37.88	20.78	7.78	21.69	4.39
2007	4	36.04	19.55	7.16	23.39	3.84
2008	1	33.54	17.76	6.87	20.81	3.26
2008	2	34.48	18.14	6.95	20.02	3.99
2008	3	34.67	20.70	7.28	23.42	5.17
2008	4	32.16	18.83	8.50	18.11	5.80
2009	1	28.12	17.79	6.50	17.22	5.32

Year	Quarter	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood
2009	2	26.26	16.11	6.26	17.55	2.97
2009	3	27.58	15.68	6.90	16.54	3.45
2009	4	29.91	19.54	8.66	17.88	4.50
2010	1	32.10	19.79	10.22	20.76	7.09
2010	2	30.06	17.31	7.96	17.92	4.24
2010	3	28.36	17.21	8.52	19.75	5.18
2010	4	26.50	17.19	7.05	20.07	4.09
2011	1	27.17	16.52	8.59	19.30	4.38
2011	2	23.29	15.54	7.43	19.05	4.13
2011	3	22.60	15.05	7.19	17.82	5.84
2011	4	25.88	14.78	7.89	19.91	3.61
2012	1	25.24	15.05	8.74	17.97	2.90
2012	2	25.07	15.41	7.47	17.38	3.39
2012	3	25.84	16.05	8.98	18.14	3.99
2012	4	26.61	16.19	10.35	21.00	4.22
2013	1	29.37	17.59	12.24	22.10	4.31
2013	2	28.76	18.06	11.11	21.43	5.31
2013	3	26.55	16.23	11.91	21.44	4.71
2013	4	27.79	16.46	13.04	24.68	4.88
2014	1	25.41	16.17	12.66	24.18	6.55
2014	2	27.41	18.62	12.05	27.19	6.89
2014	3	24.57	18.88	12.12	28.99	7.49
2014	4	26.50	20.57	13.61	30.44	6.82
2015	1	27.11	19.81	13.15	31.10	6.83
2015	2	26.55	19.01	12.10	33.16	7.13
2015	3	25.49	18.02	10.96	30.28	5.80
2015	4	25.11	19.36	11.10	28.82	6.73
2016	1	25.07	18.26	11.67	29.65	7.09
2016	2	28.59	20.91	15.28	30.01	5.30
2016	3	28.78	19.61	15.06	30.12	4.97
2016	4	28.20	18.50	14.63	31.55	5.02
2017	1	24.12	17.65	14.71	29.92	4.76
2017	2	25.12	17.59	14.83	27.70	4.37
2017	3	24.67	18.03	14.59	26.81	3.57
2017	4	24.74	19.63	14.71	29.91	3.90
2018	1	25.49	18.34	14.68	29.02	4.00
2018	2	26.11	17.76	14.02	30.63	3.80
2018	3	24.96	19.21	12.32	28.71	5.06
2018	4	27.73	20.40	13.18	29.43	5.97
2019	1	31.89	20.06	12.47	27.74	6.12
2019	2	31.86	17.84	10.39	27.21	5.23
2019	3	30.97	16.44	10.84	31.18	7.11
2019	4	30.51	17.34	13.01	28.57	7.56

Source: TimberMart-South

Enviva Chesapeake Catchment Area - Quarterly Delivered Timber Prices ($/Ton)

