MARYLAND WOOD FUEL SUPPLY CHAIN ANALYSIS

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MARYLAND CLEAN ENERGY CENTER

RENEWABLE RESOURCE SOLUTIONS

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Maryland Wood Fuel Supply Chain Analysis provides foresters, loggers, mill and plant owners, policymakers, and other stakeholders with the information necessary to make sustainability-informed decisions for forest industry and renewable energy industry expansion that will improve forest health. Additionally, this report offers policymakers targeted areas for economic growth, education, environmental sustainability, and waste reduction.

With funding from the Rural Maryland Council, the Maryland Clean Energy Center (MCEC) commissioned this study to assess the availability of wood fuel stocks in the State of Maryland and surrounding counties. Wood fuel, interchangeably referred to as biomass, is a renewable resource of solid woody material or wood residues from logging or manufacturing. It comes directly from the traditional forests through the harvest of trees, from urban and community forests via urban wood waste from tree trimmings and removals, and from wood manufacturing industries as leftovers from production of wood products. Key findings indicate that:

1) The available supply of wood fuel far exceeds its demand;
2) Wood fuel is available for heat generation, electrical power, and for use in combined heat and power plants;
3) Better utilization of Maryland's wood fuel resources will result in more productive forests with the capacity to sequester additional carbon from the atmosphere; and
4) Citizen and landowner education and engagement is called for to underscore the value and role of forest management and fuel wood harvest for the environment, economy and communities in the state.

This study identified significant wood fuel resources from the forest, both traditional forests and urban and community forests, and from manufacturing by-products that could be better utilized. Currently wood fuel is often left in the forest or disposed of in landfills. There are more than 3.1 million tons of wood fuel on timberlands across the project area and 1.2 million tons on Maryland timberlands alone. Utilization of wood fuel from urban and community forests is a growing industry and provides opportunity for an additional source of wood fuel. Currently, the majority of fuel wood generated from urban forests is being disposed of in landfills; natural wood waste recycling centers reported accepting almost 500,000 tons of wood in 2022. An additional source of fuelwood is being generated by the 53 forest product mills located throughout the state.

Maryland's forests are growing. Annual growth rates indicate that timberlands in the state grow and average of 8.5 million cubic feet of wood each year, and more than 25.7 million cubic feet of wood is grown annually across the project area. That's the equivalent of about 215,000 cords of firewood just being grown each year. Current growth rates were combined with utilization data to conduct a growth to drain analysis. The growth to drain ratio across the project area is 2.5, indicating that there is 2.5 times more wood grown each year than is harvested. In Maryland, the statewide growth to drain ratio is 3.1; the wood basket is growing three times the rate of utilization. Growth rates were used to project growth over the next 15 years. From that, sustainable rates of utilization were examined based on increased harvest levels. **Overall, growth of wood fuel resources exceeds current utilization, and projected increases in wood fuel utilization of up to 5% would not deter projected growth. In fact, data trends indicate that the wood fuel resource could tolerate a much higher harvest rate than the 5% increase.**

Increased utilization will both improve forest health through increased biodiversity and regeneration and will help Maryland achieve its climate goals by providing a carbon sink through young, healthy, faster growing trees. Maryland's

forests are generally aging out and trees are deteriorating in place. The large majority of trees in the forest are considered mature; only a small percentage of stands are young forest. In some areas, the growth rates of wood fuel-sized trees are negative while sawtimber trees show positive growth, indicating that the forest is not regenerating itself.

Maryland has environmental protections already in place regarding the harvest and use of biomass. Current guidelines exist for harvesting practices and soil and water protection, and air quality regulations provide specific requirements pertaining to use.

Further, increased utilization of wood fuel will create new demand for low value timber, making harvests more economical for the loggers and more profitable for the landowners. These new markets will allow Maryland to produce renewable, sustainable building and energy resources from its local forests, reducing the need to import products and the associated costs and environmental impacts of the transportation.

However, Maryland's social tolerance for timber harvesting is relatively low, as citizens and landowners may not understand the positive relationship between timber harvest and improved forest health, indicating that more education is needed to overcome the misunderstandings associated with both timber harvest and the removal of wood fuel.

This study concludes that Maryland is well positioned to sustainably increase wood fuel harvests, which will aid in reaching current forest health and climate goals. Increased wood fuel removals will improve local economies in addition to the forests themselves. Marylanders will also benefit from this fuel wood resource as a dependable local, renewable fuel source providing additional employment opportunities. Policy development should encourage wood fuel markets and emphasize the education of landowners - especially private landowners, loggers, and foresters - to utilize the resource guidelines currently in place to sustainably expand biomass harvesting.

INTRODUCTION

The U.S. Census Bureau estimated Maryland's population at 6.05 million in 2019; there are estimated to be 595 people per square mile in Maryland, making Maryland the 5th most densely populated state in the nation. The area between Boston, Massachusetts and Richmond, Virginia is one of the most densely populated and developed areas in the continental United States. (Maryland Department of Natural Resources) Despite its high population density, Maryland maintains approximately 39% of its land area in forest cover, equating to 0.4 acres of forest per person. Total forest cover has remained virtually unchanged from the 2010 Maryland Department of Natural Resources Forest Action Plan, which indicates a potential tapering-off of forest loss in the state.

Maryland has a long history of using its forest resources to support Marylanders and has successfully adapted its forest management practices over time in step with advancements in sustainable forest management practices and changes in the industry. Maryland's forest industry provides livelihoods for residents and products for consumers while helping to manage the forest for optimal growth to ensure sustainable forests for years to come. Maryland recognized the opportunity to better utilize its forest resource by using wood fuel or biomass, the stems, limbs, branches, sawdust or culled wood, that was previously left behind or landfilled. In order to protect forest stand health while using this resource, Maryland developed one of the first biomass harvesting guides in the country.

The Maryland Department of Natural Resources (MDNR) is responsible for the management of the state's forests and for assisting the forest industry.

The Maryland Clean Energy Center (MCEC) is a green bank and corporate instrumentality of the state of Maryland which advances the adoption of clean energy and energy efficiency products, services, and technologies. MCEC leverages private capital to help homeowners, businesses, and government entities reduce energy costs.

MCEC, as a State-Public corporation and an instrumentality of the State of Maryland, has been authorized to: 1) Promote economic development and jobs in the clean energy industry sector in the State; 2) Promote the deployment of clean energy technology in the State; 3) Serve as an incubator for the development of clean energy industry in the State; 4) Collect, analyze, and disseminate industry data; and, 5) Provide outreach and technical support to further the clean energy industry in the State. MCEC's program priorities range from providing clean energy initiative funding, technology commercialization and business incubation, and workforce development and training.

MDNR and MCEC have partnered on this study to consider the nexus between sustainable forestry and renewable energy in relation to the state goals for greenhouse gas reduction and carbon sequestration.

Study Objectives

The MCEC conducted an assessment of the current availability of wood fuel stocks in the State of Maryland and in the adjacent counties of its neighboring states. This assessment identified current wood fuel resources from the forest and as by-products from the forest products industry. Sustainable rates of utilization were identified in the context of current growth to drain rates and considerations for policy to advance wood energy usage in context of the above assessments are also discussed.

The *Maryland Wood Fuel Supply Chain Analysis* provides foresters, loggers, mill and plant owners, policy makers, and other stakeholders with the information necessary to make sustainability-informed decisions for forest industry and renewable energy industry expansion that will improve forest health. Additionally, this report offers policymakers targeted areas for economic growth, environmental sustainability, waste reduction, and education.

Study Area

Maryland's forest industry often crosses boundary lines into neighboring states. To conduct an in-depth sustainable use assessment of the wood fuel supply chain and availability for Maryland, data from counties within Maryland as well as from adjacent counties of neighboring states was collected and analyzed.

The study area, as depicted in **Figure 1**, focuses on the twenty-three counties within Maryland, with Baltimore City extrapolated separately where appropriate, nine bordering counties within Pennsylvania, seven in West Virginia, and three within Delaware and Virginia respectively. For the purposes of summarizing data, the counties within Maryland have been grouped into four primary regions: Central, Eastern, Southern, and Western.

Table 1 identifies each of the individual counties that are included in the report. Unless otherwise specified, data listed under the states of Delaware, Pennsylvania, Virginia, and West Virginia includes only data reported for the counties identified in Table 1.

Figure 1: Study Area Map

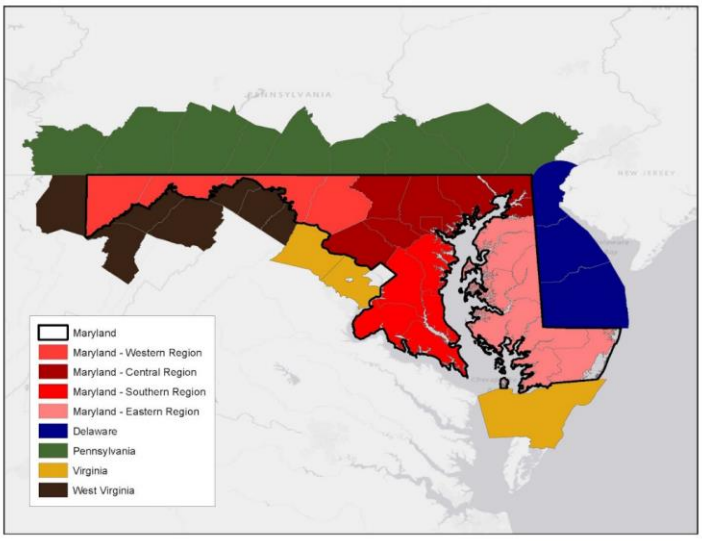


Table 1: Study Area

Maryland

Central

- Baltimore
- Baltimore City
- Carroll
- Cecil
- Harford
- Howard
- Montgomery

Eastern

- Caroline
- Dorchester
- Kent
- Queen Anne's
- Somerset
- Talbot
- Winomico
- Worcester

Southern

- Anne Arundel
- Calvert
- Charles
- Prince George's
- St. Mary's

Western

- Allegany
- Frederick
- Garrett
- Washington

Neighboring States & Counties

Pennsylvania

- Adams
- Bedford
- Chester
- Fayette
- Franklin
- Fulton
- Lancaster
- Somerset
- York

West Virginia

- Berkeley
- Grant
- Hampshire
- Jefferson
- Mineral
- Morgan
- Preston

Delaware

- Kent
- New Castle
- Sussex

Virginia

- Accomack
- Fairfax
- Loudon

Wood Fuel

Wood fuel, interchangeably referred to as biomass, is a renewable resource of solid woody material or wood residues from logging or manufacturing. It comes directly from the traditional forests through the harvest of trees, from urban and community forests via urban wood waste from tree trimmings and removals, and from wood manufacturing industries as leftovers from production of wood products.

For this report, wood fuel is defined as growing stock trees 5.0 inches in diameter at breast height (DBH) and larger, cull trees, and dead standing trees, including bole wood and top and limb wood. Growing stock trees are all live trees of commercial species that meet minimum merchantability standards. Bole wood is the portion of the tree from 1 foot above the ground to a 4-inch top outside bark or to a point where the central stem breaks

into limbs. Tree green weight was used throughout the study. Sawtimber, stumps, seedlings, and saplings are excluded from the data sampling except where noted and wood fuel does not include sawlogs.

FOREST RESOURCES

The State of Maryland and the neighboring counties of adjacent states have significant wood fuel resources that could be utilized as forest products including as fuel for heat and power generation. There is a substantial amount of wood fuel inventory across the project area that is not only under-utilized, but it is also taking away from the potential of ecological services that the forest could provide. Maryland's forests are generally aging out and trees are deteriorating on the stump, a waste of a valuable resource. Increased harvest would improve forest health, not harm it. Management would open up the forest and foster generation as well as increase biodiversity and wildlife habitat. Biomass harvesting can also be used as a tool to eradicate certain invasive plant species. Wood fuel markets would incentivize increased management of smaller diameter trees which would further result in optimization of growth, and hence enhanced carbon sequestration by Maryland's forests.

Forestland

Forest Inventory and Analysis National Program (FIA) data from the U.S. Forest Service (USDA Forest Service, 2021) was used to determine forestland. Forestland includes areas with at least 10% canopy cover and areas which are at least 1.0 acres in size and 120.0 feet wide. Forestland also includes transition zones, such as areas between forest and non-forest lands that meet the minimal tree canopy cover as well as 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 forestland. Note that 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 forestland. Forestland includes all forested areas, including those on which timber harvest is restricted.

Figure 2: Forestland Cover

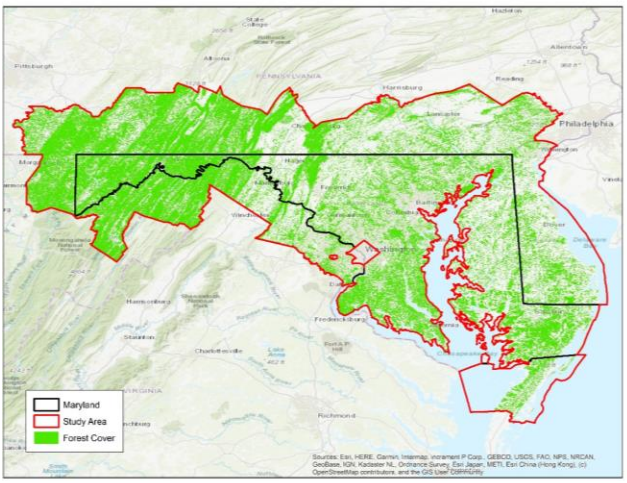
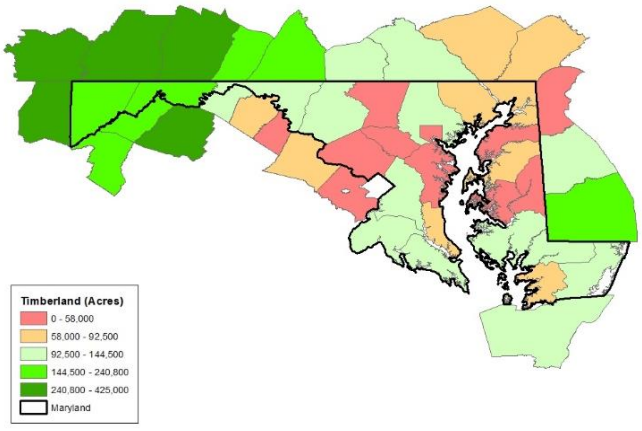


Figure 2 depicts forestland cover across the project area and shows that the Central and Western Regions are more heavily forested than the Eastern and Southern Regions. **Table 2** provides the total acres of forestland by state, region, and county. The project area contains approximately 6.2 million acres of forestland including more than 2.4 million acres in Maryland alone. Total forest cover in Maryland has remained virtually unchanged from the 2010 Maryland Department of Natural Resources Forest Action Plan, which indicates a potential tapering-off of forest loss in the state (Maryland Department of Natural Resources).

Table 2: Acres of Forestland by State, Region, County

Maryland			**2,436,643 Acres**
Central	**500,217**	**Eastern**	**704,797**
Baltimore	132,958	Caroline	51,811
Baltimore City	2,125	Dorchester	126,183
Carroll	50,199	Kent	42,993
Cecil	74,243	Queen Anne's	72,147
Harford	83,806	Somerset	87,314
Howard	47,931	Talbot	53,359
Montgomery	108,955	Winomico	123,412
		Worcester	147,578
Southern	**523,428**	**Western**	**708,202**
Anne Arundel	58,080	Allegany	198,495
Calvert	74,721	Frederick	139,437
Charles	145,950	Garrett	250,346
Prince George's	127,294	Washington	119,925
St. Mary's	117,383		
Neighboring Counties			**3,736,895 Acres**
Pennsylvania	**1,932,217**	**West Virginia**	**1,174,648**
Adams	129,516	Berkeley	77,382
Bedford	365,075	Grant	248,668
Chester	95,508	Hampshire	286,316
Fayette	319,612	Jefferson	33,209
Franklin	203,382	Mineral	144,527
Fulton	172,871	Morgan	109,945
Lancaster	85,905	Preston	274,601
Somerset	449,684		
York	110,663		
Delaware	**353,717**	**Virginia**	**276,313**
Kent	103,361	Accomack	103,667
New Castle	61,157	Fairfax	74,287
Sussex	189,199	Loudon	98,359
	Total Project Area		**6,173,538 Acres**

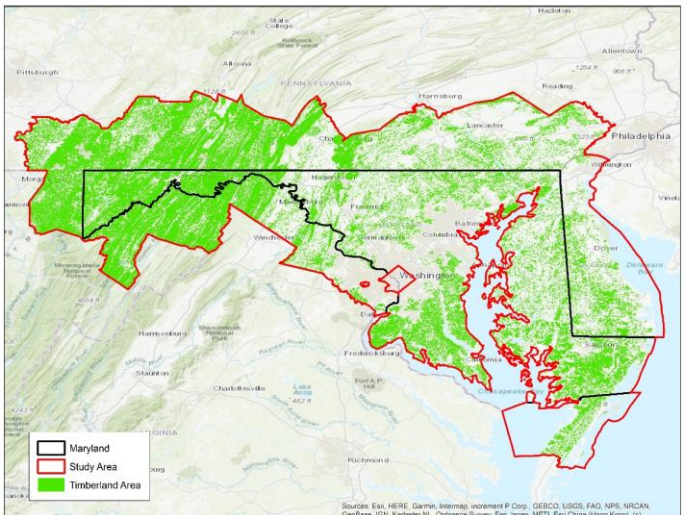
Figure 4: Timberland Acres



Timberland

Timberland is a subset of forestland defined as lands which can produce a minimum of 20 cubic feet per acre per year of forest growth. Timberland excludes those lands that are prohibited to be managed for the production of wood products. **Figure 3** shows timberland cover across the study area and **Figure 4** depicts the density of timberland. As shown, timberland is concentrated in the Central and Western regions.