Year	Quarter	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood
2000	1	52.67	39.79	23.75	31.45	19.86
2000	2	57.38	35.17	22.33	31.21	18.30
2000	3	52.25	41.73	23.64	30.14	20.15
2000	4	50.32	42.83	24.77	34.56	22.61
2001	1	48.99	39.75	23.40	36.39	21.86
2001	2	46.72	37.92	23.24	33.24	21.10
2001	3	47.43	38.45	23.78	32.06	20.37
2001	4	45.87	39.55	23.43	33.28	19.14
2002	1	46.22	40.81	23.76	32.86	19.17
2002	2	47.12	41.21	22.26	37.86	19.28
2002	3	47.78	40.96	22.33	38.69	18.07
2002	4	48.31	41.41	22.83	38.14	18.72
2003	1	49.77	42.43	22.34	39.13	19.25
2003	2	51.12	39.51	22.05	41.82	18.36
2003	3	47.84	39.12	23.72	33.89	19.53
2003	4	42.17	36.82	24.58	39.07	20.76
2004	1	40.89	40.27	25.82	33.17	21.46
2004	2	42.01	39.30	22.41	34.44	19.70
2004	3	48.66	40.88	22.63	35.07	19.72
2004	4	55.62	39.44	24.80	41.32	20.12
2005	1	51.26	39.64	23.49	38.65	20.40
2005	2	53.86	38.67	22.38	33.56	19.82
2005	3	52.38	40.59	23.54	35.98	20.55
2005	4	55.20	38.98	24.51	34.82	22.14
2006	1	55.75	40.99	24.77	30.85	21.58
2006	2	56.13	38.84	22.58	36.65	20.88
2006	3	57.22	41.13	23.68	34.04	21.32
2006	4	52.33	40.78	26.72	32.76	22.42
2007	1	58.83	37.57	25.24	36.41	21.48
2007	2	53.77	37.79	23.73	39.13	22.62
2007	3	47.72	38.25	24.18	37.26	21.63
2007	4	53.81	36.86	24.66	34.99	22.89
2008	1	52.57	35.05	24.94	35.72	22.87
2008	2	50.21	38.37	23.44	35.71	24.23
2008	3	48.73	37.76	25.64	39.52	26.00
2008	4	47.00	36.15	26.25	32.31	24.76
2009	1	44.99	35.14	23.87	33.81	22.35
2009	2	41.98	34.26	23.38	35.59	21.50
2009	3	43.78	33.58	24.75	41.56	22.13
2009	4	45.88	33.95	25.43	41.46	22.06
2010	1	48.06	36.87	26.87	38.70	24.67

Year	Quarter	Pine Sawtimber	Pine Chip-n-saw	Pine Pulpwood	Hardwood Sawtimber	Hardwood Pulpwood
2010	2	49.36	35.89	26.66	38.62	23.48
2010	3	48.47	35.38	26.95	38.23	22.98
2010	4	45.76	36.20	24.96	40.92	23.63
2011	1	45.91	34.62	25.87	40.48	23.18
2011	2	44.99	33.54	26.54	42.79	23.49
2011	3	44.30	34.42	25.34	41.79	22.46
2011	4	43.27	33.20	25.59	40.67	22.58
2012	1	43.09	33.35	25.76	37.28	22.39
2012	2	41.57	33.43	26.73	36.50	23.63
2012	3	42.35	34.24	28.19	38.03	22.67
2012	4	44.84	34.87	30.09	40.86	23.02
2013	1	45.68	34.00	29.40	42.38	22.67
2013	2	46.21	34.84	28.72	40.63	24.85
2013	3	46.68	35.07	29.69	49.10	24.73
2013	4	46.19	36.19	31.98	46.44	25.37
2014	1	46.40	37.71	31.13	47.64	27.78
2014	2	44.82	36.31	32.73	50.08	28.17
2014	3	44.95	38.17	34.43	51.68	28.48
2014	4	47.24	39.63	33.96	49.86	29.46
2015	1	46.42	39.68	33.21	53.56	29.18
2015	2	45.63	38.90	33.81	56.14	28.46
2015	3	43.79	37.87	32.45	54.14	27.70
2015	4	44.67	38.35	32.82	51.62	27.31
2016	1	44.10	38.43	32.67	49.76	27.42
2016	2	47.82	37.33	31.49	49.60	26.11
2016	3	47.68	38.64	34.30	50.97	25.74
2016	4	48.20	37.11	33.47	52.90	25.03
2017	1	46.57	37.31	33.17	50.35	24.22
2017	2	44.51	37.24	32.52	48.57	23.95
2017	3	43.57	37.97	33.37	49.15	24.32
2017	4	44.38	38.65	33.64	49.62	23.48
2018	1	44.33	37.90	33.23	47.19	22.52
2018	2	44.86	37.11	32.43	48.95	22.43
2018	3	45.90	39.65	32.73	50.32	24.17
2018	4	47.67	39.81	33.20	51.44	26.21
2019	1	49.97	41.13	33.45	53.89	27.47
2019	2	49.98	40.53	33.73	51.93	27.73
2019	3	48.85	40.29	32.45	52.27	26.20
2019	4	47.28	40.39	31.64	51.82	26.26

Source: TimberMart-South

Enviva Chesapeake Catchment Area - Pulp Quality Chip Prices ($/Ton - FOB Point of Production)