Figure 3: Timberland Cover



Environmental, social, and/or economic factors may constrict timber harvesting on timberland. Steep slopes may prevent timber harvesting due to the inability to run mechanized logging equipment. Timber harvesting is generally limited around open waters to protect water quality. Timber on small parcels may not be harvested due to lack of sufficient harvest volume to make harvest economically feasible. For the purposes of this study, areas of steep slope, buffers around open water, and small-sized parcels are determined to be "marginal harvest areas". Timber harvest is generally not prohibited in marginal harvest areas; however, harvesting on these lands is often constrained or simply not feasible. In this study, biomass on marginal harvest areas is included in total biomass but it is also identified so that the most conservative estimate of biomass inventory can be used, if desired.

To quantify marginal harvest areas, a model of the project area FIA timberland data was constructed in Geographic Information Systems software. Spatial data used in this analysis is listed in **Table 3**. It is important to note that the constructed timberland model is not an exact match to FIA's timberland data but is a close representation. The model was used to estimate marginal harvest areas contained within the project area.

Table 3: GIS Spatial Data Parameters

Feature	Data File	Source	Values Used
Flowlines	NHDFlowline.shp	https://apps.nationalmap.gov/downloader/#/	ftype: 336=canal/ditch, 460=stream/river (fcode=46007 ephems removed), 468=drainageway, 566=coastline
Open Water	NHDWaterbody.shp	https://apps.nationalmap.gov/downloader/#/	ftype: 493=estuary, 390=lakepond, 436=reservoir
Stream Area	NHDArea.shp	https://apps.nationalmap.gov/downloader/#/	Ftype: 398=lockchamber, 537=area of complex channels, 364=foreshore, 312=bayinlet, 460=streamriver, 336=canalditch, 445=seaocean
Maryland Landowner Parcels	Parcel_Polygons	Maryland Department of Planning https://planning.maryland.gov/Pages/OurProducts/DownloadFiles.aspx	Parcels under 10 acres
Urban Areas	2020 Census Urban Area TIGER/Line Shapefile (tl_2020_us_uac20)	US Census Bureau	Clipped to study area
Reserved Lands	PAD-US (CBI Edition) Version 2 (updated 9/1/16)	https://consbio.org/projects/establishment-dates-added-to-pad-us-cbi-edition/	res-status: reserved
Forestland Data	NLCD (2019)	https://www.usgs.gov/search?keywords=Geospatial%20Data	used values: 41=Deciduous Forest, 42=Evergreen Forest, 43=Mixed Forest, & 90=Woody Wetlands
Slopes	USGS 3D Elevation Program 1/3 Arc Second Digital Elevation Models	https://www.usgs.gov/3d-elevation-program/tools	NA
Maryland County Boundaries	BNDY_CountyPhyBoundaryGeneralized_SHA.shp	https://data.imap.maryland.gov/datasets/4c172f80b626490ea2cff7b699febedb	All
Delaware County Boundaries	Delaware_Political_Boundaries.shp	https://de-firstmap-delaware.hub.arcgis.com/pages/data	MD adjacent counties
Pennsylvania County Boundaries	geo_export_3d80ca23-f16b-4404-b03f-95ecd039cc70	https://data.pa.gov/browse	MD adjacent counties
West Virginia County Boundaries	WV_county_boundaries_24k_topo_updated_2022_utm83	http://wvgis.wvu.edu/data/data.php	MD adjacent counties
Virginia County Boundaries	geo_export_39cae7a8-8fca-4082-aa73-54240ba0caea	https://data.virginia.gov/	MD adjacent counties

The forested area of the study area was constructed using forest cover raster data obtained from the 2019 National Land Cover Database (NLCD), the most recent NLCD data at the time of this study. Forest cover areas were selected from the following classifications of the NLCD data:

- Deciduous Forest- areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
- Evergreen Forest- areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
- Mixed Forest- areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
- Woody Wetlands- areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Note that an alternative data source was considered for forestland cover; the Chesapeake Bay Program Office created a forested land use dataset based on higher resolution data (1mx1m lidar imagery as compared to the NLCD raster data sizes of 30mx30m) and classification more closely aligned to FIA methodology; however, this dataset was not inclusive of the entire project area. It should be noted that while NLCD classified land as forested if more than 20% of the area had canopy cover, FIA data classified area as forestland if the contiguous canopy cover was greater than 1 acre. While the Chesapeake Bay Program Office data would have been a more precise portrayal of the forestland in the study area, the NLCD data was used to ensure that data was comparable across all counties within the study area.

Ultimately the timberland model area built for this study was 6,093,465 acres compared to the FIA timberland area of 5,724,869 acres, approximately 6% higher. The most likely reason for this difference in area was the use of the woody wetlands classification from the NLCD data. Woody Wetlands included not only forested wetlands, but also areas of shrub wetland, which are not included in the FIA timberland. When the timberland model was built without the woody wetlands classification area, the total area was significantly smaller than FIA timberland which led to the decision to include it. While not exact, the timberland model acts as a representation of the FIA timberland area, from which an estimate of the marginal harvest areas was determined.

After the forested area was established, lands reserved from timber harvest and urban areas were removed. The most recent U.S. Census Bureau's Tiger data (2019) was used to remove urban areas from the timberland model. The list of reserved lands excluded from FIA timberland can be found in the FIA's Field Data Collection Procedures for Phase 2 Plots (US Forest Service, 2022). To account for reserved lands, the Protected Areas Database of the US, Conservation Biology Institute edition, was removed from the forested land. This data includes a "reserved" attribute, which aligns with the FIA's definition. Only reserved lands were removed. The Maryland DNR provided spatial data for the Maryland State Forest Wildlands, which are reserved from harvest in the state, but not included in FIA's reserved lands.

Marginal Harvest Areas

Areas of steep slope, buffers around open water, and small-sized parcels are determined to be "marginal harvest areas". Definitions of marginal harvest areas for this report were determined from a combination of existing guidance documents and input from the Maryland State Wood Energy (SWE) Team. The definitions of marginal harvest areas are outlined in **Table 4**.

Table 4: Marginal Harvest Area Definitions

Marginal Harvest Area	Definition
Open Water Buffer	50 feet from the exterior of surface water features including streams, rivers, lakes, ponds, and other open water habitats.
Steep Slopes	Areas with slopes equal to or greater than 40%.
Small Land Ownership Parcels	Parcels of land less than 10 acres in size.

Open Water Buffer

The open water buffer size was determined from the 2015 Maryland Soil and Sediment Control Standards and Specifications for Forest Harvest Operations. The standards require a minimum stream buffer of 50 feet with an extension formula for streams adjacent to slopes of certain steepness, allowing timber harvesters to remove timber down to a basal area of 60 feet^2 within the buffer (Maryland Department of the Environment, 2015). A buffer of 50 feet was applied to all open waters.

The National Hydrography Dataset's (NHD) Flowline, NHD Area, and NHD Waterbody shapefiles were the base data used to generate the 50-foot buffers. The line features from the NHD Flowlines were used for small streams and rivers; the NHD Area was used for large rivers that had mapped areas. Note that NHD Area was always used when present over the NHD Flowline. The NHD Waterbody data was used for all other open waters. From these features, a buffer of 50 feet was created around their exterior and clipped from the timberland model. The following classifications were used:

NHD Flowlines	NHD Area	NHD Waterbody
336 Canal/Ditch	312 Bay Inlet	390 Lake/Pond
460 Stream/River	336 Canal/Ditch	436 Reservoir
(46007 Ephemerals were removed)	364 Foreshore	493 Estuary
468 Drainageways	398 Lock Chamber	
566 Coastline	445 Sea/Ocean	
	460 Stream/River	
	537 Area of Complex Channels	

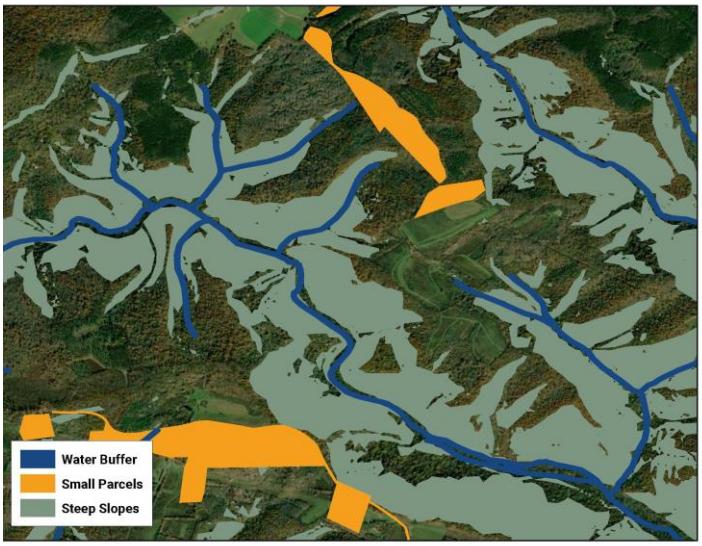
Steep Slopes

Steep slopes pose both a safety risk to the timber harvester and erosion concerns. The definition of steep slopes was based on timber harvesting activities generally practiced in the state of Maryland as identified by expert members of the SWE Team.

USGS 3D Elevation Program 1/3 Arc Second Digital Elevation Model (DEM) in 1 x 1 degree extent files were used for slope analysis of the study area. The DEMs were combined into a mosaic grid to make a seamless surface across the study area. Slope was calculated across the study area and areas with slope values equal to or greater than 40% were identified and extracted from the timberland model.

Figure 5 depicts an example of marginal harvest areas in an area within the project area.

Figure 5: Example of Marginal Harvest Area in Garrett County, Maryland



Small Land Ownership Parcels

While it can vary based on the quality of the timber, location of the property, and other factors, it is generally not economical to harvest land under ten acres in size. The small land parcel size definition was determined in consultation with foresters familiar with the project area. Parcelization of large land tracts is becoming more common and according to the National Woodland Owner Survey (USDA Forest Service, 2018), the amount of forest landowners with less than ten acres in Maryland increased from 72,400 in 1989, to 134,000 in 2006. Due to the difficulties of harvesting small-sized parcels, the most recent survey conducted in 2018 did not include parcels under ten acres.

Parcel data was processed only for the state of Maryland. Parcel data was obtained from the Maryland Department of Planning. Parcels less than 10 acres were extracted and clipped from the timberland model.

Total marginal harvest area data includes the combined areas of open water buffers, areas with equal to and greater than 40% slope, and parcels of less than 10 acres in Maryland.

Figure 6 shows the acres of timberland across the project area and differentiates the acres of land within marginal harvest areas. The project area includes 4,779,233 acres of timberland, 945,636 acres of which are considered to be in marginal harvest areas. In the state of Maryland alone, there are 2,163,5819 acres of timberland, 496,030 of which are in marginal harvest areas.

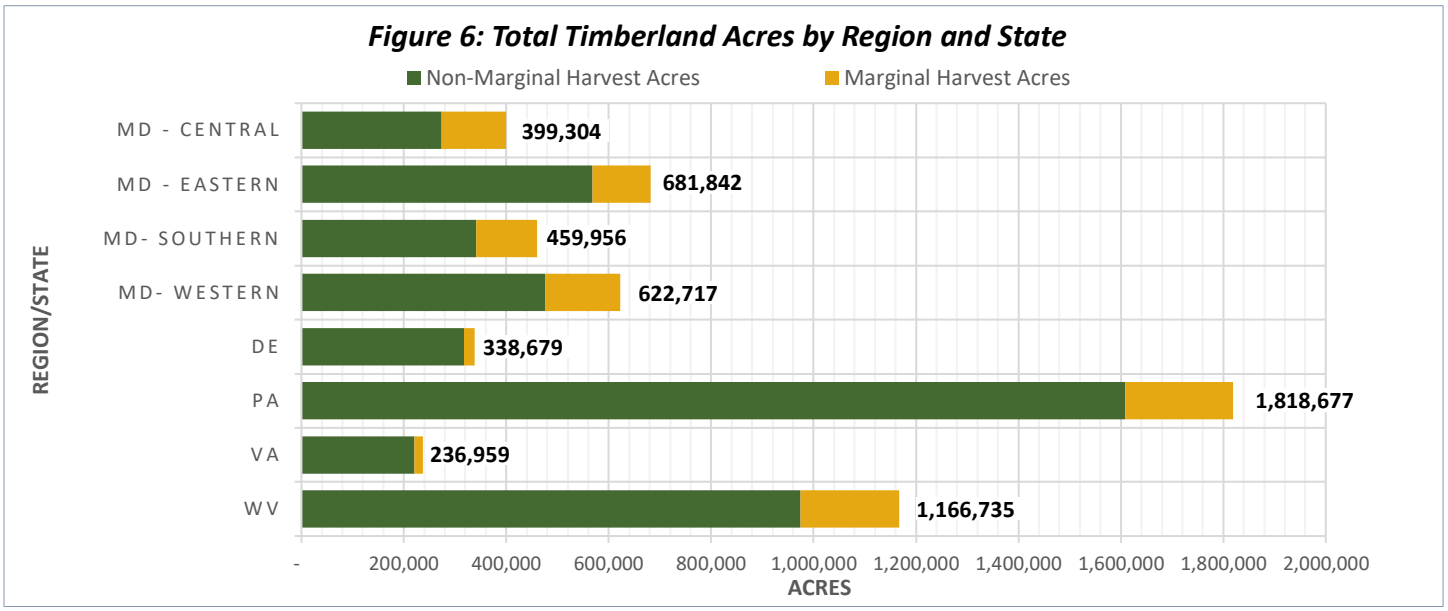


Figure 7 shows total tons of biomass on timberland by region and state. 311,627,839 tons of wood fuel are within the project area, with 120,410,470 tons in Maryland. Though potentially available for utilization, the volume of biomass on marginal harvest areas is identified separately.

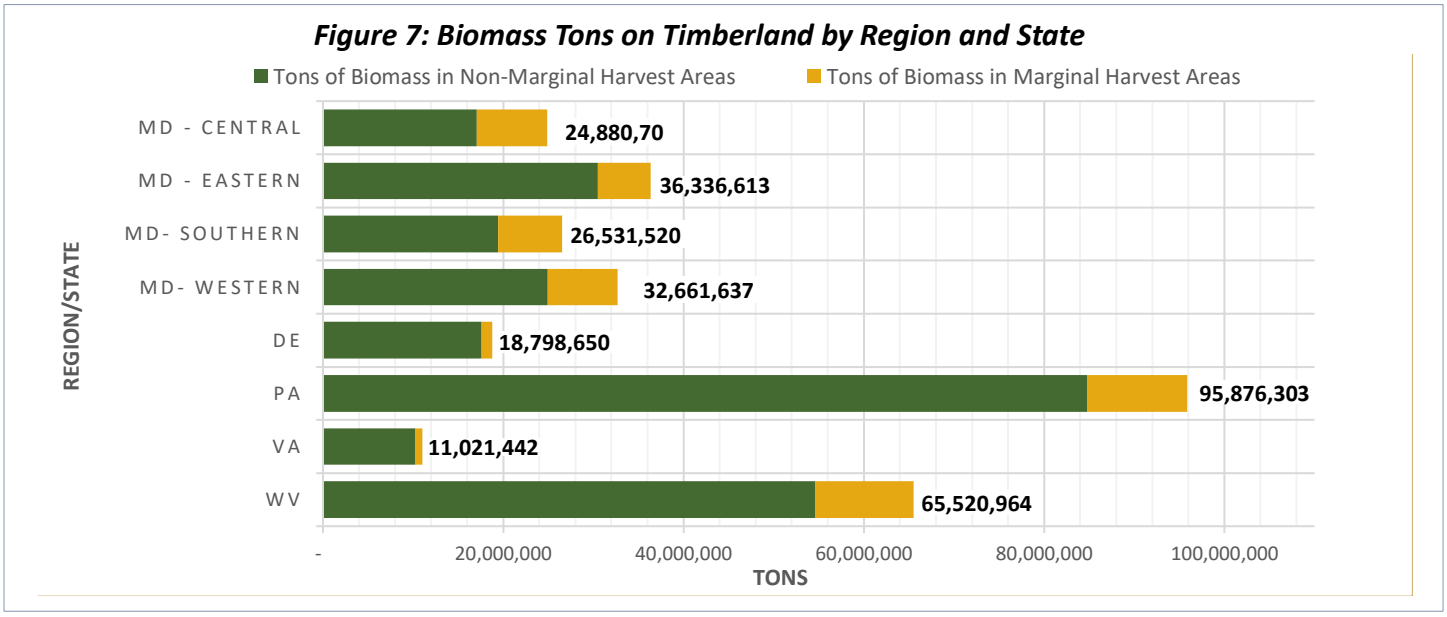


Table 5 identifies acres of forestland and timberland as well as tons of biomass by county, region and state across the project area. Total tons of biomass are shown along with the tons of biomass identified within the individual marginal harvest areas and the tons of biomass on non-marginal acres. In Maryland, the biomass within marginal harvest areas is approximately 25% of the total biomass. Within the entire project area, about 17% of the biomass is located within marginal harvest areas. It's important to reiterate that the biomass identified in the marginal harvest areas is an available

resource but is unlikely to be harvested due to economic and social constraints, so the volumes are noted here. In further analyses in this study, biomass on marginal harvest areas is included in the reported numbers.

Tons of biomass is calculated from the bole, top and limb wood of all growing stock trees minus the sawlog volume of sawtimber trees. Trees qualifying for the sawtimber market are far too valuable to redirect into a fuel market. Indeed, where paper mills can provide markets for pulpwood, it is highly unlikely that a fuel market will divert wood from the paper mill. Wood fuel markets offer opportunities to utilize wood that is otherwise unmarketable, but fuel markets are not capable of exerting pressure on existing markets with higher valuations. Thus, the production of wood fuel from timberland is only possible as a coincident byproduct of harvesting those other products but it does not include sawtimber.

When wood manufacturing businesses or energy plants evaluate opportunities or new markets, they consider the wood basket, or current inventory, in their analysis. The wood fuel inventory in Table 5 provides the amount of wood fuel available in regions across the state and in adjacent counties. Industry can use the regional inventories to determine if there is enough supply for their anticipated production as well as how far away from current or potential sites that supply is located so that they can consider transportation costs.

Table 5: Summary of Acres of Forestland and Timberland and Tons of Biomass in the Project Area

Row Labels	Forestland (Acres)	Timberland (Acres)	Total Biomass on Timberland (Tons)	Biomass Within Surface Water Buffers (Tons)	Biomass on =>40% Slopes (Tons)	Biomass on Parcels of <10 acres (Tons)	Total Biomass Minus Biomass on Marginal Harvest Areas (Tons)
MD	**2,436,643**	**2,163,819**	**120,410,470**	**6,904,191**	**2,947,422**	**19,825,645**	**91,923,208**
MD - Central	***500,217***	***399,304***	***24,880,700***	***1,710,559***	***188,848***	***6,287,887***	***17,054,930***
Baltimore	132,958	104,259	6,805,815	340,923	45,538	1,784,961	4,719,689
Baltimore City	2,125	-	-	-	-	-	-
Carroll	50,199	43,097	2,519,890	335,855	41,163	1,112,050	1,104,716
Cecil	74,243	74,243	5,040,664	328,202	30,271	823,652	3,913,195
Harford	83,806	78,849	5,152,599	338,830	59,762	1,187,115	3,628,180
Howard	47,931	41,017	3,057,504	193,342	5,104	952,046	1,964,075
Montgomery	108,955	57,840	2,304,229	173,407	7,010	428,063	1,725,076
MD - Eastern	734,866	708,623	38,130,473	2,082,922	11,575	3,004,188	33,215,287
Caroline	51,811	51,811	2,803,403	302,052	329	411,188	2,130,047
Dorchester	126,183	113,929	6,071,301	287,089	418	340,287	5,464,957
Kent	42,993	42,993	2,568,357	223,878	9,223	294,103	2,061,262
Queen Anne's	72,147	72,147	3,716,784	240,294	338	279,046	3,213,870
Somerset	117,383	109,766	5,315,344	131,361	190	411,360	4,786,358
Talbot	53,359	53,359	2,902,796	184,911	1,028	361,152	2,375,126
Winomico	123,412	123,412	6,872,187	207,705	41	524,391	6,161,181
Worcester	147,578	141,206	7,880,302	505,633	8	382,661	7,022,487
MD - Southern	493,358	433,174	24,737,660	1,480,913	177,117	6,638,736	16,741,865
Anne Arundel	58,080	41,085	2,116,557	192,744	33,000	841,531	1,095,149
Calvert	74,721	74,721	5,090,879	248,182	72,889	1,677,815	3,171,347
Charles	145,950	136,555	8,443,797	563,565	26,219	2,050,824	5,884,092
Prince George's	127,294	97,829	5,564,943	170,761	20,146	897,112	4,512,040
St. Mary's	87,314	82,985	3,521,485	305,661	24,863	1,171,454	2,079,237
MD - Western	708,202	622,717	32,661,637	1,629,797	2,569,883	3,894,835	24,911,126
Allegany	198,495	183,203	9,379,984	454,553	1,094,270	676,555	7,273,112
Frederick	139,437	99,005	5,547,617	429,505	128,308	1,184,796	3,884,463
Garrett	250,346	234,773	13,007,754	519,051	1,152,978	1,347,682	10,074,398
Washington	119,925	105,736	4,726,281	226,687	194,326	685,802	3,679,153
DE	**353,717**	**338,679**	**18,798,650**	**1,201,824**	**6,707**		**17,590,635**
Kent	103,361	98,910	5,880,679	436,788	61		5,443,531
New Castle	61,157	53,171	3,152,614	166,879	6,627		2,980,066
Sussex	189,199	186,598	9,765,357	598,158	19		9,167,039
PA	**1,932,217**	**1,818,677**	**95,876,303**	**5,733,522**	**5,479,512**		**84,805,920**
Adams	129,516	129,516	7,160,266	470,574	95,735		6,595,712
Bedford	365,075	341,779	18,712,265	1,085,849	1,807,585		15,855,672
Chester	95,508	85,516	5,352,854	453,358	52,927		4,849,681

Fayette	319,612	290,418	15,385,037	733,356	920,129		13,760,820
Franklin	203,382	196,119	9,813,958	570,141	805,021		8,452,884
Fulton	172,871	172,871	6,642,636	417,582	404,262		5,835,586
Lancaster	85,905	73,682	4,460,740	392,847	183,562		3,892,608
Somerset	449,684	424,638	22,310,319	990,215	854,672		20,484,164
York	110,663	104,139	6,038,228	619,600	355,619		5,078,793
VA	**276,313**	**236,959**	**11,021,442**	**711,523**	**62,136**		**10,252,811**
Accomack	103,667	101,953	5,095,168	321,932	223		4,772,994
Fairfax	74,287	42,526	1,934,983	85,301	6,673		1,843,721
Loudon	98,359	92,480	3,991,292	304,290	55,240		3,636,097
WV	**1,174,648**	**1,166,735**	**65,520,964**	**2,954,007**	**8,198,383**		**54,618,112**
Berkeley	77,382	77,382	3,674,414	216,634	161,890		3,305,468
Grant	248,668	240,756	15,170,567	551,398	2,358,375		12,339,341
Hampshire	286,316	286,316	16,386,982	813,637	2,005,219		13,633,489
Jefferson	33,209	33,209	1,809,956	70,993	44,926		1,697,030
Mineral	144,527	144,527	8,102,192	373,830	1,209,137		6,555,521
Morgan	109,945	109,945	5,205,179	268,873	429,088		4,531,015
Preston	274,601	274,601	15,171,674	658,643	1,989,750		12,556,248
Project Area	**6,173,537**	**5,724,869**	**311,627,829**	**17,505,067**	**16,694,160**	**19,825,645**	**259,190,686**

Stand Type

Stand types were defined as hardwood or softwood based on the major timber type. Timber types were identified within the project area in alignment with FIA definitions and are described below. Note that the oak/pine group was categorized as a hardwood type because the oak component is greater than 50% in this stand type. There are product opportunities for both hardwood and softwood biomass, including wood pellets.

Categorized as Hardwood	Categorized as Softwood
Aspen / birch group	Exotic softwoods group
Elm / ash / cottonwood group	Loblolly / shortleaf pine group
Exotic hardwoods group	Other eastern softwoods group
Maple / beech / birch group	White / red / jack pine group
Oak / gum / cypress group	
Oak / hickory group	
Oak / pine group	
Other hardwoods group	

Figure 8 identifies acres of timberland by forest type. As shown, the large majority of the project area is hardwood timber type. In total 5,042,431 acres in the project area are hardwood timber type and 658,650 acres are softwood. Maryland contains 1,757,613 acres of hardwood and 394,670 acres of softwood. Notably, Maryland's eastern region contains significantly more softwood than other areas of the state. Opportunities for product manufacturing from both hardwood and softwood wood fuel exist in pellet manufacturing and other products.

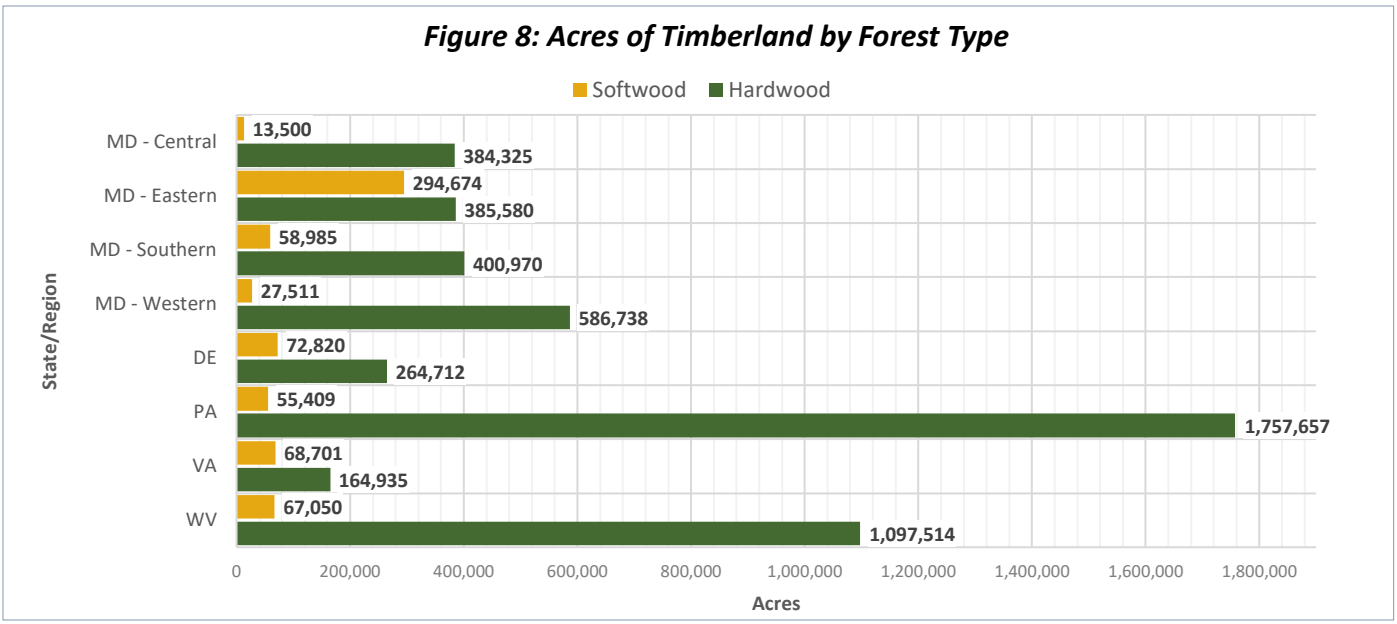


Figure 8: Acres of Timberland by Forest Type

Figure 9 identifies tons of biomass on timberland within hardwood and softwood timber types.

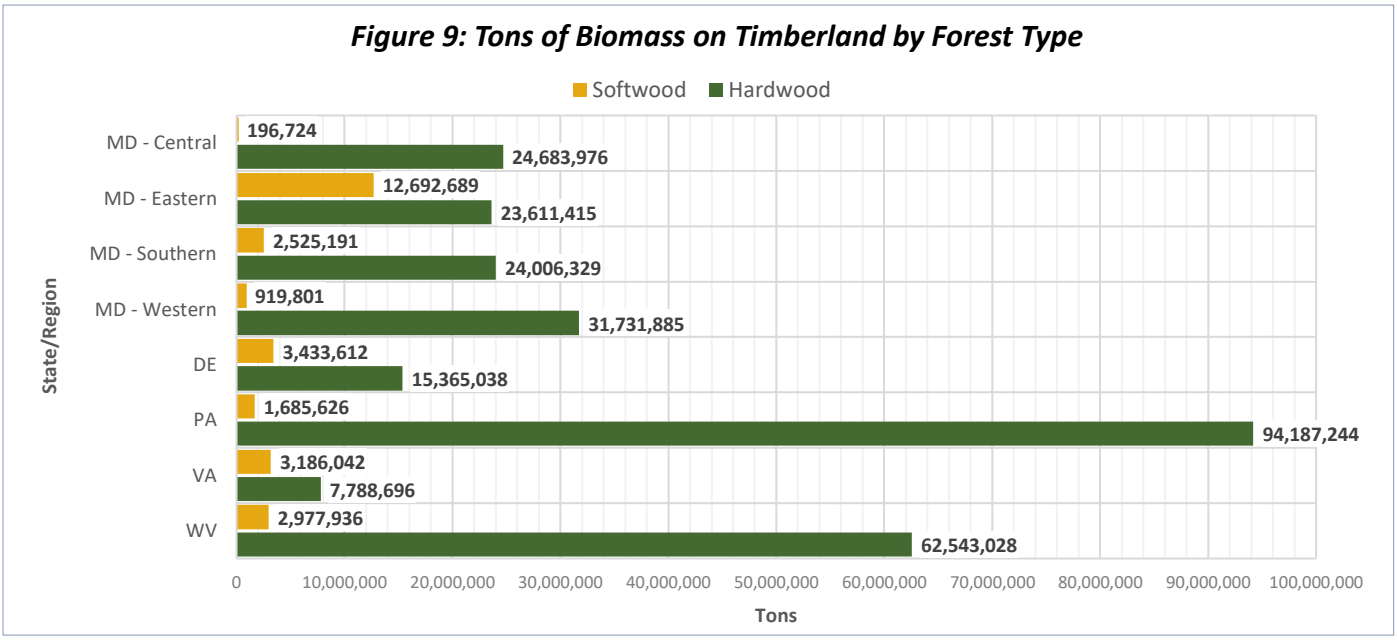


Figure 9: Tons of Biomass on Timberland by Forest Type

Ownership

The ownership categories included within the data sets are federal, state, local, and private. **Table 6** identifies acres of timberland by ownership category. Most of the land is privately owned both in Maryland and across the project area. Ownership impacts land management: the majority of acres privately owned in the state of Maryland are reported by the National Woodland Owners Survey Dashboard (U.S. Forest Service, 2018) to be managed for reasons other than timber harvest including for hunting, privacy, and recreation, among others. Timber harvesting of any kind was reported as of little importance to private landowners whether it was for timber products, non-timber products or firewood. If landowners were aware of the improved ecological services that would be provided by their woodlands through proper timber harvest, they would likely use harvests to help achieve their goals. Landowner education of the forest health

benefits of harvesting wood fuel products from their woodlands could provide an opportunity for improving the resiliency of Maryland's privately owned timberlands.

Table 6: Acres of Timberland by Ownership Category by Region and State

State/Region	Federal	State	Local	Private	Total
MD - Total	9,788	312,161	70,289	1,771,582	**2,162,819**
MD - Central	4,812	21,300	11,814	361,378	**399,304**
MD - Eastern		91,809	19,907	561,325	**673,041**
MD - Southern	4,975	49,303	11,853	402,625	**468,757**
MD - Western		149,748	26,714	446,254	**622,717**
DE	4,708	52,392	7,815	273,764	**338,679**
PA	15,364	337,228	35,982	1,430,102	**1,818,677**
VA		5,486	5,110	226,363	**236,959**
WV	22,169	71,453		1,073,113	**1,166,735**
Total Project Area	**52,028**	**778,720**	**119,196**	**4,774,925**	**5,724,869**

Number of Trees

This study considered growing stock and standing dead trees as available wood fuel material. **Figure 10** shows the number of growing stock trees on timberland by forest type by region and state, **Figure 11** shows the number of standing dead trees and **Figure 12** identifies the total number of trees.