Year	Quarter	Pine Sawmill Chips	Hardwood Sawmill Chips	Pine Chip Mill Chips	Hardwood Chip Mill Chips
2000	1	25.00	22.38	33.97	29.38
2000	2	22.50	20.00	29.75	28.13
2000	3	20.00	21.75	28.63	28.25
2000	4	21.38	23.25	28.00	27.57
2001	1	21.19	21.13	27.13	25.50
2001	2	20.44	18.69	26.75	25.94
2001	3	20.63	19.38	27.25	25.44
2001	4	20.32	20.50	25.25	25.00
2002	1	18.94	18.38	24.75	24.50
2002	2	18.76	18.25	23.88	24.05
2002	3	19.63	19.32	24.50	24.69
2002	4	21.00	20.75	24.88	25.44
2003	1	20.41	20.12	25.19	26.69
2003	2	20.38	20.25	27.25	29.50
2003	3	20.75	21.00	28.00	31.75
2003	4	19.70	20.95	28.50	30.50
2004	1	22.09	20.90	29.00	29.25
2004	2	19.96	19.44	25.50	26.75
2004	3	20.75	19.88	27.00	27.75
2004	4	21.81	19.55	26.86	27.94
2005	1	22.87	22.65	27.70	28.13
2005	2	23.74	25.00	27.81	28.75
2005	3	21.69	24.50	29.01	28.13
2005	4	23.47	25.50	29.35	27.81
2006	1	25.25	25.63	29.45	27.50
2006	2	22.88	23.60	30.01	29.63
2006	3	26.68	25.72	30.30	30.32
2006	4	22.08	23.13	29.00	30.88
2007	1	22.48	21.48	30.50	31.00
2007	2	21.40	22.21	29.88	28.50
2007	3	22.94	25.00	29.25	28.75
2007	4	24.25	23.46	29.50	30.00
2008	1	26.00	21.75	30.75	33.00
2008	2	24.54	24.63	30.85	31.25
2008	3	29.29	24.82	35.84	31.42
2008	4	29.50	25.29	35.50	31.50
2009	1	29.94	24.19	33.69	33.38
2009	2	28.73	23.57	34.58	33.44
2009	3	25.84	23.29	33.53	33.44

Year	Quarter	Pine Sawmill Chips	Hardwood Sawmill Chips	Pine Chip Mill Chips	Hardwood Chip Mill Chips
2009	4	23.11	22.71	34.19	34.02
2010	1	22.68	22.38	31.94	35.16
2010	2	22.84	22.53	35.62	36.21
2010	3	24.05	23.40	34.30	33.40
2010	4	24.33	23.45	35.04	35.70
2011	1	24.42	24.95	34.31	34.99
2011	2	24.26	24.58	34.79	34.67
2011	3	23.99	23.30	33.72	33.18
2011	4	23.48	23.69	33.09	32.70
2012	1	23.32	21.62	33.94	32.23
2012	2	23.62	23.13	34.27	33.02
2012	3	23.70	22.43	34.94	32.78
2012	4	24.32	22.43	35.61	32.87
2013	1	24.23	22.19	35.39	31.81
2013	2	25.13	22.56	35.68	32.40
2013	3	25.00	23.02	37.03	34.73
2013	4	27.01	24.05	37.08	34.24
2014	1	25.72	23.27	37.76	35.32
2014	2	25.91	24.57	37.93	35.74
2014	3	28.15	25.55	38.60	35.81
2014	4	25.93	25.18	39.22	37.22
2015	1	28.74	26.26	39.04	37.49
2015	2	30.43	27.78	38.46	36.84
2015	3	29.23	26.29	38.54	36.14
2015	4	30.20	30.34	38.31	35.71
2016	1	30.09	29.96	38.73	36.74
2016	2	30.24	29.34	38.28	35.26
2016	3	29.32	30.53	36.77	35.38
2016	4	30.56	26.23	37.13	33.33
2017	1	30.15	25.84	36.94	33.61
2017	2	30.13	24.95	36.98	31.99
2017	3	29.69	25.01	37.48	32.19
2017	4	30.15	25.84	36.94	33.61
2018	1	29.89	25.45	37.15	33.14
2018	2	30.40	24.77	37.55	32.95
2018	3	29.90	24.90	37.61	33.08
2018	4	29.43	26.26	37.98	34.34
2019	1	28.67	28.89	38.16	35.14
2019	2	28.09	30.00	38.57	37.52
2019	3	32.49	27.48	36.53	35.63
2019	4	31.87	27.39	36.68	36.05