Figure 100: Number of Growing Stock Trees on Timberland by Forest Type

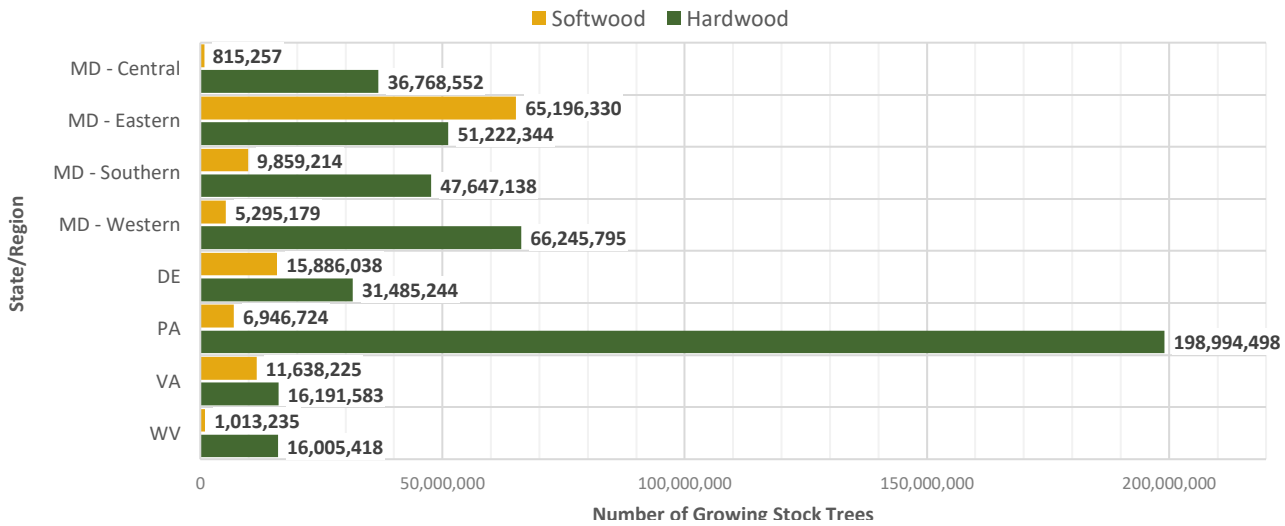


Figure 11: Number of Standing Dead Trees on Timberland by Forest Type

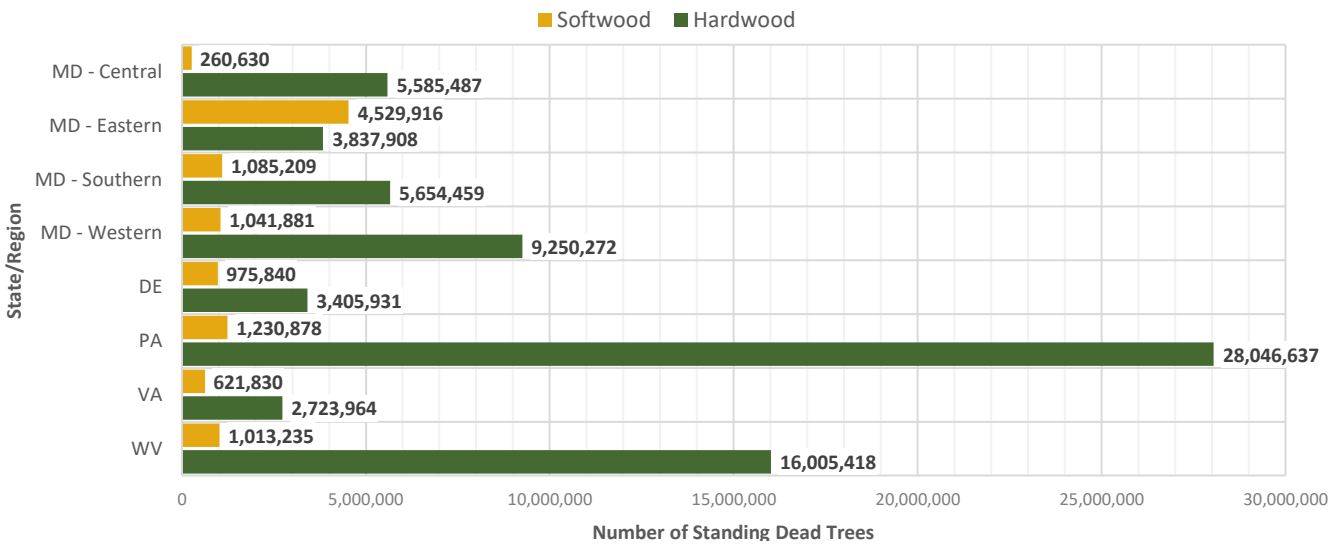
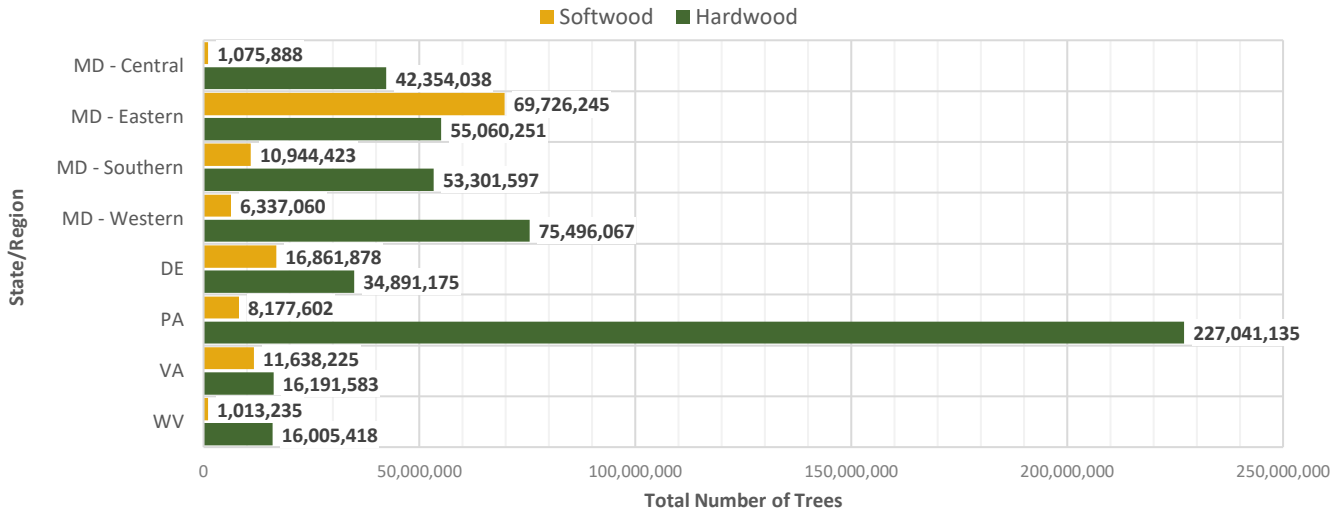


Figure 12: Total Number of Trees on Timberland by Forest Type



Basal Area

Basal Area is a measure used to describe stand density by determining the cross-sectional area of trees per acre of land. Stands are typically managed to a minimum or maximum basal area depending on species and stand characteristics. **Table 7** shows basal area on timberland acres across the project area by county. Though this variable is most useful at the stand level, aggregated data can identify areas for more in-depth assessment by local land managers. The data presented here can be utilized by timberland managers to further identify areas where harvest would be beneficial to overall forest health. While MDNR does not have standardized basal area targets for various stand types, standards of practice incorporate using basal area as a tool to identify areas where stand density is too high to support optimal growth. In combination with landowner objectives, areas in need of management via harvest can be identified at the stand level.

Table 7: Basal Area Per Acre by County

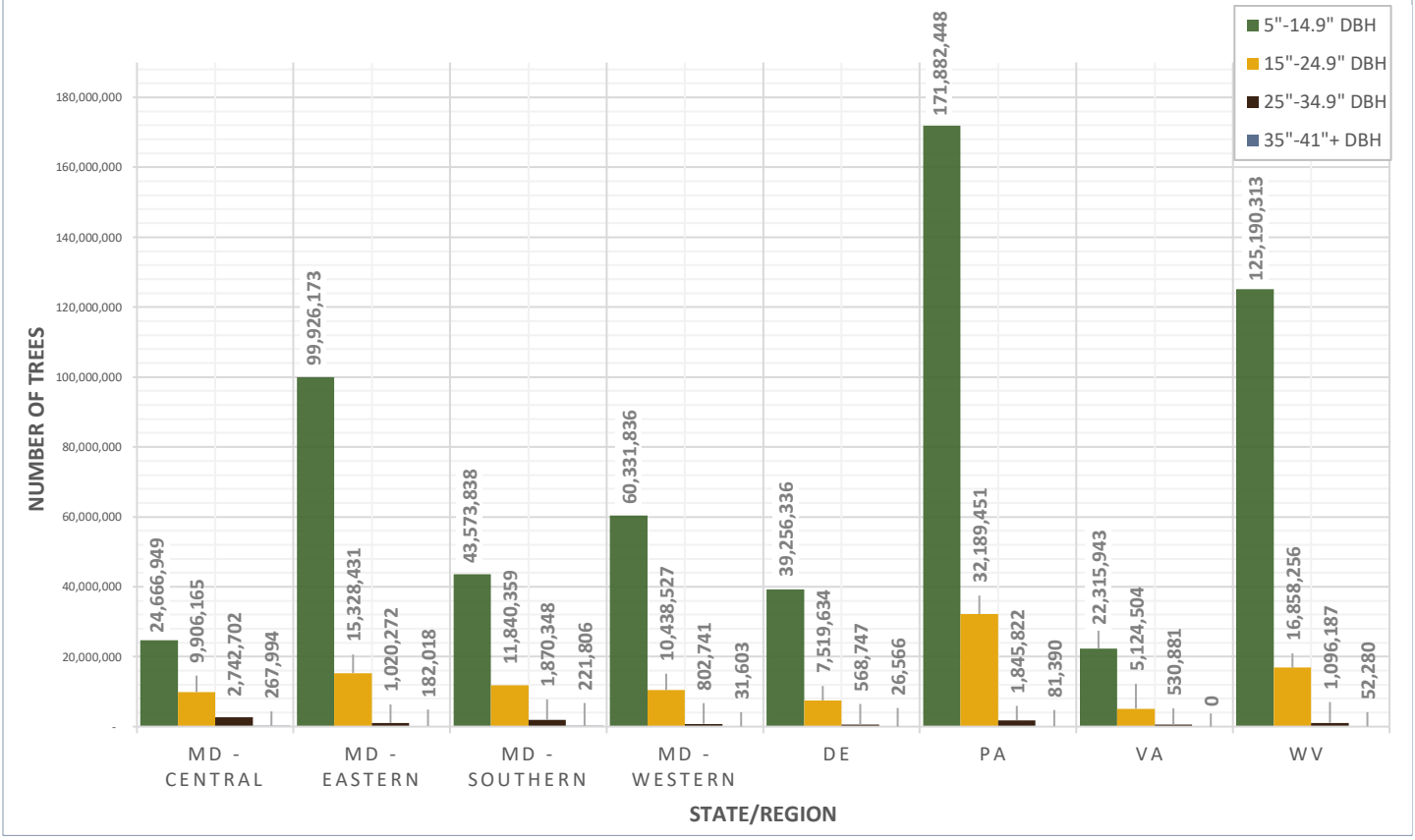
County	Basal Area/Acre	
	Hardwood	Softwood
MD		
Allegany	75.97	-
Anne Arundel	70.99	38.76
Baltimore	112.66	2.48
Calvert	136.22	-
Caroline	62.70	51.49
Carroll	110.79	-
Cecil	127.94	1.11
Charles	101.56	17.27
Dorchester	64.48	49.57
Frederick	99.83	-
Garrett	72.32	12.00
Harford	132.48	-
Howard	130.29	-
Kent	111.52	17.72
Montgomery	69.23	1.56
Prince George's	111.43	-
Queen Anne's	93.85	-
St. Mary's	105.16	29.87
Somerset	18.46	56.81
Talbot	25.98	119.35
Washington	74.10	2.38
Winomico	61.92	55.72
Worcester	79.61	39.43

	Basal Area/Acre	
	Hardwood	Softwood
DE		
Kent	97.08	9.09
New Castle	99.10	-
Sussex	55.62	44.71
PA		
Adams	93.32	-
Bedford	-	-
Chester	101.67	-
Fayette	81.96	1.03
Franklin	67.70	-
Fulton	51.32	6.10
Lancaster	112.18	-
Somerset	75.34	4.05
York	102.87	-
VA		
Accomack	34.41	81.46
Fairfax	88.64	3.01
Loudon	78.20	-
WV		
Berkeley	59.09	-
Grant	73.88	6.98
Hampshire	81.55	5.58
Jefferson	68.83	-
Mineral	66.71	4.45
Morgan	64.83	15.69
Preston	86.61	-

Size Class

Trees were analyzed by 2-inch size classes and are summarized in **Figure 14** by size class ranges.

Figure 13: Number of Trees by Size Class Range

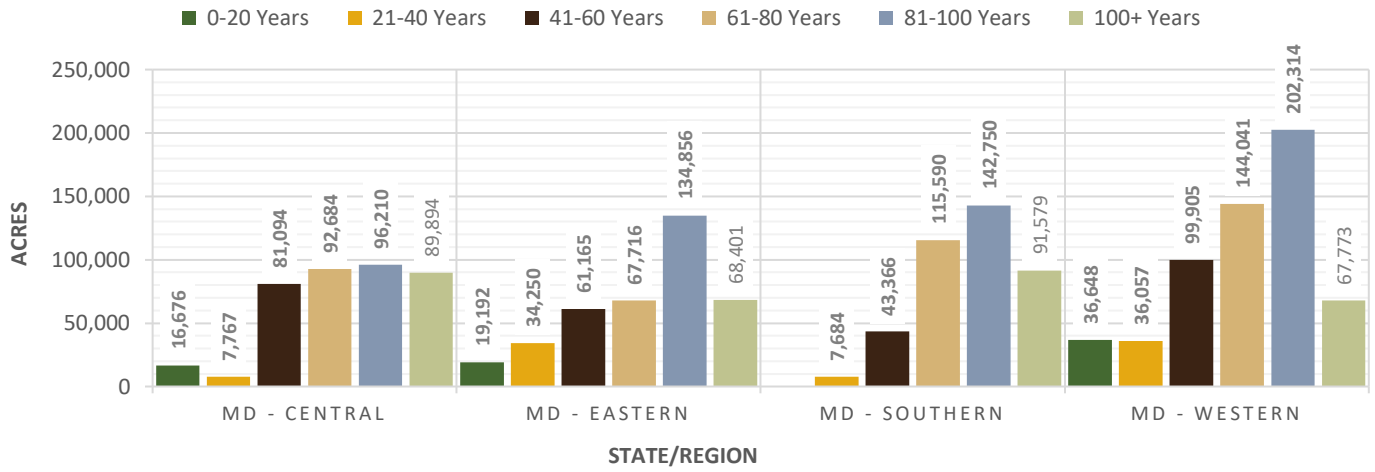


Age Class

Forest Inventory Analysis data shows that 78% of Maryland's forests are in the mature/large forest class, nearly 40% of forest is over 80 years of age, almost all of which is in the hardwood timber type, specifically in oak/hickory forest type. The U.S. Forest Service estimates that 10% of Maryland's timberland is at least 100 years old and only 8% of the state's timberland is younger than 20 years. (Maryland Department of Natural Resources). Maryland's forests are aging past their productive stage and trees are deteriorating in place. Timber harvest can be used as a management tool to improve regeneration of some species which would help foster the growth of trees that will make up Maryland's future forests. Harvesting wood fuel-sized trees will open up the canopy and allow natural regeneration to occur while at the same time making use of aging, decaying trees.

Figure 15 illustrates the acres of timberland by age class in hardwood timber type by region and state and acres in the softwood timber type are shown in **Figure 16**. Total acres by age class are shown in **Figure 17.**

Figure 14: Acres of Hardwood by Age Class



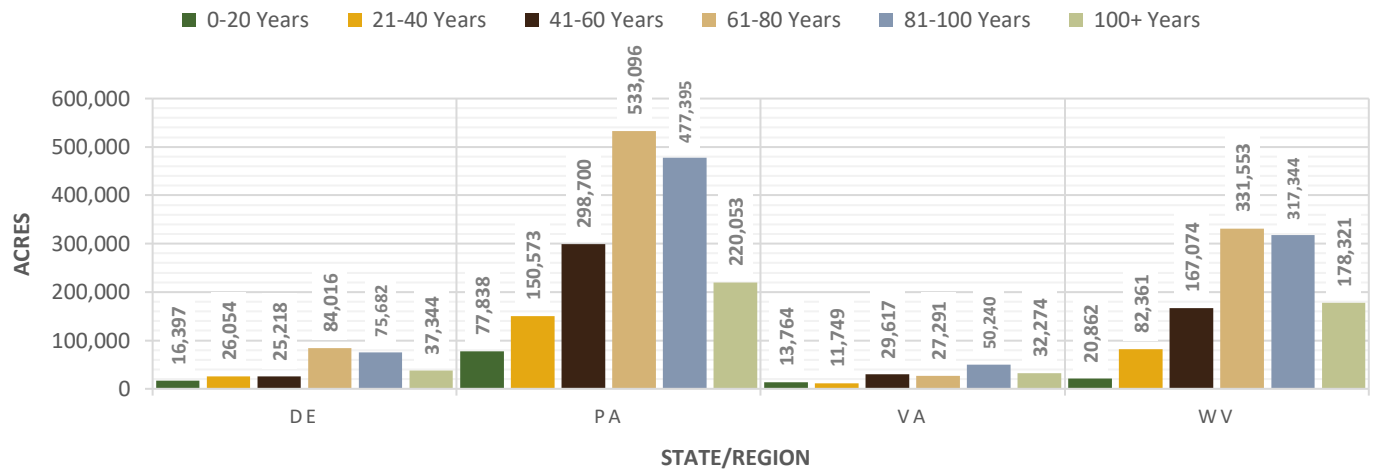


Figure 15: Acres of Softwood on Timberland by Age Class

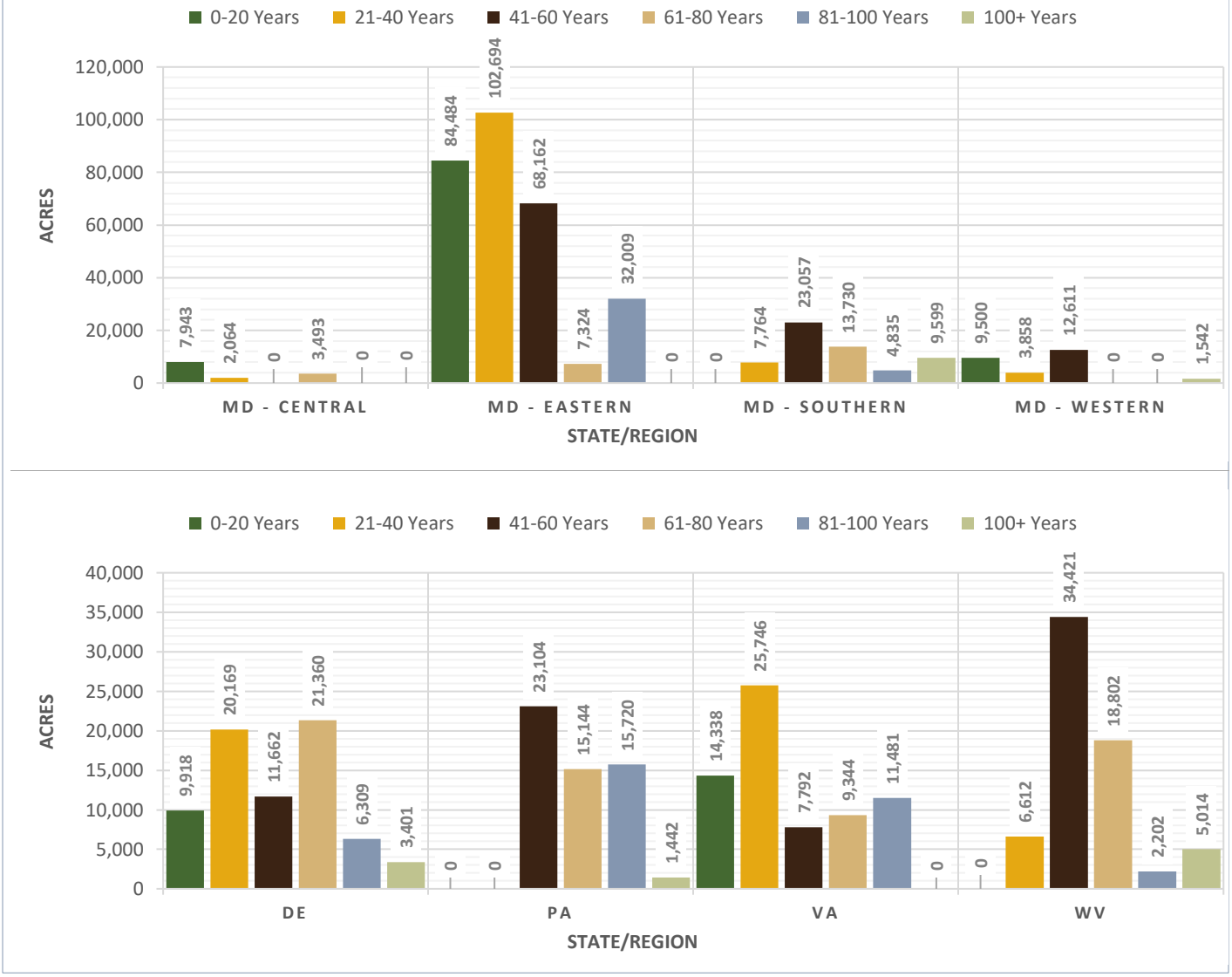
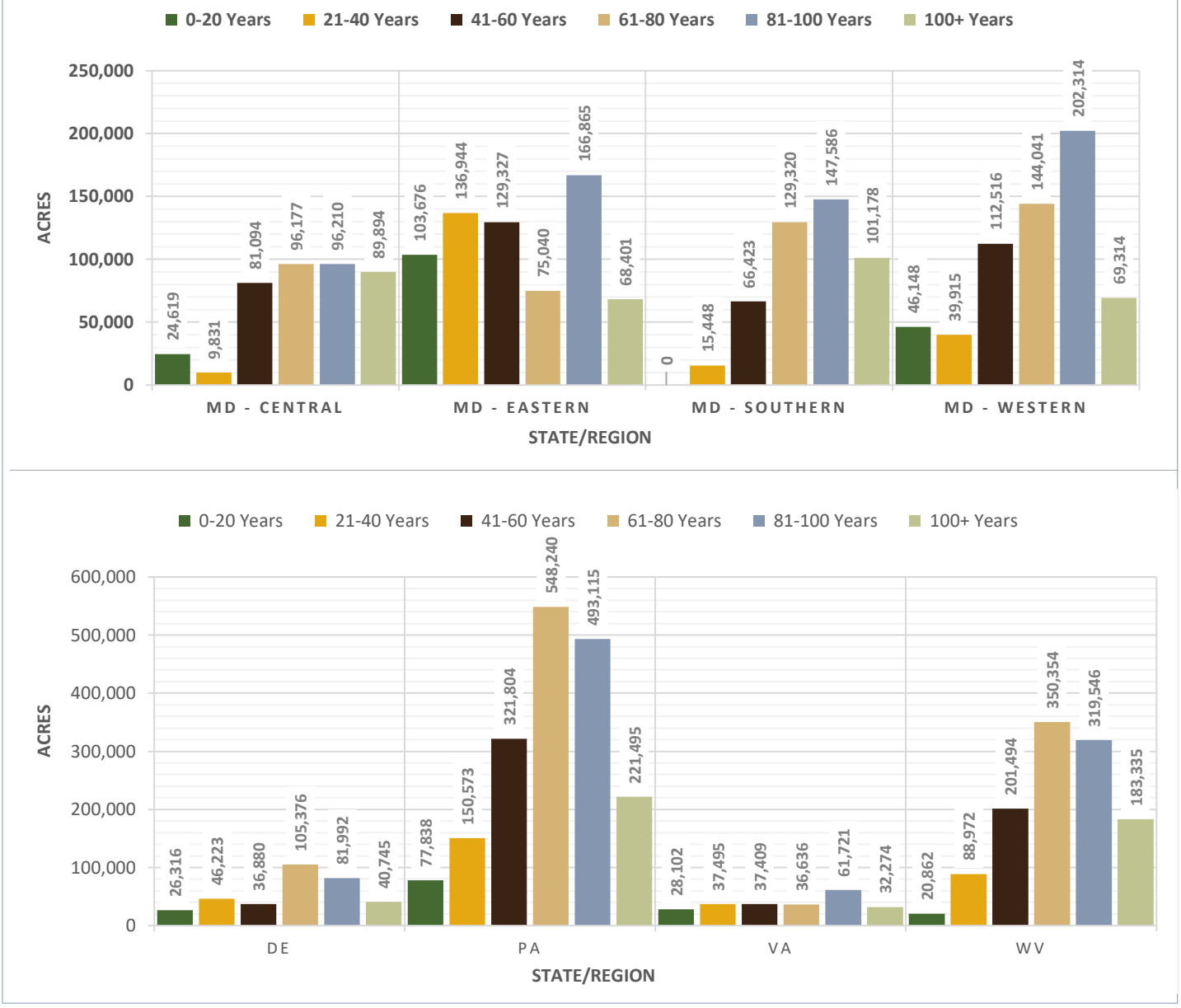


Figure 16: Total Acres of Timberland by Age Class



Wood Fuel from Urban Areas

Urban areas have extensive forest resources that are grown not for their timber value, but for their aesthetic, wellness and shade benefits. Maintenance trimming of urban trees and removals when trees reach their end of life often result in material that is wasted and is often landfilled at a cost to communities. While difficult to estimate, the volume of urban and community trees is significant and could provide additional wood fuel material. The data presented above were gathered from the U.S. Forest Service's FIA program for traditionally forested areas. This program has more recently expanded into an Urban Forest Inventory Analysis program (UFIA) and Baltimore City is one of the early survey areas. Urban wood fuel resources were identified through UFIA data and a digital survey of arborists.

Based on FIA and UFIA data (U.S. Forest Service 2023), the City of Baltimore has 2,215 acres of forestland, 1.82 million live trees at least 1 inch in diameter, and 27.8 MCF of material in the stems of live trees at least 5 inches in diameter. The number of trees in Baltimore City has declined since inventories began in 1999.

A survey of municipalities and private arborists for municipalities within the study area with populations greater than 2,500 was conducted. The purpose of this survey was to better understand the extent of urban wood available for utilization as wood fuel in the study area. Populations were determined based on annual estimates of the resident population for incorporated places from the 2020 census.

Responses were used to quantify the volume and species of urban wood produced within urban areas. Invited participants included municipal staff (forester/arborist, dept. of public works, clerk) for municipalities with a population of 2,500 or more and ISA certified arborists. A digital survey was emailed with a response time of ten days. Of the 364 invitations sent, a total of 28 were returned. Of the 28 returned, 19 had complete responses.

The limited response rate poses challenges in drawing definitive conclusions regarding the state of urban wood generation and utilization within the project area. Given the minimal engagement indicated by the response rate, it may be that many of the arborist and municipal operations are not actively tracking wood waste generation and/or utilization indicating an opportunity for expanded utilization of urban wood resources as wood fuel. Urban wood utilization is a growing industry as more people become aware of the opportunities to better utilize these forest resources. The Urban Wood Network provides further information on utilization of urban wood.

Survey Response Summary

The following provides a synopsis of the responses received, which offers a glimpse into the current state of wood waste generation, utilization, and disposal within arborist and municipal operations in Maryland and neighboring states. Of the 19 complete responses, operations located within and/or servicing Maryland represent a majority of the participants, with 15 from Maryland, 3 from Pennsylvania, and 1 from Delaware. Tree care companies were the most responsive industry sector, making up 58% of the participants. Institutions accounted for 21%, those that identified as self-employed accounted for 16%, and landscaping companies rounded out the bottom 5%.

As part of the survey, participants were asked to identify the localities (with populations greater than 2,500 residents) whose location operations generate urban wood. Of the 146 potential localities, 133 were noted as being served by the 19 participants. The results indicated that of the Maryland participants, 60% indicated that 100% of their urban wood waste was generated in state and the remaining 40% of responses indicated that between 90-98% of their urban wood waste was generated in state.

State	Total Localities Served
Maryland	109
Delaware	11
Pennsylvania	6
Virginia	7
West Virginia	0

Arboricultural Practices

The types of arboricultural practices represented in the survey answers were broken down by type of practice and percent of resulting urban wood generation. Of the responses, tree removal practices were the most significant source of urban wood generation at 55%, with tree pruning coming in second at 41%. Land clearing (4%) and curbside pickup of tree debris (1%) were reported to be minimal sources. No participants indicated small woodlot logging as a source of urban wood generation.

Urban Waste Production Measurement

Of the 19 participants, 10 noted they measure or estimate the amount of logs, brush, and chips they generate. There were 16 participants (84%) that indicated they were able to identify the fate of urban wood their operation generates.

In this instance, fate refers to what happens to urban wood after it is generated and may include disposal and/or utilization on-site, in-house, or by a third party. Of those that did know the fate, participants were asked to identify key information about each primary product type (logs, chips, brush).

Urban Wood - Logs

12 of the 19 participants indicated they generate logs as part of their operation. Of the responses, the most common fate of logs generated was transferring the logs to third parties for utilization as urban wood products (36%). In-house utilization of logs to produce urban wood products (26%) and disposal of logs at a solid waste facility or elsewhere (23%) were also common. For operations that utilize logs for in-house urban wood product production, the following were the most common: firewood (61%), lumber (14%), and unidentified "other" uses (20%). Art and novelty use were minimal at 5%.

Fate of Logs Generated	Representative Total
Transferred to a 3rd party for utilization as urban wood products	36%
Utilized in-house to produce urban wood products	26%
Disposed at a solid waste facility or elsewhere	23%
Left on-site for utilization by property owner	8%
Left on-site, resulting in no utilization	7%

Urban Wood - Chips

14 of the 19 participants indicated they generate chips as part of their operation. Of the responses, the most common fate of chips generated was transferring the chips to third parties for utilization as urban wood products (54%). In-house utilization of chips to produce urban wood products (30%) was also common. For operations that utilize logs for in-house urban wood product production, the following were the most common: mulch (62%), compost (36%), and wood fuel for energy rounded out the bottom at 2%.

Fate of Chips Generated	Representative Total
Transferred to a 3rd party for utilization as urban wood products	54%
Utilized in-house to produce urban wood products	30%
Disposed at a solid waste facility or elsewhere	2%
Left on-site, resulting in no utilization	4%
Left on-site for utilization by property owner	10%

Urban Wood - Brush

9 of the 19 participants indicated they generate brush as part of their operation. Of the responses, the most common fate of chips generated was disposing of the brush at a solid waste facility or elsewhere (54%). In-house (20%) or 3rd party (18%) utilization of brush to produce urban wood products was also common. For operations that utilize brush for in-house urban wood product production, the following were the most common: mulch (35%), compost (25%), wood fuel for energy (15%), and unidentified other uses (25%).

Fate of Brush Generated	Representative Total
Disposed at a solid waste facility or elsewhere	54%
Utilized in-house to produce urban forest products	20%
Transferred to a 3rd party for utilization as urban wood products	18%
Left on-site, resulting in no utilization	8%
Left on-site for utilization by property owner	0%

Urban Wood - Disposal

13 of the 19 participants indicated they dispose of urban wood at a solid waste facility or elsewhere.

GROWTH

The current standing forest resource has been quantified in the previous section, and growth of that resource over time is now considered in this section. Annual growth is another factor considered by industry when determining if there is adequate supply to establish a new mill or expand a current one.

To calculate annual growth of wood fuel in the project area, FIA's average annual gross growth of merchantable bole wood volume of growing-stock trees (at least 5 inches DBH), in cubic feet, on timberland was used to summarize growth for the project area by county, state and region. The average annual gross growth of sawlog wood volume of sawtimber trees was subtracted from the average annual gross growth of merchantable bole wood volume of growing-stock trees so that the reported growth rates reflect only wood fuel and not sawtimber.

Figure 18 shows the average annual net growth of merchantable bole volume of growing-stock trees in cubic feet on timberland with the sawlog growth removed. This chart shows cumulative growth by state and by region. Note that overall, the forests are growing across the project area each year. The Southern and Central regions in Maryland have negative growth rates. The growth rate variable measured by FIA is the net cubic foot stem wood volume and that volume is compared from the previous inventory volume to the current inventory volume to determine the growth rate. Negative growth can occur if a tree dies or falls or becomes cull between the time of the previous and current inventory. In addition, standing dead trees are measured so if a tree is standing dead during the previous inventory and then falls before the current inventory, then that would also be negative growth. Despite the negative growth in some areas, Maryland's forests are putting on more than 8.5 MMCF of biomass each year. Across the entire project area, growth is more than 25.7 MMCF annually.

Figure 18: Average Annual Net Growth of Merchantable Bole Volume of Growing-Stock Trees in cubic feet, on Timberland by State and Region Minus Sawlog Growth

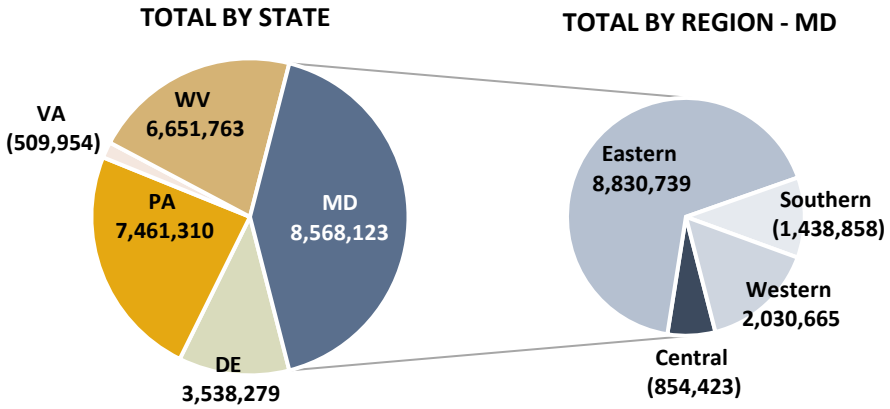


Table 8 identifies the average annual net growth of merchantable bole volume of growing stock trees minus sawlog growth in cubic feet on timberland by state, region, and county across the project area.