Source: TimberMart-South

Appendix B. Log Rules, Weight Equivalents, & Conversion Rates

Log Rule and Weight Equivalents

Pine: *Sawtimber and large logs* 15,000 lbs. (Range 13,000-17,000 lbs.) or 7.50 Tons per MBF Scribner; 16,000 lbs. or 8.0 Tons per MBF Doyle; 12,450 lbs. or 6.225 Tons per MBF International.

Chip-n-saw 15,000 lbs. (Range 13,000-17,000 lbs.) or 7.50 Tons per MBF Scribner; 19,950 lbs. or 9.975 Tons per MBF Doyle; 12,450 lbs. or 6.225 Tons per MBF International.

Pulpwood and Chip-n-saw 5,350 lbs. (Range 5,000-5,620 lbs.) or 2.68 Tons per Std.Cord. Ratio of weights between sawtimber & pulpwood is 2.80 cds. to MBF (Scribner).

Hardwood: *Sawtimber* 17,500 lbs. (Range 15,000-19,000 lbs.) or 8.75 Tons per MBF Doyle; 13,125 lbs. or 6.563 Tons per MBF Scribner; 10,850 lbs. or 5.425 Tons per MBF International.

Pulpwood 5,800 lbs./Std.Cord or 2.90 Tons (Range 5,400-6,075 lbs.) Ratio of weights between sawtimber & pulpwood 3.02 cds. to MBF (Doyle).

English & Metric Conversions

1 Std. Cord has 128 ft^3 of stacked logs: bark, air and solid wood.

1 Std. Cord has 90 ft^3 of solid wood and bark.

1 Std. Cord of pine has about 75 ft^3 or 2.124 m^3 of solid wood.

1 Std. Cord of mixed hardwood has about 80 ft^3 or 2.265 m^3 of solid wood.

1 cubic meter (m^3) = 35.315 cubic feet (ft^3)

1 short ton (2,000 lb.) of green southern pine, wood & bark, has about 0.822 m^3 of solid wood.

1 short ton (2,000 lb.) of green mixed hardwood, wood & bark, has about 0.787 m^3 of solid wood.

1 metric tonne = 1.102 short tons = 2,204 pounds

1 acre = 0.405 hectares

1 mile = 1.609 kilometers

These are "general product guides." Specific requirements may vary by area and buyer.

Glossary of Terms

Average annual mortality of growing stock: The average cubic foot volume of sound wood in growing-stock trees that died in one year.

Average annual net growth of growing stock: The annual change in cubic foot volume of sound wood in live sawtimber and poletimber trees, and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes, between 1999 and 2003.

Average annual removals from growing stock: The average net growing-stock volume in growing-stock trees removed annually for roundwood forest products, in addition to the volume of logging residues and the volume of other removals.

Basal area: Tree area in square feet of the cross section at breast height of a single tree. When the basal areas of all trees in a stand are summed, the result is usually expressed as square feet of basal area per acre.

Commercial species: Tree species suitable for industrial wood products.

County and municipal: An ownership class of public lands owned by counties or local public agencies, or lands leased by these governmental units for more than 50 years.

Cropland: Land under cultivation within the last 24 months, including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards, active Christmas tree plantations indicated by annual shearing, nurseries, and land in soil improvement crops, but excluding land cultivated in developing improved pasture.

Diameter class: A classification of trees based on diameter outside bark, measured at breast height 4.5 feet (DBH) (1.37m) above the ground or at root collar (DRC). Note: Diameter classes are commonly in 2-inch (5cm) increments, beginning with 2-inches (5cm). Each class provides a range of values with the class name being the approximate mid-point. For example, the 6-inch class (15-cm class) includes trees 5.0 through 6.9 inches (12.7 cm through 17.5 cm) DBH, inclusive.

Federal Land: An ownership class of public lands owned by the U.S. Government.