Table 8: Average Annual Net Growth of Merchantable Bole Volume of Growing-Stock Trees Minus Sawlog Growth, in cubic feet, on Timberland by State, Region, and County

State/Region/County	Total Cubic Feet	Cubic Feet per Acre
MD	**8,568,123**	**2.5**
Central	***(854,423)***	***(3.0)***
Baltimore	(202,278)	(1.9)
Carroll	(32,853)	(0.8)
Cecil	(9,247)	(0.1)
Harford	342,142	4.3
Howard	(469,275)	(11.4)
Montgomery	(482,912)	(8.3)
Eastern	**8,830,739**	**13.4**
Caroline	694,273	13.4
Dorchester	421,024	3.7
Kent	177,628	4.1
Queen Anne's	862,777	12.0
Somerset	2,780,022	33.5
Talbot	941,326	17.6
Wicomico	1,785,778	14.5
Worcester	1,167,911	8.3
Southern	***(1,438,858)***	***(2.7)***
Anne Arundel	893	0.0
Calvert	(304,490)	(4.1)
Charles	(309,372)	(2.3)
Prince George's	204,974	2.1
St. Mary's	(1,030,864)	(9.4)
Western	***2,030,665***	***2.2***
Allegany	857,936	4.7
Frederick	(277,005)	(2.8)
Garrett	1,289,158	5.5
Washington	160,576	1.5

State/County	Total Cubic Feet	Cubic Feet per Acre
DE	**3,538,279**	**9.3**
Kent	744,160	8
New Castle	409,986	8
Sussex	2,384,133	13
PA	**7,461,310**	**3.9**
Adams	1,344,741	10.4
Bedford	1,108,701	3.2
Chester	567,976	6.6
Fayette	1,669,893	5.7
Franklin	912,280	4.7
Fulton	(118,608)	(0.7)
Lancaster	(202,379)	(2.7)
Somerset	1,744,086	4.1
York	434,621	4.2
VA	**(509,954)**	**(1.4)**
Accomack	458,732	4.5
Fairfax	140,867	3.3
Loudoun	(1,109,553)	(12.0)
WV	**6,651,763**	**6.2**
Berkeley	956,204	12.4
Grant	1,787,574	7.4
Hampshire	927,419	3.2
Jefferson	323,796	9.8
Mineral	832,758	5.8
Morgan	(300,790)	(2.7)
Preston	2,124,801	7.7

	Total Cubic Feet	Cubic Feet per Acre
Total Project Area	**25,709,522**	**4.2**

WOOD UTILIZATION

Wood fuel can be produced from timber harvests, both as a primary product and incidentally, and as a by-product of wood manufacturing. Though wood fuel volumes are presented in this assessment, the supply of wood fuel is dependent on the production of sawtimber. Wood fuel is the least valuable product in the forest and the market values do not cover the costs of harvesting if the only product harvested is wood fuel. On the other hand, sawtimber offers high market values that allow for profitable harvesting of both the sawtimber and wood fuel. The additional costs of harvesting non-sawtimber trees and/or recovering the stemwood above the sawlog portion of felled sawtimber trees, is only marginally higher and wood fuel markets will generally offer enough value to warrant the extra costs involved in recovering the wood fuel. Wood fuel is a by-product of sawtimber harvesting and is left in the woods unutilized absent a market that will receive it. Many loggers will absorb the costs of wood fuel harvesting at a modest financial loss so that they can achieve

silvicultural goals and provide landowners with a more aesthetically pleasing harvest site. Wood fuel harvesting is not economically possible in the absence of sawtimber values.

Timber Removals

To calculate the annual removals of wood fuel in the project area, average annual volume of growing stock removals was determined using FIA data of project area. Volumes (MCF) were calculated by deducting sawlog harvest volume from harvest of merchantable bole volume. Per acre harvest rates were derived from growing stock removals divided by acres of timberland. **Table 9** shows merchantable bole wood volume of growing-stock removals from timberland by state, county, and region.

In addition to harvest removals, the U.S. Forest Service tracks removals due to pre-commercial thinnings, in which trees are cut but not utilized, and land-use changes where forest land is converted to non-forestland uses such as urban or agricultural use; these are described as other removals in **Table 10.**

Table 9: Average Annual Harvest Removals of Wood Fuel (CF) on Timberland by State, Region, County

State/Region/County	Merchantable Bole Volume Removals	Sawlog Volume Removals	Net Volume of Biomass Removals	Net Volume of Removals per Acre
MD	**38,542,984**	**27,350,449**	**11,070,530**	**5.6**
Central	***12,502,392***	***9,997,377***	***2,505,015***	***7.6***
Baltimore	-	-	-	-
Carroll	583,034	354,386	228,648	5.3
Cecil	-	-	-	-
Harford	6,808,138	5,514,812	1,293,326	16.4
Howard	5,111,221	4,128,179	983,041	24.0
Montgomery	-	-	-	-
Eastern	***12,464,395***	***6,804,727***	***5,659,668***	***8.4***
Caroline	1,307,047	422,986	884,061	17.1
Dorchester	6,016,730	3,732,603	2,284,128	20.0
Kent	-	-	-	-
Queen Anne's	590,109	522,609	67,500	0.9
Somerset	1,615,941	450,271	1,165,670	14.0
Talbot	1,112,931	599,909	513,022	9.6
Wicomico	193,723	162,727	30,996	0.3
Worcester	1,627,912	913,621	714,292	5.1
Southern	***1,252,952***	***709,820***	***421,127***	***0.8***
Anne Arundel	53,668	-	-	-
Calvert	-	-	-	-
Charles	68,337	-	-	-
Prince George's	-	-	-	-
St. Mary's	1,130,947	709,820	421,127	3.8
Western	***12,323,245***	***9,838,525***	***2,484,720***	***5.0***
Allegany	699,919	486,800	213,119	1.2
Frederick	1,632,967	1,358,874	274,094	2.8
Garrett	2,668,910	2,098,838	570,072	2.4
Washington	7,321,449	5,894,014	1,427,435	13.5
DE	**8,878,740**	**7,093,342**	**1,785,398**	**4.7**
Kent	4,411,975	3,601,037	810,939	8.2
New Castle	332,313	275,655	56,658	1.1
Sussex	4,134,451	3,216,650	917,801	4.9
PA	**20,333,194**	**15,521,119**	**4,812,075**	**3.3**
Adams	270,716	113,139	157,578	1.2
Bedford	2,416,748	1,759,079	657,669	1.9
Chester	-	-	-	-
Fayette	963,575	639,258	324,317	1.1
Franklin	2,503,039	1,745,767	757,272	3.9
Fulton	4,770,480	3,684,483	1,085,997	6.3
Lancaster	3,054,932	2,373,997	680,935	9.2
Somerset	3,307,971	2,659,560	648,412	1.5
York	3,045,732	2,545,837	499,895	4.8
VA	**24,691,526**	**19,923,533**	**4,767,992**	**19.8**
Accomack	15,023,746	12,378,615	2,645,131	25.9
Fairfax	6,585,244	5,752,126	833,118	19.6
Loudoun	3,082,536	1,792,792	1,289,744	13.9
WV	**11,720,481**	**8,393,556**	**3,326,925**	**2.2**
Berkeley				-
Grant	4,673,218	2,910,449	1,762,769	7.3
Hampshire	2,038,864	1,664,583	374,281	1.3
Jefferson	-	-	-	-
Mineral	1,733,537	1,129,481	604,057	4.2
Morgan	607,706	496,198	111,508	1.0
Preston	2,667,156	2,192,846	474,310	1.7
Total Project Area	**104,166,924**	**78,281,999**	**25,762,920**	**5.7**

Table 80: Average Annual Other Removals of Wood Fuel (CF) on Timberland by State, Region, County

State/Region/County	Total Cubic Feet	Cubic Feet per Acre
MD	**14,987,105**	**8.7**
Central	9,760,363	27.1
Baltimore	-	-
Carroll	-	-
Cecil	-	-
Harford	5,560,759	63.2
Howard	4,199,604	99.3
Montgomery	-	-
Eastern	310,768	0.4
Caroline	-	-
Dorchester	310,768	2.9
Kent	-	-
Queen Anne's	-	-
Somerset	-	-
Talbot	-	-
Wicomico	-	-
Worcester	-	-
Southern	2,089,780	4.0
Anne Arundel	60,031	1.3
Calvert	-	-
Charles	91,746	0.7
Prince George's	-	-
St. Mary's	1,938,003	18.0
Western	2,826,194	3.2
Allegany	701,535	3.8
Frederick	-	-
Garrett	2,124,658	8.9
Washington	-	-

State/County	Total Cubic Feet	Cubic Feet per Acre
DE	**1,789,473**	**8.6**
Kent	892,309	9.0
New Castle	897,164	16.9
Sussex	-	-
PA	**4,918,625**	**1.3**
Adams	-	-
Bedford	-	-
Chester	-	-
Fayette	-	-
Franklin	-	-
Fulton	-	-
Lancaster	-	-
Somerset	4,888,179	11.5
York	30,446	0.3
VA	**9,974,410**	**61.9**
Accomack	11,626	0.1
Fairfax	6,127,060	144.1
Loudoun	3,835,724	41.5
WV	**3,841,435**	**2.7**
Berkeley	186,179	2.4
Grant	3,385,492	14.0
Hampshire	-	-
Jefferson	-	-
Mineral	-	-
Morgan	269,765	2.8
Preston	-	-

	Total Cubic Feet	Cubic Feet per Acre
Total Project Area	**35,511,048**	**9.8**

Wood Fuel from Other Activities

Maryland has an active forest products industry whose byproducts are an additional source of wood fuel. Timber Products Output (TPO) data (2022) was used to summarize mills by species and product type and volume of roundwood by timber type and by the wood product produced. Data is available on a statewide basis.

Table 11: Number of Mills by Species Type and State in FY2022

Species Group	MD	DE	PA	VA	WV	Total
Mills Utilizing Hardwood*	34	14	366	126	72	612
Mills Utilizing Softwood*	24	6	85	83	22	220
Unknown	15	0	0	0	0	15
Number of Facilities**	**53**	**14**	**376**	**159**	**73**	**675**

*Mills utilizing both hardwood and softwood are accounted for in each species group to accurately represent the number of facilities utilizing each species group

**Represents the actual number of facilities in each state

Table 11 represents the total number of mills utilizing each species type in FY2022. Mills that utilize both hardwood and softwood are accounted for in each species group to accurately represent the number of facilities utilizing each species group. **Table 12** represents the total number of mills in Maryland utilizing each species type by product type produced from 2018 to 2022. Mills that utilize both hardwood and softwood are accounted for in each species group to accurately represent the

number of facilities utilizing each species group. **Table 13** identifies the number of mills and mill types in neighboring states for those same years.

Table 12: Number of Mills by Major Species and Mill Type in Maryland 2018-2022*

	Maryland				
	2018	2019	2020	2021	2022
Hardwood*	**44**	**29**	**28**	**32**	**34**
Biomass/energy plant			1	1	1
Miscellaneous mill	1	2	2	2	1
Pulp/Paper mill	1	1			
Firewood Processors	1		1	3	4
Sawmill	41	26	24	26	28
Softwood*	**23**	**21**	**23**	**23**	**24**
Biomass/energy plant			1	1	1
Miscellaneous mill	2	2	2	2	1
Piling mill			1	1	1
Pulp/Paper mill	1	1			
Sawmill	20	18	19	19	21
Unknown		**16**	**12**	**14**	**15**
Misc - Bark/mulch mill					1
Sawmill		16	12	14	14
Grand Total**	**48**	**48**	**44**	**50**	**53**

*Mills utilizing both hardwood and softwood are accounted for in each species group to accurately represent the number of facilities utilizing each species group
**Represents the actual number of facilities in each state

Table 13: Number of Mills by Major Species and Mill Type in Delaware, Pennsylvania, Virginia and West Virginia 2018-2022*

	Delaware					Pennsylvania					Virginia					West Virginia				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
Hardwood*	**9**	**11**	**11**	**17**	**14**	**416**	**398**	**372**	**396**	**366**	**146**	**141**	**134**	**130**	**126**	**69**	**63**	**66**	**72**	**72**
Bark/mulch mill	1	1	1	2	2	1			1				1	1	1					
Biomass/energy plant						3			2	3	16	15	15	14	14					
Composite Panel/EWP mill						3	3		3	3	2	2	2	2	2	2	2	2	2	2
Concentration/export yard						6	1	2	3	6	6	6	10	10	9	2	5	1	7	8
Miscellaneous mill						5			2	4						11	3	7	5	4
Piling mill														1	1					
Pole mill											1	1	1							
Post mill																	5	3	3	3
Pulp/Paper mill						3	3	5	2	2	4	4	4	4	4					
Firewood Processors						10	7	5	6	8						2			1	1
Sawmill	8	10	10	15	12	383	383	359	375	338	117	113	101	98	95	50	46	51	52	52
Veneer/plywood mill						2	1	1	2	2						2	2	2	2	2
Softwood*	**3**	**4**	**4**	**8**	**6**	**100**	**96**	**90**	**95**	**85**	**96**	**95**	**86**	**84**	**83**	**19**	**20**	**16**	**22**	**22**
Bark/mulch mill	1	1	1	2	2	1							1	1	1					
Biomass/energy plant											14	13	13	12	12					
Composite Panel/EWP mill						1	1		1	1	2	2	2	2	2	1	1	1	1	1
Concentration/export yard														1	1		4		3	3
Log home mill																1	1			
Miscellaneous mill										1	1					11	3	6	4	3
Piling mill														1	1					
Pole mill											4	5	4	3	3					
Post mill											3	4	3	4	4		4	3	3	3
Pulp/Paper mill						2	2	3	2	2	4	4	4	4	4					
Firewood Processors						2	2	2	2	2									1	1
Sawmill	2	3	3	6	4	94	91	85	90	79	67	66	58	55	54	6	7	6	10	11
Veneer/plywood mill											1	1	1	1	1					
Grand Total**	**9**	**11**	**11**	**17**	**14**	**428**	**411**	**383**	**408**	**376**	**179**	**175**	**166**	**163**	**159**	**735**	**710**	**670**	**711**	**675**

*Mills utilizing both hardwood and softwood are accounted for in each species group to accurately represent the number of facilities utilizing each species group
**Represents the actual number of facilities in each state

TPO production is the amount of roundwood harvested and reported as processed by mills annually. The vast majority of sawtimber is processed into lumber within 75 miles of where it was harvested, and so it is safely inferred that the residues generated during sawmilling will remain within the project area and be available as fuel. Slabs and edgings are created as by-products during the processing of round logs into square pieces of lumber, and these by-products are further reduced into chips. As chips are the final form of wood fuel, sawmills are already producing a product they could potentially sell to a fuel market if competition from paper mills and mulch plants are not strong. We make no attempt in this report to predict the relative strength of these markets in comparison to typical fuel pricing, but rather present these volumes as available supply. In practice, paper mills will continue to receive the highest quality chips and the fuel markets will capture the lower quality chips. Mulch yards are price competitive only seasonally and have ample supply of other wood to easily shift their procurement efforts to replace whatever small volume of sawmill chips are diverted. **Table 14** represents the TPO volume of industrial roundwood production by product type, major timber type (hardwood or softwood), by state in 2022.

Table 14: Volume (MCF) of Industrial Roundwood Production by Product Type, Timber Type, and State

	Maryland			Delaware			Pennsylvania			Virginia			West Virginia		
	HW	SW	*Total*	HW	SW	Total	HW	SW	*Total*	HW	SW	*Total*	HW	SW	*Total*
Roundwood	**29,279**	**13,580**	***42,859***	**2,829**	**4,696**	**7,525**	**28,142**	**1,677**	***29,819***	**17,759**	**11,219**	***28,978***	**16,262**	**1,263**	***17,525***
Bioenergy/Wood fuel	**-**	**-**		**-**	**-**	**-**	**130**	**-**	***130***	**62**	**11**	***73***	**-**	**-**	
Nongrowing	-	-		-	-	-	59	-	*59*	6	7	*13*	-	-	
Poletimber	-	-		-	-	-	39	-	*39*	5	2	*7*	-	-	
Sawtimber	-	-		-	-	-	32	-	*32*	51	2	*53*	-	-	
Composite Panel	**-**	**-**		**-**	**-**	**-**	**1,196**	**77**	***1,273***	**-**	**-**		**-**	**-**	
Nongrowing	-	-		-	-	-	407	1	*408*	-	-		-	-	
Poletimber	-	-		-	-	-	47	56	*103*	-	-		-	-	
Sawtimber	-	-		-	-	-	742	20	*762*	-	-		-	-	
Miscellaneous	**5,815**	**8,184**	***13,999***	**191**	**4,057**	**4,248**	**829**	**-**	***829***	**66**	**568**	***634***	**8,785**	**1,242**	***10,027***
Nongrowing	2,093	364	*2,457*	66	74	140	7	-	*7*	3	18	*21*	2,823	13	*2,836*
Poletimber	585	3,723	*4,308*	27	2,672	2,699	5	-	*5*	9	82	*91*	600	555	*1,155*
Sawtimber	3,137	4,097	*7,234*	98	1,311	1,409	817	-	*817*	54	468	*522*	5,362	674	*6,036*
Poles, Posts, Pilings	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**487**	***487***	**-**	**-**	
Nongrowing	-	-		-	-	-	-	-	-	-	84	*84*	-	-	
Poletimber	-	-		-	-	-	-	-	-	-	36	*36*	-	-	
Sawtimber	-	-		-	-	-	-	-		-	367	*367*	-	-	
Pulpwood	**-**	**-**		**-**	**-**	**-**	**6,816**	**791**	***7,607***	**6,640**	**3,672**	***10,312***	**-**	**-**	
Nongrowing	-	-		-	-	-	2,321	15	*2,336*	588	370	*958*	-	-	
Poletimber	-	-		-	-	-	267	571	*838*	3,427	1,830	*5,257*	-	-	
Sawtimber	-	-		-	-	-	4,228	205	*4,433*	2,625	1,472	*4,097*	-	-	
Saw logs	**23,464**	**5,396**	***28,860***	**2,638**	**639**	**3,277**	**19,171**	**809**	***19,980***	**9,376**	**6,481**	***15,857***	**7,477**	**21**	***7,498***
Nongrowing	1,360	6	*1,366*	148	1	149	1,185	1	*1,186*	377	148	*525*	453	-	*453*
Poletimber	-	-		-	-	-	-	-		541	248	*789*	-	-	
Sawtimber	22,104	5,390	*27,494*	2,490	638	3,128	17,986	808	*18,794*	8,458	6,085	*14,543*	7,024	21	*7,045*
Veneer logs	-	-		-	-	-	-	-		**1,615**	-	*1,615*	-	-	
Nongrowing	-	-		-	-	-	-	-		14	-	*14*	-	-	
Poletimber	-	-		-	-	-	-	-		66	-	*66*	-	-	
Sawtimber	-	-		-	-	-	-	-		1,535	-	*1,535*	-	-	
Logging Residues	**21,137**	**9,137**	***30,274***	**2,369**	**1,980**	**4,349**	**17,196**	**1,366**	***18,562***	**75,315**	**20,428**	***95,743***	**7,014**	**290**	***7,304***
Nongrowing	14,284	8,241	*22,525*	1,612	1,838	3,450	11,441	1,271	*12,712*	50,407	13,967	*64,374*	4,585	231	*4,816*
Poletimber	39	92	*131*	3	37	40	42	7	*49*	15,791	3,135	*18,926*	18	16	*34*
Sawtimber	6,814	804	*7,618*	754	105	859	5,713	88	*5,801*	9,117	3,326	*12,443*	2,411	43	*2,454*
Other Removals	**8,422**	**3,509**	***11,931***	**26**	**-**	**26**	**4,724**	**1,671**	***6,395***	**23,181**	**1,092**	***24,273***	**5,604**	**-**	***5,604***
Nongrowing	1,862	153	*2,015*	2	-	2	1,359	76	*1,435*	13,168	201	*13,369*	714	-	*714*
Poletimber	1,621	565	*2,186*	24	-	24	242	60	*302*	5,208	324	*5,532*	1,934	-	*1,934*
Sawtimber	4,939	2,791	*7,730*	-	-		3,123	1,535	*4,658*	4,805	567	*5,372*	2,956	-	*2,956*
Grand Total	**58,838**	**26,226**	***85,064***	**5,224**	**6,676**	**11,900**	**50,062**	**4,714**	***54,776***	**116,255**	**32,739**	***148,994***	**28,880**	**1,553**	***30,433***

The Maryland Dept. of the Environment gathers data on the intake volume for natural wood waste recycling facilities. The number of wood waste recycling facilities and their accepted volumes in 2021 are identified in **Table 15.** Note that volume is not tracked by source. Across the state, almost 500,000 tons was wood waste was accepted by natural wood waste recycling facilities.

Table 15: Number of Permitted Natural Wood Waste Recycling Facilities and Green Tons Accepted in Maryland by County (2021)

County	Number of Facilities	Green Tons Accepted
Allegany	1	14
Anne Arundel	2	48,473
Baltimore	6	81,766
Calvert	1	18,570
Caroline	2	8,339
Carroll	3	7,714
Cecil	1	4,400
Charles	4	6,678
Frederick	3	53,805
Harford	4	748
Howard	3	62,194
Kent	1	440
Montgomery	4	50,084
Prince George's	1	101,532
Queen Anne's	3	7,848
St. Mary's	1	5,630
Talbot	1	2,795
Washington	1	-
Wicomico	2	25,247
Total	**44**	**486,277**

SUSTAINABLE FORESTRY

Growth-to-Drain

Growth to drain estimates can be used in conjunction with growth and removal data to help determine how sustainable the current management schema is. The growth to drain ratio provides a snapshot and can be used to make initial feasibility assessments, which can be furthered investigated in conjunction with net growth projections to determine the amount of wood fuel available in a specific geography within the context of current markets when a mill or plant is looking to be established.

To estimate growth-to-drain ratios, FIA average annual gross growth of merchantable bole wood volume of growing-stock trees and average annual removals of merchantable bole wood volume of growing-stock trees were summarized; sawlog growth and sawlog removals are a subset of growing stock data. Removals include timber harvest removals and other removals, which include land clearing.

Growth-to drain ratios were calculated by dividing growth by removals. **Table 16** identifies growth to drain ratios across the project area, state, region and county. A growth to drain ratio of more than 1 indicates that there is more volume grown than there is harvested in the year. A growth to drain ratio less than 1 indicates that more wood was harvested than

was put on by growth. Note that when there aren't any removals in a county, a growth to drain rate is not reported due to the mathematical nature of the ratio; however, these areas have substantial growth and no removals. The growth to drain ratio across the project area is 2.5, indicating that there is 2.5 times more wood grown than harvested. In Maryland the statewide growth to drain ratio is 3.1; the wood basket is growing. Note that the growth to drain ratio is highest in the Southern Region followed by the Eastern Region and then Western Region with the lowest growth to drain ratio in the Central Region of the state. Of the neighboring states, only Virginia averages a growth to drain rate of less than 1. There is excess wood in Delaware, Pennsylvania, and West Virginia. Current utilization rates are not using all of the resource available to maintain current forest volumes.

Table 16: Growth to Drain using Average Annual Gross Growth & Timber Harvest + Other Removals of Merchantable Bole Volume of Growing-Stock Trees (CF) on Timberland by State, Region, and County

State/Region/ County	Average annual gross growth (CF)	Average annual removals (CF)	Growth to Drain Ratio
MD	178,053,674	57,647,443	3.1
Central	36,874,339	24,569,929	1.5
Baltimore	9,433,308	0	-
Carroll	2,871,716	907,069	3.2
Cecil	5,920,398	0	-
Harford	10,982,431	15,263,652	0.7
Howard	3,818,518	8,399,209	0.5
Montgomery	3,847,969	0	-
Eastern	76,020,880	12,799,881	5.9
Caroline	5,306,868	1,126,433	4.7
Dorchester	11,234,304	6,627,501	1.7
Kent	4,483,419	0	-
Queen Anne's	3,484,956	590,068	5.9
Somerset	12,214,206	1,203,563	10.1
Talbot	12,343,526	1,477,692	8.4
Wicomico	11,967,854	191,462	62.5
Worcester	14,985,746	1,583,161	9.5
Southern	30,906,505	4,179,561	7.4
Anne Arundel	2,287,370	120,063	19.1
Calvert	8,020,706	0	-
Charles	10,093,743	183,492	55.0
Prince George's	2,368,019	0	-
St. Mary's	8,136,666	3,876,006	2.1
Western	34,251,950	16,098,072	2.1
Allegany	9,404,703	1,504,541	6.3
Frederick	5,700,858	1,586,191	3.6
Garrett	14,359,343	7,080,861	2.0
Washington	4,787,046	5,926,479	0.8
DE	25,072,174	11,861,995	2.1
Kent	6,982,471	5,555,301	1.3
New Castle	3,272,852	2,152,946	1.5
Sussex	14,816,851	4,153,748	3.6
PA	91,340,331	29,841,175	3.1
Adams	6,556,576	310,457	21.1
Bedford	15,792,071	2,035,275	7.8
Chester	6,854,547	0	-
Fayette	12,318,482	829,722	14.8
Franklin	8,250,848	2,441,896	3.4
Fulton	5,925,402	4,411,322	1.3
Lancaster	6,367,530	3,272,485	1.9
Somerset	19,680,399	12,940,291	1.5
York	9,594,478	3,599,727	2.7
VA	27,394,088	37,246,175	0.7
Accomack	17,399,960	15,512,518	1.1
Fairfax	3,760,310	14,062,209	0.3
Loudoun	6,233,818	7,671,448	0.8
WV	64,834,510	16,228,238	4.0
Berkeley	4,668,443	372,357	12.5
Grant	13,703,227	9,520,609	1.4
Hampshire	14,102,148	1,728,186	8.2
Jefferson	2,393,959	0	-
Mineral	6,424,562	1,440,985	4.5
Morgan	5,271,227	698,000	7.6
Preston	18,270,944	2,468,102	7.4
Total Project Area	**386,694,776**	**152,825,026**	**2.5**

Projected Volumes with Variable Harvest Rates

To estimate the impact of increased harvesting of wood fuel, wood fuel volumes across the project area are projected at 5-, 10- and 15-year intervals given variable harvest rates above the current rate. Forest volume projections are based off most recent FIA growth and removals data. Total current biomass was divided by the most recent years growth to determine growth rates by county and state. Current volumes of wood fuel were converted from tons to cubic feet, assuming 500 lbs. of green chips is equal to 1 cubic yard (Cook, B., 2016). Calculations are based on growth (assuming growth rate is constant) and removals of wood fuel, and do not include the sawlog volumes. Three different increased harvest scenarios were projected: 0.5%, 1.5%, and 5%. The most recent year's FIA volumes were used as Year 0; each year after year 0 the increased removal rate was applied to the original harvest rate. Data was reported at years 5, 10, and 15. Harvest increases up to 5% increased harvest results in relatively small differences in volumes at each time interval indicating that the forests could likely withstand a much greater increase in harvest than 5%.

Table 17: Projected Volume (CF) of Wood Fuel at 5, 10, and 15 Year Intervals with Increased Harvest Rate of 0.5% by County, Region, and State

	Projected Volume of Wood Fuel (Cubic Feet) at 0.5% Harvest Increase			
State/Region	**Year 0**	**Year 5**	**Year 10**	**Year 15**
MD	**13,004,330,743**	**18,685,174,395**	**47,626,537,687**	**204,073,337,060**
MD - Central	***2,687,115,631***	***2,387,807,613***	***2,300,685,342***	***2,394,602,561***
Baltimore	735,028,007	657,215,203	571,625,586	497,182,368
Carroll	272,148,079	258,091,041	241,762,900	226,396,804
Cecil	544,391,722	540,693,097	536,116,517	531,578,673
Harford	556,480,675	668,016,950	861,283,946	1,121,733,373
Howard	330,210,399	158,998,054	54,262,129	5,594,144
Montgomery	248,856,748	104,793,267	35,634,264	12,117,198
MD - Eastern	***3,924,354,232***	***6,921,694,271***	***17,044,379,828***	***46,353,166,931***
Caroline	302,767,484	686,030,851	1,918,963,949	5,380,307,371
Dorchester	655,700,457	826,767,716	1,113,722,599	1,505,419,325
Kent	277,382,534	355,782,180	485,252,763	661,838,218
Queen Anne's	401,412,644	875,948,691	2,318,178,513	6,135,863,218
St. Mary's	380,320,354	100,148,854	13,665,672	(4,134,171)
Talbot	313,501,961	894,147,060	3,318,582,317	12,329,401,649
Winomico	742,196,189	1,762,130,274	5,178,317,522	15,217,847,543
Worcester	851,072,610	1,420,738,645	2,697,696,495	5,126,623,780
MD - Southern	***2,865,404,139***	***4,931,470,390***	***22,083,319,655***	***146,394,724,798***
Anne Arundel	228,588,143	228,375,189	228,249,785	228,124,135
Calvert	549,814,894	437,525,806	329,070,056	247,498,777
Charles	911,930,120	793,317,022	666,824,978	560,381,866
Prince George's	601,013,802	687,528,510	813,042,845	961,470,920
Somerset	574,057,181	2,784,723,864	20,046,131,990	144,397,249,100
MD - Western	***3,527,456,743***	***4,444,202,121***	***6,198,152,862***	***8,930,842,769***
Allegany	1,013,038,316	1,398,071,596	2,093,769,022	3,138,362,648
Frederick	599,142,630	494,306,928	388,872,108	305,658,511
Garrett	1,404,837,465	1,981,508,728	3,057,305,025	4,726,000,770
Washington	510,438,331	570,314,870	658,206,707	760,820,840
DE	**2,030,254,180**	**3,892,107,119**	**9,215,819,300**	**22,826,597,669**
Kent	635,113,305	979,658,195	1,693,973,781	2,937,015,682
New Castle	340,482,292	531,105,568	931,623,032	1,638,775,030
Sussex	1,054,658,583	2,381,343,356	6,590,222,487	18,250,806,958
PA	**10,354,640,702**	**13,787,439,441**	**20,566,663,756**	**32,079,488,291**
Adams	773,308,756	1,469,919,374	3,275,596,275	7,300,776,114
Bedford	2,020,924,569	2,499,941,640	3,261,485,090	4,256,136,732
Chester	578,108,199	841,853,102	1,345,046,225	2,149,008,350
Fayette	1,661,584,028	2,437,611,585	3,932,737,174	6,346,129,906
Franklin	1,059,907,514	1,471,449,525	2,218,984,498	3,348,582,726
Fulton	717,404,640	665,739,609	607,216,766	553,374,345
Lancaster	481,759,876	402,454,194	321,586,030	256,335,158
Somerset	2,409,514,482	3,156,807,574	4,444,964,103	6,271,881,069
York	652,128,639	841,662,837	1,159,047,596	1,597,263,889
VA	**1,190,315,772**	**1,089,653,199**	**1,384,179,247**	**1,951,098,930**
Accomack	550,278,093	742,898,289	1,092,896,332	1,615,216,634
Fairfax	208,978,133	231,491,918	280,746,448	348,995,649
Loudon	431,059,546	115,262,992	10,536,467	(13,113,354)
WV	**7,076,264,142**	**10,297,562,407**	**17,649,002,336**	**32,641,031,464**
Berkeley	396,836,718	941,866,317	2,770,356,888	8,151,513,540
Grant	1,638,421,230	2,449,791,143	4,079,230,664	6,813,860,101
Hampshire	1,769,794,067	2,170,004,687	2,799,280,649	3,611,644,911
Jefferson	195,475,241	361,473,809	777,874,778	1,673,950,243
Mineral	875,036,737	1,256,311,613	1,975,584,654	3,108,762,968
Morgan	562,159,317	449,198,686	339,493,024	256,159,808
Preston	1,638,540,832	2,668,916,152	4,907,181,678	9,025,139,894
Total Project Area	**33,655,805,539**	**47,751,936,560**	**96,442,202,325**	**293,571,553,414**

Table 18: - Projected Volume (Cubic Feet) of Wood fuel at 5, 10, and 15 Year Intervals with Increased Harvest Rates of 1.5% by County, Region, and State