Forest land: Land that has at least 10 percent crown cover by live tally trees of any size or has had at least 10 percent canopy cover of live tally species in the past, based on the presence of stumps, snags, or other evidence. To qualify, the area must be at least 1.0 acre in size and 120.0 feet wide. Forest land includes transition zones, such as areas between forest and nonforest lands that meet the minimal tree stocking/cover and forest areas adjacent to urban and built—up lands. Roadside, streamside, and shelterbelt strips of trees must have a width of at least 120 feet and continuous length of at least 363 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if they are less than 120 feet wide or less than an acre in size. Tree-covered areas in agricultural production settings, such as fruit orchards, or tree—covered areas in urban settings, such as city parks, are not considered forest land.

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

Growing stock tree: All live trees 5.0 inches (12.7) cm) DBH or larger that meet (now or prospectively) regional merchantability requirements in terms of saw-log length, grade, and cull deductions. Excludes rough and rotten cull trees.

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

Land: The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains.

Logging residues: The unused portions of trees cut or destroyed during harvest and left in the woods.

Merchantable: Refers to a pulpwood or sawlog section that meets pulpwood or sawlog specifications, respectively.

National forest: An ownership class of Federal lands, designated by Executive order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service including experimental areas.

Net annual growth: The average annual net increase in the volume of trees during the period between inventories. Components include the increment in net volume of trees at the beginning of the specific year surviving to its end, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that died during the year, and minus the net volume of trees that became cull trees during the year.

Net volume in cubic feet: The gross volume in cubic feet less deductions for rot, roughness, and poor form. Volume is computed for the central stem from a 1-foot stump to a minimum 4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

Nonforest land: Land that does not support or has never supported, forests and lands formerly forested where use of timber management is precluded by development for other uses. Includes area used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining rights-of-way, powerline clearings of any width, and noncensus water. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet (36.6m) wide, and clearings, etc., more than one acre (0.4ha) in size, to qualify as nonforest land.

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

Pulpwood: Roundwood, whole-tree chips, or wood residues used for the production of wood pulp.

Roundwood products: Logs, bolts, or other round timber generated from harvesting trees for industrial or consumer uses. Includes sawlogs; veneer and cooperage logs and bolts; pulpwood; fuelwood; pilings; poles; posts; hewn ties; mine timbers; and various other round, split or hewn products.

Saw log: A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, and with a minimum diameter inside bark of 6 inches for softwoods and 8 inches for hardwoods, or meeting other combinations of size and defect specified by regional standards.

Sawtimber tree: A live tree of commercial species containing at least a 12-foot sawlog or two noncontiguous saw logs 8 feet or longer and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches diameter outside bark (d.o.b.).

Softwood: A coniferous tree, usually evergreen, having needles or scale-like leaves.

Stand: A group of trees on a minimum of 1 acre of forest land that is stocked by forest trees of any size.

State land: An ownership class of public lands owned by States or lands leased by States for more than 50 years.

Timberland: Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Timber products output (TPO): All timber products cut from roundwood and byproducts of wood manufacturing plants. Roundwood products include logs, bolts, or other round sections cut from growing-stock trees, cull trees, salvable dead trees, trees on nonforest land, noncommercial species, sapling-size trees, and limbwood. Byproducts

from primary manufacturing plants include slabs, edging, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and screenings of pulpmills that are used as pulpwood chips or other products.

Tree: A woody perennial plant, typically large, with a single well-defined stem carrying a more or less definite crown; sometimes defined as attaining a minimum diameter of 3 inches (7.6) and a minimum height of 15 ft (4.6 m) at maturity. For FIA, any plant on the tree list in the current field manual is measured as a tree.

Tree size class: A classification of trees based on diameter at breast height, including sawtimber trees, poletimber trees, saplings, and seedlings.

Urban forest land: Land that would otherwise meet the criteria for timberland but is in an urban-suburban area surrounded by commercial, industrial, or residential development and not likely to be managed for the production of industrial wood products on a continuing basis. Wood removed would be for land clearing, fuelwood, or esthetic purposes. Such forest land may be associated with industrial, commercial, residential subdivision, industrial parks, golf course perimeters, airport buffer strips, and public urban parks that qualify as forest land.

Veneer log: A roundwood product from which veneer is sliced or sawn and that usually meets certain standards of minimum diameter and length and maximum defect.

Weight: The weight of wood and bark, oven-dry basis (approximately 12 percent moisture content).

Hood Consulting
3100 Old Canton Road, Suite 200
Jackson, MS 39216

1-601-540-8602
hbhood@hoodconsultingllc.com