	Projected Volume of Wood fuel (Cubic Feet) at 1.5% Harvest Increase			
State/Region	**Year 0**	**Year 5**	**Year 10**	**Year 15**
MD	**13,004,330,743**	**18,684,060,830**	**47,623,081,229**	**204,061,949,283**
MD - Central	***2,687,115,631***	***2,387,330,979***	***2,299,600,359***	***2,392,795,445***
Baltimore	735,028,007	657,215,203	571,625,586	497,182,368
Carroll	272,148,079	258,082,059	241,743,288	226,367,188
Cecil	544,391,722	540,693,097	536,116,517	531,578,673
Harford	556,480,675	667,716,450	860,491,470	1,120,277,905
Howard	330,210,399	158,830,902	53,989,234	5,272,113
Montgomery	248,856,748	104,793,267	35,634,264	12,117,198
MD - Eastern	***3,924,354,232***	***6,921,395,863***	***17,043,485,161***	***46,350,873,501***
Caroline	302,767,484	685,981,359	1,918,755,324	5,379,651,994
Dorchester	655,700,457	826,653,488	1,113,419,165	1,504,857,624
Kent	277,382,534	355,782,180	485,252,763	661,838,218
Queen Anne's	401,412,644	875,944,989	2,318,163,541	6,135,818,414
St. Mary's	380,320,354	100,086,392	13,583,693	(4,220,167)
Talbot	313,501,961	894,115,308	3,318,417,887	12,328,744,103
Winomico	742,196,189	1,762,128,510	5,178,309,842	15,217,822,475
Worcester	851,072,610	1,420,703,636	2,697,582,946	5,126,360,840
MD - Southern	***2,865,404,139***	***4,931,366,999***	***22,082,479,259***	***146,388,651,817***
Anne Arundel	228,588,143	228,370,638	228,239,536	228,108,177
Calvert	549,814,894	437,525,806	329,070,056	247,498,777
Charles	911,930,120	793,310,938	666,812,379	560,363,785
Prince George's	601,013,802	687,528,510	813,042,845	961,470,920
Somerset	574,057,181	2,784,631,108	20,045,314,443	144,391,210,159
MD - Western	***3,527,456,743***	***4,443,966,990***	***6,197,516,450***	***8,929,628,520***
Allegany	1,013,038,316	1,398,030,094	2,093,652,544	3,138,133,592
Frederick	599,142,630	494,296,701	388,851,542	305,629,785
Garrett	1,404,837,465	1,981,385,173	3,056,951,536	4,725,290,623
Washington	510,438,331	570,255,021	658,060,828	760,574,520
DE	**2,030,254,180**	**3,891,929,295**	**9,215,215,879**	**22,825,083,854**
Kent	635,113,305	979,577,128	1,693,725,112	2,936,475,353
New Castle	340,482,292	531,059,954	931,481,852	1,638,465,118
Sussex	1,054,658,583	2,381,292,214	6,590,008,916	18,250,143,383
PA	**10,354,640,702**	**13,787,015,186**	**20,565,543,464**	**32,077,399,365**
Adams	773,308,756	1,469,911,228	3,275,566,977	7,300,699,666
Bedford	2,020,924,569	2,499,913,088	3,261,411,103	4,256,003,404
Chester	578,108,199	841,853,102	1,345,046,225	2,149,008,350
Fayette	1,661,584,028	2,437,596,522	3,932,693,041	6,346,038,847
Franklin	1,059,907,514	1,471,415,094	2,218,887,502	3,348,391,189
Fulton	717,404,640	665,697,235	607,125,246	553,237,612
Lancaster	481,759,876	402,428,625	321,534,095	256,261,949
Somerset	2,409,514,482	3,156,560,884	4,444,294,324	6,270,611,249
York	652,128,639	841,639,407	1,158,984,951	1,597,147,099
VA	**1,190,315,772**	**1,089,086,472**	**1,382,832,581**	**1,948,702,852**
Accomack	550,278,093	742,777,976	1,092,559,873	1,614,557,609
Fairfax	208,978,133	231,184,074	279,921,691	347,454,633
Loudon	431,059,546	115,124,422	10,351,018	(13,309,389)
WV	**7,076,264,142**	**10,297,228,572**	**17,648,006,797**	**32,638,900,210**
Berkeley	396,836,718	941,855,719	2,770,310,689	8,151,362,564
Grant	1,638,421,230	2,449,548,993	4,078,504,220	6,812,320,884
Hampshire	1,769,794,067	2,169,988,497	2,799,238,968	3,611,570,322
Jefferson	195,475,241	361,473,809	777,874,778	1,673,950,243
Mineral	875,036,737	1,256,283,777	1,975,504,276	3,108,599,811
Morgan	562,159,317	449,184,616	339,465,206	256,121,547
Preston	1,638,540,832	2,668,893,160	4,907,108,660	9,024,974,839
Total Project Area	**33,655,805,539**	**47,749,320,355**	**96,434,679,951**	**293,552,035,565**

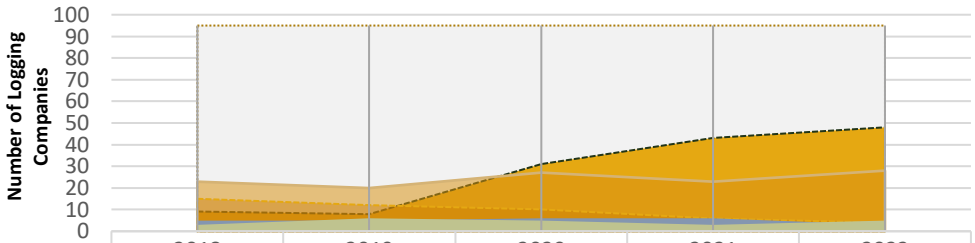
Table 19: - Projected Volume (CF) of Wood fuel at 5, 10, and 15 Year Intervals with Increased Harvest Rates of 5% by County, Region, and State

	Projected Volume of Wood fuel (Cubic Feet) at 5% Harvest Increase			
State/Region	**Year 0**	**Year 5**	**Year 10**	**Year 15**
MD	**13,004,330,743**	**18,680,163,349**	**47,610,983,625**	**204,022,092,066**
MD - Central	***2,687,115,631***	***2,385,662,758***	***2,295,802,918***	***2,386,470,538***
Baltimore	735,028,007	657,215,203	571,625,586	497,182,368
Carroll	272,148,079	258,050,624	241,674,645	226,263,531
Cecil	544,391,722	540,693,097	536,116,517	531,578,673
Harford	556,480,675	666,664,699	857,717,805	1,115,183,764
Howard	330,210,399	158,245,869	53,034,100	4,145,003
Montgomery	248,856,748	104,793,267	35,634,264	12,117,198
MD - Eastern	***3,924,354,232***	***6,920,351,434***	***17,040,353,828***	***46,342,846,496***
Caroline	302,767,484	685,808,138	1,918,025,136	5,377,358,175
Dorchester	655,700,457	826,253,691	1,112,357,149	1,502,891,670
Kent	277,382,534	355,782,180	485,252,763	661,838,218
Queen Anne's	401,412,644	875,932,033	2,318,111,139	6,135,661,599
St. Mary's	380,320,354	99,867,777	13,296,769	(4,521,150)
Talbot	313,501,961	894,004,175	3,317,842,385	12,326,442,695
Winomico	742,196,189	1,762,122,338	5,178,282,962	15,217,734,740
Worcester	851,072,610	1,420,581,103	2,697,185,526	5,125,440,550
MD - Southern	***2,865,404,139***	***4,931,005,128***	***22,079,537,873***	***146,367,396,385***
Anne Arundel	228,588,143	228,354,711	228,203,664	228,052,322
Calvert	549,814,894	437,525,806	329,070,056	247,498,777
Charles	911,930,120	793,289,641	666,768,281	560,300,499
Prince George's	601,013,802	687,528,510	813,042,845	961,470,920
Somerset	574,057,181	2,784,306,461	20,042,453,027	144,370,073,867
MD - Western	***3,527,456,743***	***4,443,144,028***	***6,195,289,005***	***8,925,378,648***
Allegany	1,013,038,316	1,397,884,838	2,093,244,869	3,137,331,895
Frederick	599,142,630	494,260,908	388,779,561	305,529,244
Garrett	1,404,837,465	1,980,952,731	3,055,714,324	4,722,805,111
Washington	510,438,331	570,045,551	657,550,251	759,712,398
DE	**2,030,254,180**	**3,891,306,914**	**9,213,103,907**	**22,819,785,500**
Kent	635,113,305	979,293,394	1,692,854,770	2,934,584,204
New Castle	340,482,292	530,900,305	930,987,721	1,637,380,425
Sussex	1,054,658,583	2,381,113,214	6,589,261,416	18,247,820,870
PA	**10,354,640,702**	**13,785,530,293**	**20,561,622,444**	**32,070,088,125**
Adams	773,308,756	1,469,882,717	3,275,464,436	7,300,432,098
Bedford	2,020,924,569	2,499,813,157	3,261,152,151	4,255,536,753
Chester	578,108,199	841,853,102	1,345,046,225	2,149,008,350
Fayette	1,661,584,028	2,437,543,803	3,932,538,574	6,345,720,143
Franklin	1,059,907,514	1,471,294,586	2,218,548,018	3,347,720,810
Fulton	717,404,640	665,548,925	606,804,929	552,759,044
Lancaster	481,759,876	402,339,135	321,352,323	256,005,718
Somerset	2,409,514,482	3,155,697,467	4,441,950,097	6,266,166,876
York	652,128,639	841,557,401	1,158,765,692	1,596,738,334
VA	**1,190,315,772**	**1,087,102,929**	**1,378,119,251**	**1,940,316,582**
Accomack	550,278,093	742,356,881	1,091,382,266	1,612,251,020
Fairfax	208,978,133	230,106,622	277,035,039	342,061,076
Loudon	431,059,546	114,639,426	9,701,946	(13,995,514)
WV	**7,076,264,142**	**10,296,060,150**	**17,644,522,412**	**32,631,440,820**
Berkeley	396,836,718	941,818,629	2,770,148,990	8,150,834,150
Grant	1,638,421,230	2,448,701,467	4,075,961,666	6,806,933,625
Hampshire	1,769,794,067	2,169,931,833	2,799,093,085	3,611,309,261
Jefferson	195,475,241	361,473,809	777,874,778	1,673,950,243
Mineral	875,036,737	1,256,186,353	1,975,222,950	3,108,028,759
Morgan	562,159,317	449,135,372	339,367,845	255,987,636
Preston	1,638,540,832	2,668,812,687	4,906,853,098	9,024,397,147
Total Project Area	**33,655,805,539**	**47,740,163,636**	**96,408,351,639**	**293,483,723,093**

FOREST PRODUCTS INDUSTRY

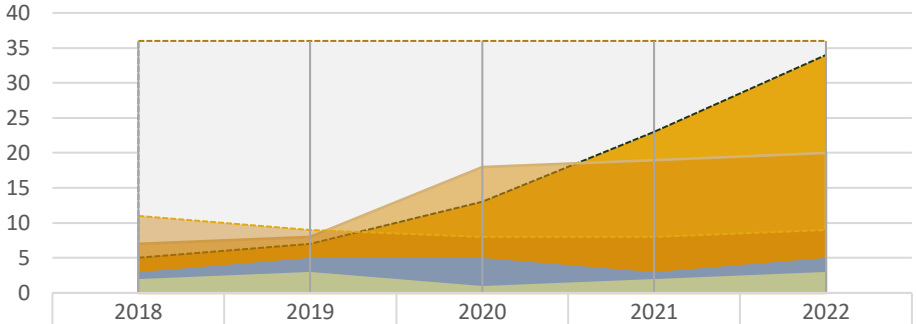
The wood fuel supply chain is strong in Maryland and the number of small logging businesses are increasing, providing the ability to produce and deliver fuel grade wood. Forest product operator data was summarized by product class for Maryland from 2018 to 2022 to determine the number of timber harvesting and land clearing businesses and their estimated production volume as identified in **Figure 19.** The number of wood manufacturing facilities, such as sawmills, generating wood suitable for use as wood fuel (e.g., wood chips, trimmings, etc.) and their estimated volume production as estimated by the State of Maryland are identified in **Figure 20.** A number of respondents didn't identify their size and those are listed an "unidentified". **Figure 21** identifies the number of licensed tree experts and provides an estimate of their volume production.

Figure 17: Number of Logging Companies in Maryland - 2018-2022



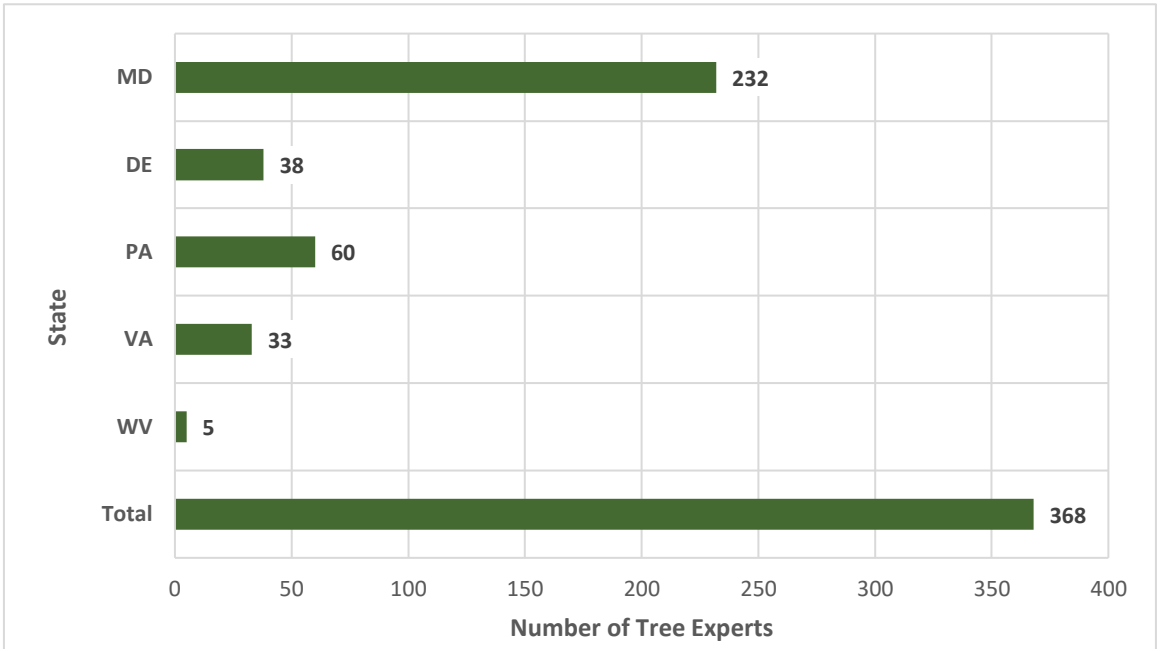
	2018	2019	2020	2021	2022
Unidentified	95	95	95	95	95
<1 million BF	9	8	31	43	48
1 million - 5 million BF	23	20	27	23	28
5 million - 10 million BF	15	12	10	6	4
10 million - 15 million BF	5	5	6	6	3
>15 million BF	3	6	5	3	5

Figure 18: Number of Sawmills in Maryland - 2018-2022



	2018	2019	2020	2021	2022
Unidentified	36	36	36	36	36
<1 million BF	5	7	13	23	34
1 million - 5 million BF	7	8	18	19	20
5 million - 10 million BF	11	9	8	8	9
10 million - 15 million BF	3	5	5	3	5
>15 million BF	2	3	1	2	3

Figure 19: Number of Tree Experts in Project Area in 2023



POLICY IMPLICATIONS

Interest in the use of wood fuel is increasing in forested regions across the country as land managers struggle to maintain forest health given the decline in markets for low value wood fuel. Land managers and policymakers are balancing the need to remove excess trees for optimal growth and fuel hazard reduction with the need to retain enough material for soil health. **This study demonstrated that wood fuel resources far exceed the current utilization rates and increased removals of wood fuel from Maryland forests could be beneficial to both local economies and the forests themselves.**

Maryland has been a leader in forest soil protection and was an early adopter of biomass harvesting guidelines. By continuing to follow the guidelines set forth in "A Guide to Forest Biomass Harvesting and Retention in Maryland", an increase in removal volume can be sustainably achieved. These guidelines call for stand level decision-making and allow enough leeway for foresters and loggers to work with landowners and conduct wood fuel removals based on localized soil conditions, silviculture, water quality, and other site-specific variables and landowner goals.

In addition, the Maryland Department of the Environment has laid out best management practices in "Maryland 's Erosion and Sediment Control Plan" and those should continue to be used when conducting timber harvests, including the wood fuel harvest. By following all previously approved water quality best management practices and ensuring an adequate amount of coarse woody debris is left after harvest, potential erosion and runoff issues will be eliminated.

Regulations pertaining to soil conditions and forestry operations are already in place and identified in "A Guide to Forest Biomass Harvesting and Retention in Maryland" as well as in the "Forest Harvest Operations Manual". Specific biomass considerations relating to soil buffering capacity and physical characteristics need to be considered when developing a forest management plan. Certain areas in Maryland require more caution and this should be called out in forest management plans and in timber harvest plans for those areas. Guidelines for sound environmental practices are in place and can be incorporated into continuing education for foresters and loggers.

This study found that some of Maryland's forests are not growing at optimal rates due to a lack of management via timber harvest. Increased utilization will both improve forest health by creating biodiversity and promoting regeneration and will also help Maryland achieve its climate goals by providing a carbon sink through younger, healthy, faster growing trees. Most of Maryland's timberlands are privately owned and Maryland's social tolerance for timber harvesting is relatively low as citizens and landowners may not understand the positive relationship between timber harvest and improved forest health. Education is needed to overcome the misunderstandings associated with both timber harvest and the removal of wood fuel.

Further, the increased utilization of wood fuel will create new demand for low value timber, making harvests more economical for the loggers and more profitable for landowners. These new markets will allow Maryland to produce renewable, sustainable building and energy resources from its local forests reducing the need to import products and the associated costs and environmental impacts of transportation of imported and non-renewable goods and fuels. **Policy should promote the development of wood fuel markets to encourage improved utilization to realize these benefits and lessen dependence on fossil fuels**.

Maryland also has protections in place regarding the use of biomass. Current air quality regulations provide specific requirements pertaining to the burning of biomass. The Code of Maryland Regulations has regulations in place for biomass-burning facilities in the state and these consider particulate matter emissions, NO_X emission standards, and initial/biennial tune-ups.

Maryland is well positioned to sustainably increase wood fuel harvests, which will aid in reaching current forest health and climate goals. Increased wood fuel removals will also benefit both local economies in addition to the forests themselves. Marylanders will benefit from added employment and a dependable local, renewable fuel source. Policy development should emphasize the education of landowners, especially private landowners, loggers, and foresters to utilize the resource guidelines currently in place to sustainably expand biomass harvesting.

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